EXHIBIT F1

SUMMARY OF TECHNICAL BASIS FOR LAKE MAUMELLE WATERSHED PLAN

TETRA TECH
3200 Chapel Hill-Nelson Hwy, Suite 105
PO Box 14409
Research Triangle Park, NC 27709
Tel 919-485-8278 Fax 919-485-8280

MEMORANDUM

Date: December 18, 2007

To: Martin Maner, P.E., Watershed Director
Central Arkansas Water

From: Trevor Clements, Director of Watershed Management Services
Tetra Tech, Inc.

Subject: Technical Basis for the Lake Maumelle Watershed Plan Recommendation for Prohibiting Point Source Discharges

Purpose

The purpose of this memo is to summarize the technical basis supporting the Lake Maumelle Watershed Plan (Tetra Tech, 2007b) recommendation for prohibiting point source discharges to the surface waters within the Lake Maumelle watershed. Central Arkansas Water (CAW) is working with local and state resource agencies to implement the Plan, and is currently coordinating with the Arkansas Department of Environmental Quality (ADEQ) and Arkansas Department of Health (ADH) to implement the wastewater handling provisions. In the case of the discharge prohibition, ADEQ must determine that the following conditions are met (Arkansas Code 8-4-203):

> "(B) (i) In the case of any discharge limit, emission limit, environmental standard, analytical method, or monitoring requirements, the record of the proposed action and the response shall include a written explanation of the rationale for the proposal, demonstrating that any technical requirements or standards are based upon generally accepted scientific knowledge and engineering practices.
>
> (ii) For any standard or requirement that is identical to a duly promulgated and applicable regulation, this demonstration may be satisfied by reference to the regulation. In all other cases, the department must provide its own justification with appropriate reference to the scientific and engineering literature or written studies conducted by the department."

Emphasis herein will be on demonstrating that the Plan recommendations are based on generally accepted scientific knowledge and engineering practices.

Background

A Task Group for Watershed Management was convened by CAW in 2004 to review the existing plan for protecting Lake Maumelle. One primary recommendation of the Task Group was for CAW to contract with an expert watershed management and planning consulting firm to assist in developing and implementing a comprehensive, scientifically-based watershed management plan. Based on its evaluation of the most technically qualified firms, the CAW Board unanimously selected Tetra Tech Inc. as the number one firm for conducting the work.

Tetra Tech has provided water resources engineering and environmental consulting services to public and private sector clients throughout the United States since 1966, and has grown to over 8,500 professional staff. Tetra Tech is a national leader in watershed assessment and planning, and is currently ranked number one in Water in the U.S. among the top 500 engineering design firms and number one in Environmental Management services in the U.S. among the top 200 engineering firms by the Engineering News Record (April 2007 and July 2007, respectively). As an example of its technical qualifications in watershed assessment and planning, Tetra Tech wrote the two lead guidance documents for these areas under contract to the U.S. Environmental Protection Agency's Office of Water:

Compendium of Tools for Watershed Assessment and TMDL Development (EPA 841-B-97-006)

Handbook for Developing Watershed Plans to Restore and Protect Our Waters (EPA 841-B-05-005)

The Lake Maumelle Project Team was led by Mr. Trevor Clements, Tetra Tech's National Watershed Program Director. With more than 24 years of water resources and watershed assessment and planning experience, Mr. Clements is one of the principal co-authors of the EPA Watershed Handbook and a co-developer of the EPA Watershed Academy.

The lead planner for the Lake Maumelle project was Ms. Kimberly Brewer, A.I.C.P., a certified planner with 23 years of water resources planning and management experience. Throughout her career, Ms. Brewer has coupled technical and policy analysis with stakeholder facilitation to develop innovative, cost-effective watershed protection strategies. As a planning consultant, she has assisted in conducting numerous local watershed protection studies, pioneered approaches for low-impact design, and co-designed the U.S. Environmental Protection Agency's Watershed Academy. Prior to consulting, Ms. Brewer worked 11 years in local, state, and regional agencies, gaining extensive experience in program development and management in the areas of water resource protection. Ms. Brewer's experience working with government agencies and diverse stakeholder groups, along with her practical experience studying and implementing cost-effective innovations, allows her to understand different perspectives and to design strategies that meet multiple objectives. Ms. Brewer has been the facilitator, principal planner and cost analyst on watershed management projects, providing comprehensive watershed management planning services, including watershed management plans, ordinance review and development, site design evaluation tools for BMPs, training, LID pilot projects and case studies, and public education/outreach. Drawing on her extensive watershed management experience, Ms Brewer helped co-author the EPA Watershed Handbook.

The watershed modeling and assessment tasks were led by Dr. Jonathan Butcher, P.H., a registered Professional Hydrologist (American Institute of Hydrology) and environmental engineer with over 20 years of experience in watershed planning, risk assessment, and the development, application, and communication of hydrologic and water quality models. Dr. Butcher has led technical efforts to support state and local governments in a variety of watershed modeling, total maximum daily load (TMDL), wasteload allocation, and water body restoration and protection studies. Dr. Butcher's current research interests include development of TMDLs to address narrative criteria for sediment and nutrients. He is highly experienced in the use of numerous lake, river, and estuarine hydrodynamic, hydrologic, and water quality models. He is a co-author for the following key guidance documents: Protocol for Developing Pathogen TMDLs (USEPA), Protocol for Developing for Developing Nutrient TMDLs (USEPA), Watershed-Scale Ecological Risk Assessment (WERF), Effluent Limits for Fluctuating Discharges (WERF), and Factoring Frequency, Magnitude, and Duration in NPDES Permit Conditions (WERF).

As the leaders of the Lake Maumelle Watershed Planning Project, Mr. Clements, Ms. Brewer and Dr. Butcher worked closely together to ensure that the Lake Maumelle Watershed Management Plan was based on sound and generally accepted scientific knowledge and engineering practices. With regard to wastewater planning recommendations, in addition to working closely with ADEQ and ADH agency staff, the Tetra Tech project team also included Mr. Barry Tonning who has a strong background in wastewater discharging and nondischarging systems. Mr. Tonning completed the Wastewater Treatment

Operator Certification Program (Level III) in 1994, and was trained at the University of Kentucky in soil profile characterization and analysis and wastewater system permitting while employed by the five-county Gateway District Health Department in central Kentucky. He is a co-author of the agency's 2002 "Onsite Wastewater Treatment Systems Manual" for system design, and the 2005 "Handbook for Managing Onsite and Clustered (Decentralized) Wastewater Treatment Systems." Mr. Tonning currently provides US EPA – sponsored training for system design and installation, and supports the agency's nationwide program to improve system operation, maintenance, and management.

Technical Modeling Approach

From the beginning of its efforts, Tetra Tech developed and followed a *Modeling Quality Assurance Project Plan for the Lake Maumelle Watershed Planning Project* (Tetra Tech, 2005). The QAPP documents how Tetra Tech approached model selection, along with the process and criteria by which Tetra Tech would calibrate and validate the models. Prior to making final selection of modeling assessment tools to support the planning effort, Tetra Tech worked closely with a Technical Advisory Council (TAC) to help define principal study questions. These were developed in the context of goals and objectives established by a Policy Advisory Council (PAC) convened for the project.

Based on research and review of the watershed, consultation with resource agency and academic experts, and best professional judgment, Tetra Tech selected key indicators to evaluate within Lake Maumelle via the baseline analysis: chlorophyll *a* concentration, total organic carbon (TOC) concentration, Secchi disk depth, and fecal coliform concentration. Inlake targets were established for each indicator based on the adopted goals and objectives, with particular emphasis on water supply and public health protection. Key watershed loading parameters identified as related to the selected lake water quality indicators included the phosphorus series, nitrogen series, sediment, organic material, and bacteria.

Following a thorough model selection process, Tetra Tech developed a linked watershed model (HSPF) and lake response model (CE-QUAL-W2) framework as the principal tools for conducting the baseline analysis. The lake model uses input from the HSPF watershed model and predicts variation in management targets, such as algal concentration, within the lakes. Together, the HSPF and CE-QUAL-W2 models provide a comprehensive simulation of loads from the watershed and in-lake impacts. Both models are publicly available, endorsed by the U.S. EPA and other resource agencies, and have undergone extensive peer review (http://epa.gov/osp/crem.htm and EPA, 1997). Specialty models including GBMM (a grid-based model under development by Tetra Tech for USEPA) and EFDC (Hamrick, 1996) were also applied to support special time of travel studies, but emphasis here will be placed on the watershed and lake response water quality models given their primary relevance to the technical basis behind the recommendation to prohibit point source discharges of wastewater in the Lake Maumelle watershed.

The HSPF model (Bicknell et al., 2001) provides a continuous simulation of flow and pollutant delivery within the watershed and stream network leading to the lake at an hourly time step. Development and calibration of the watershed model is described in detail in the *Lake Maumelle Watershed and Lake Modeling – Model Calibration Report* (Tetra Tech, 2006a). The model was calibrated to observations for 1997-2004 and model performance validated to observations for 1989 to 1996 per the process and criteria outlined in the QAPP. Model setup, calibration and validation were reviewed by an HSPF expert outside of the primary project team to ensure independence and overall quality.

The CE-QUAL-W2 model (Cole and Wells, 2005) simulates the movement and quality of water within Lake Maumelle on a daily time step. The model operates in two spatial dimensions: longitudinal and vertical. Calibration (1991–1992) and validation (2002–2004) of this model is also described the *Lake Maumelle Watershed and Lake Modeling – Model Calibration Report* (Tetra Tech, 2006a). Model setup, calibration and validation were reviewed by a separate lake modeling expert to ensure independence and overall quality.

Baseline Analysis

As a part of the process to develop a comprehensive, scientifically-based watershed management plan for the Lake Maumelle watershed, Tetra Tech performed a baseline modeling analysis. The purpose of the baseline analysis was to establish points of reference to guide plan development. This was accomplished by comparing existing conditions in the lake and watershed to potential future conditions, assuming that no additional management policies or programs are established (i.e., existing management policies and programs continue to be applied without change in the future). Through this comparison, stakeholders are able to see what impacts might occur if no action is taken and to better understand the magnitude of what should be addressed by the management plan to achieve the established goals and objectives. Detailed explanation of the baseline analysis is provided in the *Lake Maumelle Water Quality Management Plan: Baseline Analysis* document (Tetra Tech, 2006b).

In order to simulate the impact of future point and nonpoint source contaminants on Lake Maumelle, Tetra Tech worked closely with local planners, engineers, and agency resource staff to establish representative assumptions for the parameters that would drive the analyses: population increase, residential and commercial development patterns, type of waste treatment, roads, and land cover characteristics. Landsat data, U.S Census Bureau data, and County tax parcel data provided the basis for establishing existing population and land use/land cover, including the location of residential and commercial property. Input from local planners and engineers helped to identify where the future development would occur and at what density levels. As a result, Tetra Tech estimated that approximately 52,000 of the 88,000 total acres (59%) in the watershed could be developed.

After consultation with technical and policy advisers, Tetra Tech developed two scenarios describing what potential future development might look like: Scenario 1 – characterized by large lot development and, Scenario 2 – characterized by denser development near the lake. Differences between the modeling applications for the two scenarios provided stakeholders with an understanding of the sensitivity of lake water quality response to different levels of pollutant loading reflective of different development density levels.

Under Scenario 1 (predominantly Large Lot), it was estimated that approximately 8400 new residences would be added to the watershed. Under Scenario 2 (denser development near the lake), approximately 15,000 new residences would be added. These compare to the approximate 400 residences under existing conditions. Based on the different types of density predicted, levels of impervious surface, developed pervious surface, and undeveloped pervious surfaces were input to the calibrated HSPF model to estimate nonpoint source impacts on hydrology and pollutant loading for the existing and future scenarios.

Three types of wastewater treatment systems were assumed for the anticipated development based on relative lot size. Development on lots less than 5-acres was assumed to be served by package treatment systems. Development on lots greater than 5-acres would be served by subsurface or individual discharging systems, depending on the soil suitability for septic systems. Because many of the soils of the watershed are of low suitability for subsurface wastewater disposal, it was determined that a significant fraction of the wastewater would likely be treated and discharged into streams that drain to Lake Maumelle if no change in management strategy occurs. Based on the distribution and lot-sizes of forecast development, the number of people on the various treatment systems was estimated as follows for the two future scenarios (Table 1).

Tetra Tech's project team used research, regulatory requirements, and input from ADEQ and ADH agency staff to arrive at modeling input to represent the wastewater discharges for the baseline analysis. Details are documented in the Baseline Analysis Report (Tetra Tech, 2006b).

Application of the linked HSPF and CE-QUAL-W2 model predicted that the future development scenarios, in the absence of new management requirements, would result in significant increases in pollutant loading to Lake Maumelle and that the Lake would fail to meet the water quality targets adopted by the PAC. Algal concentrations near the water intake could increase by up to more than five times current levels, and up to thirteen times current levels in the upper portion of Lake Maumelle, leading to conditions in which visible algal blooms are frequent and the quality of finished water is compromised.

Table 1. Estimated Population Served by Wastewater Treatment Systems for Future Scenarios

Scenario	Subsurface Systems	Individual Systems	Package Systems	Total
1 – Large Lot	1,515	13,395	8,587	23,497
2 – Higher Density	1,312	15,225	23,893	40,431

One of the core findings of the baseline analysis was how nutrient loading could be impacted by point source discharges in particular, leading to the possible nuisance algal bloom conditions. Baseline analysis annual loading estimates from the HSPF watershed model output are summarized in Figures 1 and 2. [Note: Scenarios 1A and 2A are variations on Scenarios 1 and 2, respectively, with the assumption that CAW would acquire approximately 1,500 acres of developable land near the water supply intake to reduce the impact in that area.] The figures show that future total phosphorus loads without additional management would be expected to increase seven to fourteen fold (i.e., 700 to 1400 percent). Approximately 90 percent of that increase would be expected to come from future point source wastewater discharges. Similarly, approximately 90 percent of the predicted three to six fold increase in total nitrogen loads was attributed to wastewater point sources.

The baseline analysis demonstrated the need for managing nutrient loading to Lake Maumelle from wastewater sources. Tetra Tech then turned to establishing allowable levels of pollutant loading that would protect Lake Maumelle water quality and meet the adopted goals and objectives. Details regarding evaluation methods and results are documented in *Lake Maumelle Water Quality Management Plan: Scenario Evaluation Methods and Analyses* (Tetra Tech, 2007a). A summary of key points of the evaluation related to the recommendation for prohibiting point source wastewater discharges is provided in the next section (Watershed Load Allocations).

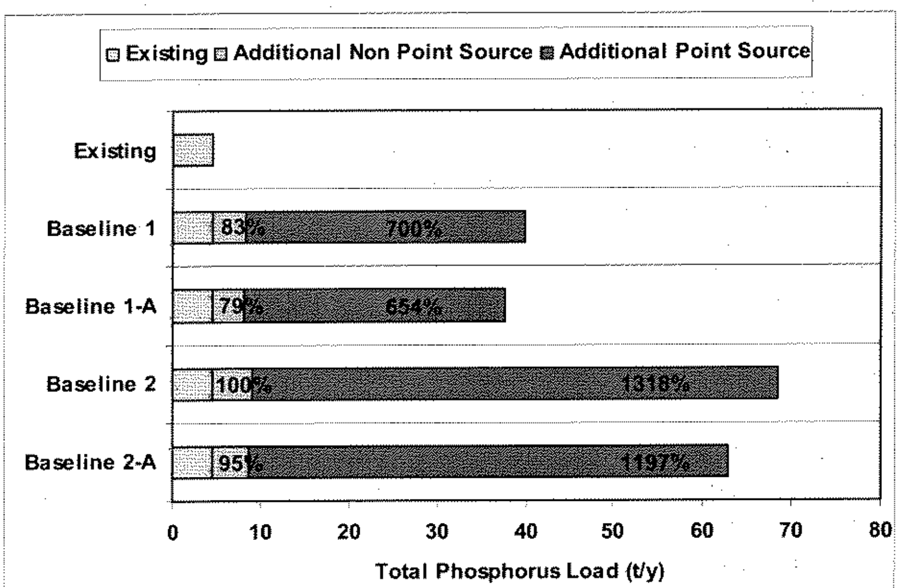

Figure 1. Predicted Point and Nonpoint Annual Phosphorus Loads to Lake Maumelle

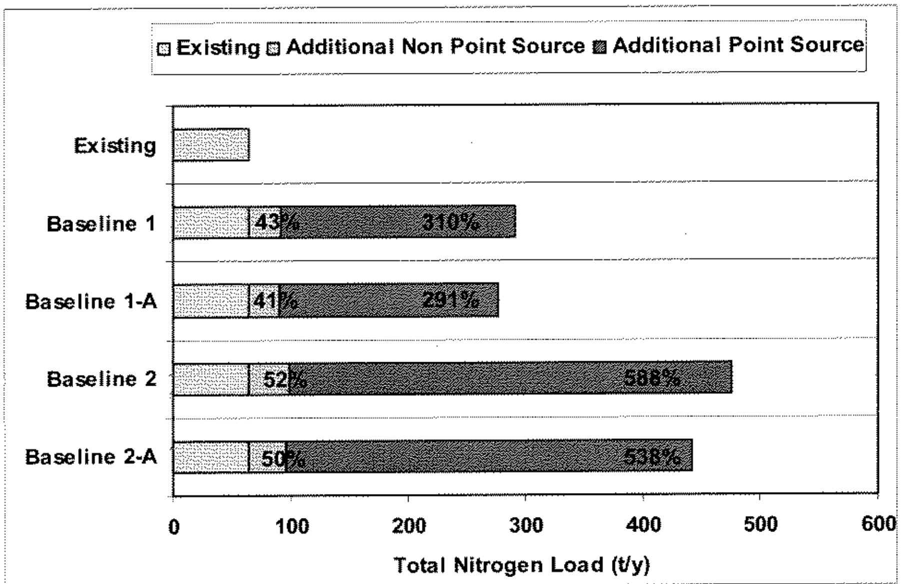

Figure 2. Predicted Point and Nonpoint Annual Nitrogen Loads to Lake Maumelle

Watershed Load Allocations

Topography, soils, precipitation patterns and hydrologic travel time differ throughout the watershed. These differences must be taken into consideration when determining allowable loads that will protect water quality. Based on detailed time of travel studies and the results of the baseline fate and transport modeling, Tetra Tech recommended and the PAC adopted three management areas within the watershed: Critical Area A in the narrower eastern portion of the watershed closest to the water supply intake; Critical Area B containing the remainder of the lake and the land draining to it up to Williams Junction along the Highway 10 corridor; and the Upper Watershed Area (UWA) containing the westernmost portion of the watershed (Figure 3).

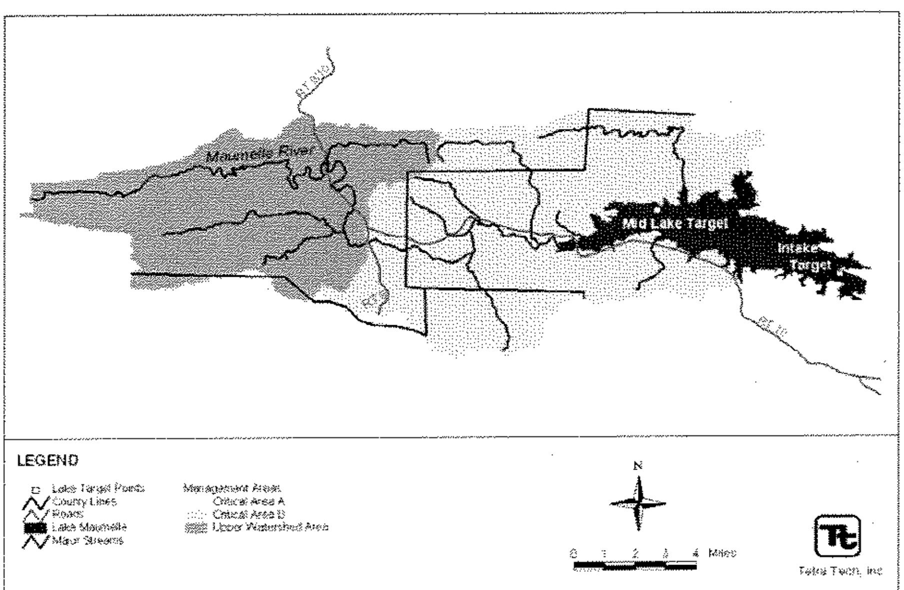

Figure 3. Adopted Lake Maumelle Watershed Management Areas

Initial allowable load allocations were established by incrementally modeling increases in loads from developable areas (accounting for expected subsurface load changes in addition to surface loading) up to the threshold at which inlake water quality targets are met. This represents the allocation that is the maximum permissible loading rate at eventual buildout, and that management planning will endeavor to ensure that loads remain less than to meet water quality objectives. Next, a two-step process was used to estimate the site-scale loads that correspond to the allocations of loads delivered to the lake. First, the watershed model was used to output site-scale, per-acre loads for each of the hydrologic response units (HRUs) in the model, with surface and subsurface loading components separated. The HRUs are areas of similar characteristics including land use/cover, soils/slopes, and weather regime. These loading rates were then combined with the land use distribution to calculate the site-scale or upland loading that corresponds to the delivered-load allocation from each management area (Table 2).

Table 2. Total Phosphorus Load Allocations by Lake Maumelle Watershed Management Zone

Constituent	Management Zone	Site-Scale Load	Delivered Load	Percent of Total Load
Total Phosphorus (lb/yr)	Critical Zone A	1,017	876	4.6%
	Critical Zone B	13,915	11,997	63.1%
	UWA	7,817	6,126	32.2%
	Entire Watershed	22,749	19,000	100%

Tetra Tech then translated the management zone allocations to per acre allowable pollutant loading rates (Table 3). These represent the average loading rate that must be achieved across all developable land to meet the inlake water quality target for chlorophyll a.

Table 3. Allowable Site-Scale Phosphorus Loading Rate Per Acre of Developed Land

Management Area	Total Phosphorus (lb/ac/yr)
Critical Zone A	0.20
Critical Zone B	0.30
UWA	0.33

Point and Nonpoint Source Management to Achieve Allocations

Once allowable loading was established, Tetra Tech initially envisioned allocating a portion of the loading to wastewater and developing performance standards for wastewater discharges. After determining the maximum extent to which loads from wastewater could be limited, Tetra Tech could then determine the remaining load allocations and performance standards for nonpoint source loading from new development. However, modeling results from the baseline assessment (Tetra Tech, 2006b) made it clear that a strategy that included direct discharges of wastewater would not meet water quality targets. In the baseline scenarios representing current regulations, wastewater discharges were predicted to become the major source of pollutant loading to the lake. Further, uncontrolled development without wastewater discharges was found to meet targets only under assumptions that most of the land in the watershed was developed with 5- and 10-acre lots, and that 76 percent to 88 percent of the area within the lots would be conserved in undisturbed open space. At the March 16, 2006 PAC meeting, members recommended capping the maximum requirement for conservation of open space at 50 percent, and targeting minimum lot size at 5 acres. Thus, a significant amount of load reduction for new development will be needed to meet targets in the absence of any direct wastewater discharges.

Tetra Tech did discuss with ADEQ the possibility of strict effluent limits on wastewater discharges. ADEQ indicated that a "feasible" limit that it might impose is 1 mg/L total phosphorus, which would be considered a very high level of treatment for a package treatment plant. Such a limit, however, would result in a loading rate of 0.95 lb/yr of total phosphorus for a household on a 5-acre lot, which would constitute over 60 percent of the available allocation for new development. As noted in the paragraph above, new management requirements will need to be established just to reduce nonpoint source loading to the allowable level (i.e., without allowing for additional point source loading).

Additionally, it was noted that because of the relative contributions from future point sources, the total nitrogen to total phosphorus ratio would be expected to change entering the lake from an existing level that favors green algal species to a lower ratio that favors nuisance (and potentially toxin-generating) blue-green algal species. Such a change would be highly undesirable from a water quality and public health and safety perspective.

As a result of Tetra Tech's evaluations and dialog with resource agency staff, the primary management alternatives focused on scenarios that included a policy of no direct surface discharges in the watershed. Subsurface discharges of wastewater could be used, as such systems are expected to contribute minimal loads of phosphorus and other targeted indictors (if properly designed, installed and maintained), and/or in some areas, waste could be pumped out of the watershed. The Plan calls for a Responsible Management Entity (RME) to oversee all nondischarging systems from design through operation and maintenance.

References

Bicknell, B.R., J.C. Imhoff, J.L. Kittle, Jr., T.H. Jobes, and A. S. Donigian, Jr. 2001. Hydrological Simulation Program - FORTRAN, Version 12, User's Manual for Version 12. AquaTera Consultants, Mountain Vista, CA

Cole , T., and S.A. Wells. 2005. CE-QUAL-W2: A Two-Dimensional Laterally Averaged, Hydrodynamic And Water Quality Model, Version 3.2. Instructional Report EL-03-01. U. S. Army Corps of Engineers, Waterway Experiment Station, Vicksburg, MS.

Hamrick, J.M. 1996. User's Manual for the Environmental Fluid Dynamics Computer Code. Special Report No. 331 in Applied Marine Science and Ocean Engineering. Virginia Institute of Marine Science, The College of William and Mary, Gloucester Point, VA.

Tetra Tech. 2005. Modeling Quality Assurance Project Plan for Lake Maumelle Watershed Planning Project. Prepared for Central Arkansas Water, Little Rock, AR by Tetra Tech, Inc., Research Triangle Park, NC.

Tetra Tech. 2006a. Lake Maumelle Watershed and Lake Modeling – Model Calibration Report. Prepared for Central Arkansas Water, Little Rock, AR. Tetra Tech, Inc., Research Triangle Park, NC.

Tetra Tech. 2006b. Lake Maumelle Water Quality Management Plan: Baseline Modeling Analysis. Prepared for Central Arkansas Water, Little Rock, AR. Tetra Tech, Inc., Research Triangle Park, NC.

Tetra Tech. 2007a. Lake Maumelle Water Quality Management Plan: Scenario Evaluation Methods and Analyses. Prepared for Central Arkansas Water, Little Rock, AR. Tetra Tech, Inc., Research Triangle Park, NC.

Tetra Tech. 2007b. Lake Maumelle Watershed Management Plan. Adopted in February 2007 and again with editing refinements in May 2007 by the Central Arkansas Water Board of Commissioners. Prepared for Central Arkansas Water, Little Rock, AR. Tetra Tech, Inc., Research Triangle Park, NC.