

1.0 INTRODUCTION

1.1 DESCRIPTION OF F.E. WALTER RESERVOIR

The U.S. Army Corps of Engineers (USACE) manages F.E. Walter Reservoir located in northeastern Pennsylvania within the Delaware River Basin. F.E. Walter Reservoir is an integral part of the Lehigh River Flood Control Program. The authorized purpose of this project is flood control. The reservoir project was authorized for recreation and specifically white water recreation as part of Public Law 100-676, Section 6, dated November 17, 1988. Located about 9 miles southeast of Wilkes-Barre, PA, the reservoir dams a drainage area of 288 square miles. The dam can impound up to 35.8 billion gallons of floodwater. The primary surface water input into the reservoir is the Lehigh River as it flows west between Luzerne and Carbon Counties. Bear Creek, a secondary surface water input, enters the reservoir from the north. Tobyhanna Creek drains an area to the southeast and joins the Lehigh River near the headwaters of the reservoir. The reservoir is approximately 3 miles long and typically approximately 50 feet deep behind the dam when not operating for flood control or recreation. In an effort to maximize recreational potential in the reservoir and on the Lehigh River downstream, specifically recreational boating and fishing, the normal operating pool of 50 feet was raised an additional 65 feet in May of 2006. The additional storage was used to augment low flows in the Lehigh River downstream and increase the number of recreational boating releases throughout the summer recreation season.

1.2 PURPOSE OF THE MONITORING PROGRAM

Foremost, F.E. Walter Reservoir provides flood control to downstream communities on the Lehigh River. Additionally, the reservoir provides important habitat for fish, waterfowl, and other wildlife, and recreational opportunities through fishing and boating. Due to the broad range of uses and demands F.E. Walter Reservoir serves, the USACE monitors water quality and other aspects related to reservoir health primarily to ensure public health safety. Water quality monitoring results are compared to state water quality standards and used to diagnose other problems that commonly effect reservoir health such as nutrient enrichment and toxic loadings. This report summarizes the results of water quality monitoring at F.E. Walter Reservoir and its tributaries from May through November 2006. This report also discusses the relevance of the water quality measures to the ecology of the reservoir and makes recommendations toward future water quality monitoring efforts.

1.3 ELEMENTS OF THE STUDY

The USACE, Philadelphia District, has been monitoring the water quality of F.E. Walter Reservoir since 1975. Over this time, yearly monitoring program designs have evolved to address new areas of concern such as health aspects of public drinking water, sediment contaminants within the reservoir basin, and a 2002 investigation of a hydrogen sulfide smell near the tail water of the dam. The 2006 monitoring program was similar to those in recent years with additional sampling to monitor water quality changes occurring within the reservoir and downstream as a result of modified operations. The major elements of the monitoring included:

- Monthly water quality and bacteria monitoring from May through November to evaluate compliance with the Pennsylvania state water quality standards;
- Multiple unscheduled profile samples for temperature, dissolved oxygen, chlorophyll, pH and conductivity at the deepest station in the reservoir;
- Sediment priority pollutant monitoring of PCB's, pesticides, and semi-volatile organic compounds to evaluate potential sediment toxicity relative to identified screening concentrations; and
- Automated half-hour temperature recorders at four stations along the Lehigh River below the reservoir.

2.0 METHODS

2.1 PHYSICAL STRATIFICATION MONITORING

Physical stratification monitoring of the water column of F.E. Walter Reservoir was conducted five times between July and November 2006 at all stations (Table 2-1). Physical stratification parameters included temperature, dissolved oxygen (DO), pH, Chlorophyll and conductivity. Monitoring was conducted at seven fixed stations located throughout the reservoir watershed (Fig. 2-1). Surface water quality was monitored at stations downstream of the reservoir (WA-1) and upstream on Tobyhanna Creek (WA-3), the Lehigh River (WA-4), and Bear Creek (WA-5). Stratification monitoring was conducted within the reservoir at a reservoir tower station (WA-2), Bear Creek arm of the lake (WA-6), and Lehigh River arm of the lake (WA-7) with water quality measured at the surface to the bottom at 5-ft intervals. Stratification monitoring at station WA-2 was conducted a total of 10 times throughout the season from May through November to monitor the changes in water quality as a result of modified operations in 2006. All of the water quality monitoring was conducted with a calibrated YSI 6600 water quality meter.

In this report, water quality data recorded from stratification monitoring were compared to water quality standards mandated by the Pennsylvania Department of Environmental Protection (PADEP Chapter 93). The standard for DO is a minimum concentration of 5 mg/L, and that for pH is an acceptable range from 6 to 9. All of the water quality data collected during physical stratification monitoring is summarized in Appendix A.

2.2 WATER COLUMN CHEMISTRY MONITORING

Water column chemistry monitoring was conducted five times at F.E. Walter Reservoir between July and November 2006 (Table 2-1). Water samples were collected at the seven fixed stations throughout the reservoir drainage area (Fig. 2-1). Surface water samples were collected at stations downstream of the reservoir (WA-1) and upstream on Tobyhanna Creek (WA-3), the Lehigh River (WA-4), and Bear Creek (WA-5). Surface, middle, and bottom water samples were collected at the reservoir-body stations WA-2, WA-6, and WA-7. Surface water samples were collected by opening the sample containers approximately 1 foot below the water's surface. Middle and bottom samples were collected with a Van Dorn design water bottle sampler.

Water samples collected from surface, middle, and bottom depths were analyzed for ammonia, nitrite, nitrate, total Kjeldahl nitrogen (TKN), total phosphorus, diss./ortho-phosphate, soluble phosphorus, total dissolved solids (TDS), total suspended solids (TSS), biochemical oxygen demand (BOD), alkalinity, total organic carbon (TOC), total inorganic carbon (TIC), total carbon, and chlorophyll *a*. Table 2-2 summarizes the water quality parameters; laboratory method detection limits, state water quality standards, and allowable and achieved maximum hold times for each.

Table 2-1. F.E. Walter Reservoir water quality schedule for 2006 monitoring							
Date of Sample Collection	Physical Stratification Monitoring (WA-2)***	Water Column Chemistry Monitoring (All Stations)	Trophic State Determination (WA-2)	Coliform Bacteria Monitoring (All Stations)	Sediment Priority Pollutant Monitoring (WA-2)	Lehigh Temperature Probes**	Drinking Water Monitoring*
5 May	X					X	
22 May	X					X	
01 June	X					X	
23 June	X					X	
19 July	X	X	X	X		X	
27 July	X					X	
24 August	X	X	X	X	X	X	
20 September	X	X	X	X		X	
18 October	X	X	X	X		X	
02 November	X	X	X	X		X	
<p>* Drinking water samples are sampled quarterly by personnel at each reservoir.</p> <p>** Lehigh River temperature probes continuously monitor river temperatures throughout the sampling period. They are periodically downloaded.</p> <p>*** Physical stratification monitoring is conducted at all stations during routine monthly sampling.</p>							

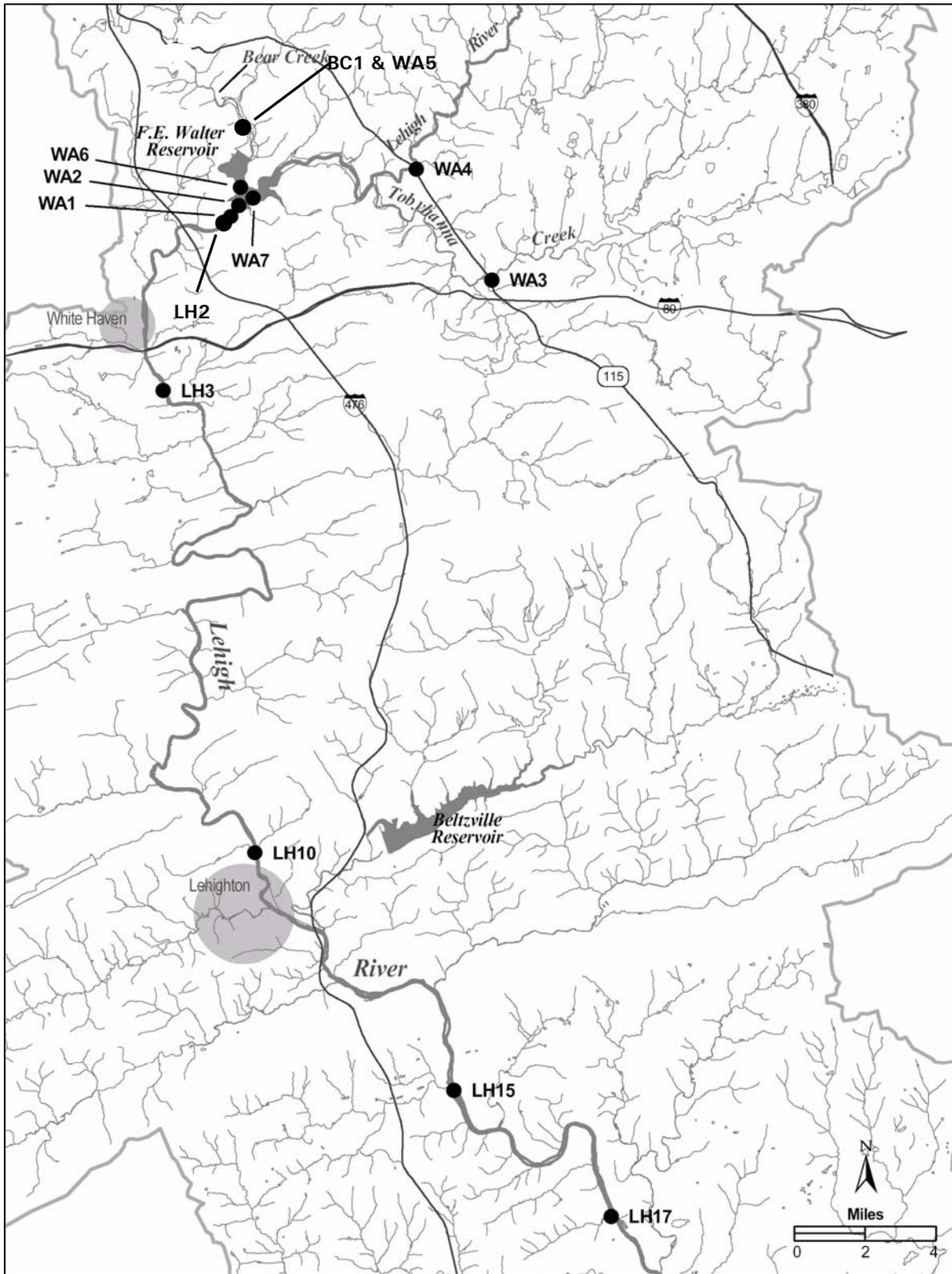


Figure 2-1. Location map for F.E. Walter Reservoir and Lehigh River temperature probe monitoring stations in 2006

Table 2-2. Water quality test methods, detection limits, state regulatory criteria, and sample holding times for water quality parameters monitored at F.E. Walter Reservoir in 2006					
Parameter	Method	Detection Limit	PADEP Surface Water Quality Criteria	Allowable Hold Times (Days)	Maximum Hold Time Achieved (Days)
Alkalinity	SM2320B	0.40 mg/L	minimum 20 mg/L CaCO ₃	14	(X)
Biochemical Oxygen Demand (BOD)	SM5210B	1.0 mg/L	None	2	(X)
Total Phosphorus	365.2	0.01 mg/L	None	28	(X)
Diss./Ortho-Phosphate	365.2	0.01mg/L	None	28	(X)
Soluble Phosphorus	365.2	0.01 mg/L	None	28	(X)
Total Organic Carbon	415.1	0.50 mg/L	None	14	(X)
Total Inorganic Carbon	415.1	0.50 mg/L	None	28	(X)
Total Carbon	415.1	0.50 mg/L	None	28	(X)
* Chlorophyll <i>a</i>			None		
Total Kjeldahl Nitrogen	351.3	0.50 mg/L	None	28	(X)
Ammonia	350.3	0.03 mg/L	Temperature and pH dependent	28	(X)
Nitrate	352.1 300.0	0.50 mg/L 0.04 mg/L	Maximum 10 mg/L (nitrate + nitrite)	28	(X)
Nitrite	354.1 300.0	0.01 mg/L 0.02 mg/L		28	(X)
Total Dissolved Solids	160.1	9.0 mg/L	Maximum 500 mg/L	7	(X)
Total Suspended Solids	160.2	3.0 mg/L	None	7	(X)
* Chlorophyll <i>a</i> samples were recorded using a YSI 6600 with a chlorophyll sensor.					
** (X) Hold times acheived					

2.3 TROPHIC STATE DETERMINATION

The trophic state of F.E. Walter Reservoir was determined by methods outlined by Carlson (1977). In general, this method calculates trophic state indices (TSIs) independently for total phosphorus and chlorophyll *a* concentrations, and secchi disk depth. Surface water measures of total phosphorus and chlorophyll *a* from chemistry monitoring were used independently in determining monthly TSI values. Secchi disk depth was measured only in surface waters in the reservoir-body. Trophic state determinations were made using criteria defined by Carlson (1977) and EPA (1983) and calculated only for Station WA-2 within the reservoir.

2.4 RESERVOIR BACTERIA MONITORING

Monitoring for coliform bacteria contaminants was conducted five times between July and November at F.E. Walter Reservoir. Surface water samples were collected in the same manner as for chemical parameter samples, and analyzed for total and fecal coliform bacteria contamination. Table 2-3 presents the test methods, detection limits, PADEP standards, and sample holding times for the bacteria parameters monitored at F.E. Walter Reservoir in 2006. The bacteria analytical method was based on a membrane filtration technique. All of the samples were analyzed within their maximum allowable hold times.

Monthly coliform bacteria counts were compared to the PADEP single sample water quality standard for bacteria. The multiple sample standard is defined as a maximum geometric mean of 200 colonies/100-ml based on five samples collected on different days within a 30-day period. Application of this standard is not necessary at F.E. Walter because swimming and other human/water contact recreation is prohibited in the reservoir.

Table 2-3. Water quality test methods, detection limits, PADEP water quality standards, and sample holding times for bacteria parameters monitored at F.E. Walter Reservoir in 2006		
Parameter	Total coliform	Fecal coliform
Test method	SM 9222B	SM9222D
Detection limit	10 clns/100-mls	10 clns/100-ml
PADEP standard	-	Geometric mean less than 200 clns/100-ml (application of this standard is conservative because swimming is not permitted in the reservoir)
Maximum allowable holding time	30 hours	30 hours
Achieved holding time	< 30 hours	< 30 hours

2.5 SEDIMENT PRIORITY POLLUTANT MONITORING

Sediment from F.E. Walter Reservoir was monitored for priority pollutant contaminants, Group 1 – PCB's, pesticides, and semi-volatile organic compounds. Sediment was collected on 24 August at station WA-2 with a petite ponar grab-sampler. Sediment from the grab-sampler was emptied into a stainless steel mixing bowl and homogenized with a stainless steel spoon. Sediments were contained in appropriately labeled sample jars and stored on ice until shipment to the analytical laboratory. Table 2-4 summarizes the parameters monitored, method detection limits, sample hold times, and the laboratory methods used in the analyses. Sediment results were compared to New Jersey residential and non-residential cleanup standards. New Jersey standards have been historically used by the Philadelphia District to screen and assess potential sediment contamination.

2.6 LEHIGH WATER QUALITY MONITORING

Ambient water temperature was recorded every ½ hour with Onset Computer Corporation TidbiT™ probes at four stations along the Lehigh River. The station locations were LH-2 (just below the F. E. Walter dam outfall), station LH-3 (Tannery Bridge located several miles downstream of the dam), LH-10 (Lehighon near the Lehighon water intake facility), and LH-15 (Walnutport). Incomplete data sets exist for stations LH-2 and LH-15. A late June rainstorm resulted in high flows within the watershed. The temperature probe at LH-2 was lost during this period. The temperature probe at LH-15 was also lost during the early portion of the sampling season. Loss of this probe is assumed to be the result of vandalism.

Table 2-4. Analytical methods, detection limits, and sample hold times for sediment priority pollutant PCB's., pesticides and semi-volatile organic compounds monitored at F. E. Walter Reservoir in 2006.

Parameter	Method	Method Detection Limit	Allowable Hold Time (days)	Max. Hold Time Achieved (X)
Metals				
(ug/kg)				
Iron	6010B		180	X
Arsenic	6010B		180	X
PCB's				
Aroclor-1016	8082	489	180	X
Aroclor-1221	8082	489	180	X
Aroclor-1232	8082	489	180	X
Aroclor-1242	8082	489	180	X
Aroclor-1248	8082	489	180	X
Aroclor-1254	8082	489	180	X
Aroclor-1260	8082	489	180	X
Pesticides				
4,4-DDD	8081A	78.2	180	X
4,4-DDE	8081A	78.2	180	X
4,4-DDT	8081A	78.2	180	X
a-BHC	8081A	39.1	180	X
a-Chlordane	8081A	39.1	180	X
Aldrin	8081A	39.1	180	X
b-BHC	8081A	39.1	180	X
d-BHC	8081A	39.1	180	X
Dieldrin	8081A	78.2	180	X
Endosulfan I	8081A	39.1	180	X
Endosulfan II	8081A	78.2	180	X
Endosulfan sulfate	8081A	78.2	180	X
Endrin	8081A	78.2	180	X
Endrin aldehyde	8081A	78.2	180	X
Endrin ketone	8081A	78.2	180	X
g-BHC (Lindane)	8081A	450	180	X
g-Chlordane	8081A	39.1	180	X
Heptachlor	8081A	39.1	180	X
Heptachlor epoxide	8081A	39.1	180	X
Methoxychlor	8081A	39.1	180	X
Toxaphene	8081A	489	180	X
Semi-volatile Organics				
1,2,4-Trichlorobenzene	8270C	20	40	X
1,2-Dichlorobenzene	8270C	20	40	X
1,2-Diphenylhydrazine	8270C	20	40	X

Table 2-4. (Continued).				
Parameter	EPA Method	Method Detection Limit (ug/kg)	Allowable Hold Time (days)	Max. Hold Time Achieved (days)
Semi-volatile Organics Cont..				
1,4-Dichlorobenzene	8270C	20	40	X
2,3,4,6-Tetrachlorophenol	8270C	100	40	X
2,4,5-Trichlorophenol	8270C	100	40	X
2,4,6-Trichlorophenol	8270C	100	40	X
2,4-Dichlorophenol	8270C	100	40	X
2,4-Dimethylphenol	8270C	20	40	X
2,4-Dinitrophenol	8270C	100	40	X
2,4-Dinitrotoluene	8270C	100	40	X
2,6-Dichlorophenol	8270C	100	40	X
2,6-Dinitrotoluene	8270C	100	40	X
2-Chloronaphthalene	8270C	20	40	X
2-Chlorophenol	8270C	20	40	X
2-Methylnaphthalene	8270C	20	40	X
2-Methylphenol	8270C	20	40	X
2-Nitroaniline	8270C	100	40	X
2-Nitrophenol	8270C	100	40	X
3,3'-Dichlorobenzidine	8270C	100	40	X
3,4-Methylphenol	8270C	100	40	X
3-Nitroaniline	8270C	100	40	X
4,6-Dinitro-2-methylphenol	8270C	100	40	X
4-Bromophenyl-phenylether	8270C	20	40	X
4-Chloro-3-methylphenol	8270C	100	40	X
4-Chloroaniline	8270C	20	40	X
4-Chlorophenyl-pheny ether	8270C	20	40	X
4-Nitroaniline	8270C	100	40	X
4-Nitrophenol	8270C	100	40	X
Acenaphthene	8270C	20	40	X
Acenaphthylene	8270C	10	40	X
Anthracene	8270C	100	40	X
Benzidine	8270C	100	40	X
Benzo(a)anthracene	8270C	100	40	X
Benzo(a)pyrene	8270C	100	40	X
Benzo(b)fluoranthene	8270C	100	40	X
Benzo(g,h,i)perylene	8270C	100	40	X
Benzo(k)fluoranthene	8270C	100	40	X
Benzoic Acid	8270C	100	40	X
Benzyl alcohol	8270C	100	40	X
bis(2-Chloroethoxy)methane	8270C	20	40	X
bis(2-Chloroethyl)ether	8270C	20	40	X
bis(2-Chloroisopropyl)ether	8270C	20	40	X
bis(2-Ethylhexyl)phthalate	8270C	20	40	X

Table 2-4. (Continued).				
Parameter	EPA Method	Method Detection Limit (ug/kg)	Allowable Hold Time (days)	Max. Hold Time Achieved (days)
Butylbenzylphthalate	8270C	20	40	X
Chrysene	8270C	100	40	X
Dibenz(a,h)anthracene	8270C	100	40	X
Diethylphthalate	8270C	20	40	X
Dimethylphthalate	8270C	20	40	X
Di-n-butylphthalate	8270C	20	40	X
Di-n-octylphthalate	8270C	20	40	X
Fluoranthene	8270C	20	40	X
Fluorene	8270C	20	40	X
Hexachlorobenzene	8270C	20	40	X
Hexachlorobutadiene	8270C	20	40	X
Hexachlorocyclopentadiene	8270C	100	40	X
Hexachloroethane	8270C	20	40	X
Indeno(1,2,3-cd)pyrene	8270C	100	40	X
Isophorone	8270C	20	40	X
Naphthalene	8270C	10	40	X
Nitrobenzene	8270C	20	40	X
N-Nitrosodimethylamine	8270C	100	40	X
N-Nitroso-di-n-propylamine	8270C	20	40	X
N-Nitrosodiphenylamine	8270C	20	40	X
Pentachlorophenol	8270C	100	40	X
Phenanthrene	8270C	20	40	X
Phenol	8270C	20	40	X
Pyrene	8270C	20	40	X
Pyridine	8270C	100	40	X