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Recreation Management Support Program

Flotation Analysis for Boat Docks on U.S. Army Corps of Engineers Projects

Julie B. Marcy and Jack Johnson

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Abstract: This report documents a survey of flotation products being used at boat docks on U.S. Army Corps of Engineers lakes, best practices and policies for dock flotation of various water managers, and potential environmental impacts from flotation products. This report conveys the findings thereof.

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Preface

The work reported herein was undertaken via a request from the U.S. Army Engineer District, Little Rock, and from Headquarters, U.S. Army Corps of Engineers (HQUSACE) Civil Works Operations (CECW-ON) as part of the Recreation Management Support Program (RMSP). The RMSP is funded by the Operations and Maintenance (O&M) General Appropriation and encompasses activities previously conducted through the Recreation Research Program and the Natural Resources Technical Support Program. The U.S. Army Engineer Research and Development Center (ERDC) provides program management support for execution of approved RMSP activities. The RMSP is managed at ERDC by Scott Jackson, Environmental Laboratory (EL). Julie Marcy served as a Principal Investigator of the work unit.

This report was prepared by Julie Marcy, ERDC, and Jack Johnson, retired employee, U.S. Army Corps of Engineers, Little Rock District. This work was conducted under the general supervision of Antisa Webb, Chief, Ecological Resources Branch (ERB); Dr. David Tazik, former Chief, Ecosystem Evaluation and Engineering Division (EEED); and Dr. Beth Fleming, Director, EL.

Peer reviewers of this report were Andrea Lewis, Deputy Chief, Operations Division, Little Rock District; Scott Hodge, Civil Engineer, PE, Little Rock District; and Tim Toplisek, Senior Policy Advisor for Natural Resource Management Stewardship Components, CECW-SAD.

COL Gary E. Johntson was Commander and Executive Director of ERDC. Dr. James R. Houston was Director.

Foreword

The U.S. Army Corps of Engineers (USACE) issued a national policy (Engineer Regulation 1130-2-406, Appendix C, Page 3, Paragraph 14 USACE 2008c)) on June 3, 1992 that “effectively precludes the future use of expanded polystyrene unless it is encased in an approved protective coating” (USACE 2008b). This requirement was based on the “Flotation Device Study” conducted by A. J. Anderson of the Waterways Experiment Station (USACE 1992). Following issuance, Corps Districts began implementing this policy to varying degrees, and some issued corresponding District guidance on flotation. Concerns relative to environmental and aesthetic impacts from older, degrading, open cell polystyrene continue.

In November of 2007, the Little Rock District of the Corps requested that the Engineer Research and Development Center (formerly called “Waterways Experiment Station”) in Vicksburg, MS update the 1992 flotation study to include addressing environmental hazards associated with flotation products and recommending best practices. In December 2007, HQUSACE requested that ERDC expand the study to include a survey of Corps Districts to determine: the number and type of floating structures, how many structures had encapsulated flotation, District policy relative to flotation requirements, and whether or not the current national policy on flotation had created challenges for them. This survey was initiated in December 2007 and was completed in March 2008 (Appendix A). Additional research was undertaken using literature reviews and personal contacts to gather corresponding study information.

1 Introduction

This report documents a survey of flotation products being used at boat docks on U.S. Army Corps of Engineers lakes, best practices and policies for dock flotation of various water managers, and potential environmental impacts from flotation products. It is an update to the "Flotation Device Study" conducted by A. J. Anderson of the Corps' Waterways Experiment Station in 1992 (USACE 1992).

The Corps of Engineers is the Nation's largest provider of outdoor recreation, hosting over 370 million visitors a year at 4,300 recreation areas across the nation. This includes 456 lakes located in 43 states (Figure 1). Corps lakes and parks include: over 100,000 campsites and 2,100 miles of trails, and the Corps hosts 33 percent of all freshwater lake fishing in the United States. Recreation facilities provided include more than 500 private concessionaires with $1 billion in assets such as marinas, bait shops, and grocery stores (USACE 2008b).

Figure 1. Corps of Engineers Recreation Projects.

In December 2007, Corps District offices were surveyed (Appendix A) concerning boat docks and marina slips, whether or not they had a District standard requiring the use of encapsulated (flotation enclosed in a material such as polyethylene) flotation for floating facilities, and whether or not the existing policy (Engineer Regulation 1130-2-406, Appendix C, Page 3, Paragraph 14) had created any problems for them concerning management of docks (USACE 2008c). Respondents indicated that they had 516 marinas, an estimated 105,761 total marina slips (42,546 with encapsulated flotation), 408 Corps slips (263 with encapsulated flotation), 73,102 private or community slips (47,478 with encapsulated flotation), and 2,001 courtesy/fishing/swim docks (1,493 with encapsulated flotation). Of the 34 respondents, 15 indicated that they had a District policy requiring encapsulated flotation for marinas, and 18 requiring its use for other floating facilities. Nine Districts had no marinas, and therefore, did not have a flotation requirement policy. They also indicated a desire for flexibility in adopting future technological advances that might produce flotation products with performance equivalent to encapsulated flotation.

This study included examining the policies of other lake managers regarding dock flotation. Examples of agencies that require or recommend encapsulated flotation or equivalent for docks include: Tennessee Valley Authority (TVA), Bureau of Reclamation (Reclamation), U.S.D.A. Forest Service (USFS), and the National Park Service (NPS) on an individual project basis. Many states also require this type of flotation such as Arkansas, California, Delaware, Georgia, Iowa, Oregon, Rhode Island, and South Carolina. In addition, entities such as Grand River Dam Authority (GRDA) in Oklahoma, Alabama Power Company (Alabama), Duke Energy (Duke), AmerenUE (Ameren), and the Lower Colorado River Authority (LCRA) have encapsulation requirements for floating docks.

Environmental impacts associated with foam used for flotation include: the rate of degradation (water and sunlight), ingestion of particles by fish and wildlife, exposure to chemical elements such as benzene, styrene, and ethylene, and aesthetics/littering associated with particles of flotation. Fortunately, there are also some efforts to recycle old flotation.

Best Management Practices (BMP's) for floating facilities such as boat docks were also reviewed. Flotation BMP product recommendations included: floatable foams encapsulated in polyethylene or other surface covering, closed cell polyethylene, and dedicated plastic float drums. Many lakes and associations have also adopted the National Oceanic and Atmospheric Administration's (NOAA) voluntary Clean Marina Initiative (NOAA). An article from Marina Dock Age and Boat and Motor Dealer indicates that the results of a 2008 Clean Marina Survey showed 701 currently certified Clean Marinas across the United States (Mendez 2007).

Lakes under this program typically require foam floats encapsulated with concrete, wood, galvanized steel, plastic, or fiberglass. Additional BMP's deal with construction techniques and recycling of old flotation where feasible and available.

2 Corps of Engineers Floating Structure Survey

In December 2007, Corps District offices were surveyed (Appendix A) concerning boat docks and marina slips, whether or not they had a District standard requiring the use of encapsulated flotation for floating facilities, and whether or not the existing policy (Engineer Regulation 1130-2-406, Appendix C, Page 3, Paragraph 14) had created any problems for them concerning management of docks (USACE 2008c). Respondents indicated that they had 516 marinas, an estimated 105,761 total marina slips (42,546 with encapsulated flotation), 408 Corps slips (263 with encapsulated flotation), 73,102 private or community slips (47,478 with encapsulated flotation), and 2,001 courtesy/fishing/swim docks (1,493 with encapsulated flotation) (Appendix B). Of the 34 respondents, 15 indicated that they had a District policy requiring encapsulated flotation for marinas, and 18 requiring its use for other floating facilities (Table 1). Nine Districts had no marinas, and therefore, did not have a flotation requirement policy. Finally, they also indicated a desire for flexibility in adopting future technological advances that might produce flotation products with performance equivalent to encapsulated flotation.

For the most part, Districts did not report problems with the current policy that basically requires encapsulation for new or replacement construction, although they noted that conversion could incur significant costs for lease holders and that other types of flotation with similar characteristics might be appropriate for policy updates. Fifteen districts reported having standards for encapsulation. Conversion rates varied across the country, as did the number of floating structures. Rolling District offices into eight Division offices indicates that: Great Lakes and Ohio River Division (LRD) reported 62 percent conversion of the total number of reported floating structures (LRD has 25 percent of total floating structures); Mississippi Valley Division (MVD) reported 39 percent conversion (MVD has 6.5 percent of total structures); North Atlantic Division (NAD) reported 95 percent conversion (NAD has 1.1 percent of total structures); Northwestern Division (NWD) reported 60 percent conversion (NWD has 7.8 percent of total structures); South Atlantic Division (SAD) reported 65 percent conversion (SAD has 30.4 percent of total structures); South Pacific Division

Table 1. Corps Districts with Recreation Area Floating Structure Policies.

District Name	Policy for Marina Encapsulation	Policy for Encapsulation on Other Floating Structures
LRD – Buffalo	NA	NA
LRD - Chicago	NA	NA
LRD - Detroit	NA	NA
LRD - Huntington	Yes	Yes
LRD - Louisville	No	No
LRD - Nashville	Yes	Yes
LRD - Pittsburgh	Yes	Yes
MVD – New Orleans	NA	NA
MVD – Rock Island	Yes	Yes
MVD – St. Louis	No, but under discussion	No, but under discussion
MVD – St. Paul	No	Yes
MVD - Vicksburg	No	No
NAD – Baltimore	No	No
NAD – New England	No	No
NAD – Norfolk	NA	Yes
NAD – Philadelphia	NA	NA
NWD – Kansas City	Yes	Yes
NWD – Omaha	Yes	Yes
NWD – Portland	Yes	Yes
NWD – Seattle	No	No
NWD – Walla Walla	Yes	Yes
POD - Alaska	NA	NA
SAD – Jacksonville	Yes	Yes
SAD – Mobile	Yes	Yes
SAD – Savannah	Yes	Yes
SAD – Wilmington	Yes	Yes
SPD – Albuquerque	No	No
SPD – Los Angeles	NA	NA
SPD – Sacramento	Yes	Yes
SPD – San Francisco	No	No
SWD – Fort Worth	Yes	Yes
SWD – Galveston	NA	NA
SWD – Little Rock	Yes	Yes
SWD – Tulsa	No	Yes
Total with Policies	15 Yes	18 Yes

(SPD) reported 23-percent conversion (SPD has 1.1 percent of total structures); Pacific Ocean Division (POD) reported 0 percent conversion with only one floating structure; and Southwestern Division (SWD) reported 28 percent conversion (SWD has 28 percent of total structures) for a total of 52 percent of all reported floating structures converted (Table 1).

3 Water Management Policies for Floating Structures

This study included examining the policies of other lake managers regarding dock flotation. Examples of agencies that require or recommend encapsulated flotation or equivalent for docks include: Tennessee Valley Authority (TVA), Bureau of Reclamation (Reclamation), U.S.D.A. Forest Service (USFS), and the National Park Service (NPS) on an individual project basis. Many states also require this type of flotation such as Arkansas, California, Delaware, Georgia, Iowa, Oregon, Rhode Island, and South Carolina. In addition, entities such as Grand River Dam Authority (GRDA), Alabama Power Company (Alabama), Duke Energy (Duke), AmerenUE (Ameren), and the Lower Colorado River Authority (LCRA) have encapsulation requirements for floating docks.

Policy language includes the following examples:

- Alabama (Alabama Power Company 2005) – “Establish January 1, 2010 as a deadline by which all unencapsulated beaded foam flotation must be removed from all permitted structures. Permits for construction of new floating structures will require flotation be of materials which will not become water-logged or sink when punctured. Closed cell (extruded) expanded polystyrene of good quality and manufactured for marine use will be required. Lesser quality foam bead flotation may be used if it is encased (encapsulated) in a protective coating, and manufactured for marine use, to prevent deterioration and resultant loss of beads. Permits for modifications to existing floating structures will require signed certification from the permittee that beaded foam materials have been removed from the project and disposed of in an appropriate manner.”
- AmerenUE (AmerenUE 2008) – “A deadline date of December 31, 2008 for eliminating the use of all non-encapsulated foam in boat dock construction on the Lake of the Ozarks. The elimination of the non-encapsulated foam is intended to reduce the amount of dock foam that breaks free and deposits on the shoreline of the lake.”
- California (California 2005) – Excerpt from Guidelines for Marina Berthing Facilities: “Exposed foam pontoons will not be approved for use on marina projects….Where polyethylene pontoons are used, it is

recommended that...Roto-Cast, Linear Low Polyethylene, 0.150 nominal wall thickness be used...with minimum freeboard of 10 inches (Dead Load + Live Point Load)."

- Duke (Duke Entergy 2006) – "Flotation for all facilities shall be of materials manufactured specifically for marine use. Materials must not lose significant buoyancy if punctured, must not generally be subject to damage by animals, and must resist breaking apart under a broad range of wave energies. Uncoated, beaded polystyrene will not be permitted for any new construction or as replacement for existing facilities. Reuse of plastic, metal, or other previously used drums or containers for encasement of flotation purposes is prohibited. Existing flotation on previously approved structures is authorized until it has severely deteriorated and is no longer serviceable, at which time it must be replaced with approved flotation."
- Lower Colorado River Authority (LCRA) (LCRA 2004) – "Docks using flotation may continue to use non-encased flotation until Feb 18, 2014 (10 years from effective date of the standards), at which time all flotation will be required to be encased flotation only. If the flotation is being replaced in conjunction with the replacement of the structures of the residential dock in its entirety, encased flotation must be used."
- National Park Service (NPS) (NPS 2001, 2008) – "Use flotation foams that are encoated or encapsulated in plastic or wood. As these floats age, the covering contains the degraded foam." Further, "2.1 FLOTATION UNITS: The flotation units shall have a minimum 0.150 inch wall thickness and be manufactured from linear virgin polyethylene resin containing UV ray inhibitors and carbon black pigment to protect against ultra-violet deterioration. All units shall be rotationally molded for seamless, one piece construction. The polyethylene shell shall have molded mounting slots, and be unaffected by petroleum and other chemicals. The floats shall be completely foam filled using 0.9 to 1.5 PCF density polystyrene (EPS). All floats shall feature a float top configuration, air pressure relief valve and have a heavy duty mounting flange. Floats shall comply with Corps of Engineer Regulation #36 CFR Part 327, the Hunt Absorption test, the Hunt Falling Dart test and appropriate ASTM and fire resistance standards. 2.2 The flotation units shall be easily installed and replaceable, bolted to the frame or other suitable connectors with not less that 3/8" diameter galvanized bolts or lag screws."
- Reclamation (U.S. Bureau of Reclamation 2007) – "Dock flotation will not be permitted if it is unenclosed foam or other installation that

results in break up and trashing the lake. This common condition will apply to the upgrades of currently existing facilities as well as new construction."

- Rhode Island (Rhode Island 2007) – Excerpt "foam billets or foam bead shall not be utilized unless they are completely encapsulated within impact resistant plastic." The Residential Docks, Piers, and Floats Standards also include guidance on placement, freeboard, float load, etc.
- Tennessee Valley Authority (TVA) (TVA 2008) – "All flotation for docks, boat mooring buoys, and other water-use structures and facilities, shall be of materials commercially manufactured for marine use. Flotation materials shall be fabricated so as not to become water-logged, crack, peel, fragment, or be subject to loss of beads. Flotation materials shall be resistant to puncture, penetration, damage by animals, and fire. Styrofoam floatation (sic) must be fully encased."
- U.S.D.A. Forest Service (USFS) (USFS 2008) – "Open cell Expanded Polystyrene Foam (EPS) has an open structure that easily lets water into its interior. It becomes water-logged quickly. Molten, closed-cell EPS, while water resistant, is weak and breaks into tiny pieces on impact or while being cut. The internal framework of extruded, closed-cell EPS is much like wood, giving it additional strength and water resistance. Forest Service floating structures should only use extruded closed-cell EPS and the foam should be encased in a protective covering."

4 Environmental Impacts of Flotation Products

A common type of dock flotation is expanded polystyrene foam (EPS). It is white in color and is the same material used in inexpensive "coolers" or "ice chests." Environmental impacts associated with EPS and other plastics used for flotation include: the rate of degradation (water and sunlight), ingestion of particles by fish and wildlife, exposure to chemical elements such as benzene, styrene and ethylene, and aesthetics/littering associated with particles of flotation. Fortunately, there are also some efforts to recycle old flotation.

Breakdown of plastics mainly occurs through photo-degradation that causes surface cracking, embrittlement and disintegration (Williams et al. 2005). This also includes physical abrasion where flotation is impacted by wave energy, rocks, etc. Andrady notes that "outdoor exposure of expanded, extruded polystyrene foam in air results in rapid discoloration and embrittlement of the exposed surface....and formation of a possibly protective yellow surface layer." (Andrady and Pegram 1991). He did follow-up studies on enhanced degradable plastics that showed faster disintegration occurring in both marine and freshwater environments with a slower rate of foulant buildup in marine settings (Andrady et al. 1993b), and indicated that the rate of disintegration was dependent on the exposure location (Arizona test site had highest rate) (Andrady et al. 1993a).

Additional studies have shown that the small foam beads may choke air-breathing species or take up space in their digestive track limiting their ability to absorb nutrients (Burns 1999). The U.S. Department of Labor, Occupational Safety & Health Administration notes that the principal health impacts from exposure to styrene are "headache, fatigue, dizziness, confusion, drowsiness, malaise, difficulty in concentrating, and a feeling of intoxication." General environmental impacts of small docks and piers to vegetation, contaminants, and sediments is addressed in "Management of Small Docks and Piers – Environmental Impacts and Issues" (Bliven 2005). Pollution impacts from recreational boating is addressed in a review by the Rhode Island Sea Grant program (Milliken and Lee 1990).

Individual foam products have different chemical compositions. Polystyrene, often referred to as Styrofoam (Dow Chemical) includes several commonly used chemical elements - Benzene, Styrene, and Ethylene. The following are extracted from a report by Andrea Kramer (Kramer 2003). Note that most health studies done on these chemicals pertain to employee exposure during the manufacturing process versus exposure to end products.

- Benzene is extracted from coal, but is also found in gasoline. Long-term benzene exposure may lead to skin scaling, leukemia, plastic anemia, and death.
- Styrene is extracted from petroleum, but is also found naturally in foods such as strawberries, beef, peanuts, beans, and wheat. Long-term exposure to styrene can cause trouble balancing, learning impairments, fetal damage, decreased fertility in females, and lung cancer.
- Ethylene is present in most plants. It is flammable in large quantities.

Relatedly, studies of benzene indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 5,300 ug/l (USEPA 1980).

Aesthetic issues pertaining to floating debris on bodies of water are also a concern. A 1991 study in Illinois on differences in water quality perceptions between recreators and managers (Mullens et al. 1991) found that the three most important characteristics to recreators were “absence of unpleasant odors, litter and floating debris.” For managers, the three top rated characteristics were the “absence of litter, odor and dissolved oxygen.” Overall, recreators ranked floating debris of higher concern than managers, but both groups felt it was important. Many lakes managed by the Corps and others have annual shoreline cleanups where blocks of EPS are commonly collected, particularly after a storm season. In Georgia, a Lake Hartwell Association newsletter referred to these as “icebergs” (Brenner 2006). AmerenUE’s Lake of the Ozarks in Missouri found that 90 percent of the solid waste littering the lake is dock foam with 130 tons or 2,207 yd^3 of foam and other debris collected along 500 miles of shoreline from Truman Lake to Bagnell Dam (Miller 2008). In sufficient quantity or size, these foam “icebergs” may also pose a hazard to boat traffic (Missouri Department of Natural Resources 2006).

Impacts may also occur with regard to floating structure stability when less durable types of flotation become waterlogged or damaged by chemicals, animals, or storms and lose their ability to provide adequate buoyancy. As buoyancy decreases, dock structural components may contact the water and corrode, safety hazards associated with uneven footing may emerge, and utility connections may be compromised. Some of these impacts may be avoided or mitigated by using "environmentally friendly" components made from recycled materials and lacking many of the areas of concern noted.

Special environmental requirements for protected species such as salmonids may be required in areas such as the Pacific Northwest. Young species of salmonid fish such as Chinook salmon (*Oncorhynchus tshawytscha*), seek out cover in the form of overhanging vegetation and may use floating docks as an alternative cover (Chapman 2008). However, fish prey species such as Smallmouth bass (*Micropterus dolomieu*) and Northern pike minnows (*Ptychocheilus oregonensis*) may also congregate around dock structures and increase predation threats to protected species. Dock structure design may need to be modified to address this situation. For example, the National Marine Fisheries Service (NMFS), Washington State Department of Fish and Wildlife, and the U.S. Army Corps of Engineers Walla Walla District, developed residential overwater structure design criteria for Lake Wallula/McNary Pool in February 2008 (NMFS, Washington State Department of Fish and Wildlife, and U.S. Army Engineer District, Walla Walla 2008). The design requirements are intended to: minimize degradation of aquatic, near-shore, and shoreline habitats; not impede any juvenile or adult salmonid life stage including migration, rearing, and spawning; and not enhance habitats used by potential salmonid predators, especially fishes and birds. Accordingly, the design specifications include features such as white-colored flotation, permanent encapsulation, and grating of the float surface area.

A good assessment of why encapsulation of EPS or other flotation may be environmentally beneficial is provided by Enviro-Float (Enviro-Float Manufacturing 2008), a manufacturer of dock flotation:

> Encapsulating the flotation eliminates the breaking down of the foam, which when broke(n) down, shows up as little white beads and flakes of foam floating in the water. Encapsulation enables the flotation to last indefinitely. The hard plastic exterior does not allow marine borers

> (muscles (sic), barnacles, pile worms, etc.) to dig into and breakup the foam resulting in the loss of buoyancy. In addition, the plastic exterior prevents otters and other marine life from "nesting" the raw foam. Lastly, the raw, exposed foam in marinas has a tendency to absorb any gas, oil and other contaminants in the water. This will result in further breakdown of the foam and the retention of unwanted odors.

Absorption of oil and fuel can also react with EPS to create a thick, flammable sludge according to Douglas Pluth (Pluth 2003). Corps-managed lakes have documented marina gas docks with EPS flotation catching fire following a fuel spill.[1]

While it may solve several environmental issues, encapsulation should not be considered a total panacea. Dexndox Inc., a marine contractor on Lake Murray in South Carolina, lists examples of hard plastic-encapsulated floats being chewed by beaver and muskrat, the encased tubs filling with water, and the encasement sustaining damage from rocks or roots on the lake bottom (Dexndox Inc. 2008). Dexndox also recommends solutions for many of the issues related to design and installation that will be discussed in the best management practices section of this report.

[1] Personal Correspondence. November 20, 2007. Andrea Lewis, Deputy Chief, Operations Division, U.S. Army Engineer District, Little Rock, AK.

5 Best Management Practices for Floating Structures

Best Management Practices (BMP) for floating facilities such as boat docks were also reviewed. Flotation BMP product recommendations included: floatable foams encapsulated in polyethylene or other surface covering, closed cell polyethylene, and dedicated plastic float drums. Many lakes and associations have also adopted the National Oceanic and Atmospheric Administration's (NOAA) voluntary Clean Marina Initiative (NOAA 2008). An article from Marina Dock Age and Boat and Motor Dealer indicates that the results of a 2008 Clean Marina Survey showed 701 currently certified Clean Marinas across the United States (Mendez 2007). Lakes under this program typically require foam floats encapsulated with plastic, fiberglass, concrete, wood, or galvanized steel.

Encapsulation challenges

As mentioned in the preceding section, Dexndox Inc., has noted problems with encapsulated flotation relative to rodents, leaks, and punctures and recommends the following best practices to address them (Dexndox Inc. 2008):

- **Rodents chewing floats** – It is believed that darker, more enclosed docks are attractive to rodents. Avoid closing the dock's sides down to the water to allow daylight under the dock and through the sides.
- **Leaks from plastic threaded plugs or "weep holes" around bolt slots on the tub's perimeter** – If the flotation has threaded plugs, be sure to insert them prior to placing the floats under the dock. Try to select factory-sealed flotation versus those with "weep holes" that can build up condensation inside the float over a period of time.
- **Punctures from floats contacting the lake bottom** – Add "legs" to the flotation when installed to keep it a few inches off the lake bottom. The legs should be cut to the lake bottom contour, and allow the dock to rest fairly level for extended periods of time when the lake level is low.
- **General note** – Use an experienced dock builder for installation.

Additional best practices

- **Existing materials** - During construction and remodeling, contain all foam and debris with a floating boom; recycle old foam through the foam installer, a marine contractor, or a garbage hauler; help clean the marina of foam particles and pick up foam noted along the way (Oregon Foam Encapsulation Program 2008).
- **Float construction** - Polyethylene-encased floats are generally made using a blow-molded process or a roto-molded process. Some processing techniques may produce edges and corners of the encasement that are thinner and weaker than the flat portions (Pluth 2003). Relatedly, Technidock recommends a seamless float shell with no weaker weld points, structural ribs on the top and bottom for added strength, and external mounting flanges and slots to avoid penetration of the float body (Technicdock 2008). Protection against ultra-violet (UV) deterioration is another concern that may be addressed with UV inhibitors and carbon black pigment (Tiger Docks 2008). Construction using environmentally friendly, recyclable materials is recommended by COON Manufacturing and by Tiger Docks (COON Manufacturing 2008, Tiger Docks 2008).
- **Impermeability –** Flotation material should be fire resistant and impervious to water and damage from gasoline and other marine fuels (USACE, Little Rock District 2008a). Additional available tests include: an ASTM International Falling Dart Puncture Test to determine resistance to punctures, tank testing to verify buoyancy ratings, wall thickness testing to verify wall consistency and compliance with acceptable wall thickness, and a 7-day Hunt Absorption Test to test water absorption of foam blocks (Premier Materials 2008).
- **Warranty** – Warranties for flotation material against sinking, becoming waterlogged, cracking, peeling, fragmenting, or losing beads generally range from 8-15 years based on products from manufacturers listed in this section.
- **Flotation serviceability** - Serviceability for new and replacement construction is determined by ability to maintain the lowest part of the dock structure a minimum of 8 in. above the water's surface (USACE, Little Rock District 2008a). Additional policies referenced in the Water Management Policies for Flotation section recommend minimum freeboard of 8-24 in. It should be noted that freeboard discussions should define the type of freeboard – Dead Load, Uniform Live Load, Live Point Load, Lateral Loads, Wind Loads, Current Loads, Wave Loads, Impact Loads, Environmental Loads or combinations thereof

(California 2005). Freeboard is defined as the distance from the water surface to the topmost surface of the structure. If not referring to the topmost surface, the term "clearance" should be used. For example, if there is an 8-in. clearance requirement, the typical minimum freeboard would be approximately 16 in.

- **Protected species requirements** – As mentioned in Section 4 of this report, additional flotation design requirements should be used as applicable for protected aquatic species.

Recycling

Recycling of used flotation is another area in which interest and capabilities are increasing. One company that combines the idea of recycling with encapsulated flotation is "Seaco Marine." One of their products is an "earth-friendly" flotation module that is foam free and roto molded from recycled polyethylene. Its secondary flotation system consists of 80 pressure tested and sealed 2-litre plastic soft drink bottles (Seaco Marine 2008).

AmerenUE notes that there has been some industry interest in recycling clean polystyrene dock foam as parking material, soiled foam as a gravel supplement in septic tank drain fields, and used foam as fill in concrete construction or concrete landscaping walls (Missouri Department of Natural Resources 2006). In addition, some researchers have developed organic solvents that reduce the foam to a liquid or gel for use in other products such as protective coating for metal and wood (Missouri Department of Natural Resources 2007). A similar application from BioSpan involves combining dock foam scraps with a solvent. The dissolved blend is then used with recycled asphalt in highway cold patching in several Midwestern states (Missouri Department of Natural Resources 2007).

Flotation replacement costs

According to a report by Ralph Morely that appeared in Marina Dock Age Magazine, building a new floating structure or "refloating" an existing structure can be a significant financial investment (Morely 2005). He notes that in the past, flotation was often an "afterthought," but now accounts for "nearly 20% of the total dollars spent on waterfront construction projects." In general, a sheet of encapsulated flotation costs approximately twice as much as a comparable sheet of plain polystyrene foam (Weith 2007, 2008). For example, a 48- × 96- × 20-in. polystyrene foam billet sells for $148 as compared to $306 for a comparably sized encapsulated foam billet. Once properly installed, it generally provides significantly longer length of service while requiring significantly less recurring maintenance than non-encapsulated products.

6 Study Limitations and Error

Corps offices that participated in the flotation survey generally used existing database information regarding the number and types of docks and flotation in use versus conducting detailed, individual site assessments for every project. Therefore, some variation in reported and actual numbers is expected. The Corps shoreline management program is dynamic with ongoing requests for new or expanded docks, marinas, etc. This results in periodic changes in the number and types of floating structures present.

Product information is reported from manufacturers based on their printed and online publications and no independent product testing was conducted in conjunction with this report. References are provided for informational purposes only and do not represent a government endorsement of specific products or companies.

7 Summary and Discussion

Environmental impacts associated with certain types of dock flotation have been a challenge for lake and river managers for many years. These include degradation from water, sunlight, and chemicals (to include flammability hazards), aesthetics/littering associated with particles of flotation, ingestion of particles by fish and wildlife, and the possibility of health impacts from exposure to chemicals used to manufacture various types of flotation. In addition, floating structures may lose their buoyancy and suffer related consequences. These impacts are frequently associated with exposed, open cell, expanded polystyrene foam (EPS). Lake managers often assess these impacts through the Corps' environmental compliance assessment process using the Environmental Review Guide for Operations (ERGO) manual.

Lake managers have sought to deal with these issues by adopting policies that reflect best management practices (BMP's) for boat docks and marinas. Seventeen entities examined (including the U.S. Army Corps of Engineers) have policies that require or recommend the use of encapsulated flotation or equivalent for floating structures. Examples of BMP's include: Clean Marina certification, construction techniques to ensure long service life, careful selection of products and installers, and recycling old flotation.

In June of 1992, the U.S. Army Corps of Engineers issued a policy to require the use of appropriate encapsulated flotation or equivalent for floating structures such as docks and marinas following a survey of field offices (USACE 2008c). In December 2007, a follow-up field survey was conducted to assess progress made in the implementation of this policy. Respondents indicated that they had 516 marinas, an estimated 105,761 total marina slips (42,546 with encapsulated flotation), 408 Corps slips (263 with encapsulated flotation), 73,102 private or community slips (47,478 with encapsulated flotation), and 2,001 courtesy/fishing/swim docks (1,493 with encapsulated flotation) (Appendix B).

Of the 34 respondents, 15 indicated that they had a District policy requiring encapsulated flotation for marinas, and 18 requiring its use for other floating facilities (Table 1). Nine Districts had 0 marinas, and therefore, did not have a flotation requirement policy. They also indicated a desire for flexibility in adopting future technological advances that might produce flotation products with performance equivalent to encapsulated flotation.

The current Corps policy, "Shoreline Management Flotation Requirements," allows for some interpretation and ambiguity with regard to suitable flotation requirements for existing floating structures, policy application by dock ownership, and by stating that lease conditions and requirements will determine types of flotation for lessees. The lack of a more definitive policy may have contributed to the uneven flotation conversion rates across the country observed in the 2008 survey, and Districts establishing their own flotation policies. While significant progress has been made, additional improvements could be enacted if the Corps desires to uniformly eliminate environmental impacts from unencapsulated EPS foam flotation, and encourage safer, more sustainable floating structures. These could include: requiring the use of encapsulated flotation with BMP characteristics or an equivalently performing product for all floating facilities on Corps-managed waters; establishing a timeline whereby all existing facilities would be converted to or constructed with appropriate flotation; requiring the proper disposal or recycling of old flotation; and developing a methodology whereby future flotation products could be assessed to determine suitability for use on Corps-managed waters. If a policy update is issued, it may be helpful to do so jointly with the Corps' Operations Division and Real Estate Division for the portion pertaining to outgrant concessions such as marinas.

Finally, consideration might also be given to incorporating flotation BMP's in the Corps' national Regulatory program under the Clean Water Act and the Rivers and Harbors Act. Some Corps Districts such as Little Rock have General Permits for recreation facilities (e.g., #10972-GI) that include flotation material requirements, but this requirement does not appear to be in place nationwide (USACE, Little Rock 2008b). Additional clarification may be needed for permits issued on both riverine and reservoir systems.

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Appendix A: USACE Encapsulated Foam Survey 2008

Appendix A. USACE Encapsulated Foam Survey 2008

MSC	District	# Marinas *(SWD , NRMS, OMBIL)**	# of Marina Slips	Has a District Standard Requiring Encapsulated Foam for Marinas (Y, N, N/A)	Has a District Standard Requiring Encapsulated Foam for Other Floating Facilities, (Y, N, N/A)	Estimate d # of Marina Slips with Encapsulated Foam	# of Corps Slips	# of Corps Slips with Encapsulate d Foam	# of Private/ Community Slips	Estimated # of Private/ Community Slips with Encapsulated Foam	# of Courtesy/ Fis hing/ Swim Docks	# of Courtesy/ Fishing/Swim Docks with Encapsulated Foam
LRD	Buffalo											
LRD	Chicago											
LRD	Detroit											
LRD	Huntington											
LRD	Louisville											
LRD	Nashville											
LRD	Pittsburgh											
MVD	New Orleans											
MVD	Rock Island											
MVD	St Louis											
MVD	St Paul											
MVD	Vicksburg											

Appendix B: 2008 USACE Encapsulated Foam Survey Results

Appendix B. 2008 USACE Encapsulated Foam Survey Results
(Estimated figures are based on existing databases)

Division	# Marinas	# Marina Slips	# Corps Slips	# Private or Community Slips	# Courtesy/Fish/Swim Docks
LRD	124	29,738	45	14,230	189
		20,817 encapsulated - 70%	41 encapsulated - 91%	6,312 encapsulated - 44%	177 encapsulated - 94%
MVD	59	10,163	24	1,254	75
		4,154 encapsulated - 41%	21 encapsulated - 87%	262 encapsulated - 21%	19 encapsulated - 25%
NAD	5	1,855	54	2	49
		1,772 encapsulated - 95%	51 encapsulated - 94%	2 encapsulated - 100%	37 encapsulated - 75%
NWD	87	10,380	239	2,716	493
		6,122 encapsulated - 59%	124 encapsulated - 52%	1,783 encapsulated - 66%	310 encapsulated - 63%
POD	0				
SAD	65	13,829	34	39,514	673
		6,563 encapsulated - 47%	18 encapsulated - 53%	27,803 encapsulated - 70%	622 encapsulated - 92%
SPD	7	1,732	16	36	43
		400 encapsulated - 23%	6 encapsulated - 37%	0 encapsulated - 0%	30 encapsulated - 70%
SWD	169	34,755	2	15,350	478
		2,745 encapsulated - 8%	2 encapsulated - 100%	11,316 encapsulated - 74%	298 encapsulated - 62%
Total	516	102,452	414	73,102	2,000
		42,573 encapsulated - 42%	263 encapsulated - 63%	47,478 encapsulated - 65%	1,493 encapsulated - 75%

Legend:

LRD - Great Lakes & Ohio River Division	POD - Pacific Ocean Division
MVD - Mississippi Valley Division	SAD - South Atlantic Division
NAD - North Atlantic Division	SPD - South Pacific Division
NWD - Northwestern Division	SWD - Southwestern Division

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14. ABSTRACT

This report documents a survey of flotation products being used at boat docks on U.S. Army Corps of Engineers lakes, best practices and policies for dock flotation of various water managers, and potential environmental impacts from flotation products. This report conveys the findings thereof.

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