be used on noncohesive beds but are unsuitable for rock, organic materials, or wet clays and silts. The units can be installed in a variety of configurations at the site (Figure I-3-16) (Department of the Army 1990).

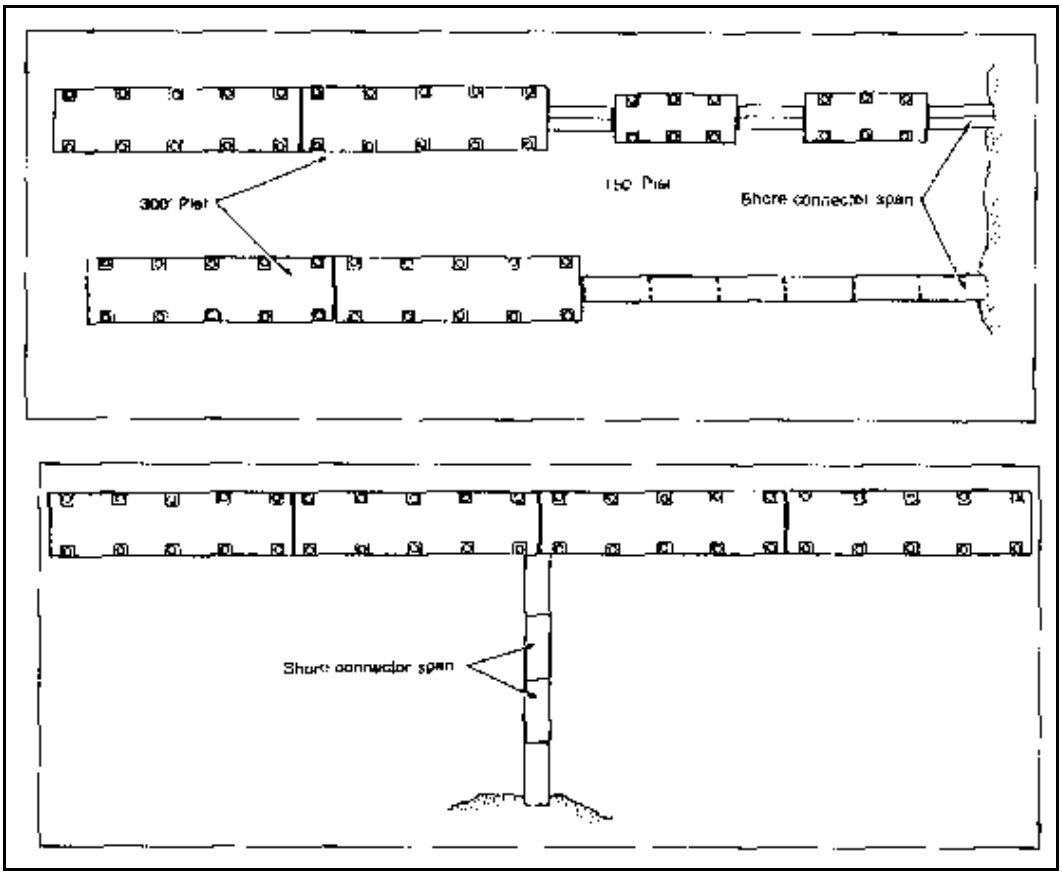

Figure I-3-16. DeLong self-elevating barge piers. Upper figure shows finger piers, lower a T-type marginal wharf (from Department of the Army 1990)

g. Rapidly Installed Breakwater System. Engineers and scientists at CHL are developing a Rapidly Installed Breakwater (RIB) system to address problems encountered by the U.S. armed forces while offloading ships during Logistics Over The Shore operations. When seas become sufficiently energetic during offloading, the capabilities of ship-based crane operators and stevedore crews are severely restricted. The RIB system, consisting of a series of floating breakwater units that are assembled in a "V" orientation, is designed to create a "pool" of calmer water where the crews will be able to continue to unload vessels even during storms. For many years, CHL had been involved with the design and deployment of floating breakwaters, primarily for application within bays or estuaries which are semi-protected from large waves. But, these structures were intended to attenuate waves with heights not exceeding 4 ft and periods not exceeding 4 sec, while in an oceanic environment, waves with heights up to 10 ft are common during storms, with associated periods up to 10 sec. To date, research efforts have concentrated on military applications for the RIB system. Potential civil applications include rescue and recovery operations, temporary small vessel shelter from energetic seas, and to protect exposed dredging and marine operations (e.g., bridge repair, rubble-mound breakwater construction),.

I-3-9. Summary

For most of the nation's history, the U.S. Army Corps of Engineers has played an active role in the coastal zone. To the mid-1800s, this role was largely confined to coastal defense and some harbor protection. But, in the mid-1800s, the USACE's mission expanded to include developing civil works projects in support of a growing nation. These responsibltiies included harbor construction, dredging and clearing waterways, building canals and channels, and protecting coastal areas threatened by erosion (*e.g.*, Presque Isle). During the second half of the 20th century, the USACE's role further expanded to include environmental restoration and preservation of threatened coastal areas. Since the 1930s, coastal-related research and development have been conducted to advance the technical foundations and basis for conducting coastal civil works.

The 20th century was witness to a large-scale evolution in the development of, use of, and interest in the coastal zone. National defense, agriculture, navigation, economic development, recreation, and environmental worth all contribute to the definition of coastal policy and action. During the early years of the 21st century there will be continuing development pressure in the coastal zone . Coastal engineers and scientists will undoubtedly be asked to play an increasing role in planning, designing, and maintaining infrastructure projects, in coastal management and environmental mitigation, and will continue their more traditional missions of navigation and flood protection.

In fiscal year 1998, the USACE and contractor-owned dredges removed 182 million cubic meters of material from Federally-constructed and maintained channels at a cost of $713 million. Dredged material is a valuable resource with numerous potential benefits, including construction of protective dunes and beaches, maintenance of beaches through bypassing to reestablish natural sediment-transport paths, and restoration and creation of wetlands and coastal habitat. Demand for dredged material usage is increasing, but environmental concerns and constraints present new engineering challenges that must be addressed.

Erosion and flooding threaten an estimated $3 trillion of development along the coast, with 80 to 90 percent of the nation's sandy beaches eroding (Hillyer 1996). Shore protection and restoration throughout the developed areas of the coast will increase, especially if the growing value of coastal property and recreation benefits are factored into the cost benefit calculations.

Because of the age of many harbor structures, improving and rebuilding jetties and breakwaters will be a major mission area. Wetlands restoration should also be growth areas, and already the USACE is involved in major restoration projects in the Everglades, in south Louisiana, and along many stretches of the intracoastal waterway.

Emergency coastal response work is also likely to be a growth area for the USACE. Many of the recent arrivals to the coastal zone have not personally experienced a major disaster like the Galveston hurricane of 1900, the 1962 Ash Wednesday storm, or the Great New England Hurricane of 1938. Much of the population is ignorant of the hazards that exist and is not prepared to respond to the aftermath of a catastrophic storm. The USACE has actively participated in disaster emergency and recovery efforts in Puerto Rico and other Caribbean islands, and many of these skills are applicable to mainland disasters.

I-3-10. References

Alperin 1977
Alperin, L. M. 1977. *Custodians of the Coast: History of the United States Army Engineers at Galveston*. Galveston District, U.S. Army Corps of Engineers, Galveston, TX, 318 p.

Barber 1989
Barber, H. E. 1989. *A History of the Savannah District, U.S. Army Corps of Engineers*. Savannah District, U.S. Army Corps of Engineers, Savannah, GA, 554 p.

Becker 1984
Becker, W. H. 1984. *From the Atlantic to the Great Lakes, a history of the U.S. Army Corps of Engineers and the St. Lawrence Seaway.* Office of the Chief of Engineers, Washington, DC. 179 p.

Bijker 1996
Bijker, E. W. 1996. History and Heritage in Coastal Engineering in the Netherlands. *History and Heritage of Coastal Engineering,* N. C. Kraus, ed., Coastal Engineering Research Council, American Society of Civil Engineers, Reston, VA, pp. 390 - 412.

Birkemeier, Dolan, Fisher 1984
Birkemeier, W. A., Dolan, R., and Fisher, N. 1984. The Evolution of a Barrier Island: 1930-1980. *Shore and Beach*, Vol. 52, No. 2, pp 2-12.

Buker 1981
Buker G. E. 1981. *Sun, Sand and Water: a History of the Jacksonville District U.S. Army Corps of Engineers, 1821-1975.* U.S. Government Printing Office, Washington, DC., 288 p.

Chambers 1980
Chambers, J. W., II. 1980. *The North Atlantic Engineers : a History of the North Atlantic Division and its Predecessors in the U.S. Army Corps of Engineers, 1775-1975.* North Atlantic Division, U.S. Army Corps of Engineers, New York, NY, 167 p.

Chrzastowski 1999
Chrzastowski, M. J. 1999. Geology of the Chicago Lakeshore, Shaping the Chicago Shoreline, poster produced by the Department of Natural Resources, Illinois State Geological Survey, Champaign, IL.

Cowdrey 1977
Cowdrey, A. E. 1977. *Land's End: a History of the New Orleans District, U. S. Army Corps of Engineers, and its Lifelong Battle with the Lower Mississippi and Other Rivers Wending Their Way to the Sea.* New Orleans District, U.S. Army Corps of Engineers, New Orleans, LA, 118 p.

Davis 1975
Davis, V. S. 1975. *A History of the Mobile District 1815 to 1971.* Mobile District, U.S. Army Corps of Engineers, Mobile, AL, 109 p.

Department of the Army 1990
Department of the Army. 1990. Port Construction and Repair. Field Manual FM 5-480, Headquarters, Department of the Army, Washington, DC.

DeWan 1999
DeWan, G. 1999. "The Master Builder, How planner Robert Moses transformed Long Island for the 20th Century and Beyond." *Long Island, Our Story.* **http://www.lihistory.com/** (18 May 2000).

Dobney 1978
Dobney, F. J. 1978. *River Engineers on the Middle Mississippi: a History of the St. Louis District, U.S. Army Corps of Engineers.* U.S. Government Printing Office, Washington, DC., 177 p.

Drescher 1982
Drescher, N. M. 1982. *Engineers for the Public Good, A History of the Buffalo District, U.S. Army Corps of Engineers,* U. S. Army Corps of Engineers, Buffalo, NY, pp 155-173, 203-235.

Empereur 1997
Empereur, J. Y. 1997. "The Riches of Alexandria." Transcript of a 1997 Interview on NOVA Online, **http://www.pbs.org/wgbh/nova/sunken/empereur.html** (28 Aug 2000).

Farley 1923
Farley, P. P. 1923. Coney Island public beach and boardwalk improvement. *The Municipal Engineers Journal*, Vol. 9, Paper 136, pp 136.1-136.32.

Fasso 1987
Fasso, C. A. 1987. "Birth of hydraulics during the Renaissance period," Hydraulics and Hydraulic Research; a Historical Review, IAHR, G. Garbrecht Editor, Balkema, pp 55-79

Franco 1996
Franco, Leopold. 1996. "History of Coastal Engineering in Italy," *History and Heritage of Coastal Engineering,* American Society of Civil Engineers, New York, NY. pp 275-335.

Frost 1963
Frost, H. 1963. *Under the Mediterranean, Marine Antiquities*. Prentice-Hall, Englewood Cliffs, N.J. p 278.

Goreki and Pope 1993
Goreki, R. J., and Pope, J. 1993. Coastal Geologic and Engineering History of Presque Isle Peninsula, Pennyslvania. Miscellaneous Paper CERC-93-8, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Hagwood 1982
Hagwood, J. J., Jr. 1982. *Engineers at the Golden Gate: a History of the San Francisco District, U.S. Army Corps of Engineers, 1866-1980.* San Francisco District, U.S. Army Corps of Engineers, San Francisco, CA, 453 p.

Hartzer 1984
Hartzer, R. B. 1984. *To Great and Useful Purpose: a History of the Wilmington District U.S. Army Corps of Engineers,* Wilmington District, U.S. Army Corps of Engineers, Wilmington, NC, 172 p.

Herodotus 1992
Herodotus. 1992. *The Histories,* Written in the middle of the 5th century B.C., translation by George Rawlinson and introduction by Hugh Bowden, J. M. Dent & Sons Ltd.,London.

Hillyer 1996
Hillyer, T. M. 1996. *Shoreline Protection and Beach Erosion Control Study, Final Report: An Analysis of the U.S. Army Corps of Engineers Shore Protection Program.* IWR Report 96-PS-1, Shoreline Protection and Beach Erosion Control Task Force, Water Resources Support Center, Institute for Water Resources, U.S. Army Corps of Engineers, Alexandria, VA (prepared for the Office of Management and Budget, Washington, DC.)

Inman 1974
Inman, D. L. 1974. Ancient and Modern Harbors: a Repeating Phylogeny. *Proceedings of the 14th Coastal Engineering Conference,* Copenhagen, Denmark, June 1974, American Society of Civil Engineers, Reston, VA, pp. 2049-2067.

Inman 2001
Inman, D. L. 2001. History of Early Breakwaters. *Association of Coastal Engineers Newsletter*, Alexandria, VA.

Institute of Civil Engineers 1948
Institution of Civil Engineers. 1948. *The Civil Engineer in War. A Symposium of Papers on War-time Engineering Problems. Vol. 2, Docks and Harbors.* Papers and discussions, published by The Institution of Civil Engineers, London, United Kingdom.

Jacobs 1976
Jacobs W. A. 1976. *The Alaska District, United States Army, Corps of Engineers, 1946-1974: a History.* From a manuscript researched and compiled by Lyman L. Woodman, Alaska District, U.S. Army Corps of Engineers, Elmendorf AFB, Alaska, 145 p.

Johnson 1979
Johnson, L. R. 1979. *The Headwaters District: a History of the Pittsburgh District, U.S. Army Corps of Engineers.* Pittsburgh District, U.S. Army Corps of Engineers, Pittsburgh, PA, 380 p.

Johnson 1992
Johnson, L. R. 1992. *The Ohio River Division, U.S. Army Corps of Engineers, the History of a Central Command*. Ohio River Division, U.S. Army Corps of Engineers, Cincinnati, OH, 484 p.

Kana 1999
Kana. T. 1999. Long Island's South Shore Beaches, A Century of Dynamic Sediment Management. *Coastal Sediments '99,* Kraus, N. C., and McDougal, W. G. (eds.), American Society of Civil Engineers, Reston, VA, pp.1584-1596.

Karanek 1978
Kanarek, H. K. 1978. *The mid-Atlantic engineers: a History of the Baltimore District, U.S. Army Corps of Engineers, 1774-1974.* U.S. Government Printing Office, Washington, DC., 196 p.

Keay 1942
Keay, T. B. 1942. Coast Erosion in Great Britain, General Question of Erosion and Prevention of Damage; and the Drainage of Low-Lying Lands. *Shore and Beach,* Vol. 10, No. 2, pp. 66 - 68.

Klawonn 1977
Klawonn, Marion J. 1977. *Cradle of the Corps, A History of the New York District, U.S. Army Corps of Engineers, 1975-1975,* New York District, U.S. Army Corps of Engineers, New York, NY, 310 p.

Lamb 1930
Lamb, H. 1930. *The Crusades, Iron Men and Saints,* Doubleday, Doran & Co., Garden City, NY.

Larson 1979
Larson, J. W. 1979. *Those Army Engineers: a History of the Chicago District, U.S. Army Corps of Engineers,* Chicago District, U.S. Army Corps of Engineers, Chicago, IL, 307 p.

Larson 1981
Larson, J. W. 1981. *Essayons: a History of the Detroit District, U.S. Army Corps of Engineers.* Detroit District, U.S. Army Corps of Engineers, Detroit, MI, 215 p.

Lenček and Bosker 1998
Lenček, L., and Bosker, G. 1998. *The Beach: The History of Paradise on Earth.* Viking, New York, 310 p.

Maass 1951
Maass, A. 1951. *Muddy Waters, the Army Engineers and the Nation's Rivers.* Harvard University Press, Cambridge, MA, 306 p.

Mason 1979
Mason, Curtis. 1979. "The Coastal Engineering Research Center's Field Research Facility at Duck, North Carolina," *Shore & Beach, Journal of the American Shore and Beach Preservation Association,* Vol. 47, No. 2, pp 13-16.

Merritt 1979
Merritt, R. H. 1979. *Creativity, Conflict & Controversy : a History of the St. Paul District, U.S. Army Corps of Engineers*. U.S. Government Printing Office, Washington, DC., 461 p.

Moore 1981
Moore, 1981. *The Lowcountry Engineers: Military Missions and Economic Development in the Charleston District,* U.S. Army Corps of Engineers. U.S. Government Printing Office, Washington, DC., 140 p.

Moore and Moore 1982
Moore, Jamie W., and Moore, Dorthy P. 1982. *The Lowcountry Engineers, Military Missions and Economic Development in the Charleston District,* U.S. Army Corps of Engineers (Atlanta, GA: Government Printing Office), pp16-21

Moore and Moore 1983
Moore, Jamie W., and Moore, Dorthy P. 1983. The Corps of Engineers and Coastal Engineering, A 50 Year Retrospective,? Orville T. Magoon, ed., *Coastal Zone 83 III,* New York: ASCE, 1983, pp 1627-1639

Moore and Moore 1991
Moore, Jamie W. and Moore, Dorthy P. 1991. *History of the Coastal Engineering Research Center, 1963-1983,* U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS

Morison and Commager 1962
Morison, S. E., and Commager, H. S. 1962. *The Growth of the American Republic.* Fifth Ed., Oxford University Press, New York.

Palmer and Tritton., eds. 1996
Palmer, R., and Tritton Limited (eds.). 1996. History of Coastal Engineering in Great Britain. *History and Heritage of Coastal Engineering,* N. C. Kraus, ed., Coastal Engineering Research Council, American Society of Civil Engineers, Reston, VA, pp. 214 - 274.

Parkman 1978
Parkman, Aubrey. 1978. *Army Engineers in New England, The Military and Civil Works of the Corps of Engineers, 1775-1975,* Waltham, MA, U.S. Army Engineer Division, 1978, pp34-38.

Parker 1980
Parker 1980. "Structures in the Beach Zone-To Be or Not to Be," paper presented at the American Soc. Of Civil Engineers Convention and Exposition, Florida, 27-1 Oct, 1980, ASCE Reprint No.80-648.

Patton 1934
Patton, R. S. 1934. "The Purpose of the American Shore and Beach Preservation Association," *Shore and Beach II,* Journal of the American Shore and Beach Preservation Association Oct. 1934, pp132-136.

Quinn 1972
Quinn, Alonzo DeF. 1972. *Design and Construction of Ports and Marine Structures,* Second Edition, Mc Graw-Hill Book Company, New York, N.Y., 611p.

Rathburn 1990
Rathbun, M. Y. 1990. *Castle on the Rock, 1881-1985: the History of the Little Rock District, U.S. Army Corps of Engineers.* Little Rock District, U.S. Army Corps of Engineers, Little Rock, AK, 192 p.

Reuss 1998
Reuss, M. 1998. *Designing the Bayous: the Control of Water in the Atchafalaya Basin: 1800-1995.* Office of History, U.S. Army Corps of Engineers, Alexandria, VA, 474 p.

Richter 1970
Richter, J. P. 1970. *The Notebooks of Leonardo da Vinci,* Dover Publishing, New York, NY.

Rouse and Ince 1963
Rouse, H. and Ince, S. 1963. *History of Hydraulics,* Dover, NY.

Seattle District 1969
Seattle District. 1969. *History of the Seattle District, 1896-1968 : United States Army, Corps of Engineers : 72 Years in Peace and War.* Seattle District, U.S. Army Corps of Engineers, Seattle, WA, 222 p.

Shore Protection Manual 1984
Shore Protection Manual. 1984. 4th ed., 2 Vol., U.S. Army Engineer Waterways Experiment Station, U.S. Government Printing Office, Washington, DC.

Shore Protection, Planning, and Design 1954
Shore Protection, Planning, and Design. 1954. Technical Report No. 4, U.S. Beach Erosion Board, Washington, DC, 393 p.

Snyder and Guss 1974
Snyder, F. E. and Guss, B. H. 1974. The District; a History of the Philadelphia District, U.S. Army Corps of Engineers, 1866-1971, U.S. Army Engineer District, Philadelphia, PA,
263 p.

Stanton 1999
Stanton, J. 1999. "Coney Island - Nickel Empire (1920's-1930's)." *Coney Island History Site.* North American Integration & Development Center, School of Public Policy and Social Research, University of California, Los Angeles, CA, **http://naid.sppsr.ucla.edu/coneyisland/** (16 May 2000).

Straub 1964
Straub, Hans. 1964. *A History of Civil Engineering,* English Translation by Erwin Rockwell, The M.I.T. Press, Massachusetts Institute of Technology, Cambridge, Massachusetts, 258 p.

Sudar, Pope, Hillyer, and Crumm 1995
Sudar, R. A., Pope, J., Hillyer, T., and Crumm, J. 1995. "Shore Protection Projects of the U.S. Army Corps of Engineers." *Shore and Beach*. Journal of the American Shore and Beach Preservation Association, Vol. 63, No. 2, pp. 3-16.

Thompson 1981
Thompson, E. N. 1981. *Pacific Ocean Engineers-History of the U.S. Army Corps of Engineers in the Pacific, 1905-1980.* U.S. Army Engineer Division, Pacific Ocean, Honolulu pp 460.

Turhollow 1975
Turhollow, Anthony F. 1975. *A History of the Los Angeles District, U. S. Army Corps of Engineers, 1898-1965,* Los Angeles, CA, U. S. Army Engineer District, pp 20-48.

UCB, IER 1952
University of California, Berkeley, Institute of Engineering Research. 1952. *Manual on Amphibious Oceanography,* R. L. Wiegel, Project Engineer and Editor, under contract with Office of Naval Research, Amphibious Branch, Contract N7-29535, Project No. NR 252-003, Pentagon Press, July 1952, 2 volumes.

USACE 1971
U.S. Army Corps of Engineers. 1971. National Shoreline Study: Shore Protection Guidelines. Department of the Army, Corps of Engineers, Washington, DC.

USACE 1980
U.S. Army Corps of Engineers. Army 1980. *Annual Report of Civil Works Activities of the Chief of Engineers for FY 1979, Volume 1, Summary/Highlights,* Department of the, Office of the Chief of Engineers, Washington, DC. 12 August 80, pp 44-47.

U.S. Army Corps of Engineers 1998
U.S. Army Corps of Engineers. 1998. *The History of the US Army Corps of Engineers.* Engineer Pamphlet EP 360-1-21, Washington, DC.

Waterborne Commerce Statistics Center 1999
Waterborne Commerce Statistics Center, Water Resources Support Center, Navigation Data Center, U.S. Army Corps of Engineers, Alexandria, VA. **http://www.wrsc.usace.army.mil/ndc/** (6 Dec 1999).

Wilson and Eaton 1960
Wilson, MG Walter K., Jr. and Eaton, Richard O. 1960. "A History of the Beach Erosion Board," *Shore and Beach,* Journal of the American Shore and Beach Preservation Association, Volume Twenty-eight, Number one, April 1960, pp 4-9.

Wiegel 1999
Wiegel, Robert L. 1999. *Military Examples of Coastal Engineering,* Miscellaneous Paper CHL-99-3, September 1999, Prepared for Coastal Engineering Research Board, U.S. Army Corps of Engineers Research and Development Center, Vicksburg, MS 39180-6199.

Wiegel and Kimberly 1949
Wiegel, Robert L., and Kimberly, H. L. 1949. *Operation MIKI, Hawaiian amphibious phase (ground coverage),* University of California, Berkley, Inst. Engrg. Res., Series 29, Issue 14.

Wiegel and Saville 1996
Wiegel, R. L., and Saville, T., Jr. 1996. History of Coastal Engineering in the United States. *History and Heritage of Coastal Engineering,* N. C. Kraus, ed., Coastal Engineering Research Council, American Society of Civil Engineers, Reston, VA, pp. 214 - 274.

Willingham 1983
Willingham, W. F. 1983. *Army Engineers and the Development of Oregon, a History of the Portland District U.S. Army Corps of Engineers.* Portland District, U.S. Army Corps of Engineers, Portland, OR.

van Hoften 1970
van Hoften, E. 1970. *History of the Honolulu Engineer District, 1905-1965.* U.S. Army Engineer District, Honolulu, pp 133.

Vitruvius, Rowland, and Howe, eds. 1999
Vitruvius, P., Rowland, I. D., and Howe, T. N. eds. 1999. Vitrivius: Ten Books on Architecture. Cambridge University Press, Cambridge, MA.

I-3-11. Acknowledgments

Authors of Chapter I-3, "History of Coastal Engineering:"

John H. Lockhart. Jr., Headquarters, U.S. Army Corps of Engineers, Washington, DC, (retired).
Andrew Morang, Ph.D., Coastal and Hydraulics Laboratory (CHL), Engineer Research and Development Center, Vicksburg, Mississippi.

Reviewers:

Joan Pope, CHL
Martin A. Reuss, Ph.D., Office of History, U.S. Army Corps of Engineers, Alexandria, Virginia.