Adverse Environmental Impacts Associated with Proposed Shady Oaks and Jagger Branch Developments

Jagger Branch Embayment
Guntersville Lake
Alabama

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Prepared for:

Joe W. McCaleb and Associates
Attorneys-at-Law
Hendersonville, Tennessee

and the

Honeycomb Community Association
Guntersville, Alabama

Prepared by:

Mark A. Quarles, P.G.
(Tennessee No. 3834)

Globally Green Consulting

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SUMMARY OF KEY FINDINGS

There is ample evidence to suggest the need for a comprehensive evaluation of the cumulative impacts of the proposed Jagger Branch and Shady Oaks developments. As currently proposed, the projects should be denied because of the failure to identify the direct, indirect, and cumulative effects on the area. At a minimum, a public hearing to gather knowledgeable conditions from local people and completion of an Environmental Impact Statement (EIA) are warranted.

To-date, the applicants, the US Army Corps of Engineers (USACE), nor the Tennessee Valley Authority (TVA) has completed an in-depth evaluation of the combined environmental impacts of either proposed development. Although the USACE completed an Environmental Assessment for Shady Oaks that concluded there would be no significant impact, there was no detailed science to support that claim, based upon a review of the USACE file through a Freedom of Information Act search.

There are signs that Guntersville Lake embayments are already impaired by nutrients that cause the water quality to not meet designated use criteria established by ADEM, based upon 10 months of detailed monitoring by ADEM in 2003. The data indicate the most severe level of eutrophication, according to US EPA standards. The proposed activities associated with the developments, both on and off-water, are known to contribute pollutants that will worsen the existing lake conditions, based upon information provided in US EPA guidance documents, TVA marina design standards, and published reports by water quality experts.

An expansive investigation meeting National Environmental Policy Act (NEPA) standards for an Environmental Impact Statement (EIS) should be completed to truly evaluate the area of potential effect (APE) and the direct, indirect, and cumulative impacts from these developments. A public hearing meeting the USACE and TVA standards for public notification should be performed so that the all available information and input is gathered. The investigation should include the embayment and the surrounding upland areas where construction will occur. The investigation should include a comprehensive carrying capacity analysis that includes four (4) components: ecological carrying capacity; social carrying capacity; managerial carrying capacity; and physical / facility carrying capacity. These analyses should evaluate the effects to the sensitive, likely already impaired embayment environment associated with the construction of almost 300 new single-family homes and town homes, three community boat docks, and associated support structures.

Key findings of this Globally Green Consulting assessment are as follows:

Design Standards

- The community boat boathouses do not meet TVA Regulation 26a standards for allowable dredge quantities. Only through completion of a detailed embayment bathymetry analysis will the actual dredged sediment quantity be determined.
- The community boathouses do not meet TVA Regulation 26a size requirements for length.
- The community boathouse locations do not meet TVA's (or EPA's) marina design standards.
- The developments do not meet the USACE's small boat basin design standards for protecting the environment.
- The placements of the boathouse structures given in the Public Notices and applications were based on inaccurate, out-of-date topographic maps that do not indicate the actual conditions.
- TVA is required by the NEPA to evaluate the cumulative, direct, and indirect effects of proposed activities.

Water Quality

- Excessive sediment deposition in Jagger Branch embayment already indicates low flushing rates and an inflow with high solids. The length of the bay has decreased over 2,000 feet in less than 25 years. Construction will likely increase that rate of deposition.
- Low flushing of the embayment worsens water quality, as indicated by the eutrophic conditions in the embayments monitored by ADEM.
- The discharge of approximately 80,000 gallons per day of domestic sewage for 1,100 more residents will add nitrogen and phosphorous to the embayment through direct or indirect discharges to the embayment. These nutrients will only increase the likely eutrophic conditions that already exist.
- According to ADEM monitoring data collected in 2003, eight (8) of ten (10) embayments sampled in 2003 are eutrophic for at least nine months of the year, resulting in dissolved oxygen and chlorophyll-a concentrations that do not meet ADEM water quality criteria for designated uses. <u>All</u> of the embayments were eutrophic in the late summer months. These monitoring results were available during the USACE preparation of the Environmental Assessment for Shady Oaks; however, there is no indication that this data was considered in its evaluation.
- Additional loadings of pollutants to the embayment will likely violate ADEM's water quality Anti-Degradation Policy. TVA and the USACE should consult directly with ADEM regarding water quality of the cumulative development impact.
- The planned developments have the potential to further degrade the water quality for low dissolved oxygen, pathogens, toxic metals, chlorophyll, and man-made organic chemicals – conditions that ADEM and TVA have

already documented on the reservoir.

- Development activities will likely increase the toxicity of the water column, increase pollutant concentrations in aquatic organisms, increase pollutants in sediments, increase the level of pathogens, re-suspend settled sediments, destroy aquatic habitat, and further decrease flushing of the embayment.
- Given that the winter pool / summer pool depth variance is only approximately 2.0 feet, water quality will be afforded little protection during construction at "low", winter pool elevations.

Recreational Boating Density

- The expected 62 percent increase in boating traffic will result in less than 0.5 acre per boat density standard, not including non-resident boat traffic that uses Jagger Branch embayment. Furthermore, given the narrowness of the embayment that is compounded by the extraordinary width of the boathouses, such an increase in boat traffic might render the embayment unusable for safety reasons.
- The projected boat density greatly exceeds the 10 acres per boat maximum density established by TVA in 2002. Furthermore, to meet TVA's recommended density, no more than six (6) boats can be on the embayment at any given time. With the addition of 64 more slips, the boat total for the embayment will be 224.

Habitat Alteration

- The US Fish and Wildlife Service has documented the present of 15 federally protected Threatened and Endangered (T&E) species in the Marshall County area. Furthermore, 6 or the 15 species were mussels.
- The Alabama Department of Conservation and Natural Resources considers the Jagger Branch embayment a "hot spot" for bald eagle roosting and potential nesting habitat. In addition, the area is known habitat for the protected gray bat and the Indiana bat. Any foreseeable alteration of the hillside constitutes a cumulative effect of the proposed activity and therefore, must be evaluated.
- Habitat destruction associated with boathouse and home construction will occur.
- Boating activities are expected to have an adverse effect on the reservoir habitat due to the extreme shallow nature of the reservoir, small usable acreage, and a narrow shoreline.
- Sensitive wetland and natural resource areas identified by TVA in the land management plan exist in the immediate vicinity of the developments.
- The proposed developments will degrade the existing rural landscape.

Section 1

Background

1.1 Current and Proposed Land Use

The Tennessee Valley Authority (TVA) developed a Final Environmental Impact Statement and Land Management Plan (from hereinafter referred to as the "plan") in August 2001. The purpose of that plan was to update the 1983 Land Use management plan. The plan included certain zones of shoreline properties designated for use types, ranging from sensitive environment areas to those set aside for commercial and residential development. Specifically, the plan designated fourteen (14) special use parcels in the Jagger Branch / Honeycomb Branch embayment(s) located upstream of the US Highway 431 causeway bridge. Of those fourteen, nine (9) were designated as Natural Resource Conservation and Sensitive Resource Management areas because of the uniqueness of these resources. Those zone designations are summarized in Table 1.

Table 1

Zones Set Aside for Protection

Parcel	Acres	Description	Reason
10	63.8	Natural Resource Conservation	Manage important wildlife habitat and shoreline vegetation
11	16.7	Sensitive Resource Management	Protect wetland resources
12	46.4	Sensitive Resource Management	Protect wetland resources
14	14.2	Natural Resource Conservation	Manage important wildlife habitat and shoreline vegetation
15	18.4	Sensitive Resource Management	Provide protective buffer around cave
16	28.2	Natural Resource Conservation	Manage important wildlife habitat and shoreline vegetation
19	49.6	Sensitive Resource Management	Protect wetland and cultural resources
20	12.0	Natural Resource Conservation	Manage important wildlife habitat and shoreline vegetation
282a	0.7	Natural Resource Conservation	Manage important wildlife habitat and shoreline vegetation

According to the land management plan, Sensitive Resource Management zones are established" for the protection and enhancement of sensitive resources". Example areas included in this zone are wetlands, habitat protection areas, small wild areas, and ecological study areas. Also, according to the plan, Natural Resource Conservation zones were established for the "enhancement of natural resources for human use and appreciation". Example areas found in this zone included shoreline conservation areas, wildlife observation areas and recreational activities such as bird watching, hunting, and hiking.

The plan described the current visual conditions of the Honeycomb Creek embayment nearest the Tennessee River channel as having "excellent" scenic value and a "high" scenic integrity. The plan further described the upper reaches of Honeycomb Branch north of Highway 431 as having a "fair" scenic value and "low" scenic integrity. This is the area that has been designated as needing protection with the nine (9) natural resource conservation and sensitive wetland resource areas.

The Honeycomb Branch embayment north of Highway 431 and its Jagger Branch sub-embayment is also the area that is currently being planned for extensive residential development. Two residential developments are currently proposed: Jagger Branch and Shady Oaks subdivisions. The developments are expected to include shoreline community boathouse structures, parking lots, roadways, and single-family homes and town homes within the currently forested areas.

An application for a US Army Corps of Engineers (USACE) permit was first submitted for the Jagger Branch development on July 26, 2006. According to the amended application dated December 27, 2006, the development intended to construct two (2) community boathouses capable of holding 44 boats. A boat ramp and pier requested in the July application were apparently deleted in the amended application and therefore are not planned.

The October 27, 2006 Public Notice issued jointly by the USACE (Section 10 permit) and TVA (Section 26a permit) for the Jagger Branch development described the planned activities as consisting of "construction of two fixed community boat slips, one fixed pier, once concrete boat ramp, channel dredging for boat access, and rip rap bank stabilization". According to the topographic map included in the Public Notice, the proposed development would be located approximately 2,500 feet south of the northern-most terminus of the Jagger Creek embayment, where wetland habitat exists. To-date, it seems that neither the USACE Section 10 permit nor the TVA Section 26a permit have been issued for the development.

The joint USACE and TVA Public Notice for the Shady Oaks subdivision was issued on June 15, 2006. The described activities included development of a community boathouse and placement of riprap for bank stabilization. The planned community dock has 20 slips. A USACE Section 10 Permit was apparently issued after the Statement of Findings and its corresponding Findings of No Significant Impact (FONSI) was made by the USACE on January 12, 2007. The FONSI followed the completion of a Final Environmental Assessment (EA) dated January 9, 2006.

Section 1.2 Purpose of this Report

The purpose of this report is to evaluate the cumulative effect of the planned land and water development activities relative to the potential impact to the environmental quality on the Jagger Branch and Honeycomb Creek embayment areas. Globally Green Consulting was retained to evaluate the likely effects of the increased boating and ancillary activities associated with planned developments.

This report has been prepared at the request of the Honeycomb Community Association, an Alabama non-profit corporation composed of riparian landowners on Jagger Branch and Honeycomb Creek, and other individuals who will be directly and indirectly impacted by proposed construction projects.

Section 2

Current and Planned Reservoir Conditions

2.1 Planned Shoreline Developments

Jagger Branch

The developer has initiated plans to construct land, shoreline, and water-based structures associated with the subdivision, as described in the joint Public Notice. The Public Notice did not include any reference to the planned construction of homes, roads, and associated structures and utilities in the wooded upland and near-flood plain environments. The proposed development includes 182 single-family homes. The development proposes two (2) boathouses (20 and 24 slips, respectively) that extend across up to 175 feet (from the summer pool elevation) of the applicant-estimated 520 feet wide embayment at the proposed location. One boathouse is 144 feet long by 66 feet wide (9,504 square feet), and the other is 169 feet long by 66 feet wide (11,154 square feet).

The applicant recognized that substantial dredging would be required because of the extremely shallow conditions in the area both beneath the proposed boathouses and also the entrance channel to reach the proposed boathouses. Information provided by the applicant in the July 26, 2006 USACE Regulation 26a application stated that the final depth of the channel would need to be 4.5 feet, while not specifying the required depth around the docks. The applicant estimated in their December 27, 2006 revised application to the USACE and TVA that 4,700 cubic yards of sediment will require dredging to construct an entrance channel 50 feet wide by 900 feet long in Jagger Branch embayment and to construct the boathouses.

No publicly available wastewater treatment system is available in the Jagger Branch development area and according to TVA at the May 8, 2007 public meeting in Guntersville, Alabama, the applicant plans to have individual septic tanks for each of 182 single family homes. The homes will be located on the plateau escarpment that consists of karst limestone and dolomite bedrock found at or near the surface. A preliminary plat drawing for the development indicates that the minimum lot size will be approximately 0.5 acre.

The applicant for Jagger Branch did not detail a vegetative management plan for the post-construction shoreline other than stating that rip rap would be placed along the shoreline after the riparian vegetation is removed.

Neither the USACE Section 10 permit nor the TVA Regulation 26a permit have been issued for the development. Further, neither the USACE nor the TVA have completed an EA.

Shady Oaks
The developer intends to construct land, shoreline, and water-based structures, although unclear what the actual plan will include. At least one plan included at least 105 single-family town home lots. One 135 feet long by 65 feet wide (8,775 square feet) community dock including 20 slips is planned. The applicant apparently terminated plans to construct a boat ramp. The boathouse is expected to extend at least 155 feet from the shoreline and 158 feet from normal summer pool. As with Jagger Branch, the applicant for Shady Oaks did not detail a vegetative management plan for the shoreline other than stating that riprap would be placed along the shoreline after the riparian vegetation is removed. Further, no construction best management practices (BMPs) were detailed.

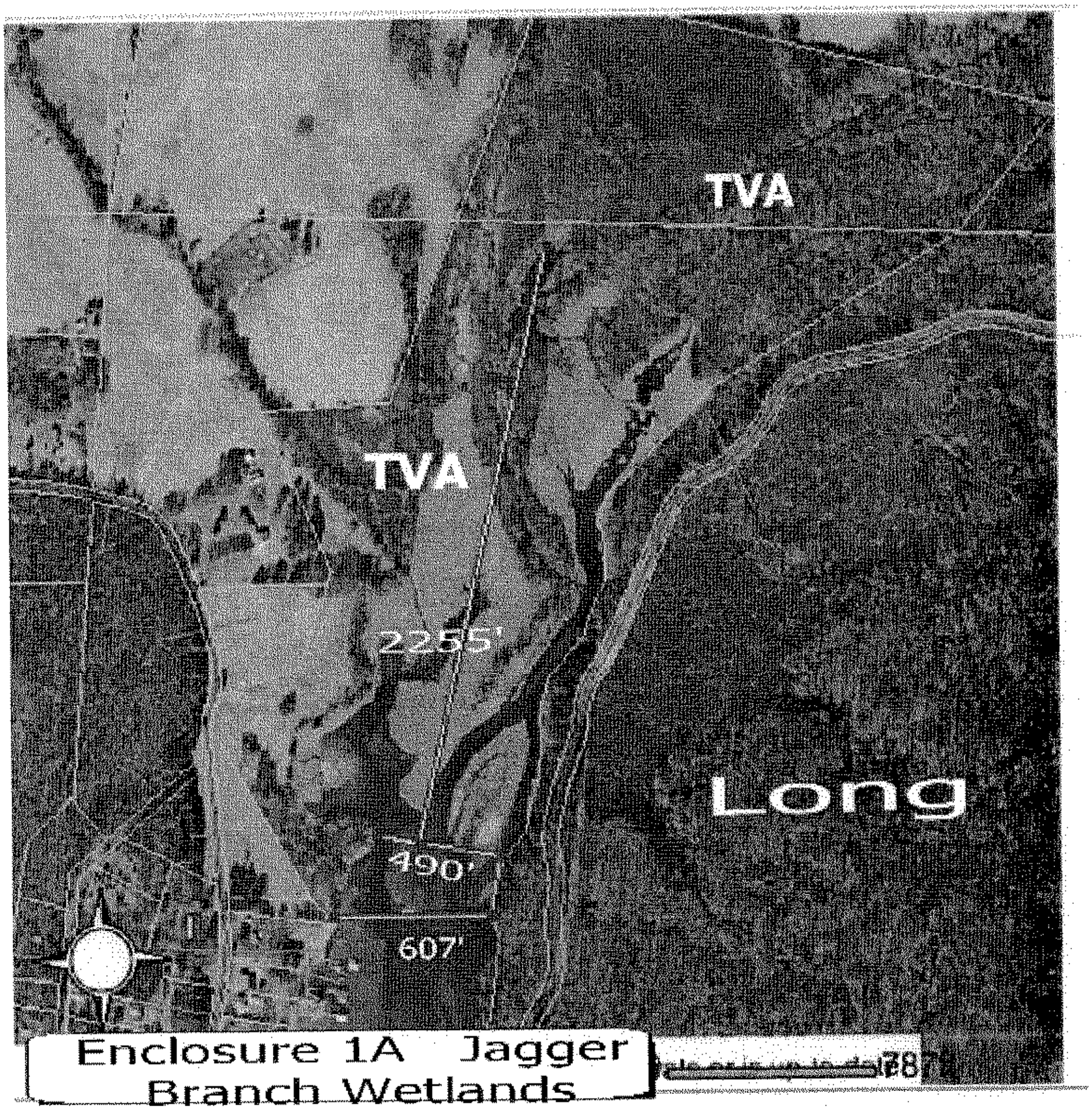
In the FONSI for the Shady Oaks subdivision, the USACE concluded that only "minor" impacts to air quality, water quality, wildlife habitat, noise, traffic patterns, navigation, and environmental justice would occur. The Statement of Findings also concluded that there would be "no effect on endangered or threatened species or on cultural resources, per the US Fish and Wildlife Service (USFWS) and Alabama State Historic Preservation Officer (SHPO), respectively. The USFWS also concluded "no wetlands would be affected" and recommended that construction be conducted during low winter pool to "minimize adverse impacts" and that BMPs should be employed. From a boating safety / density perspective, the Statement of Findings acknowledged that there would be an increase in the density of boats on the reservoir, without discussing what that increase might be. The Statement of Findings also concluded that any impact on boater user experience and boating safety would be "minor". Lastly, the investigations concluded that the development would have "minor impacts" on the visual resources of the area.

There is also no publicly available wastewater treatment system in the Shady Oaks development area. It is presumed that the applicant plans to have individual septic tanks or a small packaged wastewater treatment plant for each of the 100-plus town homes located on the karst geologic plateau escarpment.

The permit applications submitted by both the Shady Oaks and Jagger Branch developers seem to have used out-dated topographic maps to illustrate where the docks will be located. The map that was used in the applications seems to have been based upon a 1983 United States Geologic Survey (USGS) topographic map made in 1983. Current aerial photography included in Figure 1 indicates that that the wetted area of Jagger Branch embayment is now approximately 2,255 feet less than what was present in 1983. The proposed Jagger Branch development is situated at the southern most terminus of what is now an extension of the wetland that was designated in the land management plan as needing protection. Sediment deposition in the embayment has resulted in an approximate 26 percent reduction (43 acres) in bay aerial extent in less than 25 years. What was lost in usable acres of water to the northern extent of

Jagger Branch embayment has been gained in the creation of 43 more acres of protected sensitive resource area.

Figure 1
Recent Aerial Photo
Northern Jagger Branch Embayment



2.2 Threatened and Endangered Species

The US FWS responded to the October 27, 2006 Public Notice for the Jagger Branch development in a November 17, 2006 letter to the USACE. The US FWS concluded, based upon their review of known locations of T&E species in the area, that there were no known sites of T&E species or critical habitat in the proposed project site or in the vicinity. That conclusion was conditional given that their database may not be all-inclusive or current because their database "is seldom based on comprehensive surveys" and "thus does not necessarily provide conclusive evidence that protected species are present or absent at the specific locality".

The US FWS recommended in their response to the Jagger Branch development that the USACE consider the actual need for the new boathouses, given the apparent over-abundance of existing available slips in the vicinity area based upon recent permits that had been granted by the USACE and TVA. Further, the US FWS described specific protective measures that should be strictly implemented during construction and that bioengineering should be used for bank stabilization rather than riprap.

The US FWS responded to the June 15, 2006 Public Notice for Shady Oaks in a July 12, 2006 to the USACE. As with Jagger Branch, the agency concluded that their database did not indicate any locations of Federally protected T&E species or critical habitat in the proposed construction site or in the vicinity. The agency also "strongly recommends" that activities be conducted to protect fish and wildlife resources, including constructing only during periods of low winter pool and allowing treated wood products four (4) weeks or longer to air dry.

A review of the Federally listed T&E species for Alabama was conducted by accessing the list developed by the Alabama office of the US FWS. The species are listed by county, where past detailed site inspections have identified their presence. The database listed 15 species as potentially being present in the Marshall County area. A list of those species is provided in Table 2.

Table 2

Threatened and Endangered Species in the Area

Gray Bat - endangered	Fine-Rayed Pigtoe Mussel – endangered
Indiana Bat - endangered	Orange-Footed Pimpleback Mussel – endangered
Red-Cockeyed Woodpecker-endangered	Rough Pigtoe Mussel – endangered
Bald Eagle - threatened	Price's Potato Bean – threatened
Flattened Musk Turtle - threatened	Green Pitcher Plant – endangered
Snail Darter - threatened	Slabside Pearly Mussel – critical habitat
Pink Mucket Pearly Mussel – endangered	Black Warrior Waterdog – critical habitat
Shiny Pigtoe Pearly Mussel - endangered	

Residents in the Jagger Branch embayment spotted bald eagles in the area in April 2007 and are aware of gray bat populations in nearby caves. A review of the T&E list species identified several species that would consider the proposed development area as prime habitat. Trees along the shoreline and upland provide suitable roosting and nesting areas for bald eagles and suitable roosting habitat for bats.

Mr. Keith Hudson of the Alabama Department of Conservation and Natural Resources was contacted on May 9, 2007 to discuss the proposed developments and his knowledge of any T&E species and critical habitat in the Jagger Branch / Honeycomb Creek embayments. Mr. Hudson responded that the area was a "hot spot "for bald eagles, and that caves along the plateau escarpment in the immediate vicinity are known gray and Indiana bat habitat. He stated that both migratory and resident Bald Eagles exist in the embayment areas and at least four nesting zones exist down-river near the intersection of Honeycomb Creek and the Tennessee River.

2.3 Water Pollutants in Alabama

The Alabama Department of Environmental Management (ADEM) has conducted water quality assessments of the state's reservoirs, rivers, and streams. In 1997, an intensive monitoring program was initiated, and Guntersville Lake was assessed in 2003 with the sampling of 10 tributary embayments. The results of the Alabama lake sampling were summarized in the *2006 Integrated Water Quality Monitoring and Assessment Report* completed by ADEM. The results indicated that nutrients and organic enrichment were the most widespread impairment, combining for 67 percent of the total, as summarized in Table 3. Where excess nutrients exist, there is a potential for eutrophication to occur, creating excess scum, low dissolved oxygen concentrations, and worst-case, fish kills.

Table 3

Leading Causes of Lake Impairments

Rank	Cause	Percent of Acres Impaired
1.	Nutrients	35
2.	Organic Enrichment	32
3.	Priority Organics (PCBs)	23
4.	pH	9
5.	Metals	<1
6.	pH	<1
	Total	100

2.4 Water Quality – ADEM Sampling Results

Both TVA and ADEM have conducted or continue to conduct water quality monitoring of Guntersville Lake. ADEM's data come primarily from the 2003 study. TVA's monitoring is conducted annually from three locations but none of the sampling is conducted in embayments, but rather from the main Tennessee River channel.

As indicated in Table 3, nutrient enrichment and the result of that enrichment are the leading causes of lake impairment in Alabama. ADEM determines and tracks the degree of enrichment according to the Carlson Trophic State Index (TSI) based upon the concentration of chlorophyll-a. The TSI is considered by ADEM "to give the best estimate of biotic response of lakes to nutrients enrichment when phytoplankton is the dominant plant community" as an indicator of trophic status. According to the 2006 water quality assessment report, ADEM has determined that lakes with a range of 50 to 70 indexes are eutrophic; mesotrophic conditions exist within the TSI range of 40 to 50; and oligotrophic conditions exist at values less than 40. A summary of ADEM's sampling for Guntersville Lake relative to the TSI and a description of what conditions are likely is provided in Table 4.

Table 4

Trophic Status of Alabama Lakes

Status	TSI Range	Alabama Lakes (%)	Descriptions of Conditions
Hypereutrophic	>70	3	Heavy algal blooms / scum, fish kills possible
Eutrophic	50 to 70	50	Decreased transparency, anoxic stratification, scums possible, threatened swimming uses
Mesotrophic	40 to 50	41	Moderately clear visibility, increased chance of anoxia
Oligotrophic	<40	6	Clear water, high dissolved oxygen most of the year
		100%	

As of May 24, 2002, ADEM established numeric, lake-specific criteria for nine reservoirs in Alabama, including Guntersville Lake. The mean of monthly samples collected on a growing-season basis is used to compare to the designated criteria. The growing season defined by ADEM for Guntersville Lake is April through September. ADEM established criteria for reservoirs to be used for a specific location within the main channel, not as a lake-wide average. The numeric criteria established by ADEM in Chapter 335-6-10-.11(g), Water Quality Criteria for Guntersville Lake is 18 ug/L (as determined as the mean of all samples) of a photic-zone composite chlorophyll-a sample.

Data for the 2003 embayment sampling program was assessed to determine the average and trends in the data. When the ADEM criterion is compared to the 2003 sampling program for ten embayments, the results indicated that five (5) of the ten (10) exceeded criterion for chlorophyll-a. When the TSI results were also evaluated, all of the embayments were eutrophic during the late summer, and eight (8) of (10) were eutrophic throughout the nine-month monitoring season. Generally, the maximum TSI values generally occurred in July, August, and September. The complete data provided by ADEM and sorted by embayment are included in Appendix A. A summary of the embayment sampling is provided in Table 5.

Table 5

Embayment Sampling Compared to Numeric Nutrient Criteria

	Chlorophyll-A			Trophic State Index		Description of TSI
Bay	**Avg.**	**Max.**	**Criteria**	**Avg.**	**Max.**	
Crow Creek	5.2	9.9	18	44.8	53	Mesotrophic Average Eutrophic late summer
Raccoon Creek	12.5	21	18	54.0	60	Eutrophic for nine months
Mud Creek	6.0	12.3	18	39.0	55	Oligotrophic Average Eutrophic late summer
Roseberry Creek	39.8	68.9	18	65.5	72	Eutrophic for nine months
N. Sauty Creek	14.7	22.1	18	56.6	61	Eutrophic for nine months
S. Sauty Creek	30.5	39.9	18	62.9	67	Eutrophic for nine months
Town Creek	17.4	33.4	18	56.8	65	Eutrophic for nine months
Short Creek	20.2	43.1	18	58.0	67	Eutrophic for nine months
Spring Creek	25.5	33.1	18	62.0	65	Eutrophic for nine months
Brown's Creek	29.7	47.0	18	63.4	68	Eutrophic for nine months

The US Environmental Protection Agency (EPA) considers that waters with TSI values greater than 60 are hypereutrophic (source, *Protocol for Developing Nutrient TMDLs,* November 1999, EPA), meaning that the water is the most severely impaired by nutrients. As a result, fish kills, heavy algal blooms, and heavy scum are possible. A review of the ADEM sampling data for maximum TSI values in Table 5 indicates that eight (8) of ten (10) embayments were hypereutrophic at least one month during the assessment year.

When the ADEM data are further evaluated by depth to observe changes in dissolved oxygen, the data indicated that low, anoxic conditions (<5 mg/L) existed from as early as April and as late as October, as summarized in Table 6. The data also indicated that the depths at which the anoxic conditions existed were relatively shallow in terms of total depth of the embayment. The predominant period of anoxic conditions was in July, August, and September – just as the eutrophic conditions that were noted in Table 5. The 5 mg/L standard was used as a reference comparison concentration because this concentration is the minimum allowed under ADEM Water Quality Criteria for swimming and other whole body water-contact and for fish and wildlife classifications.

Table 6

Embayment Dissolved Oxygen Trends

Bay	Months Dissolved Oxygen <5 mg/L	Shallowest Depth Dissolved Oxygen <5 mg/L
Crow Creek	August, September	3 meters (total depth 3.7 m)
Raccoon Creek	June, July, August	1.5 (total depth 3 m)
Mud Creek	None	n/a
Roseberry Creek	April, May, June, July, August	2 meters (total depth 2.7 m)
N. Sauty Creek	April, June, July, August	2 meters (total depth 4.5 m)
S. Sauty Creek	June, July, August	4 meters (total depth 6.6 m)
Town Creek	July, August, September, October	3 meters (total depth 9 m)
Short Creek	August	4 meters (total depth 8.6 m)
Spring Creek	April, May, June, July, August	4 meters (total depth 7.8)
Brown's Creek	April, June, July, August	3 meters (total depth 7 m)

When the embayment water depth fluctuations for the 10-month period are examined, the depths indicated little fluctuation. The average water level fluctuations for the ten embayments indicated that the highest depths were present generally in April and the lowest were observed in late summer. The average depth fluctuation from April through October was 1.3 meters, and fluctuation ranged from 0.6 meter in the Roseberry Creek embayment to 3.0 meters in the Short Creek embayment.

2.5 Water Quality – TVA Sampling Results

Information provided by TVA to Globally Green Consulting on June 1, 2006 determined that the lake has an average hydraulic residence time of 12 days for the period 1976 through 2004, indicating that the reservoir main channel experiences relative quick flushing. The flushing time may not however, be representative of the numerous embayments that perhaps have small drainage basins, small inflows, and corresponding long hydraulic residence times. Low inflows and low outflows can result in sediment deposition in the embayment when low flushing is present.

TVA conducts water quality studies at each of the reservoirs that it manages. The results of the sampling are summarized and reported on TVA's website (http://www.tva.gov/environment/ecohealth/guntersville.htm). The sampling is performed at three locations in the main steam of the Tennessee River channel. Baseline ecological conditions were established by studies performed from 1991 to 1994, and studies were conducted every two years thereafter to monitor changes in the quality. The most recent study performed in 2004 indicated that the reservoir rated as "good", which was the same rating that the reservoir received in 1994.

The reservoir received a "good" rating because dissolved oxygen, chlorophyll, and bottom life all rated as "good". Although chlorophyll was apparently elevated in 2002 for several sampling periods, the water quality apparently recovered according to TVA's interpretation of the data. The numeric criterion that TVA used for making the chlorophyll determination was not given. The reservoir received a "fair" rating of ecological health for sediment and fish. The low rating for sediment was reportedly due to the presence of chlordane, PCBs, and zinc. The "fair" rating for fish was based on historical low catch rates.

TVA concluded in their most recent reservoir rating that water samples have indicated unsafe conditions for swimming at four (4) study locations because of the presence of *E. coli* bacteria at Carlisle Park, Lake Guntersville State Park, Siebold Creek, and Jackson County Park.

2.6 Recreational Boating Capacity

Globally Green Consulting contacted Mr. Jerry Fouse of TVA's resource stewardship group in Knoxville, Tennessee on April 18, 2007 to determine if a recreational boating capacity study had ever been completed for Guntersville Lake or if one was planned for the near future. Mr. Fouse responded by saying that a boating capacity study has not been performed nor was one planned. His hope was that the pilot capacity study performed on Tims Ford Reservoir (a TVA managed reservoir in Tennessee) in 2002 would become a template to be performed at all TVA reservoirs; however, Tims Ford was apparently the first and last reservoir to be assessed for boating capacity in any form.

For purposes of discussion, assuming that Tims Ford and Guntersville Lake have similar boats and recreational activities, virtually all (97 percent) of the boats are motorized, 84 percent of the motors were greater than 50 horsepower (hp), and almost 20 percent had motors greater than 200 hp. The most common activity on the lake was cruising.

The Tims Ford study identified several impacts that would likely result in serious environmental impacts due to increased boat traffic. The study concluded that the following adverse conditions could result from the increased boating activity:

1. Increased shoreline erosion and decreased water clarity due to suspended sediments.
2. Discharge of petroleum products that are known or suspected of being carcinogens and have a noticeable taste and odor. Concentrations in low inflow areas may be higher than other areas. Two-cycle engines are noticeably worse in polluting.
3. Pathogens associated with septic discharges.

The boating capacity study used a 10 acres-per-boat density standard to define the "threshold beyond which a body of water is considered overcrowded". Although no boating capacity study was completed for Guntersville Lake or more particularly, for Honeycomb Creek embayment or Jagger Branch, possible density scenarios were examined as part of this Globally Green Consulting study.

Possible boating densities can be determined using the number of boat slips that currently exist and by calculating the acres of Jagger Branch embayment. A visual survey conducted by the Honeycomb Community Association in April 2007 resulted in the existence of 66 slips on the western Jagger Branch shoreline (Honeycomb Road) and 37 slips on the eastern shoreline (White Elephant Road). With the planned three (3) additional community docks for the Shady Oaks and Jagger Branch subdivisions, there will be 64 more slips on the eastern shoreline alone - a 62% increase in Jagger Branch embayment boats. When the additional 57 slips located in Snug Harbor located south of Highway 431 are considered, the total boat count (224 boats) and density scenario gets even higher – further demonstrating safety issues and the need for a more in-depth analysis.

Sediment deposition in the wetted aerial extent of the bay has also resulted in a substantial reduction in the "usable acreage" of the embayment for recreational boating purposes. The useable area is generally the area of the bay where the water depth is deep enough for safe motorized boat operation – generally at least four feet deep, accounting for seasonal depth fluctuations. Preliminary depth measurements collected from the reservoir by Globally Green Consulting on March 2, 2007 indicated that the water was less than 1.5 feet deep in the middle of the bay south of the proposed Jagger Branch subdivision and slightly over 4 feet deep in the near center portion of bay at Shady Oaks. ADEM reported that the highest water elevations for the April through October period occurred in April and therefore, the March depths should represent higher-than-normal conditions. When the March depths are plotted on the existing USGS topographic map, the approximate usable acres of Jagger Branch embayment is only 63 acres of the current wetted area 166 acres. Although this acreage was based upon limited field data, the net impact of the shallowness of the embayment is significant from a water-use standpoint and warrants collection of more detailed bathymetry data.

When one considers the 10 acres per boat general density established by TVA for safe recreational boating, the existing and proposed Jagger Branch embayment conditions both exceed the threshold, as reported in Table 7. For the threshold to be met, more than 16 boats for the entire embayment acreage or 6 boats for the usable 63 acres of water will result in overcrowding conditions according to TVA.

Table 7

Boating Capacity Evaluation

Location	No. of Slips	Jagger Branch Bay (total acres)	Jagger Branch Bay (usable acres)
Western Shore Jagger Branch	66	166 acres	63 acres
Eastern Shore Jagger Branch	37		
Snug Harbor	57		
Proposed Shady Oaks	20		
Proposed Jagger Branch	44		
Proposed total	***224***	***0.74 acres / boat density***	***0.28 acres / boat density***

Section 3

Published Resources: Boating Activity Degradation

Note: *this section contains some information that was obtained directly from published sources. The relevance of this section to the proposed developments is that the US EPA and other notable public agencies with a responsibility to protect water quality associated with marine activities, have all recognized for years the risks associated with similar land and water-based activities. The source of such information is provided at the end of each paragraph.*

3.1 Pollutants Associated with Boating Activity

Technical resources that document these adverse effects are common from the US EPA and other governmental and non-governmental organizations. The bottom line is that numerous types of pollutants associated with increased boating activity are created when people visit the lake.

Marina and boating activities are known to produce many different types of pollutants into the environment. Scientists have found these pollutants can reach harmful concentrations in the water column, in sediments on the reservoir bottom, and in tissues of organisms inhabiting the marine environment. (NOAA, Appendix C3).

Motorized watercraft can be a source of a range of water quality contamination, not only from the operation of the engine, but also from fuel spills, discharges of oil and grease, and other sources. The contamination from engines is due to the fact that outboard motors discharge their exhaust directly into the water, and inboard/stern drive motors typically discharge their exhaust below or at the water line. (LTRPA, Appendix C6).

Marine engines emit petroleum hydrocarbons and oxides of nitrogen, typically nitrogen oxide and nitrogen dioxide. Some portion of these nitrogen oxides, which are directly emitted into the lake, can potentially be converted to nitrate. The nitrogen oxides that enter the atmosphere are potentially available to be transformed into nitrate through atmospheric processes that can result in atmospheric deposition of nitrate. No marine engines (outboards or inboards, gasoline or diesel powered) have had to comply with the emissions regulations for automobiles. (LTRPA, Appendix C6).

EPA studies have indicated that carbureted two-stroke outboard engines emit unburned, one-quarter of the fuel that they consume. On a per-gallon basis, personal watercraft can emit a minimum of 23 percent more ambient hydrocarbon emissions than other two-stroke engine watercraft. (LTRPA, Appendix C6).

3.2 *Toxicity in the Water Column*

ADEM studies already indicate toxic conditions in the water column in most of 10 embayments. Further, TVA has reported the presence of a toxic metal, the presence of an organic chemical (pesticide), and the presence of *E. coli*, which is an indicator of warm-blooded fecal waste being present. Current boating and human activity around the lake already negatively affects the water quality of the reservoir.

Pollutants can result in toxicity in the water column in both lethal and sub-lethal amounts. The most common pollutants in the water column reported by the US EPA are related to decreased levels of dissolved oxygen, elevated levels of metals, and the presence of petroleum hydrocarbons. These pollutants may enter the water through discharges from boats or other sources, spills, or storm water runoff. (EPA, Appendix C1).

Low Dissolved Oxygen

The organic matter in human sewage discharged from recreational boats, septic field drains, and wastewater treatment outfalls require dissolved oxygen to decompose. Accumulation of organic material in sediment will result in a sediment oxygen demand (SOD) that can negatively impact water column dissolved oxygen. The effect of sewage on dissolved oxygen can be intensified in temperate regions, such as Tennessee. The peak boating season coincides with the highest water temperatures, the lowest solubilities of oxygen in the water, and the highest metabolism rates of aquatic organisms. (EPA, Appendix C1).

Untreated sewage discharged from recreational boats and fish wastes discarded into the water body deplete dissolved oxygen levels in the water as they decompose. Fish and other aquatic organisms need dissolved oxygen in the water to survive. Low dissolved oxygen levels have been responsible for fish kills. (NOAA, Appendix C3).

Metals

Metals such as lead, copper, arsenic, zinc, and tin and metal-containing compounds have many functions in boat operation, maintenance, and repair. Common metal containing products include: gasoline, anti-fouling paints, pesticides, and wood preservatives. Metals can enter the waterways during uncontrolled pressure washing, painting, or fueling activities. The metals then accumulate in the sediments and water column. Metals can be toxic to marine organisms resulting in death, or chronic impairments such as deformity, reduced fertility, and reduced species diversity. (NOAA, Appendix C3).

Lead is used as a fuel additive and ballast, and it may be released through incomplete fuel combustion and boat bilge discharges. Arsenic is used in paint pigments, pesticides, and wood preservatives. Zinc anodes are used to deter corrosion of metal hulls and engine parts, and copper and tin are used as biocides in anti-foulant paints. Other metals (iron, chrome, etc.) are used in the construction of marinas and boats. (EPA, Appendix C1)

Petroleum Hydrocarbons

Elevated concentrations of petroleum hydrocarbons have been detected in areas near marinas. EPA reported that refueling activities and bilge or fuel discharge from nearby boats are sources of petroleum hydrocarbons in the water. (EPA, Appendix C1).

Oils and other petroleum products can enter the aquatic environment during refueling and bilge or fuel discharge from boats. Oils are poisonous to marine organisms. Oils coat bird's feathers, preventing them from flying or staying warm. Petroleum products can also cause cancer and impair immune response in fish and other aquatic life. (NOAA, Appendix C3).

Although the toxicity of the oil and gas mixture burned by outboards appears to be low, the combustion process can potentially lead to the formation of polynuclear aromatic hydrocarbons (PAHs). PAHs can remain in the micro-layer on the surface of the water, which is a breeding ground for small organisms that form the base for aquatic food chains. They can also be found bound to the sediments at the bottom of bodies of water. (LTRPA, Appendix C6).

In 2003, the US EPA designated fifteen PAHs as being priority pollutants because of their suspected harmful health effects on humans. PAHs have been found to be toxic to aquatic organisms, even in very low concentrations. The larger molecules, with more rings, tend to be much less water-soluble, biodegradable, and volatile than those containing fewer rings. Although the greater solubility of the smaller molecules makes them more available to organisms, their low persistence reduces the time that these organisms are exposed to them. The larger molecules, on the other hand bind strongly to tissues of exposed organisms. In general, the lighter molecules are more of an acute threat while the heavier molecules are a more persistent or chronic threat. In addition, some of these PAHs are modified in the presence of sunlight causing toxic effects in the cells of exposed organisms. This is termed "phototoxicity". (LTRPA, Appendix C6).

3.3 Increased Pollutants in Aquatic Organisms

Aquatic organisms can concentrate pollutants in the water column through biological activity. Common pollutants that are known to bio-accumulate in organisms include toxic metals and PAHs associated with petroleum hydrocarbon releases. (EPA, Appendix C1).

3.4 Increased Pollutants in Sediments

Many of the contaminants found in the storm water runoff from marinas do not dissolve well in water and accumulate to higher concentrations in sediments than in the overlying water. Contaminated sediments may, in turn, act as a source from which these contaminants can be released into the overlying waters. Benthic organisms (those organisms that live on the bottom or in the sediment) are exposed to pollutants that accumulate in the sediments and may be affected by this exposure or may avoid the contaminated area. (EPA, Appendix C1).

Metals

Copper is the major contaminant of concern because most common anti-fouling paint preparations contain cuprous oxide as the active biocide component. In most cases metals have a higher affinity for sediments than for the water column and therefore tend to concentrate on the bottom. Lead is found as a trace metal in fuel and therefore, can be discharged to the water to eventually settle on the bottom or adhere to suspended sediment. Concentrations of arsenic, cadmium, chromium, copper, lead, zinc, and mercury have all been reported to be associated with marinas and large docks. Maintenance activities of boats at marinas and large docks are also associated with an increase in metal pollutant concentrations. (EPA Appendix C1).

Petroleum Hydrocarbons

Petroleum hydrocarbons, particularly PAHs, tend to adsorb to particulate matter and become incorporated into sediments. They may persist for years, resulting in exposure to benthic (bottom) organisms. Sources of petroleum hydrocarbons from marinas have been identified as the origin of sediment contamination. Bottom sediment contamination was less likely when adequate flushing occurs in and around the structure, such as marinas and large docks. (EPA, Appendix C1).

3.5 Increased Levels of Pathogens

Studies have shown that boats can be a significant source of fecal coliform bacteria in areas with high boat densities and low hydrologic flushing. Fecal coliform levels in marinas and mooring fields become elevated near boats during periods of high boat occupancy and usage. (EPA, Appendix C1).

Often underestimated or ignored by the public, the discharge of sewage and waste from boats, septic systems, and wastewater outfalls can degrade water quality, especially in marinas with high boat use. Fecal contamination from the improper disposal of human waste can make water unsightly and unsuitable for recreation, destroy fishing areas, and cause severe human health problems.

Sewage discharge stimulates algae growth, which can reduce the available oxygen needed by fish and other organisms. Although fish parts are biodegradable, when many fish are gutted and cleaned in the same area on the same day, a water quality problem can result. Like raw sewage, excess fish waste can stimulate algae growth. (EPA, Appendix C2).

3.6 Disruption of Sediment and Habitat

Boat operation and dredging can destroy habitat, re-suspend bottom sediment (resulting in the re-introduction of toxic substances into the water column), and increase turbidity, which affects the photosynthetic activity of algae and estuarine vegetation. Studies have shown that propeller-induced flows can contribute significantly to bottom scour in shallow embayments and may have adverse effects on water clarity and quality. The increase in turbidity was generally accompanied by an increase in organic carbon and phosphorus concentrations. (EPA, Appendix C1).

Inappropriate boat operation can destroy habitat, re-suspend bottom sediment, and reduce water clarity. Constructing marinas, ramps, and related facilities can physically alter or destroy wetlands, shellfish beds and other bottom communities. As agitated sediments settle, they can bury benthic organisms, suffocating them. Cloudy, or turbid water, blocks light from reaching aquatic plants, such as submerged aquatic vegetation (SAV), reducing their photosynthetic activity. SAV provides valuable habitat for many important fish and shellfish. (NOAA, Appendix C3).

Construction at marinas can lead to the physical destruction of sensitive ecosystems and bottom-dwelling aquatic communities. (EPA, Appendix C2).

3.7 Shoaling and Shoreline Erosion

Waves and currents result in the physical transport of shoreline sediment creating shoaling and shoreline erosion. These waves and currents may be natural (wind-induced, rainfall runoff, etc.) or human-induced (alterations in current regimes, boat wakes, etc.). Studies have demonstrated that waves in shallow margins of a waterway can erode the banks and the bed, tending to wash away fringing plants and their associated animal life. (EPA, Appendix C1).

The construction of boat ramps and related facilities can result in the alteration and destruction of protective shoreline vegetation and the alteration and destruction of bottom communities in the areas. (Appendix C-1)

3.8 Marina Siting to Minimize Degradation

3.8.1 Design to Maximize Flushing

Marina siting and design play important roles in determining how good water quality within a marina basin will be. Marina location affects circulation in a marina basin, and, therefore, how well it flushes. Marina design, especially the configuration of the basin and its orientation to prevailing winds, waves, and currents, affects the retention of pollutants in the marina and the movement of pollutants out of a basin. (TVA, Appendix D1).

Poorly planned marinas can disrupt natural water circulation and cause shoreline soil erosion and habitat destruction. To reduce activities that cause non-point source pollution, marinas should be located and designed so that natural flushing regularly renews marina waters. In addition, predevelopment water quality and habitat assessments should be conducted to protect ecologically valuable areas. (EPA, Appendix D2).

Water quality assessments are generally done as a part of marina development or significant expansion. The widespread use and proven effectiveness of water quality assessments in determining the suitability of a location for marina development, the best marina design for ensuring good water quality, and the causes and sources of water quality problems make this management measure broadly applicable to marina management. (TVA, Appendix D1).

Maintaining water quality within a marina basin depends primarily on flushing as determined by water circulation within the basin. If a marina is not properly flushed, pollutants will concentrate to unacceptable levels in the water and/or sediments, resulting in impacts to biological resources. (EPA, Appendix D3).

Marinas that restrict water flushing and movement can contribute to low dissolved oxygen levels and a build-up of toxic compounds. (NOAA, Appendix C3).

The degree of flushing necessary to maintain water quality in a marina should be balanced with safety, vessel protection, and sedimentation. Wave energy should be dissipated adequately to ensure that boater safety and protection of vessels are not at risk. The protected nature of marina basins can result in high sedimentation rates in waters containing high concentrations of suspended solids. (EPA, Appendix D3).

3.8.2 *Siting to Consider Bottom Depth*

Existing water depths can affect the entire marina layout and design. Therefore, if depth information is not available, bathymetric surveys should be conducted in the proposed marina basin area as well as in those areas that will be used as channels, whether existing or proposed. Flushing rates in marinas can be maximized by proper design of the entrance channel and basins. (EPA, Appendix D3).

Good flushing alone does not guarantee that a marina's deepest waters will be renewed on a regular basis. Deep areas can act as traps for fine sediment and organic detritus and exhibit low dissolved oxygen concentrations. Lower-layer stagnation can occur in holes of depths less than ten (10) feet. The low dissolved oxygen concentrations, resulting from an oxygen demand exerted by re-suspended sediments and decaying organic matter can impact aquatic life in the warmer months when the normal dissolved oxygen concentration is lower because of higher temperatures. Fine sediments trapped in deep holes may form a thin surface ooze, which gives poor internal oxygen circulation and leads to oxygen reduction both within the sediments and in the overlying water. (EPA, Appendix D3).

3.8.3 *Design to Limit Segments*

Flushing efficiency for a marina is inversely proportional to the number of segments. For example, a one-segment marina will not flush as well as a marina in open water, and a two-segment marina will not flush as well as a one-segment marina. The physical configuration of the proposed marina as determined by the orientation of the marina toward the natural water flow can have a significant effect on the flushing capacity of the waterway. As the shape of the basin becomes more elongated (i.e., more than one segment) with respect to total surface area, the dispersive mixing processes become more confined along a single flow path, and it takes longer for a water particle originating in the inner part of the basin to travel the greater distance to the boundary. (EPA, Appendix D3).

3.8.4 *Poorly Flushed Area Considerations*

In poorly flushed waterbodies, special arrangements may be necessary to ensure adequate overall flushing. Consideration of the need for efficient flushing of marina waters should be a prime factor along with safety and vessel protection. For example, sites located on open water or at the mouth of creeks and tributaries usually have higher flushing rates. These sites are generally preferable to sites located in coves or toward the heads of creeks and tributaries, locations that tend to have lower flushing rates. (EPA, Appendix D3).

3.8.5 Entrance Channel Design

Entrance channel alignment should follow the natural channel alignment as closely as possible to increase flushing. Any bends that are necessary should be gradual. Further, channel design and placement can alleviate potential water quality problems. Flushing rates can be enhanced by wind action when entrance channels are aligned parallel to the direction of prevailing winds because wind-generated currents can mix basin water and facilitate circulation between the basin and the adjacent waterway. (EPA, Appendix D3).

Shoaling may be significant in areas of significant bed load transport if the entrance channel is located perpendicular to the waterway. Increased shoaling could require extensive maintenance dredging of the channel or create a sill at the entrance to the marina basin. Shoaling at the marina entrance can lead to water quality problems by reducing flushing and water circulation within the basin. (EPA, Appendix D3).

3.9 Sediment Re-Suspension by Recreational Watercraft

Published academic studies have indicated that boating operations in shallow waters can result in the re-suspension of bottom sediments and can destroy bottom habitat. Turbulent prop wash accounts for these types of degradation. Large horsepower motors that are common today increase the amount of prop wash. The maximum degree of bottom scouring associated with prop wash occurs at relatively slow speeds – from approximately 2 to 12 miles per hour.

These studies have indicated that re-suspended sediments can lead to erosion, internal nutrient loading, elevated turbidity, re-suspension of toxic pollutants that have accumulated on the bottom, and disrupt aquatic feeding patterns. Studies have indicated that for shallow water areas only four feet deep, such as what is observed at a large portion of the Jagger Creek embayment, prop wash velocities are great enough to re-suspend bottom sediments and destroy bottom habitat. A published academic study that made this conclusion is included in Appendix E.

Section 4

Summary of Adverse Impacts

4.1 Regulations and Design Non-Conformity

The actions planned for community boathouse construction at both the Shady Oaks and Jagger Branch subdivisions clearly do not meet TVA Regulation 26a standards for vegetation management, boathouse size, boathouse location, bottom sediment removal, wetland destruction without mitigation, and carrying capacity analyses.

According to the TVA's own regulations, TVA should not permit the boathouses without first completing a carrying capacity analysis of the entire embayment area (40 CFR 1304.206). A complete analysis should include four (4) components that are typical for comprehensive evaluation: ecological carrying capacity; social carrying capacity; managerial carrying capacity; and physical / facility carrying capacity. There is no indication that the applicants, TVA, nor the USACE have completed any component of such a capacity analyses. If such an analysis had been performed, it would likely have determined that the existing and proposed boat densities do not meet TVA's own boating density standard as discussed in Section 2.6 of this report. Further, an ecological study would have determined that the embayment is susceptible to bottom and shoreline habitat destruction because of its shallow depth and narrow width. The analyses would have also determined that the boathouses are out of character with the other structures in the vicinity. Further, the boathouses will impede flow. Lastly, according to the results of the Land Management Plan and Final EIS for the entire Guntersville Lake reservoir, additional boat storage, as proposed in the new developments, is not necessary according to a survey by lake users. "Need" is a relevant factor to consider in the NEPA analysis and in the USACE's Public Interest Review process.

Given the current embayment water and wetland conditions, the boathouses and access corridor associated with the Jagger Branch subdivision will be constructed in a possible shallow wetland environment associated with the 2,000 plus feet southerly expansion of a Sensitive Resource Management zone. This amounts to both direct and indirect impacts to TVA-identified sensitive wetland resources. Although the land management plan was completed in 2001, it seems that all parties involved used maps that were based upon 1983 conditions to make land use decisions. The construction should not proceed without proper wetland mitigations approved and permitted by the USACE and special considerations accepted by TVA according to Regulation 26a.

When the proposed subdivision boathouses are compared to TVA's Regulation 26a (18 CFR Part 1304), the planned construction activities are not consistent with the regulations. Specifically, these standards seem to have not been met:

- Vegetation Management – neither subdivision applicant seems to have submitted a vegetation management plan for written approved by TVA. The only "plan" that has been submitted for either subdivision was part of the Regulation 26a application that stated that rip rap would be used for bank stabilization after riparian vegetation removal. The altered corridor leading to water facilities cannot be more than 20 feet wide and special considerations must be made for tree protection and vegetative replacement.
- Wetland Protection – wetland alterations require alternative construction and vegetation management and development of mitigations.
- Dock Size – docks cannot extend more than 150 feet from shore or be more than 1/3 the distance to the opposite shoreline, whichever is less. Also, docks and boathouses greater than 1,000 square feet are not allowed, especially when considering unique bay characteristics such as shallow depth and sensitive environments exists. The three (3) boathouses planned are far in excess of the length and square footage requirements and will impede navigation to the northern most wetted portion of the embayment.
- Community Water Use Facility Location – an area carrying capacity is recommended whenever a community boathouse is proposed.
- Channel Excavation – excavation can only be performed if there is no practical alternative and the action would not substantially impact sensitive resources. No more than 150 cubic yards can be removed for any individual boat channel. Excavation must be performed during winter drawdown.

The boathouses associated with both Shady Oaks and Jagger Branch subdivisions exceed Regulation 26a standards related to size, especially when the shallow nature of the embayment and sensitive natural resources are concerned. They exceed the 1,000 square feet standard (9,504 and 11,154 square feet for Jagger Branch and 8,775 square feet for Shady Oaks). Further, at least one Jagger Branch dock extends over 150 feet (175 feet) from the shoreline and is greater than 1/3 the width of the embayment, as required by the regulation. The approximate width of the embayment at Jagger Branch subdivision is 500 feet given the significant shoreline changes that occurred because of sediment deposition. The boathouse at Shady Oaks also exceeds the 150-foot standard from the adjacent shoreline, thus possibly impeding navigation and recreational uses of the embayment.

The revised application submitted in December 2006 for Jagger Branch estimated that 4,700 cubic yards of sediment would be removed during proposed dredging to allow for an access channel along the center of the embayment and to create unimpeded depths at the two boathouses. This amount of dredged material grossly exceeds the allowable 150 cubic yard amount. When one considers the actual shallow depths of the reservoir, it is likely that the 4,700 cubic yards grossly underestimates the volume required. The applicant estimated that the channel would need to be 900 feet long; however, preliminary measurements collected in March 2007 when the water is typically at a higher elevation, indicated that the channel would have to be at least 1,500 feet long. The channel would also have to accommodate for the low water scenario that is typical in late summer and during winter "drawdown". As a result, more material will require excavation to provide the year-round 4.5-foot channel depth proposed by the applicant. The volume of sediment requiring excavation could likely be in excess of 10,000 cubic yards. A detailed depth analysis of the embayment will be required to determine actual amounts. Because of the rate of deposition in the embayment, dredging will likely have to occur on a regular basis.

Regulation 26a requires the construction of water-based and shoreline facilities to be during the "reservoir drawdown" period. TVA officials have stated that the winter / summer pool fluctuations are only two (2) feet, thus construction during winter pool will offer little water quality benefit and in fact, threaten water quality. Given that construction will likely occur within periods of normal water elevations, special BMPs will need to be employed. Excavation during this period is likely to result in especially high sediment oxygen demand when deposited nutrients are re-introduced into the dissolved phase water column – further worsening the existing eutrophic conditions that exist in Guntersville Lake embayments. Further, the suspended sediments will reduce water clarity through increased turbidity.

In addition to the shortcomings of the boathouses relative to Regulation 26a, there is no evidence to suggest that the large boathouses meet TVA or EPA's marina siting standards. Specifically, none of the USACE's siting considerations included in the *Engineering and Design, Environmental Engineering for Small Boat Basins*, October 31, 1993 design manual were met. The manual is included in Appendix F. Those standards have been established to maximize flushing and reduce environmental impacts. Specifically, the guidance recognized that "site selection for a small boat basin is probably the single most important aspect of developing a marina in an environmentally sound manner". TVA guidance states that water quality assessments are generally done as a part of marina development or significant expansion, yet none have been performed. Specifically, TVA guidance recognizes the widespread use and proven effectiveness of water quality assessments in determining the suitability of a location for marina development and the best marina design for ensuring good water quality. Although the applicants do not formally call the boathouses a "marina", their sheer size and net effect on water quality and flushing are the same. Pre-design assessments are required to properly design and locate these large structures. If not properly designed and located, the structures will create stagnant water conditions, destroy bottom habitat, and degrade water quality.

4.2 Habitat Destruction

Joint Public Notices by TVA and USACE for both Jagger Branch and Shady Oaks developments only described the shoreline and water-based activities associated with the developments. They did not include specifics of the net cumulative impact of the near-shore and upland environments. The proposed developments have the potential to negatively impact environmental conditions for the entire area of Jagger Branch and Honeycomb Creek embayments, unless a detailed investigation of an expanded area of potential effect (APE) is considered.

The US FWS has identified 15 species that are listed as federally protected threatened or endangered species that could possibly be present in the development area. Bald eagles are common in the Jagger Branch embayment, and the Alabama Department of Conservation and Natural Resources recognizes this area as a "hot spot" for bald eagle roosting and possibly nesting. The Department also recognizes the area as known gray and Indiana bat populations. Although T&E species were not identified by the US FWS during pre-consultation for either development, this does not mean that the species are not present in the area – they just have not yet been documented.

TVA already ranks Guntersville Lake as having a low fish catch rate. The poor water quality in the embayments, as determined by ADEM monitoring, indicated that many of the bays are anoxic at shallow depths during several months of the year. Anoxic conditions cannot support bottom life or the associated fish in that portion of the water column. As a result, poor fishing conditions exist.

The planned additional boating operations in such shallow water areas will likely result in habitat destruction from turbulent prop wash. Re-suspended sediments have the potential to smother areas that might otherwise be healthy. Dissolved phase nutrients will likely increase eutrophication and reduce dissolved oxygen and water clarity. The substantial excavation of bottom sediments for the Jagger Branch access channel and boathouse construction will certainly destroy existing bottom habitat through the complete removal of that habitat. Further, construction of boathouses will eliminate sunlight to approximately 10,000 square feet for each structure, killing existing bottom habitat that depend on photosynthesis to survive.

Given the extremely shallow and narrow conditions and its popularity for recreational boating, Jagger Branch shoreline will be subjected to substantially more harm. The USACE recognized in the *Engineering and Design,* *Environmental Engineering for Small Boat Basins* that increased wave action from boats will result in more erosion of the shoreline, destruction of shoreline habitat, and reduction in the visual resource of the reservoir. The applications submitted for Regulation 26a permits indicated that no detailed vegetative management plan has been or will be submitted to TVA for written approval. The only shoreline mitigation method discussed by either applicant has been the placement of riprap along the shoreline where the native vegetation has been removed. The destruction of shoreline habitat can result in increased water temperatures, decreased fish habitat, and reduced pollutant attenuation from land-based runoff.

Given the proximity of both the Shady Oaks and Jagger Branch subdivisions to the wetland sensitive area that now extends to the area planned for construction, the additional loading of the land, shoreline, and water-based activities should be evaluated. In fact, the *Engineering and Design, Environmental Engineering for Small Boat Basins* manual developed by the USACE concluded that small boat basins "should not be located in or immediately adjacent to wetlands". The sensitive resource management zone established by TVA to protect the wetland has now increased in size approximately 43 acres and extends to the proposed development area. Therefore, impacts to the wetlands will be both direct and indirect. Had TVA used a current topographic site map or had made a current site visit to view actual conditions prior to development of the most recent land use plan, the 43 acre area would have been included in the sensitive resource zone. The extent of this zone will continue to grow with the rapid deposition of solids in the embayment.

Significant construction activities in the upland areas will result in virtual complete de-forestation of the karst plateau escarpment. That deforestation will result in the removal of wildlife habitat and will eliminate the natural buffering capacity of the soil and bedrock. Blasting will be required to construct on the bedrock escarpment. The forest canopy will be replaced with impervious rooftop, parking lot, and roadway surfaces that will result in virtually no attenuation of man-made pollutants, result in increased temperatures of stormwater runoff, and addition of herbicides, pesticides, fertilizers, and petroleum hydrocarbons into the groundwater and stormwater runoff.

The applicant for the Jagger Branch development proposes to dispose of at least 4,700 cubic yards of dredged material at a yet-to-be-determined location in the upland environment. Given the extremely karst environment of the escarpment, such placement will provide a likely re-connection back to the embayment through conduit groundwater flow in the limestone bedrock.

4.3 Wastewater Discharges

Domestic sewage production and boathouse construction are directly connected. The proposed boathouses will not be constructed if the subdivisions are not constructed. Both Shady Oaks and Jagger Branch developments will add additional nutrient loadings to the Jagger Branch embayment – an embayment that is likely already experiencing eutrophic conditions. The addition of 182 single-family homes at the Jagger Branch development will result wastewater generated for approximately 750 people (4 persons per home assumed). The Shady Oaks town home development will add wastewater flows for approximately 325 persons (3 persons per home assumed). Assuming 75 gallons of wastewater per person per day and 1,075 additional persons, this equates to wastewater discharges of 80,625 gallons per day to the environment. Further, assuming 35 milligrams per liter (mg/L) average nitrogen concentration and 10 mg/L phosphorus (source, Water and Wastewater Technology, Mark J. Hammer) in raw domestic wastewater, approximately 25 pounds per day (lb/day) of nitrogen and 7 lb/day of phosphorous will be generated.

ADEM already recognizes that nitrogen and phosphorous loadings have caused and continue to cause eutrophication of Guntersville Lake embayments. Neither phosphorous nor nitrogen can be completely removed by biological treatment or sedimentation. As a result, loads of nitrogen and phosphorous can be expected for either indirect discharge to the shallow groundwater environment through subsurface drain fields or through a direct discharge to the embayment, if the applicants applies for a National Pollutant Discharge Elimination System (NPDES) permit. According to EPA criteria, the lake embayment concentrations are already at times hypereutrophic - the most severe degree of nutrient excess. The addition of domestic sewage into the Jagger Branch and Honeycomb Creek embayments will likely make existing conditions worse.

4.4 Water Quality Degradation

There is no indication that the TVA / USACE-completed Environmental Assessment (EA) for the Shady Oaks subdivision included the carrying capacity components, as suggested by TVA Regulation 26a. The finding of no significant impact by TVA and the USACE does not conform to the results of scientific studies that indicate that development activities are likely to create environmental degradations. The FONSI seems to have been made with little scientific basis to support the claim.

The subdivisions planned for Jagger Branch embayment are apparently being planned without any ecological carrying capacity assessment being performed. If one had been performed, published information clearly suggests that additional pollutants will be added to the water column, resulting in additional nutrients, metals, petroleum hydrocarbons, and pathogen loadings. Water quality problems can made worse because of the seemingly very low flushing rate of the embayment due to the small inflow volume associated with a small watershed and the causeway constriction at the Highway 431 bridge. Sediment deposition in Jagger Branch embayment gives an indication of the stagnant, low flushing rate of the embayment.

There is ample evidence to suggest that the water quality in the Jagger Branch and Honeycomb Creek embayments should be similar to ten embayments that ADEM sampled in 2003. Jagger Branch embayment perhaps is more urbanized than most other embayments sampled, therefore making it likely that the water quality is currently at least as poor or worse as those that are already defined as eutrophic by ADEM. The monitoring data were available at the time of the EA development for Shady Oaks, however, it was apparently not considered by the USACE.

According to ADEM's Anti-Degradation Policy (Chapter 335-6-10-.04) "existing stream water uses and the level of water quality necessary to protect existing uses shall be maintained and protected". Assuming Jagger Branch embayment is similar to the impaired embayments already sampled, dissolved oxygen concentrations already do not support either the *Swimming and Other Whole Body Water Contact Sports* or the *Fish and Wildlife* use classifications. Further, chlorophyll-a concentrations likely do not meet the standard set by ADEM. As a result of these probable impairments, the embayment is a candidate for mandatory pollutant reductions through the implementation of Total Maximum Daily Load (TMDL) restrictions. Adding additional pollutant loadings, such as those proposed for the two developments, to an already impaired waterbody would be contrary to ADEM's Anti-Degradation Policy.

Increased nutrient loadings associated with sediment re-suspension (creating sediment oxygen demand), petroleum hydrocarbon emissions from boats at and below the water surface, wastewater discharges into the lake, and other man-made chemicals can be expected. Increased nutrient loadings can be expected to decrease water clarity, increase algal scum, decrease already low levels of dissolved oxygen, and extend the period of anoxic conditions to more months / days in a year.

Land-based construction will result in a higher rate of stormwater runoff without attenuation for pollutant removal. Possible pollutants can include increased petroleum hydrocarbons and sediment from impervious areas and from improperly maintained construction sites, as examples.

Water-based structures can add pollutants such as pressure treated wood contaminants, metals from boat maintenance, and spills of petroleum products. Pollutants associated with petroleum discharges include carcinogenic polynuclear aromatic hydrocarbons (PAHs) and lead. Pollutants associated with maintenance activities include lead, copper, arsenic, cadmium, chromium, mercury, and zinc. Some of those pollutants are known to be persistent in the environment by adhering to suspended particles in the water column and sediments on the bottom of the reservoir. Dredging will re-introduce those into the dissolved phase water column.

The applicants, the USACE, and TVA have the responsibility to protect the natural resources of Guntersville Lake, to evaluate the ecological carrying capacity of the lake, and then determine if the proposed developments will negatively affect the lake. There is no evidence to demonstrate that the environmental investigations completed to-date for the Shady Oaks subdivision meet the ecological or physical / facility carrying capacity requirements of Honeycomb Creek and Jagger Branch embayments.

4.5 Recreational Boating Carrying Capacity

There is no indication that TVA, the USACE, nor the applicants have completed a carrying capacity analyses to determine the effects of increased boat traffic. Had TVA or the USACE performed a boat density analysis, the results would have indicated existing overcrowded conditions and that the additional 64 boats from Jagger Branch and Shady Oaks subdivisions alone will result in a 62 percent increase of boats. The statement in the FONSI for Shady Oaks that the proposed subdivision will only account for an additional "10 to 15 percent of vessels in the area on a busy day" is not based upon fact. The additional boats associated with Shady Oaks alone results in a 20 percent increase in Jagger Branch embayment slips.

Honeycomb Creek and Jagger Branch embayments are popular by boaters because of their calm water when compared to the main Tennessee River channel. Residents and other non-residents use the embayment on a regular basis. To meet TVA's 10 acres per boat standard for over-crowding, approximately 3 percent of the boats (7 of 224) planned would exceed the threshold when the usable acreage of Jagger Branch is considered. The increased boat traffic will certainly increase the safety risks to embayment users. The calculated existing boating density of less than 0.5 acre per boat does not include boats that are non-residents that travel to reach the bays. Therefore, the actual density and increased safety risks could even be greater.

These additional boating activities have the potential to further degrade the water quality for the main pollutants that have for years continued to plague the reservoir: low dissolved oxygen, pathogens, toxic metals, chlorophyll, and man-made organic chemicals. These pollutants also compromise the designated uses of the Waterbody, according to ADEM regulations. Published information indicates the likelihood of an increase in pollutant levels in the water column, in aquatic organisms, and in sediments due to increased boat traffic.

4.6 Visual Aesthetics

The land use management plan rated the northern section the Honeycomb Creek embayment as being less aesthetically pleasing when compared to the portion to the south between Highway 431 and the main Tennessee River channel. Approval of the planned subdivisions and their associated boats, homes, roads, and parking lots will further degrade the visual aesthetics of the embayment.

Appendix A

ADEM Sampling Results

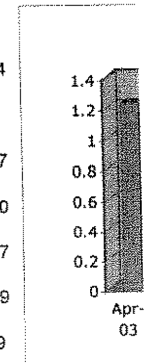
Nutrient Analyses

Appendix A
Trophic State Index and Chlorophyll-a, 10 Embayments

Reservoirs	Sta	Rep	Date MMDDYY	Time HHMMSS	Max Depth m	Secchi m	Photic-zone m	Turb NTU	TSS mg/l	Chl.a ug/l	TOC mg/l	TSI	NH3-N mg/l	NO2+ NO3 mg/l	TKN mg/l	Total P mg/l	DRP mg/l	Alk mg/l	Hard mg/l	TDS mg/l
GUNM-1	Deepest point, main creek channel, Crow Creek embayment, approximately 0.5 mile downstream of US HWY 72 bridge.				34.83665															
																	CROW			
Guntersville	1	A	4/15/03	112509	3.9	1.01	3.66	11.10	11	2.4	1.935	39	0.047	0.164	<0.15	0.054	0.011	107	103	118
Guntersville	1	A	5/20/03	1135	4.3	0.61	2.23	18.3	22	1.34	3.409	33	0.043	0.129	<0.15	0.042	0.018	125	92.6	126
Guntersville	1	A	6/17/03	1138	3	0.78	3.02	13.30	12	6.41	2.458	49	<0.015	0.136	<0.15	0.043	0.018	94	109	188
Guntersville	1	A	7/15/03	1135	3.8	1.07	3.57	9.13	13	4.54	2.679	45	<0.015	0.063	<0.15	0.086	0.003	5	99	124
Guntersville	1	A	8/19/03	1250	3.8	1.41	3.6	5.31	15	6.41	2.525	49	<0.015	0.044	0.718	0.028	<0.004	96.9	88.8	100
Guntersville	1	A	9/16/03	1340	3.7	1.16	3.3	7.24	6	9.88	3.242	53	<0.015	0.024	<0.15	0.017	0.005	101.1	97.9	136
Guntersville	1	A	10/23/03	1451	3.9	1.29	4.01+	7	9	4.81	2.646	46	<0.015	<0.003	<0.15	0.033	0.016	124	104	131
					1.3															
GUNM-2	Deepest point, main creek channel, Raccoon Creek embayment, approximately 2 miles upstream of lake				34.75049				Avg	**5.163**		**44.772**								
																	RACCOON			
Guntersville	2	A	4/15/03	121845	4.6	1.41	3.97	7.43	10	3.74	2.43	44	0.024	0.481	<0.15	0.041	0.008	46	37.8	97
Guntersville	2	A	5/20/03	1219	3.6	0.68	2	15.1	15	10.4	3.236	54	0.069	0.265	<0.15	0.052	0.016	31	37.2	88
Guntersville	2	A	6/17/03	1221	3	1.15	2.9	8.11	7	13.35	2.524	56	<0.015	0.17	0.293	0.032	0.008	19	52	105
Guntersville	2	A	7/15/03	1217	3.6	0.93	3.39	11.5	14	13.88	2.654	56	<0.015	0.094	<0.15	0.108	0.018	84	63	115
Guntersville	2	A	8/19/03	1346	4	0.83	2.45	9.18	9	21	3.022	60	<0.015	0.034	0.345	0.017	<0.004	55.1	59.9	88
Guntersville	2	A	10/23/03	1541	4.1	0.88	2.61	10.1	18	2.85	2.28	41	<0.015	0.033	<0.15	0.045	0.012		69.2	77
					1.6				Avg.	**12.47**		**54**								
GUNM-3*	Deepest point, main creek channel, Mud Creek embayment, immediately upstream of Hwy. 72 bridge at powerline				34.76665															
																	MUD			
Guntersville	3	A	4/24/03	1000	surface	N/A	1+	8.00	8	12.28	N/A	55	0.015	0.078	0.316	0.004	<0.004	100	112	143
Guntersville	3	A	5/8/03	1050	2	N/A	2+	27.1	9		N/A		0.092	0.246	0.15	0.049	0.014	55	68	107
Guntersville	3	A	6/17/03	950	surface	N/A	1+	5.00	6	<1	N/A	24	<0.015	<0.003	0.182	<0.004	<0.004	66	74	82
Guntersville	3	A	7/8/03	950	surface	N/A	2+	1.50	2	<1	N/A	24	<0.015	<0.003	0.283	<0.004	<0.004	63	66	86
Guntersville	3	A	8/19/03	1000	1	N/A	N/A	4	5	N/A	N/A	N/A	<0.015	<0.003	0.403	0.02	0.005	67	80	94
Guntersville	3	A	9/23/03	1115	1	N/A	N/A	8.9	4	9.89	N/A	53	<0.015	<0.003	0.692	0.022	0.006	76	90	109

Appendix A
Trophic State Index and Chlorophyll-a, 10 Embayments

									Avg.	A		39								
GUNM-4	Deepest point, main creek channel, Roseberry Creek embayment, approximately 0.5 mile downstream of Jackson County Park.				34.6323											ROSEBERRY				
Guntersville	4	A	4/15/03	140341	3.2	1.23	3.02	4.89	10	19.22	4.565	60	0.096	<0.003	0.332	0.061	0.013	78	81.7	124
Guntersville	4	A	5/20/03	1401	3	0.89	2.11	6.93	9	21.3	5.452	61	0.016	<0.003	<0.15	0.043	0.014	52	52.6	41
Guntersville	4	A	6/17/03	1414	2.6	0.76	2.5	8.02	10	24.21	4.12	62	<0.015	<0.003	0.683	0.059	0.008	63	74	127
Guntersville	4	A	7/15/03	1357	2.8	0.67	1.69	11.3	10	46.46	5.23	68	<0.015	0.004	<0.15	0.081	0.003	69	76	120
Guntersville	4	A	8/19/03	1640	2.7	0.56	1.92	12.4	12	58.74	4.721	71	<0.015	0.04	1.18	0.041	<0.004	64.7	56.2	107
Guntersville	4	A	9/16/03	1613	2.8	0.59	1.55	17.1	18	68.89	4.42	72	<0.015	<0.003	<0.15	0.06	0.008	69.9	63.7	119
Guntersville	4	A	10/23/03	1706	2.9	0.9	2.48	8.56	15	6.41	3.64	49	<0.015	<0.003	0.617	0.033	0.016	74	74.3	89
					0.6				Avg.	39.8		65.471								
GUNM-5	Deepest point, main creek channel, North Sauty Creek embayment, immediately upstream of AL Hwy. 79 bridge.				34.59347											NORTH SUATY				
Guntersville	5	A	4/15/03	415058	4.5	1.29	4.13	4.99	11	16.55	3.5	58	0.14	0.079	0.343	0.05	0.009	112	111	131
Guntersville	5	A	5/20/03	1445	4.7	1.06	2.94	9.8	12	10.7	3.492	54	0.111	0.1	<0.15	0.031	0.014	85	85	124
Guntersville	5	A	6/17/03	1611	3.5	1.28	3.47	6.10	9	12.82	2.85	56	<0.015	0.046	<0.15	0.033	0.006	50	74	114
Guntersville	5	A	7/15/03	1456	4.2	1.52	3.05	5.75	6	12.82	3.456	56	<0.015	<0.003	<0.15	0.043	<0.004	89	65	106
Guntersville	5	A	8/19/03	1727	4.5	1.42	3.16	5.68	11	13.08	3.605	56	<0.015	0.025	0.796	0.023	<0.004	63.4	62.1	99
Guntersville	5	A	9/16/03	1626	4.2	0.85	2.88	8.65	15	22.07	2.855	61	<0.015	<0.003	<0.15	0.029	0.012	69.8	6.5	122
Guntersville	5	A	10/23/03	1753	4.5	1.15	3.35	8.11	15	10.32	2.75	53	<0.015	0.004	<0.15	0.059	0.01	93	75.1	108
					1.2															
GUNM-6	Deepest point, main creek channel, South Sauty Creek embayment, immediately upstream of CR 67 bridge.				34.51906				Avg.	14.67		56.638			SOUTH SUATY					
Guntersville	6	A	4/15/03	153533	8.1	1.71	4.82	4.20	10	9.08	2.701	52	0.098	1.381	0.171	0.046	0.008	48	31.2	73
Guntersville	6	A	5/20/03	1522	8.9	0.85	2.31	10.4	9	44.9	4.043	68	0.029	0.945	<0.15	0.071	0.022	20	19.4	59
Guntersville	6	A	6/17/03	1523	6.5	1.02	3.48	5.53	7	26.7	3.03	63	0.038	0.261	<0.15	0.058	0.01	21	39	99
Guntersville	6	A	7/15/03	1541	6.6	1.1	3.03	5.77	10	39.16	3.678	67	<0.015	0.01	<0.15	0.08	0.007	75	46	93
Guntersville	6	A	8/19/03	1819	9.3	0.94	3.17	5.73	11	23.14	3.55	61	<0.015	0.03	0.601	0.022	<0.004	45.7	43.1	71
Guntersville	6	A	9/16/03	1743	9.2	0.78	1.75	9.09	10	39.87	3.162	67	<0.015	<0.003	<0.15	0.035	0.006	54.2	50.9	122
Guntersville	6	A	10/22/03	1552	6.8	1.11	3.41	5.33	13	21.36	2.831	61	<0.015	0.004	0.253	0.07	0.013		56.4	90
					1.6				Avg.	30.48		62.927								



Appendix A
Trophic State Index and Chlorophyll-a, 10 Embayments

GUNM-7	Deepest point, main creek channel, Town Creek embayment, approximately 0.5 miles downstream of Hwy. 227 bridge.				34.40582										TOWN					
Guntersville	7	A	4/16/03	74353	8.2	1.35	4.13	5.72	6	4.01	2.31	44	0.051	0.613	<0.15	0.061	0.008	65	61.2	105
Guntersville	7	A	5/21/03	838	9	0.99	2.53	11.4	10	12	4.99	55	<0.015	0.844	<0.15	0.094	0.053	16	23.2	66
Guntersville	7	A	6/18/03	816	7.5	0.84	2.62	15.60	9	13.88	3.354	56	<0.015	0.672	0.283	0.087	0.018	25	36	107
Guntersville	7	A	7/16/03	811	9	1.43	3.41	3.97	11	33.38	2.768	65	<0.015	0.054	<0.15	0.084	0.007	40	61	113
Guntersville	7	A	8/20/03	848	9	1.44	4.4	3.95	5	24.83	2.08	62	<0.015	0.115	0.32	0.023	<0.004	63.6	63.3	79
Guntersville	7	A	9/17/03	817	9.1	1.3	3.2	5.69	10	16.29	2.471	58	<0.015	<0.003	<0.15	0.029	<0.004	76.1	64.2	135
Guntersville	7	A	10/23/03	910	8.9	1.16	3.69	5.09	17	44.5	2.107	68	<0.015	0.073	0.335	0.037	0.016		65.7	107
					1.6				Avg.	**17.4**		**56.754**								
GUNM-8	Deepest point, main creek channel, Short Creek embayment, immediately upstream of AL Hwy. 227 bridge.				34.36859										SHORT					
Guntersville	8	A	4/16/03	82344	9.5	1.38	4.51	4.74	13	8.28	2.566	51	0.038	1.91	<0.15	0.125	0.017	51	38.4	110
Guntersville	8	A	5/21/03	811	7.8	0.94	2.82	10.2	11	6.41	3.874	49	0.063	1.132	<0.15	0.075	0.047	20	23.1	61
Guntersville	8	A	6/18/03	853	6.5	1.18	3.52	7.30	6	19.94	2.54	60	0.124	0.372	0.152	0.059	0.003	38	50	111
Guntersville	8	A	8/20/03	930	8.6	0.96	3.25	5.21	8	43.08	3.074	67	<0.015	0.032	0.302	0.069	<0.004	58.5	57.7	68
Guntersville	8	A	9/17/03	905	8.5	1.22	3.15	6.06	8	23.14	2.495	61	<0.015	0.044	<0.15	0.04	0.015	65.4	65.9	102
Guntersville	8	A	10/23/03	941	7.6	1.34	3.76	4.86	15	5.87	2.092	48	<0.015	0.186	<0.15	0.041	0.025	83.9	71.2	130
					3				Avg.	**20.17**		**58**								
GUNM-9	Deepest point, main creek channel, Big Spring Creek embayment, immediately upstream of AL Hwy. 227 bridge.				34.34552										BIG SPRING					
Guntersville	9	A	4/16/03	95204	8.4	1.79	5.98	3.24	9	14.15	2.183	57	0.065	0.478	0.162	0.139	0.002	64	57.3	112
Guntersville	9	A	5/21/03	1023	8	1.45	4.49	5.4	9	24	3.038	62	<0.015	0.259	<0.15	0.032	0.013	43	43	79
Guntersville	9	A	6/18/03	1011	8	1.11	4.35	5.50	8	25.99	2.243	63	<0.015	0.073	0.621	0.037	0.002	50	56	119
Guntersville	9	A	7/16/03	1028	8	1.15	3.92	3.98	11	30.26	3.585	64	<0.015	0.012	<0.15	0.046	0.004	91	63	129
Guntersville	9	A	8/20/03	1108	7.8	1.07	4.22	4.18	11	25.56	2.598	62	<0.015	0.073	0.293	0.024	<0.004	63.7	63.2	86
Guntersville	9	A	9/17/03	1052	7.5	1.08	2.83	6.72	14	33.11	2.615	65	<0.015	0.007	<0.15	0.035	0.008	68.2	65.7	127
Guntersville	9	A	10/23/03	1115	8	1.12	4.03	6.13	16	15.66	2.552	58	<0.015	0.046	0.431	0.059	0.021		69	100
					0.9				Avg.	**25.51**		**62**								

Appendix A
Trophic State Index and Chlorophyll-a, 10 Embayments

GUNM-10	Deepest point, main creek channel, Brown's Creek embayment, approximately 1 mile upstream of Hwy.				34.34464															
															BROWNS					
Guntersville	10	A	4/16/03	102546	7.7	1.31	4.8	3.24	9	17.62	2.797	59	0.054	0.034	<0.15	0.059	0.006	83	64.6	119
Guntersville	10	A	5/21/03	1100	8.6	1.1	3.39	6.4	8	26.4	2.769	63	0.031	0.131	<0.15	0.03	0.015	36	49.3	71
Guntersville	10	A	6/18/03	1045	7	1.11	3.96	5.60	11	26.7	2.288	63	<0.015	0.016	<0.15	0.042	0.006	40	65	128
Guntersville	10	A	7/16/03	1119	6.6	1.01	3.79	5.34	15	33.46	3.476	65	<0.015	0.005	<0.15	0.082	<0.004	89	67	170
Guntersville	10	A	8/20/03	1149	7	1.11	3.96	5.13	7	26.7	2.86	63	<0.015	0.027	0.864	0.019	<0.004	63	61.4	86
Guntersville	10	A	9/17/03	1131	7.1	0.77	2.12	8.41	9	46.99	3.114	68	<0.015	<0.003	<0.15	0.04	<0.004	68.9	67	92
Guntersville	10	A	10/23/03	1203	6.9	1.14	3.35	5.22	14	17.8	2.475	59	<0.015	<0.003	<0.15	0.03	0.016		69.4	111
					1.7				Avg.	29.65		63.388								

Appendix B

ADEM Sampling Results

Dissolved Oxygen Analyses

Appendix B

Water Quality Assessent Results - 10 Embayments

Reservoirs	Sta	Rep	Date MMDDYY	Time HHMMSS	Depth m	Temp degC	pH units	DO mg/l	SpCond mS/cm
GUNM-1	Deepest point, main creek channel, Crow Creek embayment, approximately 0.5 mile				34.8366535	-85.825		Apr - Oct	
Guntersville	1	A	4/15/03	112509	--------	--------	--------	--------	--------
					0.2	19.62	7.52	9.69	0.2302
					1	18.44	7.47	9.73	0.2305
					1.5	18.05	7.46	9.74	0.2299
					2	17.96	7.43	9.68	0.2305
					3	17.60	7.39	9.59	0.2316
					3.9	17.16	7.27	8.84	0.2334
Guntersville	1	A	5/20/03	1135	--------	--------	--------	--------	--------
					0.2	17.33	7.00	7.2	0.2001
					1	17.3	7.00	7.14	0.2005
					1.5	17.24	7.00	7.19	0.1987
					2	17.27	7.00	7.12	0.1994
					2.5	17.27	7.00	7.14	0.1994
					3	17.28	7.00	7.12	0.1994
					3.5	17.28	7.00	7.09	0.1994
					4	17.3	7.00	7.08	0.1998
					4.3	17.3	7.00	6.99	0.2
Guntersville	1	A	6/17/03	1138	--------	--------	--------	--------	--------
					0	26.4	7.49	7.88	0.1662
					0.2	26.19	7.51	7.79	0.1672
					0.5	26.1	7.5	7.76	0.1677
					1	25.94	7.47	7.7	0.1684
					1.5	25.9	7.47	7.73	0.1688
					2	25.78	7.45	7.54	0.1693
					2.5	25.77	7.45	7.49	0.1695
					3	25.78	7.44	7.44	0.1695
Guntersville	1	A	7/15/03	1135	--------	--------	--------	--------	--------
					0.2	26.41	7.58	8.41	0.2132
					1	25.65	7.51	8.31	0.216
					1.5	25.59	7.48	8.22	0.2168
					2	25.57	7.47	8.18	0.2169
					3	25.41	7.45	8.16	0.2179
					3.8	25.41	7.45	8.04	0.2179
Guntersville	1	A	8/19/03	1250	--------	--------	--------	--------	--------
					0.6	28.54	7.26	5.48	0.218
					0.2	30.17	7.6	5.93	0.215
					1	28.29	7.58	5.37	0.221
					1.5	28.17	7.57	5.29	0.221
					2	27.99	7.55	5.06	0.222
					3	27.86	7.53	4.78	0.223
					3.8	27.86	7.5	4.7	0.223
Guntersville	1	A	9/16/03	1340	--------	--------	--------	--------	--------

Appendix B

Water Quality Assessent Results - 10 Embayments

					0.2	24.75	7.24	6.14	0.226
					1	24.09	7.34	5.85	0.226
					1.5	23.84	7.39	5.74	0.226
					2	23.73	7.43	5.49	0.226
					3	23.58	7.41	4.68	0.23
					3.7	23.6	7.48	4.8	0.223
Guntersville	1	A	10/23/03	1451	--------	--------	--------	--------	--------
					0.2	18.85	7.79	10.43	0.209
					1	18.77	7.84	10.24	0.21
					1.5	18.73	7.84	10.13	0.206
					2	18.68	7.84	10.06	0.207
					3	18.3	7.79	9.32	0.213
					3.9	18	7.7	8.84	0.216
GUNM-2	Deepest point, main creek channel, Raccoon Creek embayment, approximately 2 miles				34.7504927	-85.837		Apr - Oct	
Guntersville	2	A	4/15/03	121845	--------	--------	--------	--------	--------
					0.2	19.45	7.10	9.42	0.1061
					1	16.78	6.95	9.55	0.1036
					1.5	16.36	6.82	9.37	0.1039
					2	15.85	6.76	9.11	0.1052
					3	15.18	6.65	8.73	0.1077
					4	14.56	6.56	8.26	0.1041
					4.6	14.44	6.55	7.55	0.1038
Guntersville	2	A	5/20/03	1219	--------	--------	--------	--------	--------
					0.2	20.38	6.76	8.33	0.0981
					1	20.27	6.74	8.26	0.0973
					1.5	20.24	6.74	8.27	0.097
					2	20.19	6.73	8.26	0.0969
					2.5	20.16	6.72	8.23	0.0966
					3	20.1	6.69	8.12	0.0962
					3.6	19.79	6.62	7.41	0.0953
Guntersville	2	A	6/17/03	1221	--------	--------	--------	--------	--------
					0.2	28.3	7.45	8.77	0.0908
					0.5	27.71	7.72	8.92	0.0919
					1	27.15	7.43	7.82	0.0936
					1.5	25.84	7.05	4.31	0.0984
					2	25.31	6.72	3.46	0.0899
					2.5	24.6	6.58	3.91	0.0892
					3	24.29	6.51	3.95	0.0876
Guntersville	2	A	7/15/03	1217	--------	--------	--------	--------	--------
					0.2	28.9	7.34	7.48	0.1385
					1	28.86	7.32	7.31	0.139
					1.5	27.98	7.14	6.72	0.1382
					2	27.55	6.94	5.51	0.1523
					3	26.73	6.74	2.97	0.1637
					3.6	25.38	6.59	2.4	0.1399

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Water Quality Assessent Results - 10 Embayments

Guntersville	2	A	8/19/03	1346	--------	--------	--------	--------	--------
					0.2	30.49	7.87	8.54	0.171
					1	29.87	7.74	7.45	0.17
					1.5	29.23	7.62	6.47	0.17
					2	28.95	7.41	5.4	0.172
					3	28.25	7.25	2.26	0.177
					4	27.13	7.06	0.17	0.185
Guntersville	2	A	10/23/03	1541	--------	--------	--------	--------	--------
					0.2	18.83	7.87	10.08	0.172
					1	18.82	7.9	10.09	0.171
					1.5	18.73	7.87	9.98	0.171
					2	18.63	7.86	9.96	0.173
					3	18.1	7.75	8.9	0.173
					4	17.66	7.58	8.24	0.174
					4.1	17.66	7.53	8.21	0.175
GUNM-3*	Deepest point, main creek channel, Mud Creek embayment, immediately upstream of Hwy. 72				34.76665	-85.901		Apr - Oct	
Guntersville	3	A	4/24/03	1000	--------	--------	--------	--------	--------
					surface	19.90	7.97	8.79	0.1900
Guntersville	3	A	5/8/03	1050	--------	--------	--------	--------	--------
					surface	21.5	7.53	12.24	0.157
					1	21.1	7.52	11.22	0.155
					1.5	20.8	7.48	9.97	0.148
					2	20.6	7.45	9.35	0.145
Guntersville	3	A	6/17/03	950	surface	27.9	7.67	5.74	0.147
Guntersville	3	A	7/8/03	950	surface	27.90	7.69	9.95	0.1500
Guntersville	3	A	8/19/03	1000	1	30.8	8.09	6.14	171
Guntersville	3	A	9/23/03	1115	1	24.33	7.86	8.41	187
GUNM-4	Deepest point, main creek channel, Roseberry Creek embayment, approximately 0.5 mile downstream of Jackson				34.6323045	-86.018		Apr - Oct	
Guntersville	4	A	4/15/03	140341	--------	--------	--------	--------	--------
					0.2	20.23	8.04	10.88	0.1905
					1	19.70	8.01	10.79	0.1910
					1.5	17.61	8.19	11.63	0.1919
					2	16.67	7.53	9.41	0.1961
					3	15.86	6.83	3.76	0.2005
					3.2	15.95	6.74	1.88	0.2053
Guntersville	4	A	5/20/03	1401	--------	--------	--------	--------	--------
					0.2	22.69	7.07	6.59	0.1242
					1	22.61	7.05	6.45	0.1239

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					1.5	22.57	7.05	6.46	0.1234
					2	22.33	7.02	6.43	0.1233
					2.5	22.06	6.87	4.32	0.1313
					3	21.8	6.72	2.42	0.1437
Guntersville	4	A	6/17/03	1414	--------	--------	--------	--------	--------
					0.2	29.52	8.22	8.26	0.1207
					0.5	29.33	8.29	8.57	0.1208
					1	27.99	8.11	7.97	0.1214
					1.5	27.2	7.65	6.38	0.1233
					2	26.6	7.24	4.77	0.123
					2.5	26.38	6.99	2.62	0.1263
					2.6	26.27	6.84	1.81	0.1288
Guntersville	4	A	7/15/03	1357	--------	--------	--------	--------	--------
					0.2	30.71	8.79	9.55	0.1705
					1	30.45	8.77	9.35	0.1696
					1.5	30.22	8.74	8.97	0.1687
					2	30.13	8.71	8.69	0.1679
					2.8	28.93	7.28	2.06	0.1813
Guntersville	4	A	8/19/03	1640	--------	--------	--------	--------	--------
					0.2	30.7	9.12	11.12	0.16
					1	30.47	9.08	10.5	0.16
					1.5	29.97	8.96	8.88	0.161
					2	27.96	7.68	0.4	0.175
					2.7	27.8	7.62	0.22	0.177
Guntersville	4	A	9/16/03	1613	--------	--------	--------	--------	--------
					0.1	26.33	8.18	9.33	0.169
					1	26.3	8.41	9.06	0.172
					1.5	26.24	8.42	8.8	0.169
					2	26.09	8.4	8.26	0.169
					2.8	25.6	8.25	6.69	0.173
Guntersville	4	A	10/23/03	1706	--------	--------	--------	--------	--------
					0.2	20.06	7.97	8.77	0.171
					0.5	20.04	8.04	8.75	0.171
					1	20.04	7.98	8.73	0.173
					1.5	20.06	8	8.65	0.171
					2	20.06	8	8.67	0.171
					2.5	20.02	8	8.63	0.169
					2.9	20.02	8	8.53	0.169
GUNM-5	Deepest point, main creek channel, North Sauty Creek embayment, immediately upstream				34.593467	-86.091		Apr - Oct	
Guntersville	5	A	4/15/03	415058	--------	--------	--------	--------	--------
					0.2	20.50	8.22	11.50	0.2488
					1	18.74	8.23	12.11	0.2508
					1.5	18.16	8.17	11.88	0.2498
					2	16.77	7.78	10.45	0.2567

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					3	15.67	7.36	8.74	0.2578
					4	15.21	6.94	4.44	0.2609
					4.5	15.31	6.90	2.91	0.2636
Guntersville	5	A	5/20/03	1445	--------	--------	--------	--------	--------
					0.2	21.85	7.74	8.43	0.1943
					1	21.69	7.68	8.27	0.1914
					1.5	21.64	7.63	8.08	0.1922
					2	21.63	7.61	7.91	0.1936
					2.5	21.63	7.60	7.88	0.1938
					3	21.59	7.59	7.89	0.1932
					3.5	21.51	7.59	7.86	0.1947
					4	21.51	7.59	7.8	0.1947
					4.5	21.5	7.57	7.75	0.1947
					4.7	21.49	7.27	5.76	0.201
Guntersville	5	A	6/17/03	1611	--------	--------	--------	--------	--------
					0.4	28.67	8.27	8.45	0.1237
					0.5	27.78	8.38	8.92	0.1247
					1	27.32	8.39	8.92	0.1246
					1.5	27.11	8.33	8.62	0.124
					2	26.69	8.09	7.65	0.123
					2.5	26.28	7.74	6.01	0.1244
					3	26.05	7.5	5.04	0.1249
					3.5	25.98	7.31	4.05	0.1272
Guntersville	5	A	7/15/03	1456	--------	--------	--------	--------	--------
					0.2	30.03	8.63	8.59	0.1565
					1	29.44	8.52	7.67	0.1557
					1.5	28.92	8.36	6.77	0.1543
					2	28.85	8.29	6.44	0.155
					3	28.07	7.35	1.63	0.1722
					4	27.07	6.98	0.68	0.1844
					4.2	26.97	6.88	0.43	0.1874
Guntersville	5	A	8/19/03	1727	--------	--------	--------	--------	--------
					0.2	29.93	8.59	8.1	0.159
					1	29.69	8.49	7.68	0.16
					2	28.86	8.09	4.33	0.158
					3	28.37	7.7	2.42	0.167
					4	27.88	7.5	0.48	0.176
					4.2	27.73	7.42	0.2	0.179
					1.5	29.09	7.86	5.7	0.161
Guntersville	5	A	9/16/03	1626	--------	--------	--------	--------	--------
					0.2	26.35	8.01	9.71	0.176
					1	26.24	8.17	9.48	0.176
					1.5	26	8.18	8.88	0.177
					2	25.88	8.17	8.64	0.178
					3	25.73	8.1	7.9	0.175
					4	25.58	8.03	7.29	0.175
					4.2	25.57	8.01	7.07	0.183

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Water Quality Assessent Results - 10 Embayments

Guntersville	5	A	10/23/03	1753	--------	--------	--------	--------	--------
					0.2	19.71	8.03	9.15	0.179
					1	19.68	8.04	9.11	0.18
					1.5	19.68	8.03	9.1	0.179
					2	19.64	8.04	9.08	0.18
					3	19.47	7.99	8.67	0.179
					4	19.35	7.94	8.36	0.179
					4.5	19.19	7.83	7.81	0.18
GUNM-6	Deepest point, main creek channel, South Sauty Creek embayment, immediately upstream				34.5190576	-86.104		Apr - Oct	
Guntersville	6	A	4/15/03	153533	--------	--------	--------	--------	--------
					0.2	19.23	7.78	10.47	0.0964
					1	18.82	7.72	10.56	0.0950
					1.5	18.36	7.69	10.68	0.0952
					2	17.69	7.74	10.84	0.0952
					3	16.57	7.57	10.72	0.0936
					4	16.25	7.15	9.89	0.0937
					5	15.24	6.88	9.05	0.0949
					6	15.06	6.70	7.99	0.0980
					7	14.88	6.67	8.52	0.1055
					8	14.83	6.59	7.18	0.1079
					8.1	14.79	6.57	5.58	0.1085
Guntersville	6	A	5/20/03	1522	--------	--------	--------	--------	--------
					0.2	20.47	6.93	9.44	0.062
					0.5	20.47	6.98	9.5	0.062
					1	20.47	6.99	9.46	0.062
					1.5	20.46	6.84	9.2	0.0623
					2	20.46	6.88	9.1	0.0625
					2.5	20.44	6.84	8.94	0.0625
					3	20.43	6.80	8.75	0.0626
					3.5	20.42	6.77	8.94	0.0624
					4	20.39	6.70	8.52	0.0629
					4.5	20.35	6.64	8.3	0.0629
					5	20.32	6.60	8.13	0.0631
					5.5	20.26	6.58	8.17	0.0631
					6	20.23	6.59	8.28	0.0628
					6.5	20.21	6.60	8.38	0.0625
					7	20.2	6.59	8.18	0.0627
					7.5	20.16	6.60	8.29	0.0625
					8	20.15	6.60	8.32	0.0627
					8.5	20.11	6.56	7.83	0.0627
					8.9	20.07	6.53	7.62	0.0632
Guntersville	6	A	6/17/03	1523	--------	--------	--------	--------	--------
					0.2	27.89	8.53	9.73	0.0716
					0.5	28.01	8.66	9.84	0.0725
					1	27.49	8.73	10.26	0.0683
					1.5	27.04	8.79	10.52	0.0657
					2	26.45	8.54	9.68	0.0637

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					2.5	26.26	8.46	9.73	0.0632
					3	26.17	8.08	8.72	0.0639
					3.5	25.31	7.44	6.26	0.0669
					4	23.78	6.9	3.08	0.0748
					4.5	23.71	6.71	2.77	0.0749
					5	23.21	6.53	2.03	0.0767
					5.5	22.77	6.45	1.71	0.0763
					6	22.68	6.41	1.51	0.0762
					6.5	22.62	6.38	1.42	0.076
Guntersville	6	A	7/15/03	1541	--------	--------	--------	--------	--------
					0.2	29.98	8.84	10.03	0.1293
					1	28.85	8.98	10.1	0.1099
					1.5	28.37	8.68	8.32	0.1089
					2	28.32	8.61	8.11	0.1092
					3	28.07	8.14	6.95	0.1123
					4	26.97	7.16	2.67	0.1228
					5	25.34	6.76	0.34	0.1325
					6	24.84	6.65	0.26	0.1329
					6.6	24.34	6.6	0.22	0.1348
Guntersville	6	A	8/19/03	1819	--------	--------	--------	--------	--------
					0.2	30.61	8.83	9.71	0.133
					1	30.53	8.84	9.6	0.133
					1.5	30.53	8.83	9.5	0.1329
					2	30.33	8.76	8.89	0.133
					3	29.83	8.41	7.52	0.1325
					4	27.59	7.46	0.43	0.158
					5	26.47	7.3	0.18	0.1409
					6	25.83	7.24	0.16	0.132
					7	25.47	7.16	0.15	0.1312
					8	25.36	7.09	0.13	0.1297
					9	25.27	7.04	0.13	0.1283
					9.3	25.27	7.03	0.12	0.13
Guntersville	6	A	9/16/03	1743	--------	--------	--------	--------	--------
					0.2	26.32	7.3	8.88	0.1466
					1	26.32	7.47	8.82	0.1468
					1.5	26.33	7.54	8.64	0.1464
					2	26.32	7.61	8.31	0.1468
					3	26.18	7.6	7.8	0.1466
					4	26.15	7.58	7.6	0.1467
					5	26.03	7.53	6.96	0.1481
					6	25.77	7.42	5.85	0.1489
					7	25.73	7.37	5.77	0.1482
					8	25.62	7.33	5.37	0.157
					9	25.58	7.3	5.15	0.155
					9.2	25.58	7.28	5.12	0.141
Guntersville	6	A	10/22/03	1552	--------	--------	--------	--------	--------
					0.2	19.87	8.03	9.55	0.153
					1	19.64	8.02	9.43	0.15
					1.5	19.47	7.97	9.27	0.147

Appendix B

Water Quality Assessent Results - 10 Embayments

					2	19.14	7.91	8.99	0.1441
					3	19.04	7.87	8.97	0.1451
					4	19.02	7.82	8.81	0.145
					5	19.01	7.78	8.47	0.1454
					6	18.99	7.7	8.34	0.1456
					6.8	19.01	7.65	8.24	0.146
GUNM-7	Deepest point, main creek channel, Town Creek embayment, approximately 0.5 miles				34.4058167	-86.183		Apr - Oct	
Guntersville	7	A	4/16/03	74353	--------	--------	--------	--------	--------
					0.2	16.07	6.95	8.60	0.1845
					1	16.04	6.94	8.55	0.1854
					1.5	15.99	6.94	8.71	0.1848
					2	15.96	6.94	8.71	0.1828
					3	15.82	6.90	8.21	0.1831
					4	15.55	6.85	7.87	0.1756
					5	14.35	6.42	8.00	0.0828
					6	14.03	6.14	7.74	0.0807
					7	13.52	6.10	7.84	0.0796
					8	13.40	6.04	7.43	0.0810
					8.2	13.25	6.20	5.43	0.0860
Guntersville	7	A	5/21/03	838	--------	--------	--------	--------	--------
					0.2	19.95	6.58	8.14	0.07
					1	19.88	6.55	7.99	0.0667
					1.5	19.71	6.51	7.86	0.0643
					2	19.52	6.45	7.8	0.0615
					2.5	19.44	6.42	7.82	0.0607
					3	19.1	6.39	7.97	0.0573
					3.5	18.64	6.35	8.19	0.0546
					4	18.05	6.29	8.48	0.0519
					4.5	17.87	6.26	8.58	0.0515
					5	17.83	6.23	8.62	0.0516
					5.5	17.8	6.22	8.63	0.0514
					6	17.76	6.22	8.59	0.0516
					6.5	17.73	6.21	8.58	0.0516
					7	17.72	6.21	8.57	0.0516
					7.5	17.72	6.20	8.59	0.0516
					8	17.72	6.19	8.56	0.0516
					8.5	17.72	6.19	8.52	0.0518
					9	17.72	6.11	7.83	0.0549
Guntersville	7	A	6/18/03	816	--------	--------	--------	--------	--------
					0.2	25.78	6.92	7.07	0.1105
					0.5	25.68	6.9	7.03	0.109
					1	25.13	6.84	6.7	0.0983
					1.5	24.64	6.71	6.52	0.0947
					2	24.36	6.65	6.73	0.092
					2.5	23.69	6.6	6.81	0.0864
					3	23.07	6.54	6.87	0.0791
					3.4	22.28	6.44	7.08	0.0723
					4	22.12	6.36	7.14	0.0708

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					4.5	22.06	6.32	7.13	0.0699
					5	22.01	6.28	7.16	0.0697
					5.5	22	6.27	7.12	0.0697
					6	21.97	6.25	7.06	0.0696
					6.5	21.95	6.24	7.05	0.0694
					7	21.94	6.22	6.97	0.0694
					7.5	21.93	6.04	5.71	0.0699
Guntersville	7	A	7/16/03	811	--------	--------	--------	--------	--------
					0.2	29.63	8.66	9.79	0.1067
					1	29.64	8.66	10.03	0.1066
					1.5	29.59	8.63	9.72	0.1067
					2	28.9	7.88	7.13	0.1042
					3	27.67	7.08	4.75	0.1068
					4	27.11	6.72	3.01	0.099
					5	26.48	6.49	1.15	0.0865
					6	25.64	6.3	3.06	0.0643
					7	24.79	6.11	2.34	0.0631
					8	24.45	6.04	1.69	0.0639
					9	23.53	6.07	0.28	0.0744
Guntersville	7	A	8/20/03	848	--------	--------	--------	--------	--------
					0.2	28.68	7.58	7.94	0.182
					1	28.68	7.57	7.83	0.182
					1.5	28.68	7.57	7.77	0.18
					2	28.64	7.53	7.12	0.183
					3	28.44	7.25	3.97	0.186
					4	28.23	7.12	2.73	0.182
					5	27.76	6.98	1.24	0.161
					6	26.69	6.84	2.14	0.1178
					7	25.77	6.73	1.7	0.1087
					8	25.29	6.62	0.75	0.1062
					9	25.01	6.53	0.29	0.1082
Guntersville	7	A	9/17/03	817	--------	--------	--------	--------	--------
					0.2	25.86	6.81	7.13	0.177
					1	25.94	6.91	7.06	0.177
					1.5	25.95	6.96	6.99	0.177
					2	25.94	6.99	6.96	0.177
					3	25.92	7.04	6.88	0.177
					4	25.96	7.05	6.82	0.177
					5	25.96	7.08	6.74	0.178
					6	25.94	7.1	6.62	0.177
					7	25.79	7.04	4.35	0.168
					8	25.42	6.9	1.49	0.153
					9	25.08	6.71	0.66	0.152
					9.1	25.08	6.68	0.64	0.152
Guntersville	7	A	10/23/03	910	--------	--------	--------	--------	--------
					0.2	20.16	7.76	9.93	0.171
					1	20.16	7.79	9.88	0.17
					1.5	20.16	7.78	9.75	0.171
					2	20.15	7.78	9.68	0.17

					3	20.11	7.77	9.58	0.171
					4	20.02	7.69	9	0.168
					5	19.82	7.49	7.79	0.163
					6	19.31	7.3	5.6	0.153
					7	19.13	7.14	4.44	0.149
					8	19.02	6.93	3.21	0.146
					8.9	18.94	6.8	1.77	0.1456
GUNM-8	Deepest point, main creek channel, Short Creek embayment, immediately upstream of AL Hwy.				34.3685908	-86.22		Apr - Oct	
Guntersville	8	A	4/16/03	82344	--------	--------	--------	--------	--------
					0.2	17.28	7.10	9.80	0.1057
					1	17.15	7.07	9.77	0.1056
					1.5	17.16	7.05	9.75	0.1056
					2	17.13	7.02	9.61	0.1058
					3	16.38	6.94	8.79	0.1554
					4	16.05	6.93	8.39	0.1772
					5	15.63	6.81	8.14	0.1483
					6	15.29	6.72	7.83	0.1399
					7	15.05	6.47	6.18	0.1308
					8	14.56	6.40	6.42	0.1114
					9	14.42	6.32	6.41	0.1082
					9.5	14.38	6.29	6.17	0.1088
Guntersville	8	A	5/21/03	811	--------	--------	--------	--------	--------
					0.2	19.89	6.65	8.29	0.0854
					1	18.75	6.62	8.64	0.0686
					1.5	18.22	6.53	8.91	0.0617
					2	18.19	6.47	8.89	0.0617
					2.5	17.97	6.44	8.98	0.0612
					3	17.96	6.43	9.01	0.0614
					3.5	17.91	6.42	9.04	0.0614
					4	17.88	6.42	8.97	0.0621
					4.5	17.89	6.43	8.97	0.0626
					5	17.82	6.43	8.98	0.0632
					5.5	17.67	6.39	8.94	0.063
					6	17.48	6.36	8.95	0.0638
					6.5	17.43	6.34	9.01	0.0635
					7	17.43	6.32	8.93	0.0636
					7.5	17.44	6.31	8.86	0.0635
					7.8	17.46	6.28	8.55	0.0648
Guntersville	8	A	6/18/03	853	--------	--------	--------	--------	--------
					0.2	26.44	8.11	9.17	0.1241
					0.5	26.46	8.17	9.2	0.1238
					1	26.07	7.72	7.87	0.1423
					1.5	25.82	7.36	7.41	0.144
					2	25.75	7.29	7.61	0.1334
					2.5	25.65	7.18	7.88	0.1207
					3	25.51	7.05	7.57	0.1275
					3.5	25.26	7.03	7.69	0.1105

					4	25.12	6.92	7.41	0.1177
					4.5	24.7	6.82	7.2	0.1129
					5	24.5	6.77	7.12	0.1106
					5.5	23.54	6.71	7.23	0.1003
					6	22.72	6.61	7.11	0.0934
					6.5	22.71	6.53	7.08	0.0934
Guntersville	8	A	8/20/03	930	--------	--------	--------	--------	--------
					0.2	29.19	7.88	9.08	0.178
					1	29.17	7.89	8.85	0.179
					1.5	29.13	7.85	8.61	0.179
					2	29.11	7.85	8.53	0.182
					3	29.03	7.8	8.01	0.176
					4	28.46	7.44	4.41	0.185
					5	28.17	7.14	2.45	0.167
					6	27.97	6.92	1.95	0.166
					7	27.59	6.79	0.74	0.164
					8	27.48	6.71	0.23	0.17
					8.6	27.46	6.67	0.17	0.181
Guntersville	8	A	9/17/03	905	--------	--------	--------	--------	--------
					0.3	25.88	6.94	7.28	0.185
					1	25.88	7.03	7.34	0.186
					1.5	25.86	7.16	7.49	0.186
					2	25.86	7.2	7.51	0.186
					3	25.85	7.23	7.54	0.185
					4	25.85	7.25	7.55	0.188
					4	25.85	7.26	7.55	0.188
					5	25.85	7.28	7.51	0.189
					6	25.83	7.28	7.37	0.189
					7	25.83	7.27	7.21	0.189
					8	25.85	7.25	6.91	0.19
					8.5	25.83	7.21	6.41	0.183
Guntersville	8	A	10/23/03	941	--------	--------	--------	--------	--------
					0.2	20.25	7.32	8.43	0.179
					1	20.15	7.37	8.57	0.182
					1.5	20.09	7.4	8.67	0.18
					2	20.02	7.41	8.74	0.18
					3	19.94	7.42	8.78	0.181
					4	19.87	7.43	8.84	0.181
					5	19.82	7.44	8.84	0.182
					6	19.82	7.43	8.68	0.18
					7	19.76	7.34	8.19	0.189
					7.6	19.76	7.28	8.1	0.189
GUNM-9	Deepest point, main creek channel, Big Spring Creek embayment, immediately upstream				34.3455162	-86.292		Apr - Oct	
Guntersville	9	A	4/16/03	95204	--------	--------	--------	--------	--------
					0.2	19.74	8.34	10.60	0.1590
					1	19.40	8.39	10.83	0.1570
					1.5	19.29	8.38	10.90	0.1566

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					2	19.24	8.38	10.87	0.1569
					3	18.85	8.26	10.48	0.1605
					4	15.89	7.12	8.04	0.1817
					5	15.15	7.02	7.51	0.1623
					6	14.63	6.74	5.39	0.1509
					7	14.21	6.55	3.37	0.1415
					8	14.06	6.46	2.36	0.1392
					8.4	14.10	6.44	2.15	0.1397
Guntersville	9	A	5/21/03	1023	--------	--------	--------	--------	--------
					0.2	21.62	7.46	8.51	0.1028
					1	21.61	7.42	8.45	0.1031
					1.5	21.49	7.14	7.35	0.1041
					2	21.27	6.99	7.09	0.1042
					2.5	21.26	6.95	7.11	0.1038
					3	21.28	6.93	7.06	0.1038
					3.5	21.14	7.04	7.94	0.1032
					4	21.07	7.00	7.54	0.1031
					4.5	20.93	6.80	6.46	0.1036
					5	20.86	6.72	6.13	0.1034
					5.5	20.68	6.61	4.72	0.1046
					6	20.55	6.53	4	0.1075
					6.5	20.48	6.48	2.71	0.1081
					7	20.31	6.43	1.82	0.1112
					7.5	20.2	6.42	1.41	0.1121
					8	20.14	6.40	1.13	0.1133
Guntersville	9	A	6/18/03	1011	--------	--------	--------	--------	--------
					0.2	27.46	8.43	8.89	0.136
					0.5	27.49	8.52	9	0.1368
					1	27.32	8.47	9.01	0.1381
					1.5	27.08	8.44	9.06	0.1387
					2	26.52	8.22	8.3	0.1407
					2.5	26.02	7.81	7.4	0.1457
					3	25.8	7.55	6.92	0.1455
					3.5	25.35	7.29	5.66	0.1462
					4	24.95	6.98	4.45	0.1451
					4.5	24.87	6.78	3.73	0.1441
					5	24.55	6.69	2.9	0.1441
					5.5	24.26	6.59	1.67	0.144
					6	24.11	6.52	1.27	0.145
					6.5	23.84	6.45	0.39	0.1459
					7	23.62	6.43	0.28	0.1472
					7.5	23.32	6.44	0.26	0.1515
					8	23.06	6.46	0.25	0.1595
Guntersville	9	A	7/16/03	1028	--------	--------	--------	--------	--------
					0.2	29.46	8.58	10.14	0.1059
					1	29.34	8.59	9.97	0.1061
					1.5	29.12	8.56	10.01	0.1063
					2	29.04	8.53	9.8	0.1066
					3	28.64	8.37	8.96	0.1077
					4	27.71	7.39	6.68	0.1133

					5	27.28	6.97	5.19	0.1145
					6	26.72	6.61	1.13	0.1114
					7	26.21	6.52	0.28	0.1131
					8	25.34	6.47	0.25	0.1256
Guntersville	9	A	8/20/03	1108	--------	--------	--------	--------	--------
					0.2	30.44	8.71	10.67	0.168
					1	30.15	8.72	10.39	0.169
					1.5	29.95	8.72	10.12	0.169
					2	29.76	8.67	9.68	0.17
					3	28.8	7.91	5.46	0.187
					4	28.54	7.57	2.88	0.183
					5	28.23	7.37	1.11	0.18
					6	28.09	7.25	0.46	0.18
					7	27.78	7.15	0.4	0.183
					7.8	27.34	7.06	0.35	0.195
Guntersville	9	A	9/17/03	1052	--------	--------	--------	--------	--------
					0.2	25.9	7.31	7.75	0.178
					1	25.95	7.47	7.64	0.178
					1.5	25.95	7.52	7.59	0.177
					2	25.92	7.55	7.41	0.175
					3	25.92	7.58	7.2	0.182
					4	25.91	7.58	7.01	0.176
					5	25.86	7.56	6.73	0.173
					6	25.85	7.53	6.46	0.175
					7	25.79	7.48	6.02	0.176
					7.5	25.79	7.46	5.95	0.174
Guntersville	9	A	10/23/03	1115	--------	--------	--------	--------	--------
					0.2	20.13	7.43	8.41	0.173
					1	20.18	7.49	8.43	0.172
					1.5	20.15	7.52	8.43	0.172
					2	20.13	7.53	8.35	0.173
					3	20.04	7.5	7.99	0.175
					4	20.04	7.5	8.05	0.172
					5	19.99	7.52	8.02	0.174
					6	19.95	7.55	8.2	0.169
					7	19.94	7.57	8.17	0.176
					8	19.9	7.56	7.99	0.177
GUNM-10	Deepest point, main creek channel, Brown's Creek embayment, approximately 1 mile				34.3446389	-86.331		Apr - Oct	
Guntersville	10	A	4/16/03	102546	--------	--------	--------	--------	--------
					0.2	19.97	8.50	11.44	0.1880
					1	19.70	8.52	11.67	0.1874
					1.5	19.21	8.56	11.72	0.1862
					2	19.12	8.54	11.73	0.1858
					3	18.25	8.54	11.89	0.1849
					4	16.70	8.21	10.43	0.1880
					5	15.36	7.30	7.79	0.1935
					6	15.04	7.10	6.85	0.1879

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					7	14.68	6.74	3.85	0.1865
					7.7	14.73	6.64	2.58	0.1909
Guntersville	10	A	5/21/03	1100	--------	--------	--------	--------	--------
					0.2	21.14	7.24	8.37	0.1209
					1	21.13	7.32	8.49	0.1205
					1.5	21.12	7.31	8.41	0.1203
					2	21.11	7.30	8.38	0.1202
					2.5	21.15	7.30	8.33	0.121
					3	21.16	7.34	8.41	0.1209
					3.5	21.14	7.33	8.29	0.1209
					4	21.12	7.30	8.33	0.1203
					4.5	21.05	7.29	8.26	0.1199
					5	20.94	7.25	8.24	0.1172
					5.5	20.96	7.23	8.19	0.1176
					6	21	7.25	8.14	0.1184
					6.5	20.96	7.24	8.22	0.1176
					7	20.91	7.22	8.21	0.1164
					7.5	20.92	7.22	8.24	0.1168
					8	20.93	7.22	8.18	0.1171
					8.5	20.94	7.23	8.15	0.1172
					8.6	20.94	7.22	8.11	0.1172
Guntersville	10	A	6/18/03	1045	--------	--------	--------	--------	--------
					0.2	27.77	8.42	9.03	0.1621
					0.5	27.79	8.56	9.33	0.163
					1	27.79	8.57	9.52	0.1632
					1.5	27.72	8.57	9.56	0.1631
					2	27.08	8.24	8.2	0.1612
					2.5	26.45	7.79	6.34	0.1663
					3	25.9	7.36	4.53	0.1675
					3.5	25.58	7.08	3.45	0.1678
					4	25.28	6.87	2.54	0.1672
					4.5	25.11	6.82	3.02	0.1622
					5	24.99	6.78	3.24	0.1598
					5.5	24.82	6.73	2.9	0.1591
					6	24.76	6.66	1.81	0.1632
					6.5	24.24	6.53	0.9	0.1633
					7	23.82	6.52	0.22	0.1697
Guntersville	10	A	7/16/03	1119	--------	--------	--------	--------	--------
					0.3	29.51	8.58	9.44	0.111
					1	29.5	8.6	9.43	0.1111
					1.5	29.51	8.61	9.43	0.111
					2	29.48	8.61	9.35	0.1109
					3	29.36	8.56	8.97	0.1105
					4	29.37	8.55	8.93	0.1104
					5	27.15	7.09	3.69	0.117
					6	26.53	6.75	1.53	0.1177
					6.6	26.45	6.64	1.07	0.12
Guntersville	10	A	8/20/03	1149	--------	--------	--------	--------	--------
					0.2	30.98	8.71	10.63	0.166
					1	30.53	8.82	11.03	0.166

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					1.5	30.31	8.85	11.1	0.166
					2	30.17	8.85	10.77	0.167
					3	28.88	8.19	3.81	0.182
					4	28.46	7.77	0.95	0.181
					5	28.06	7.59	0.24	0.186
					6	27.75	7.43	0.19	0.182
					7	27.27	7.29	0.17	0.2
Guntersville	10	A	9/17/03	1131	--------	--------	--------	--------	--------
					0.2	26.01	7.69	8.14	0.177
					1	26.01	7.96	7.81	0.179
					1.5	25.94	7.97	7.7	0.179
					2	25.9	7.97	7.49	0.177
					3	25.9	7.96	7.44	0.174
					4	25.88	7.95	7.32	0.177
					5	25.88	7.94	7.26	0.176
					6	25.86	7.93	7.16	0.175
					7	25.86	7.91	6.99	0.173
					7.1	25.86	7.88	6.86	0.183
Guntersville	10	A	10/23/03	1203	--------	--------	--------	--------	--------
					0.2	20.15	8.17	9.68	0.172
					1	20.11	8.18	9.61	0.171
					1.5	20.01	8.14	9.43	0.169
					2	19.95	8.1	9.24	0.176
					3	19.94	8.1	9.22	0.175
					4	19.83	7.99	8.73	0.169
					5	19.71	7.91	8.33	0.172
					6	19.69	7.84	8.2	0.174
					6.9	19.69	7.79	8.06	0.169

Appendix C

Water Quality Degradation References and Supporting Information

Section C1: Guidance Specifying Management Measures for Sources of Non-point Pollution in Coastal Waters, Chapter 5 - Management Measures for Marinas and Recreational Boating

Information obtained directly from
http://www.epa.gov/owow/nps/MMGI/Chapter5/ch5-1.html#Pollutant

Because marinas are located right at the water's edge, there is often no buffering of the release of pollutants to waterways. Adverse environmental impacts may result from the following sources of pollution associated with marinas and recreational boating:

- Poorly flushed waterways where dissolved oxygen deficiencies exist;
- Pollutants discharged from boats;
- Pollutants transported in storm water runoff from parking lots, roofs, and other impervious surfaces;
- The physical alteration or destruction of wetlands and of shellfish and other bottom communities during the construction of marinas, ramps, and related facilities; and
- Pollutants generated from boat maintenance activities on land and in the water.

The management measures described in this chapter are designed to reduce NPS pollution from marinas and recreational boating. Effective implementation will avoid impacts associated with marina siting, prevent the introduction of nonpoint source pollutants, and/or reduce the delivery of pollutants to water resources.

Pollution prevention should be at the fore of any NPS management strategy. It is expected that each coastal State's decision on implementation of these management measures will be based on a management strategy that balances the need for protecting the coastal environment and the need to provide adequate public access to coastal waters.

Pollutant Types and Impacts

A marina can have significant impacts on the concentrations of pollutants in the water, sediment, and tissue of organisms within the marina itself. Although sources of pollutants outside the marina are part of the problem, marina design, operation, and location appear to play crucial roles in determining whether local water quality is impacted (NCDEM, 1991).

Marina construction may alter the type of habitat found at the site. Alterations can have both negative and positive effects. For example, a soft-bottom habitat (i.e., habitat characterized by burrowing organisms and deposit feeders) could be replaced with a habitat characterized by fouling organisms attached to the marina pilings and bulkhead. These fouling organisms, however, may attract other organisms, including invertebrates and juvenile fish.

The presence of a marina is not necessarily an indicator of poor water quality. In fact, many marinas have good water quality. Despite this, they may still have degraded biological resources and contaminated sediments resulting from bioaccumulation in organisms and adhesion of pollutants to sediments. A brief summary of some of the impacts that can be associated with marina and boating activities is presented below.

Toxicity in the Water Column

Pollutants from marinas can result in toxicity in the water column, lethal and sub-lethal, related to decreased levels of dissolved oxygen and elevated levels of metals and petroleum hydrocarbons. These pollutants may enter the water through discharges from boats or other sources, spills, or storm water runoff.

Low Dissolved Oxygen

The organics in sewage discharged from recreational boats require dissolved oxygen (DO) to decompose. The biological oxygen demand (BOD) of a waterbody is a measure of the DO required to decompose sewage and other organic matter (Milliken and Lee, 1990). Accumulation of organic material in sediment will result in a sediment oxygen demand (SOD) that can negatively impact water column DO. The effect of boat sewage on DO can be intensified in temperate regions because the peak boating season coincides with the highest water temperatures and thus the lowest solubilities of oxygen in the water and the highest metabolism rates of aquatic organisms. (As temperature increases, dissolved oxygen levels decrease.) Cardwell and Koons (1981) recorded significant decreases in DO in several northwestern marinas in the late summer and early fall, which are the peak times of marina use. Nixon et al. (1973) measured lower DO levels in an area of marina development than in an adjacent undeveloped bay of similar size. An intensive study in several North Carolina marinas showed significant decreases in DO concentration compared to ambient concentrations in the receiving waterbody. These decreases in DO were thought to result from high SOD within the marinas and poor flushing resulting from improper marina design (NCDEM, 1990).

Metals

Metals and metal-containing compounds have many functions in boat operation, maintenance, and repair. Lead is used as a fuel additive and ballast and may be released through incomplete fuel combustion and boat bilge discharges

(NCDEM, 1991). Arsenic is used in paint pigments, pesticides, and wood preservatives. Zinc anodes are used to deter corrosion of metal hulls and engine parts. Copper and tin are used as biocides in antifoulant paints. Other metals (iron, chrome, etc.) are used in the construction of marinas and boats.

Many of these metals/compounds are found in marina waters at levels that are toxic to aquatic organisms. Copper is the most common metal found at toxic concentrations in marina waters (NCDEM, 1990, 1991). Dissolved copper was detected at toxic concentrations at several marinas within the Chesapeake Bay (Hall et al., 1987). The input of copper via bottom paints and scrapings has been shown to be quite significant (Young et al., 1974). Tin in the form of butyltin, an extremely potent biocide, has been detected at toxic levels within marina waters nationwide (Stephenson et al., 1986; Maguire, 1986; Grovhoug et al., 1986; Stallard et al., 1987). The use of butyltins in bottom paint is now regulated, and butyltins cannot be used on nonaluminum recreational boats under 25 meters in length. High levels of zinc, chromium, and lead were also detected in waters within North Carolina marinas (NCDEM, 1990).

Petroleum Hydrocarbons
McMahon (1989) found elevated concentrations of hydrocarbons in marina waters and attributed them to refueling activities and bilge or fuel discharge from nearby boats.

Increased Pollutant Levels in Aquatic Organisms

Aquatic organisms can concentrate pollutants in the water column through biological activity. Copper and zinc concentrations in oysters were significantly higher in oysters in South Carolina and North Carolina marinas than at reference sites (NCDEM, 1991; SCDHEC, 1987). Increased levels of copper, cadmium, chromium, lead, tin, zinc, and PCBs were found in mussels from southern California marina waters (CARWQCB, 1989; Young et al., 1979). Three months after planting, concentrations of lead, zinc, and copper in oysters transplanted to several Australian marinas were two to three times higher than those of control sites (McMahon, 1989). Concentrations of copper in a green algae and the fouling community were significantly higher in a Rhode Island marina area than in adjacent control areas (Nixon et al., 1973). Several polynuclear aromatic hydrocarbons were detected in oyster tissue at marinas in South Carolina (Marcus and Stokes, 1985; Wendt et al., 1990).

Increased Pollutant Levels in Sediments

Many of the contaminants found in the storm water runoff of marinas do not dissolve well in water and accumulate to higher concentrations in sediments than in the overlying water. Contaminated sediments may, in turn, act as a source from which these contaminants can be released into the overlying waters. Benthic organisms those organisms that live on the bottom or in the sediment are exposed to pollutants that accumulate in the sediments and may be affected by this exposure or may avoid the contaminated area.

Metals

Copper is the major contaminant of concern because most common antifouling paint preparations contain cuprous oxide as the active biocide component (METRO, 1992a). In most cases metals have a higher affinity for sediments than for the water column and therefore tend to concentrate there. A recent Puget Sound area study of wastewater from boat hull pressure washing found that suspended solids accounted for 96 percent of the copper, 94 percent of the lead, and 83 percent of the zinc in the wastewater. Most of the metal concentrations were associated with particles less than 60 microns in size, resulting in their settling out of solution slowly (METRO, 1992a). Stallard et al. (1987) noted that the sediments of nearly every California marina tested had high concentration of butyltins. Marina sites in North Carolina had significantly higher levels of arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc than did reference sites (NCDEM, 1991). McMahon (1989) found significantly higher concentrations of copper, lead, zinc, and mercury in the sediments at a marina site than in the parent waterbody. Within the marina, higher levels of copper and lead were found near a maintenance area drain and fuel dock, suggesting the drain as a source of copper and lead and the fuel dock as a possible source of lead. Sediments at most stations within Marina Del Rey were sufficiently contaminated with copper, lead, mercury, and zinc to affect fish and/or invertebrates, especially at the larval or juvenile stage (Soule et al., 1991). Researchers thought that this contamination might account for the absence of more sensitive species and the low diversity within the marina. However, the extent of the sediment contamination resulting from marina-related activities was unclear.

Petroleum Hydrocarbons

Petroleum hydrocarbons, particularly polynuclear aromatic hydrocarbons (PAHs), tend to adsorb to particulate matter and become incorporated into sediments. They may persist for years, resulting in exposure to benthic organisms. Voudrias and Smith (1986) reported that sediments from two Virginia creeks with marinas contained significantly higher levels of hydrocarbons than did control sites. The North Carolina Division of Environmental Management (NCDEM, 1990) found PAHs in the sediments of six marinas, all of which had fuel docks. Nearby reference areas did not appear to be affected. Marcus et al. (1988) found an increase in PAHs in the sediments of two South Carolina marinas. Sources of petroleum hydrocarbons were identified as the origin of sediment contamination within several Australian marinas; however, a well-flushed marina in this study did not have an increase in sediment hydrocarbons (McMahon, 1989). This finding supports the supposition that sufficient flushing within a marina basin prevents build-up of pollutants in marina sediments.

Increased Levels of Pathogen Indicators

Studies conducted in Puget Sound, Long Island Sound, Narragansett Bay, North Carolina, and Chesapeake Bay have shown that boats can be a significant source of fecal coliform bacteria in areas with high boat densities and low hydrologic flushing (NCDEM, 1990; Sawyer and Golding, 1990; Milliken and Lee, 1990; Gaines and Solow, 1990; Seabloom et al., 1989; Fisher et al., 1987). Fecal coliform levels in marinas and mooring fields become elevated near boats during periods of high boat occupancy and usage. NOAA identified boating activities (the presence of marinas, shipping lanes, or intracoastal waterways) as a contributing source in the closure to harvesting of millions of acres of shellfish-growing waters on the east coast of the United States (Leonard et al., 1989).

Disruption of Sediment and Habitat

Boat operation and dredging can destroy habitat; re-suspend bottom sediment (resulting in the reintroduction of toxic substances into the water column); and increase turbidity, which affects the photosynthetic activity of algae and estuarine vegetation. Paulson and Da Costa (1991) demonstrated that propeller-induced flows can contribute significantly to bottom scour in shallow embayments and may have adverse effects on water clarity and quality. The British Waterways Board (1983) noted that propeller-driven boats may impact the aquatic environment and result in bank erosion. Waterways with shallow water environments would be affected as follows:

1 The propeller would cut off or uproot water plants growing up from the bottom, and
2 The propeller agitation of the water (propwash) would disturb the sediments, creating turbidity that would reduce the light available for photosynthesis of plants, impact feeding and clog the breathing mechanisms of aquatic animals, and smother animals and plants.

EPA (1974) noted a re-suspension of solids from the bottom and disturbance to aquatic macrophytes following boating activity. Changes in turbidity were dependent on water depth, motor power, operational time and type, and nature of sediment deposits. The increase in turbidity was generally accompanied by an increase in organic carbon and phosphorus concentrations. However, the possible contribution of these nutrients to eutrophication was not determined. The biological communities of rivers may be impacted by boat traffic, which can increase turbidity; resuspend sediments that move into backwaters; create changes in waves, velocity, and pressure; and increase shoreline erosion (USFWS, 1982).

Dredging may alter the marina and the adjacent water by increasing turbidity, reducing the oxygen content of the water, burying benthic organisms, causing disruption and removal of bottom habitat, creating stagnant areas, and altering water circulation (Chmura and Ross, 1978). Some of these impacts (e.g., turbidity and reduced DO) are temporary and without long-term adverse effects.

Dredging is addressed under CWA section 404 and associated regulations and is therefore not discussed further in this chapter.

Shoaling and Shoreline Erosion

Shoaling and shoreline erosion result from the physical transport of sediment due to waves and/or currents. These waves and currents may be natural (wind-induced, rainfall runoff, etc.) or human-induced (alterations in current regimes, boat wakes, etc.).

The British Waterways Board (1983) noted that when vessel-generated waves reach the shallow margins of a waterway, they can erode the banks and the bed, tending to wash away fringing plants and their associated animal life. The Waterways Board also found that a substantial volume of the sediment that results in shoaling comes from bank erosion and that removal of this material by dredging is a costly recurrent expense, especially where boat traffic causes extensive bank erosion. Factors influencing vessel-generated shoreline erosion include the distance of the boat from shore, boat speed, side slopes, sediment type, and depth of the waterway (Camfield et al., 1980; Sorensen, 1986; Zabawa and Ostrom, 1980).

Section C2: Managing Nonpoint Source Pollution from Boating and Marinas Pointer No. 9 EPA841-F-96-004I

Information obtained directly from:
http://www.epa.gov/owow/nps/facts/point9.htm

Millions of people regularly enjoy recreational boating, and more than 10,000 marinas dot the coastline and waterfront property of North America. Because boats operate and are maintained directly in the water or near the shore, the growing number of recreational boaters and marina managers must take special care to manage activities that cause water pollution.

Individual boats and marinas usually release only small amounts of pollutants. Yet, when multiplied by thousands of boaters and marinas, they can cause distinct water quality problems in lakes, rivers, and coastal waters. The U.S. Environmental Protection Agency has identified the following potential environmental impacts from boating and marinas: high toxicity in the water; increased pollutant concentrations in aquatic organisms and sediments; increased erosion rates; increased nutrients, leading to an increase in algae and a decrease in oxygen (eutrophication); and high levels of pathogens. In addition, construction at marinas can lead to the physical destruction of sensitive ecosystems and bottom-dwelling aquatic communities.

Managing Boat Sewage and Waste

Often underestimated or ignored by the public, the discharge of sewage and waste from boats, can degrade water quality (especially in marinas with high boat use). Fecal contamination from the improper disposal of human waste during boating can make water unsightly and unsuitable for recreation, destroy shellfishing areas, and cause severe human health problems. Sewage discharged from boats also stimulates algae growth, which can reduce the available oxygen needed by fish and other organisms. Although fish parts are biodegradable, when many fish are gutted and cleaned in the same area on the same day, a water quality problem can result. Like raw sewage, excess fish waste can stimulate algae growth.

Section C3: Clean Marina Initiative

Information obtained directly from:
http://cleanmarinas.noaa.gov/marinapollution.html

Stressors From Marina And Boating Activities

Marina and boating activities can introduce many different types of pollutants into the coastal environment. Scientists have found these pollutants can reach harmful concentrations in the water column, sediments, and tissues of organisms inhabiting the marine environment. Improper marina siting and design can also damage the coastal environment.

Low Dissolved Oxygen
Untreated sewage discharged from recreational boats and fish wastes discarded into the water body deplete dissolved oxygen (DO) levels as they decompose. Fish and other aquatic organisms need DO in the water to survive; they suffocate without enough oxygen. Low DO levels have been responsible for fish kills.

Metals
Metals such as lead, copper, arsenic, zinc, and tin and metal-containing compounds, have many functions in boat operation, maintenance, and repair. Common metal containing products include: gasoline, anti-fouling paints, pesticides, and wood preservatives. Metals can enter the waterways during uncontrolled pressure washing, painting, or fueling activities. The metals then accumulate in the sediments and water column. Metals can be toxic to marine organisms resulting in death, or chronic impairments such as deformity, reduced fertility, and reduced species diversity.

Oils
Oils and other petroleum products can enter the aquatic environment during refueling and bilge or fuel discharge from boats. Oils are poisonous to marine organisms. Oils coat bird's feathers, preventing them from flying or staying warm.