Committee on Tidal Hydraulics

Minutes of the 104th Meeting

18-20 April 1995

Executive Summary

The U.S. Army Corps of Engineers Committee on Tidal Hydraulics (CTH) met in Sausalito, CA, on 18-20 April 1995 at the request of the San Francisco District.

The San Francisco District briefed the CTH on two navigation projects: the proposed John F. Baldwin Phase III project, which will extend an enlarged San Francisco Bay navigation channel from near Richmond, CA, to Suisun Bay near Avon; and a possible later enlargement of the channel upstream to Stockton, CA. The effects of the John F. Baldwin Phase III Project on salinity intrusion are being

evaluated using the San Francisco Bay-Delta physical model in Sausalito and a three- dimensional numerical model of the system. The San Francisco District posed questions for the CTH on the relative present and future roles of the physical and numerical models and how to resolve apparent differences in model salinity results.

The CTH also heard of the completed numerical modeling performed for the District's Long-Term Management Strategy (LTMS) study to provide options for dredged material disposal in the San Francisco Bay area. A two-dimensional numerical model of sediment transport using the TABS-MD system of models, a three-dimensional numerical model of hydrodynamics, and a conservative tracer using the model RMA-10 were used to predict the fate of sediments placed in open water at several sites in the bay system.

The New Orleans District made a special presentation to the CTH on the Bonnet Carre′ Freshwater Diversion project near New Orleans, LA, which is intended to reduce the rate of marsh loss in the Lake Pontchartrain Basin and improve fisheries production by diverting Mississippi River water into the lake. Opponents of the project fear environmental damage to the basin. An interagency team has reevaluated the project and recommended some changes to the project's design and operation, including lower diversion rates and consideration of means to reduce salinity intrusion to the lake through the Mississippi River-Gulf Outlet. The District asked the CTH to consider the contribution of the Mississippi River-Gulf Outlet to basin salinities and recommend methods that might reduce that contribution.

In Executive Session the CTH considered the questions posed by the two districts and formed two subcommittees to draft replies. Items of other business considered included the need for tidal hydraulics research and development, publication of the Lessons Learned report, and publication of the final installment of the Tidal Hydraulics Bibliography. Chairman Frank Herrmann announced his retirement and the CTH thanked him for his long and valuable service to the committee and the Corps of Engineers.

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1. The 104th meeting of the Committee on Tidal Hydraulics (CTH) was held 18-20 April 1995 in Sausalito, CA, at the invitation of LTC Michael Walsh, District Engineer, U.S. Army Engineer District, San Francisco.

2. On 18-19 April, the CTH held Technical Sessions on San Francisco District Projects and on the New Orleans District Bonnet Carre′ Freshwater Diversion Project. The CTH met in Executive Session during the afternoon of 19 April and morning of 20 April. All sessions were held at the San Francisco Bay-Delta Model in Sausalito.

3. Attendees were:

Committee on Tidal Hydraulics

Frank A. Herrmann, Jr., Chairman	Waterways Experiment Station
William H. McAnally, Jr., Executive Secretary	Waterways Experiment Station
A. Jay Combe	New Orleans

District
Jaime R. Merino South Pacific Division
Virginia R. Pankow Water Resources
Support Center
Edward A. Reindl, Jr. Galveston District
Michael R. Palermo Waterways Experiment
Station

Consultants

Ray B. Krone Professor
Emeritus, University of California at Davis
Donald W. Pritchard Professor Emeritus, State
University of New York at Stony Brook

Other Corps of Engineers Representatives[1]

John H. Lockhart, Jr.	Headquarters, U.S. Army Corps of Engineers
Bill Angeloni	San Francisco District
Tom Kendall	San Francisco District
Wardell Johnston	San Francisco District, Retired
Nick Raptis	San Francisco District
Len Madalon	San Francisco District
David Fry	San Francisco District
Lyn Hawkins	San Francisco District
Geof Chatfield	San Francisco District
George Domurant	South Pacific Division
Donna Richey	Waterways Experiment Station
Robert F. Athow	Waterways Experiment Station
Jack Fredine	New Orleans District

Guests[1]

Rod Sobey	University of California, Berkeley
Volker (Tim) Harms	University of California, Berkeley

4. The minutes are divided into discussions of presentations made at the Technical Sessions and actions taken at the Executive Session. The order of the minutes is not necessarily the chronological order in which these matters were considered at the meeting.

[1] Attended Technical Sessions only.

Technical Sessions

5. Mr. William C. Angeloni, San Francisco District, welcomed the CTH and guests on behalf of LTC Walsh, who was on temporary duty assignment elsewhere. He noted that it had been several years since the CTH had met in San Francisco, and said that it was an honor to host the Committee again.

6. Mr. Frank A. Herrmann, Jr., Chairman of the CTH and Director of the U.S. Army Engineer Waterways Experiment Station (WES) Hydraulics Laboratory, thanked Mr. Angeloni for the invitation to hold the meeting in the Bay area. He noted that the CTH has a long history of involvement in the San Francisco Bay-Delta Model (Bay Model), advising the District during the planning and construction stages, and the first Bay Model Director, Mr. Edward Schultz, was a long-time member of the CTH.

7. Mr. Herrmann said that the CTH misses the members who could not attend this meeting, particularly Mr. Henry Simmons, who has a long affiliation with the Bay Model. He serves on the Bay Model Advisory Group along with CTH members Drs. Donald W. Pritchard and Ray B. Krone, Consultants.

8. Of the members and consultants present at this meeting, Dr. Pritchard has the longest tenure, serving since 1955. Mr. Herrmann extended a special welcome to him and to Mr. Wardell Johnston, who, prior to his retirement from the San Francisco District, had been associated with the Bay Model since before its construction.

John F. Baldwin Project, Phase III

9. Mr. Angeloni opened the discussion of the John F. Baldwin Phase III (JFB) project. A primary question for the project is how it will affect salinities in upper San Francisco Bay. He said that the Bay Model, currently being used to evaluate the project's salinity effects, constitutes a unique technical and public education resource. The Bay Model tests are complemented by three-dimensional numerical model tests at WES.

10. In January 1995 an interagency panel met at the Bay Model to review both models and their application to the JFB project. The panel members advised the District on the studies, and the District also wanted the CTH's advice. Specifically, he posed these questions to the CTH:

"*a.* Is the physical model still a viable tool and worth keeping operational given recent developments in numerical modeling and the fact that the Corps has only the John F. Baldwin Project, and possibly the Stockton Project, which might need its services in near term? Could this facility be of assistance to the State of California as they work to develop a comprehensive water management plan to meet the new Bay-Delta Standards?

"*b*. A number of tests have been run for the J.F.B. Project over the years to estimate salinity impacts upstream of the Project. An interagency meeting was held in January, 1995, to discuss the results of the most recent test. This group, as past groups have, suggested that a varying spring/neap condition should be run in the physical model. This has not been done in the past because the HP 1000 made this a very difficult thing to do. Recent conversion to PC control will now make this a simpler modification. Is it still a desirable thing to do, or would simply running repetitive spring and neap tides and measuring the relative difference against the 19year repetitive mean tide be just as meaningful?

"*c*. Additionally, after the January, 1995 meeting, a list of proposed actions was included as part of the minutes. We request that the Committee evaluate these proposed actions and provide input as regards their effectiveness in addressing the salinity issues for this project.

"*d*. The Corps has been asked to study a 40 to 45 ft deep navigation channel from Avon (the upstream limit of J.F.B. III) to the Port of Stockton. Should this project be modeled to estimate upstream salinity changes using both the numerical and physical models, or will the numerical model be adequate?"

11. Mr. Geof Chatfield, San Francisco District, JFB Project Manager, described the four phases of the project. Phase I enlarged the bar channel and Phase II enlarged the Richmond and Southampton Shoal Channels. Phase III, when constructed, will extend the enlargement from Richmond through the Pinole Shoal Channel to Suisun Bay near Avon, CA. Phase IV is proposed to extend the enlargement from Suisun Bay to the Port of Stockton. The local sponsor for Phase III is Contra Costa County. Enclosure 1 shows the bay and channels.

12. Phase III will require new work dredging of about 9 million cubic yards. Disposal of that material and subsequent maintenance dredging are the subjects of the District's Long-Term Management Strategy (LTMS) study. Available disposal sites include an ocean site, designated in 1994 by the Environmental Protection Agency for up to 6 million cubic yards per year; Bay Farm, a confined aquatic site in South Bay; Montezuma Wetlands, an upland site with a 20-million-cubic-yard capacity; and Leonard Ranch, a rehandling facility at San Pablo Bay.

13. A contract has been awarded to write the Environmental Impact Statement for the JFB project. A scoping meeting is scheduled for 1 June 1995 in Martinez, CA. Environmental concerns include salinity intrusion to the points of withdrawal of water supply for Contra Costa County and for State and Federal water diversion plus effects on the endangered species chinook salmon, delta smelt, and Sacramento split tail.

Modeling of JFB

14. Mr. William H.McAnally, Jr., WES, summarized the history of JFB project modeling and the CTH's involvement. Drs.Krone and Pritchard, together with Mr.Simmons, have constituted the Bay Model Advisory Board, which assisted in the formulation of modeling plans. In 1987, the CTH as a whole met to review the Bay Model's past, present, and future uses. In a 23 September 1987 letter to the District Engineer from Mr.Herrmann, the CTH concluded that

"Review of the present capabilities of the San Francisco Bay-Delta Model, its potential usefulness, and the strengths and limitations of physical and numerical models at this time led to the following conclusions and recommendations:

a. The San Francisco Bay-Delta Model is the best available means for evaluating impacts of changes on the hydrodynamics and salinities of the system at the present time.

b. In view of its readiness and the pressing need for such capability, the model should be upgraded to simulate tides throughout a lunar month, and the items of deferred model maintenance should be completed.

c. The District should maintain awareness of progress in the development of numerical hydrodynamic models and utilize numerical transport models when appropriate as it is doing in the present hybrid model study with WES.

d. When both the capabilities and costs of numerical three-dimensional hydrodynamic models make them more attractive than those of the physical model, an orderly transition should be planned.

e. Improvements in both computing equipment and software development cannot be predicted with certainty. An interim physical modeling capability should be maintained as long as there is need, which is expected to be at least 3 to 5 years.

f. In order to prepare for a possible transition and to better address the questions of appropriate modeling technology in future years, the existing two-dimensional TABS model developed at WES should be used as the basis for an experimental three-dimensional TABS-3 numerical model.

g. After development of the three-dimensional numerical model, a carefully designed series of tests should be implemented in both the physical and numerical models and the results analyzed and compared to provide a sound basis for future decisions.

h. The value of the Bay-Delta Model for public and public agency relations should be given serious consideration. Its value in this respect will be diminished if it is converted into a tourist attraction only."

15. The District and Bay Model staff have followed this advice, with the exception of adding a capability to model a lunar month's tidal variation in the physical model. Numerical modeling in three dimensions began as sensitivity studies in the late 1980's and has assumed a larger role as the technology developed.

Numerical model tests of JFB

16. Mr. McAnally described the ongoing numerical modeling of the JFB project. WES numerical modeling of the JFB project was begun in 1988 to complement the Bay Model tests, particularly by providing results in the shallowest part of the estuary, where scale effects and a lack of wind-induced mixing are known to make physical model results less reliable. Initial applications of the numerical models involved verifying them to the physical model, making them reproduce the along-channel salinity distribution observed in the physical model. Other developments of the models were intended to support the District's LTMS for dredged material study.

17. Six comprehensive numerical models have been developed and applied to the San Francisco Bay system by WES, and they are designated as Models A-E and LJ (for LTMS and JFB combined). Their characteristics are given in the following tabulation. Mesh LJ is shown in Enclosure 2. It is three-dimensional from the ocean to the delta, with variable resolution in the vertical ranging from one (depth-integrated) to seven computational nodes. The quadratic basis functions of the model mean that seven nodes is equivalent to about 15 linear cells.

JFB Numerical Models

Model	Dimensionality	Approximate No. of Horizontal Elements	Boundaries	Verified To	Tidal Boundary Condition	Channel Deepened To
A	1-D & 2-D	2000	2-D Ocean thru 1-D Delta	Physical Model	19-Year Mean	Suisun Point
B	1-D & 2-D	700	2-D Ocean thru 1-D Delta	Physical Model	19-Year Mean	Suisun Point
C	1-D, 2-D, & 3-D	980	3-D Golden Gate thru 1-D Delta	Physical Model	19-Year Mean	Suisun Point
D	1-D & 2-D	3320	2-D Ocean to	Physical Model	19-Year Mean	Davis Point

			Delta			
E	1-D, 2-D, & 3-D	3320	2-D Ocean to Delta	Physical Model	19-Year Mean	Davis Point
LJ	1-D, 2-D, & 3-D	4750	3-D Ocean to Delta	Field Data	Neap-Spring	Edith Point

18. The computational code used is RMA10, which was originally developed by Dr. Ian King of Resource Management Associates and the University of California, Davis. The code was subsequently modified extensively by both WES and Dr. King, and has been used in a number of studies in the United States and Australia. It employs a finite element solution scheme. The turbulence closure is a turbulent kinetic energy/mixing length model similar to a Mellor-Yamada Level II, with modifications to better account for density stratification effects.

19. Enclosure 3 shows JFB salinity change results from the several numerical models. Models A-E showed maximum salinity change effects of the JFB project to be from about 0.4 ppt fresher (at the surface in Carquinez Strait with Model E) to 0.8ppt saltier (near bottom in Carquinez Strait with Model E). At Chipps Island, a standard measuring point in prior studies, Models A-E showed maximum salinity increases of about 0.1 ppt, whereas Model LJ indicated an increase of about 0.9 ppt. Base salinities at the Chipps Island station were about 5 ppt. Mr. McAnally showed a series of video clips displaying animated salinity contours.

20. The lower salinity change predictions of numerical Models A-E are consistent with the physical Bay Model predictions of JFB effects, but since those numerical models were verified to the physical model, agreement is not independent confirmation of the effect. The following are possible reasons for the differences of Model LJ:

a. The Model LJ test was the only one in the full series of physical and numerical tests to use a neap range to spring range variable tidal boundary condition instead of the repetitive 19-year mean tide. It has been recognized in some prior physical model studies (e.g., Chesapeake Bay, Columbia River, Cape Fear River) that salinities with neap-spring tides can be significantly different from the artificial repetitive mean tide. If San Francisco Bay responds in a similar nonlinear fashion, the Model LJ results could be more realistic than previous test results.

b. Models A-E were verified to the physical model channel salinity results, and Model LJ is the first of the numerical models in this series to generate fully independent results. The difference may be indicative of the range of accuracy of both the physical and numerical model predictions, or indicate error in either model.

c. The Model LJ test from which these differences were taken may not have been fully spun up—the salinity values were not necessarily independent of the initial test conditions. If base and plan tests were approaching full spin-up at different rates, the difference between base and plan salinities could be in error.

d. The two models may be using slightly different bathymetric data.

21. The San Francisco District has tasked WES with conducting additional tests to explore these potential explanations of the model differences. The initial test of this series—running Model LJ with the same boundary conditions as the physical model, including the mean tide—is underway and will be complete within a few weeks.

Physical model tests of JFB

22. Dr. Volker Harms of the Bay Model and University of California, Berkeley, presented the Bay Model information. The model operational and measurement procedures have been revised to compensate for air temperature effects and to produce more repeatable test results. Ocean salinity is now controlled to within ±0.04 ppt, and headbay water level is controlled directly. Base versus plan salinity comparisons are limited to time periods when the shelter air temperature is well matched in absolute temperature and in trend. Noise in the model salinity results has now been reduced to 0.01-0.02 ppt.

23. To address the question of model credibility, model salinities have been compared to several weeks in summer 1968 during which net delta outflow was near the 4,400 cfs used in the model, and the model compared well with field observations for that period. Dr. Harms noted the earlier CTH statement that the physical model is less reliable in shallow waters, but said he has never seen any data to support that statement.

24. Incremental depth changes of the Pinole Shoal channel from 37 ft to 57 ft were conducted to test the model's ability to detect salinity changes induced by channel enlargement. Measured salinity increases at Martinez were about 0.2 ppt for a 47-ft-deep channel and 0.3 ppt for a 57-ft-deep channel.

25. The physical model test of the latest JFB plan channel, including a turning basin at Avon, showed salinity changes at Chipps Island very much the same as in previous tests—about 0.1 ppt. Boundary conditions included a 19-year mean tide in the ocean and a constant net delta outflow of 4,400 cfs.

26. Dr. Harms concluded by saying that successful use of the Bay Model requires continuity of staff and purpose.

Discussion

27. Mr. Edward A. Reindl, Jr., Galveston District, asked if the net delta outflow of 4,400 cfs was based on present or future freshwater flows to the bay. He noted that in the Galveston Bay study, they have projected basin changes and resulting riverflow changes out through the year 2024. Mr. Johnston explained that the original model verification was attempted with an estimated net delta outflow of 3,400 cfs, but salinities were too high. By trial a flow of 4,400 cfs was found to generate the correct salinity

profiles, so it was concluded that was the correct value. Drs. Pritchard and Krone agreed, noting that reanalysis of the field data showed 4,400 cfs to be a reasonable value, but no confirmatory field measurements were taken. The 4,400 cfs was subsequently selected as a representative low flow. Mr. Tom Kendall, San Francisco District, said that Professor Shen has analyzed the delta outflow and advocates testing both higher and lower delta outflows.

28. Ms. Virginia R. Pankow, Water Resources Support Center, said that the Chesapeake Bay physical model verification began with an semidiurnal (M2) repetitive tide, but had to shift to a lunar month variation in order to obtain verification. She said she wasn't surprised that the neap-spring numerical tests produced a different result. She asked if the physical model has ever been run with a variable tide range over a lunar month. Mr. Johnston said the only tide variation from the 19-year mean was a single spring range tide inserted manually during a mean tide run.

29. Ms. Pankow said that there must be active projects in testing on the physical model to keep it viable.

30. Mr. John H. Lockhart, Jr., asked when the physical model would be able to generate a variable boundary tide. Dr. Harms replied that a planned computer upgrade would provide that capability in a relatively short time. Mr. Kendall added that the capability won't be available in time for the JFB Environmental Impact Statement preparation.

31. Mr. Jaime R. Merino, South Pacific Division, noted that the numerical model video clips showed an apparently sudden increase in surface salinities in Carquinez Strait. He suggested that sequence be examined in detail to see if it reflected a numerical instability.

32. Dr. Krone agreed that the numerical results should be examined for instabilities. He also said that both models' vertical mixing characteristics should be carefully examined to ensure that they are realistically portraying prototype behavior.

33. Mr. Herrmann made four points: (a) numerical models are not inherently cheaper to run or quicker to restart after a hiatus than physical models; (b) the physical model should be retained until it can be demonstrated that the numerical model will provide comparable accuracy; (c) the visualization capabilities of the physical model are still much stronger that the numerical model at present, although that may change; and (d) it should be recognized that the Operations and Maintenance funds presently used to keep the physical model operating will not be available to support a numerical model.

34. Dr. Rod Sobey, University of California at Berkeley, asked about limitations of the numerical model and what sort of peer reviews it has undergone. Mr. McAnally replied that RMA10-WES code, like other three-dimensional circulation models, makes a number of approximations that are reasonable, yet diminish accuracy in some cases. For example, the hydrostatic approximation turns the vertical momentum equation into a simple pressure equation. The turbulence closure, though an advanced and complex formulation, is far less complex than actual turbulent energy dissipation, so accuracy suffers, particularly at small scales. The computer code has been used by WES, Dr. Ian King of University of California at Davis, and others; and it has been peer reviewed through journal articles and agency reviews and for the JFB project by Professor Shen of Berkeley. The application to JFB has been reviewed in detail by San Francisco Bay area modelers through a series of meetings like the model review meeting in January and reviews of the JFB and LTMS open water disposal study (described next). Dr. Sobey said that he could add to the list of limitations, but would refrain at that time. He suggested that WES ask one of its

competitors to review the computer code in detail.

Modeling for Long-Term Management Strategy

35. Mr. McAnally described the WES numerical modeling effort to support the District's LTMS study of open water dredged material disposal. The work began in 1988 with development of a dredged material disposal model (the Corps' DIFID model) by Mr. Al Mathesien of the District and WES development of a TABS two-dimensional sediment transport model, both in support of the District's Dredging Management Program (DMP). Ms. Pankow worked on the early TABS model setup and verification while she was at WES.

36. The District and other agencies drew up an LTMS study plan that called for a verified three-dimensional model of sediment transport in the San Francisco Bay system. When they asked modelers in the region plus WES how they would develop such a model given the time and cost constraints of the LTMS, all replied that it would take longer and cost more than allowed. At that point the In-Bay Disposal Studies Work Group of the LTMS management structure decided to do no modeling. Dr. Krone told them that decision was unwise, that one didn't wait to make a cross-town trip until all the traffic lights were green at the same time. At his urging, Mr. Tom Wakeman, then of the District, invited Mr. McAnally to address the subcommittee on the issue.

37. Messrs. McAnally and Wakeman and Ms. Jessie Lacy of the State worked out a plan that would address many of the subcommittee's requirements while remaining within the available budget and schedule. It involved a limited field program, the existing disposal model, the existing two-dimensional sediment transport model, and an improved version of the then-existing JFB three-dimensional numerical model (Model E in the tabulation in paragraph 17).

38. The LTMS models were verified to 1988 and 1992 field data sets, including the first ever reliable sediment flux data for the Golden Gate, which were obtained with Acoustic Doppler Current Profiling (ADCP) meters. Then the two-dimensional sediment model (STUDH) and three-dimensional hydrodynamic model (RMA10-WES with a conservative tracer) were both applied to sediment clouds and bed deposits resulting from disposal operations at the Alcatraz site and four other potential open water placement sites. By comparing the STUDH results, which included tidal pumping and the deposition-resuspension effect, and the RMA10-WES results, which included gravitational circulation effects, a good picture of short-term (2 weeks) sediment fate was obtained. The results showed that the two-dimensional approximation was appropriate for Central Bay and South Bay, and less appropriate but still useful for the Carquinez Strait area.

39. The model tests showed that dredged material plume concentrations fell quickly, and were less than 3 ppm above background sediment concentrations within a few hours.

40. Four reports from the LTMS modeling have been written and are undergoing review by the subcommittee.

41. Mr. Angeloni noted that the ocean disposal site, with a 100-mile round trip from the bay, has been designated as an approved disposal site by the Environmental Protection Agency, and there is significant

pressure to halt in-bay aquatic disposal of dredged material. He hopes that the model results can be used to design open water placement that is environmentally safe. Mounding at the Alcatraz disposal site reduced the water depth from 100 ft to 30 ft before changes in disposal practices were mandated.

42. Dr. Krone said that at one time ten open water bay disposal sites were used and fisheries were healthy. In the 1960's radioactive tracer tests, 8 to 10 percent of sediment dumped in open water returned to the Mare Island Strait channel.

Stockton Ship Channel

43. Mr. Angeloni presented the Stockton Ship Channel project on behalf of the Sacramento District. Enclosure 4 illustrates the Stockton Channel. The proposal is to deepen the channel to 45 ft from Suisun Bay to the Port of Stockton in order to take advantage of the JFB project deepening. Issues that must be resolved are the same as those for JFB: salinity intrusion, including effects on the Contra Costa County and U.S. Bureau of Reclamation water intakes. Dredged material is not a serious problem, since there are shoreline and levee restoration projects in need of the sediment. A reconnaissance study is scheduled for 1996.

Bonnet Carre′ Freshwater Diversion and Mississippi River-Gulf Outlet

44. Mr. Jack Fredine, New Orleans District, presented the Bonnet Carre′ Freshwater Diversion Project and posed several questions for the CTH regarding salinity intrusion to Lake Pontchartrain, Louisiana, through the Mississippi River-Gulf Outlet (MRGO) canal.

45. Substantial wetlands loss has occurred in coastal Louisiana due to subsidence, salt intrusion, lack of sediment supply, and sea level rise; and continued losses are expected. Since 1932, 66,000 acres of marsh have been lost in the Pontchartrain Basin, and another 63,000 acres are expected to disappear within 50 years if no action is taken. Salinity increases in the basin are attributed to subsidence and sea level rise, levee confinement of the Mississippi River preventing annual flooding, and salinity intrusion through the MRGO and Inner Harbor Navigation Canal (IHNC). The MRGO is thought to have contributed to salinity increases by allowing high-salinity waters to intrude through the deep channel into Lakes Pontchartrain and Borgne. Model studies and field data suggest that average salinities in the lakes have increased by 1 to 2 ppt as a consequence of the MRGO construction.

46. The New Orleans District and State of Louisiana have embarked on projects, including freshwater diversions, to reduce and/or offset those losses. A freshwater diversion has been constructed at Caernarvon, one is under construction at Davis Pond, and a third has been authorized for Bonnet Carre′ (Enclosure 5.)

47. The Bonnet Carre′ diversion would divert Mississippi River water from above New Orleans into western Lake Pontchartrain through the existing Bonnet Carre′ spillway, using a new control structure and channel within the spillway, as shown in Enclosure 6. The project design called for six 18-ft box culverts

diverting flows ranging up to 30,000 cfs as needed to achieve desired salinity targets. Benefits from the project will include reduction of salinities in the marshes surrounding Lakes Pontchartrain and Borgne and in the Biloxi Marshes, which lie between Lake Borgne and Chandeleur Sound along the Louisiana-Mississippi boundary.

48. The project's oyster production benefits have been tied to achieving a target range of salinities in the Biloxi Marshes. The targets, called the Chatry-Dugas Salinities, consist of an annual cycle of salinities that were found to result in superior oyster harvests in the following year.

49. The Bonnet Carre′ diversion project was authorized in 1988 on the basis of oyster production benefits for the Biloxi Marshes, but is also projected to preserve 4,200 acres of marsh and 63,000 acres of swamp in the area. An Environmental Impact Statement and Environmental Assessment were prepared; however, opponents of the project assert that Mississippi River water contains pollutants and excess nutrients and will harm Lake Pontchartrain, leading to algal blooms, sediment resuspension and turbidity, and fisheries displacement.

50. A letter-writing campaign by project opponents led Louisiana's Congressman Bob Livingston to request that the Environmental Protection Agency review the project. During March 1994 an interagency team met and drafted a consensus document stating the following:

> "Representatives of EPA, COE, Louisiana, Mississippi, the Coalition to Restore Coastal Louisiana, and the Lake Pontchartrain Basin Foundation met on March 8, 1994, and formed a Group Consensus on Additional Analysis of the Bonnet Carre′ Diversion Project.
>
> "It was agreed that additional analysis should be directed at the following:
>
> *a*. Investigate the feasibility of overflowing all or part of the diversion through wetlands.
>
> *b*. Initiate development of guidelines for an operational schedule of the project to ensure the ecological protection of the upper Lake Pontchartrain Basin.
>
> *c*. Investigate projected effects of a. and b. above on the capacity of the completed project to control salinity in the Mississippi Sound. (i.e., benefits will support project)
>
> "-- A steering/review panel and a technical team were formed; the technical team, under direction of the steering/review panel, was to `... draw on the expertise of credible specialists, including participants from out of state.' The findings of the technical team are to be presented to the steering/review panel.
>
> "-- The analysis shall be completed as soon as possible and a Progress Report shall be provided to the Congressional Delegation by May 31, 1994."

51. The agencies formed a Steering and Policy Group to oversee a Technical Team's reanalysis of the

project. Enclosure 7 illustrates the relationships among the various participants in the process.

52. In May 1994 the Technical Team oversaw an experimental diversion through the Bonnet Carre′ spillway that sent a sustained flow of about 8,000cfs into Lake Pontchartrain. Data collection during the release monitored the freshwater plume as it moved into the lake. Data were not expressly collected in the Biloxi Marshes following the diversion, although some long-term stations there may have been in operation.

53. On 2-3 November 1994, the Technical Team met for 2 days to forge the following set of consensus recommendations:

"Item 1 -- Feasibility of overflowing all or part of the diverted water through the wetlands.

a. Using the spillway and adjacent wetlands is scientifically feasible for diverting 2,000 - 6,000cfs of Mississippi River water. Retention time would be about one day, and about 20 to 60 percent of the nutrients and sediments would be removed.

b. Qualifications to the above statement:

(1) Excess loading reduces the removal efficiency of overland flow.

(2) Systems used for estimates of nutrient removal were somewhat similar, but also had significant differences. Site specific data was lacking.

(3) Diversions through adjacent wetlands will probably require modifications to the design of this project and other Corps projects nearby, like the St. Charles Hurricane Protection Levee.

(4) Diversions through adjacent wetlands will require cooperation and coordination with owners of these wetlands.

c. The Corps should pursue maximizing that portion of the diversion that is feasible to put into the wetlands, limited by physical/biological constraints.

d. Nutrients in the Lake

(1) To minimize risk of eutrophic impact, the N/P ratio of water reaching the lake should be 10 or above and not exceed specific concentrations.

(2) The lake bottom can also remove some nutrients."

"Item 2 -- Guidelines for and operational schedule to ensure the Ecological Protection and Enhancement of the upper Lake Pontchartrain Basin.

a. Salinities in the target area should not exceed 20ppt more than one month in the period from March to October, and should be maintained near or below 15. Review of flow scenarios investigated by Hoese and Melancon divided them into tiers.

b. Circulation and salinity analysis by McAnally suggested that target salinities can be substantially achieved with flows significantly below the GDM by a 4 month freshening effect, and the `steering the Pearl' concept.

c. The Technical Team recommends that:

(1) Design modifications be initiated to divert the maximum amount possible through the wetlands (current estimate, 6,000 cfs).

(2) A `comprehensive' monitoring plan for the project be developed.

(3) Any excess spoil material from the spillway should be used to create wetlands in the spillway or along the shore of Lake Pontchartrain, or in the la Branche marsh whichever is most cost and ecologically effective.

d. An intensive long range monitoring system will be used to prevent damage to the wetlands, the Lake, and the fisheries in the Lake. Use of the data developed from monitoring to fill the information gaps that were apparent from the reanalysis process. This much needed information to be used to prevent damage to the Basin ecosystem, to improve environmental conditions in this and other Basins and to enhance fin and shellfish production. This should be a combined effort of agencies, environmental groups and the academic community.

e. A monitoring program will be fashioned for the Lake Pontchartrain Basin (to include Lakes Pontchartrain, Maurepas and Borgne).

f. The COE will work toward placement of an EWOCDS station above La Place.

g. In addition to wetlands, we should pursue using non-wetland systems for pre-processing diverted water, i.e., headwater stilling basin."

"Item 4 -- Other Findings and Recommendations Beyond Original Charge

1. Investigate the possibility of smaller local diversions to provide sediments to the LaBranche and Lake Maurepas wetlands.

2. Repair leakage in the existing Bonnet Carre′ structure to provide better control of the flow entering the wetlands and to prevent hazardous spills from entering the wetlands and the Lake during high water periods.

3. The Steering Panel request Congress to pass the additional authorization necessary to construct a sill or other barrier across the IHNC, as soon as possible.

4. State of Louisiana & COE assess potential financial exposure from oyster and other fisheries dislocations due to the project, and ways of fixing or avoiding that exposure.

5. Immediately notify Mr. Allen Ensminger of the progress made during the retreat, and that overland flow through La Branche wetlands was unanimously endorsed."

54. Mr. Fredine called to the CTH's attention point 3 under Item 4 above. He said that there is a general conclusion that the MRGO has increased salinities in the lakes, and asked the CTH to address these questions:

a. Can the MRGO-IHNC salinity contribution be economically controlled by reducing either

(1) The volume of MRGO flow into the lake, or

(2) The salinity concentration of the MRGO flow into the lake?

b. If so, can the Bonnet Carre′ freshwater diversions be reduced in magnitude while still producing

(1) The desired freshening effect in project wetlands and marshes, and

(2) The target salinities for increased oyster production?

55. Mr. A. Jay Combe, New Orleans District, presented information on the MRGO and Lake Pontchartrain. The lake has a surface area of 640 square miles and experiences diurnal tides ranging from 39 cm in Lake Borgne to 20 cm at the IHNC and 12 cm in Lake Pontchartrain. The tidal prism is estimated to be between 150 million cubic meters and 300 million cubic meters. Tidal exchange for Lake Pontchartrain occurs through two natural passes—The Rigolets, which passes about 50 percent of the tidal flow, and Chef Menteur, which passes about 35 percent—and the IHNC-MRGO channel, which accounts for about 10 percent of the tidal exchange. Salt contributions to the lake from The Rigolets, Chef Menteur, and IHNC are estimated to be 40 percent, 40 percent, and 20 percent, respectively.

56. Average lake depth is about 12 ft, but there is a 60-ft-deep hole off the IHNC from which sediments were dredged in 1930 to build the airport. The hole has not filled in, and when it fills with salt water, hypoxia occurs.

57. The IHNC exhibits some salinity stratification, with a 1976-77 data set showing mean monthly surface to bottom salinity differences of 0 to 9.2 ppt and a mean difference of 2.7 ppt.

58. There is a lock between the Mississippi River and the IHNC, but the Seabrook Lock intended to separate Lake Pontchartrain from the IHNC was never built. Salinity increases from pre- to post-MRGO construction are estimated to be 0.4 to 2.4 ppt in Lake Pontchartrain and 4.3 ppt in Lake Borgne. Since construction of the MRGO, salinities do not appear to have increased any additional amount.

59. Questions posed by the CTH and replies by Messrs. Fredine and Combe were as follows:

Dr. Michael P. Palermo, WES: Is it possible to use the IHNC-Mississippi River lock to divert water into the system?

Answer: The feasibility study examined that possibility and found it would take about twice as much fresh water to achieve the desired salinity reduction.

How was the diversion structure sized?

Answer: By using a regression based on natural freshwater diversions.

What is the nutrient problem in the Mississippi River water that causes concern?

Answer: Phosphorous levels were high, but recent upstream cleanup efforts are reducing the problem. Evaluations of nutrient impacts on the lake vary, but there is substantial agreement that some reduction in nutrient loads in the diverted water is desirable.

Mr. Merino: How much traffic to and from the lake uses the IHNC?

Answer: Quite a few crewboats and fishing vessels. Some 9-ft-draft barges. Existing velocities sometimes make vessel handling difficult into and out of the IHNC.

What are the concentration of dissolved solids in the river water?

Answer: About 200-400 ppm.

Mr. Reindl: How will the projected salinity change affect oysters?

Answer: A twofold increase in oyster production has been predicted if the target salinities are met one year in three.