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Implementation Plan for Fort Worth Legacy Pollutant TMDLs

For Segments 0806, 0806A, 0806B, 0829, and 0829A

Prepared by the:
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TEXAS NATURAL RESOURCE CONSERVATION COMMISSION

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Implementation Plan for Fort Worth Legacy Pollutant TMDLs

Introduction

In keeping with the Texas commitment to restore and maintain water quality in impaired water bodies, the Texas Natural Resource Conservation Commission (TNRCC) recognized from the inception of the total maximum daily load (TMDL) program that implementation plans would need to be established for each TMDL developed.

The TMDL is a technical analysis that:

(1) determines the maximum loadings of the pollutant a water body can receive and still both attain and maintain its water quality standards, and

(2) allocates this allowable loading to point and non-point source categories in the watershed.

Based on the TMDL, an implementation plan is then developed. An implementation plan is a detailed description of regulatory and voluntary management measures that are intended to achieve the pollutant reductions identified in the TMDL, and a schedule under which the commission anticipates TMDL implementation will proceed. The plan is a flexible tool that governmental and non-governmental agencies involved in TMDL implementation will use to guide their program management. Actual implementation will be accomplished by the participating entities by rule, order, guidance, or other appropriate formal or informal action.

The implementation plan contained herein will provide the following components:

(1) a description of control actions and management measures[1] that generally will be implemented to achieve the water quality target;

(2) legal authority under which the participating agencies may require implementation of the control actions;

(3) development of a schedule for implementing activities to achieve TMDL objectives;

(4) a follow-up surface water quality monitoring plan to determine the effectiveness of the control actions and management measures undertaken;

(5) a statement as to why TNRCC has concluded that the implementation of voluntary management measures will achieve the load allocations for nonpoint sources; and

(6) identification of measurable outcomes TNRCC will review to determine whether the implementation plan has been properly executed and whether water quality standards are being achieved.

[1] Control actions refer to point source pollutant reduction strategies, generally TPDES permits. Management measures refer to nonpoint source pollutant reduction strategies, generally voluntary best management practices.

This implementation plan is designed to guide the achievement of reductions in legacy pollutant concentrations in fish tissue in several Fort Worth water bodies as defined in the adopted TMDLs.

This implementation plan was prepared by:

- the TMDL Team in the Strategic Assessment Division of the Office of Environmental Policy, Analysis, and Assessment of the TNRCC, and
- the Region 4 Office of the Field Operations Division of the Office of Compliance and Enforcement of the TNRCC

Technical assistance was provided by:

- the City of Fort Worth Department of Environmental Management,
- the Seafood Safety Division of the Texas Department of Health, and
- the U.S. Geological Survey.

This implementation plan was approved by the TNRCC on July 13, 2001. This implementation plan, combined with the TMDL, establishes a Watershed Action Plan (WAP). A WAP provides local, regional, and state organizations a comprehensive strategy for restoring and maintaining water quality in an impaired water body. TNRCC has primary responsibility for ensuring that water quality standards are restored and maintained in impaired water bodies.

Summary of TMDLs

The water bodies addressed by the TMDL document *Eleven Total Maximum Daily Loads for Legacy Pollutants in Streams and Reservoirs in Fort Worth* (TNRCC 2000) are portions of two Trinity River segments and three small urban lakes in the City of Fort Worth (see Figure 1). These water bodies were included on the Texas §303(d) List as a result of the issuance of Aquatic Life Orders by the Texas Department of Health (TDH), which prohibit the consumption of fish (Table 1; see TDH 2001). Consumption bans were issued following determinations of unacceptable human health risk due to elevated concentrations of one or more legacy pollutants in fish tissue. Legacy pollutant is a collective term used to describe substances whose uses have been banned or severely restricted by the U.S. Environmental Protection Agency (EPA). Because of their slow rate of decomposition, these substances frequently remain at elevated levels in the environment for many years after their widespread use has ended.

Legacy pollutant contamination in the Trinity River and urban lakes appears to have originated from urban runoff, as the watersheds of these water bodies (Figure 2 and 3) are highly urbanized. Erosion as a result of extensive urban development over the past 10 to 15 years may have contributed contaminants attached to source soil particles.

Table 1. Fort Worth water bodies listed on the 303(d) list due to legacy pollutant concentrations in fish tissue and fish consumption bans by the Texas Department of Health, and endpoint targets necessary to meet the fish consumption use.

Segment	Fish Tissue Contaminants	TDH Action	TMDL Endpoint Targets
0829 - Clear Fork Trinity River Below Benbrook Lake (lower one mile)	Chlordane	01/1990	$\leq$ 1.17 mg/kg chlordane in fish tissue for adults $\leq$ 0.50 mg/kg chlordane in fish tissue for children
0806 - West Fork Trinity River Below Lake Worth (lower 22 miles)	Chlordane	01/1990	$\leq$ 1.17 mg/kg chlordane in fish tissue for adults $\leq$ 0.50 mg/kg chlordane in fish tissue for children
0829A - Lake Como	Chlordane, DDT, Dieldrin, and PCBs	04/1995	additive cancer risk $\leq 2.33 \times 10^{-4}$ cumulative noncarcinogenic hazard index $\leq$ 1
0806A - Fosdic Lake	Chlordane, DDE, Dieldrin, and PCBs	04/1995	additive cancer risk $\leq 2.33 \times 10^{-4}$ cumulative noncarcinogenic hazard index $\leq$ 1
0806B - Echo Lake	PCBs	12/1995	$\leq$ 0.05 mg/kg total PCBs in fish tissue for adults $\leq$ 0.02 mg/kg total PCBs in fish tissue for children
All water bodies	---	---	Removal of fish consumption ban

Because of the particular nature of these TMDLs, the TNRCC modified the typical load allocation approach of more conventional TMDLs, which typically limits the amount of a pollutant that can be added to an impaired water body. Because legacy pollutants are already restricted, and no significant additional loading is expected, the TMDLs do not specifically attempt to quantify allowable loads for these contaminants.

The allowable load is based on acceptable, risk-based fish tissue concentrations. EPA guidance (1997) and TDH assumptions concerning risk levels, consumer body weight, and fish consumption rates were used to develop endpoint targets for tissue contaminant levels that result in an acceptable risk level. The endpoint target of these TMDLs is the reduction of fish tissue contaminant concentrations to levels that constitute an acceptable risk to fish consumers, allowing TDH to remove the bans on fish consumption (Table 1). The ultimate endpoint goal for the affected water bodies is the complete removal of the fish consumption bans.

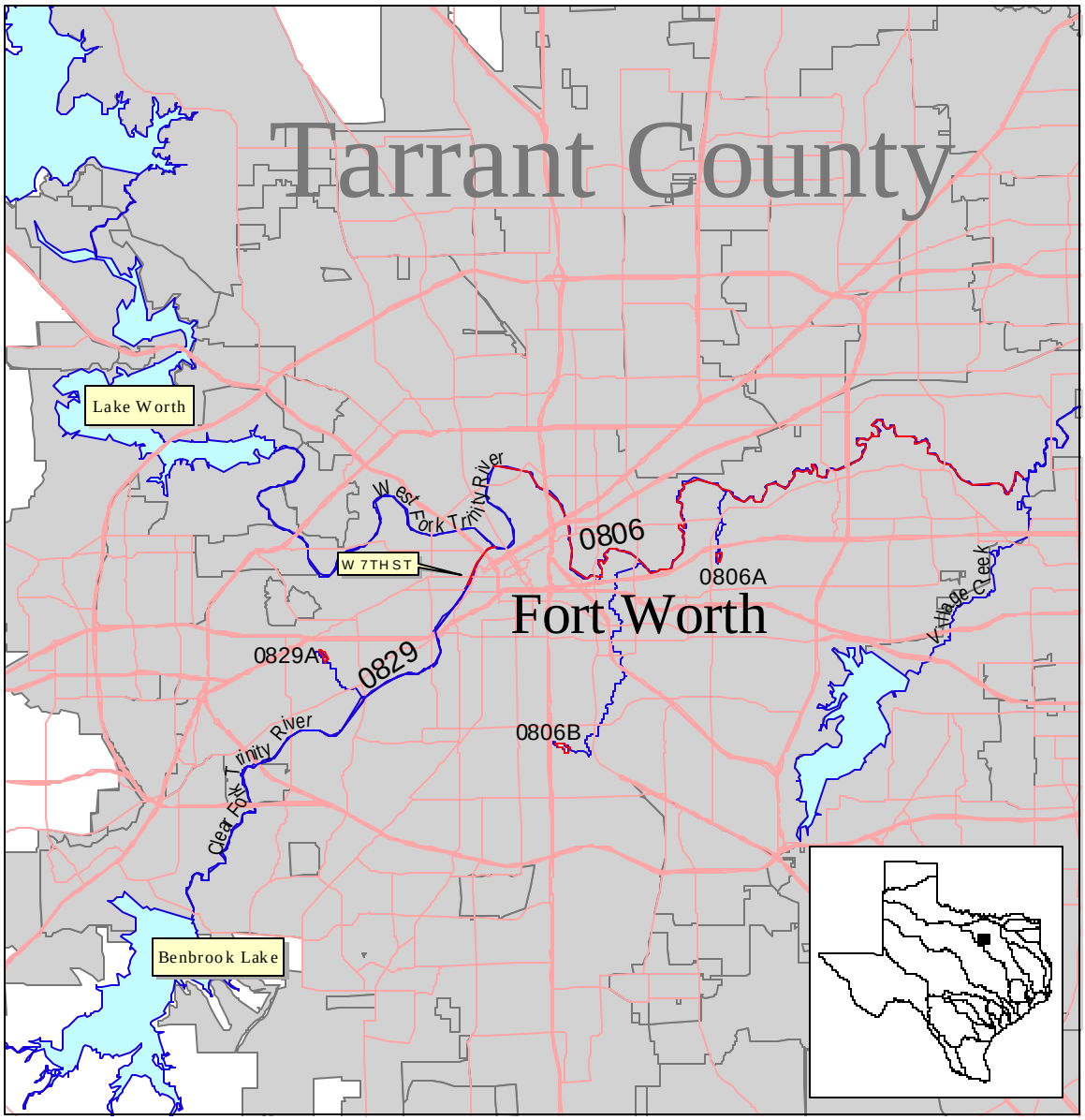

Figure 1. Locations of impaired water bodies
Clear Fork Trinity River (Segment 0829), West Fork Trinity River (Segment 0806), Lake Como (Segment 0829A), Fosdic Lake (Segment 0806A), and Echo Lake (Segment 0806B).

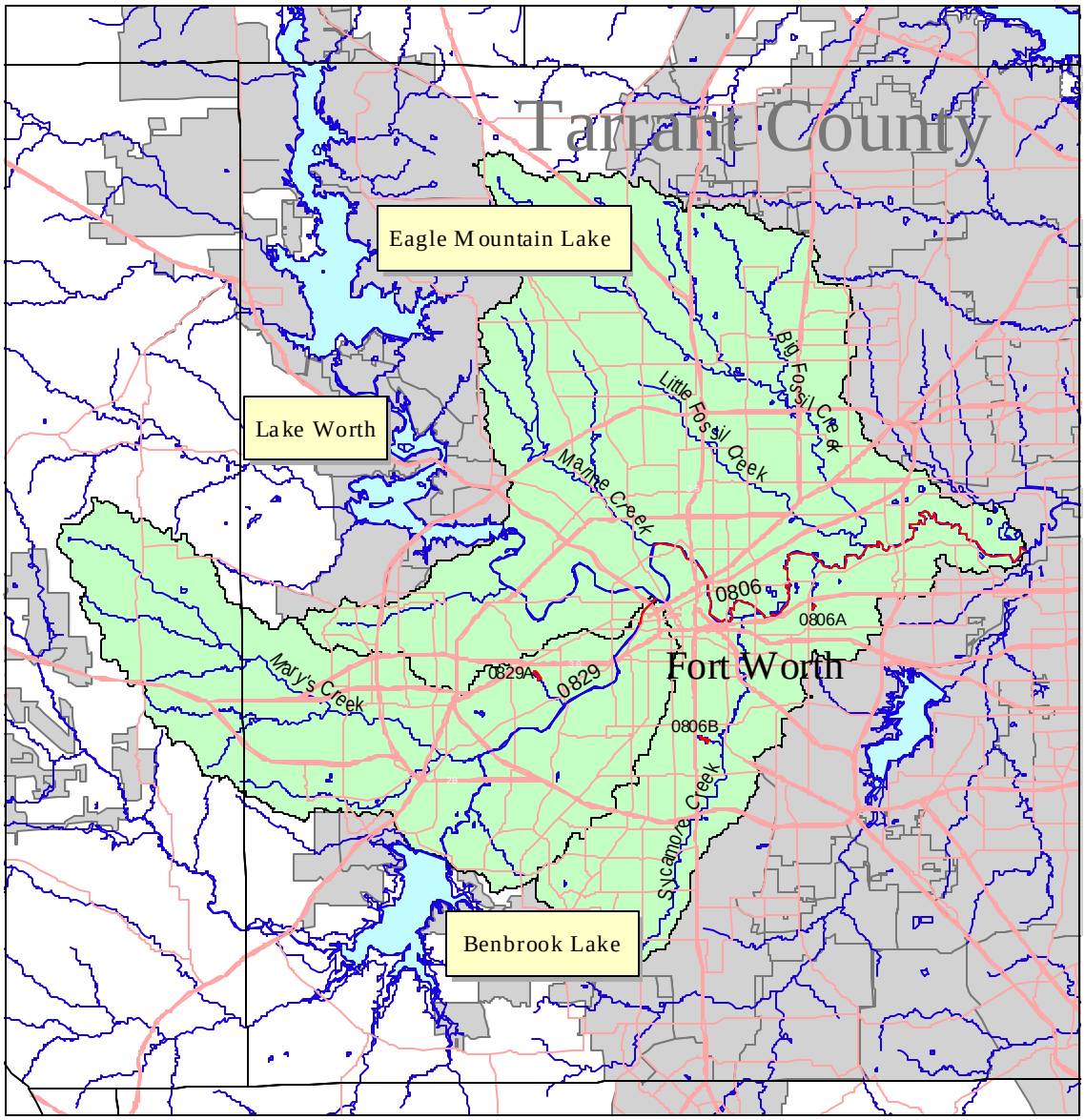

Figure 2. Clear Fork Trinity River (Segment 0829) and West Fork Trinity River (Segment 0806) watershed and major tributaries.
Urban lakes (Segments 0829A, 0806A, and 0806B) are indicated.

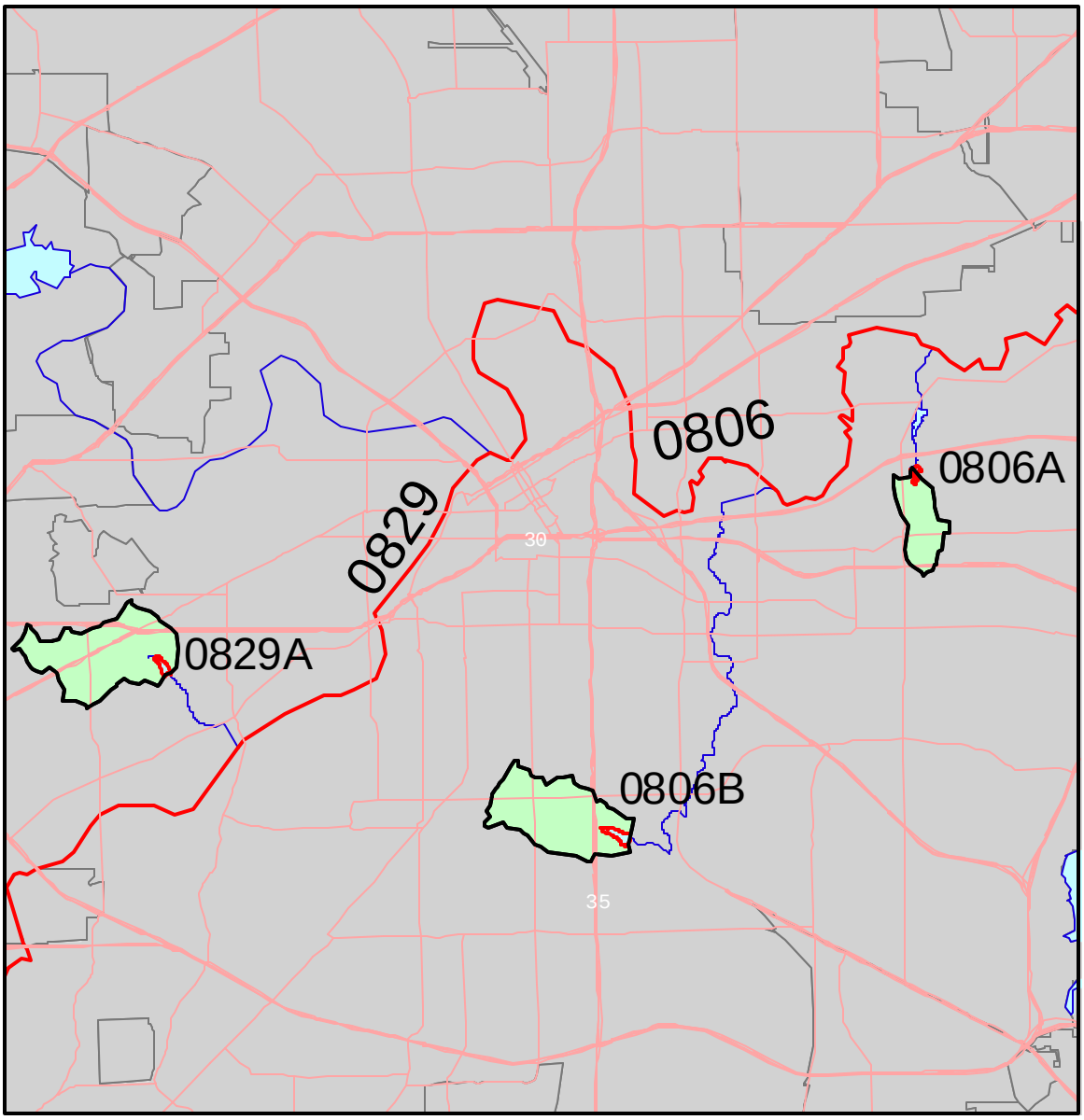

Figure 3. Fort Worth urban lakes and associated watersheds
Lake Como (Segment 0829A), Fosdic Lake (Segment 0806A), and Echo Lake (Segment 0806B).

Control Actions and Management Measures

Gradual declines in environmental legacy pollutant concentrations occur as a result of natural attenuation processes. Legacy pollutants in the Fort Worth water bodies are considered background sources that reflect site-specific application histories and loss rates. Any continuing sources of pollutant loadings occur from nonpoint source runoff, leaching, or erosion of sinks that may exist within the watersheds. No authorized point source discharges of these pollutants are allowed by law.

Available evidence suggests that legacy pollutants are generally declining in the fish tissue of the affected water bodies, and recent samples indicate some pollutant levels may already be less than their endpoint target concentrations (TNRCC 2000; see Reasonable Assurance of Success section of this document). Continuing natural attenuation is expected via degradation and metabolism of the contaminants, burial of contaminated sediment through natural sedimentation in the urban lakes, and scouring and redistribution of sediments in the river.

Although tissue contaminant levels are expected to continue to decline through natural attenuation processes, investigations are underway to address any remaining pollutant loads to these water bodies. As part of a $475,000 grant from the EPA, and as part of the City's storm water monitoring and management program, the City of Fort Worth Department of Environmental Management (FWDEM) is investigating the feasibility of several structural and nonstructural best management practices (BMPs) to address any remaining pollutant inputs (see *Work Plan Summary—Mitigation Options for Urban Lakes Affected by Legacy Pollutants, FWDEM, January 2000*). BMPs under investigation include:

- the use of high-efficiency street sweepers to remove any contaminated soils that have eroded from nearby land;
- storm drain cleaning to remove sediment accumulation that may include eroded contaminated source soils;
- erosion control measures at redevelopment construction sites to prevent the loss of source soils contaminated by previous use of legacy substances;
- focused watershed education and pollutant collection programs intended to remove any remaining legacy substances from continued use in the area;
- sedimentation and filtration structural controls to capture eroded contaminated source soils prior to entry into a water body; and
- lake dredging to remove contaminated bottom sediments.

Depending upon the findings of suspended sediment monitoring by the U.S. Geological Survey (see Monitoring Plan section of this document), FWDEM may collect sediment deposited along street curbs and within the storm sewer system for analysis of legacy pollutants. In areas where sufficient loading has been verified, some of the potential BMPs can be further evaluated through controlled pilot projects. The City will obtain assistance from a consultant to evaluate control structures and lake dredging. Final evaluation of the various BMPs will include

considerations such as attainable pollutant loading reductions, associated environmental benefits, and technical feasibility.

FWDEM has modified Fort Worth Environmental Collection Center (ECC) record-keeping to help identify, quantify, and track the receipt of legacy pollutants in its household hazardous waste collections, in an effort to determine the extent of any recent or current use in the area. The ECC is a permanent year-round facility that accepts household hazardous waste from residents of Fort Worth and 23 other cities in the area. The ECC has periodically received chlordane, suggesting some recent or possible continued use of legacy pesticides in the area.

The TNRCC and the City of Fort Worth will further evaluate the need for, and effectiveness of, the various mitigation and remediation options, including site-specific natural attenuation, based on the results of the BMP evaluation, assessment of ECC records, and the results of the various monitoring efforts described in the Monitoring Plan section of this document. These evaluations will gage the effectiveness of the various options. Decisions concerning the need for and implementation of any additional control actions or management measures, including implementation of selected BMPs, will be further developed as the results of the ongoing studies are known (see Implementation Schedule section of this document).

Legal Authority

TNRCC

Texas statutory provisions require the commission to establish the level of quality to be maintained in, and to control the quality of, water in the state (Texas Water Code (TWC) §26.011). Texas fulfills its obligations under Section 303(d) of the Clean Water Act to list impaired segments and create TMDLs through functions assigned by the legislature to TNRCC. The §303(d) list is prepared by TNRCC as part of its monitoring, planning and assessment duties (TWC §26.0135).

TMDLs are part of the state water quality management plans that TNRCC is charged by statute to prepare (TWC §26.036). As the state environmental regulatory body, the Commission has primary responsibility for implementation of water quality management functions within the State (TWC §26.0136 and §26.127). The Executive Director of the TNRCC must prepare and develop, and the Commission must approve, a comprehensive plan for control of water quality in the state (TWC § 26.012). The list of impaired segments and resulting TMDLs are tools for water quality planning.

Texas Surface Water Quality Standards are contained in Title 30, Chapter 307 of the Texas Administrative Code (30 TAC Chapter 307). TNRCC procedures for implementing the these standards are described in *Implementation of the Texas Natural Resource Conservation Commission Standards Via Permitting* (RG-194, August 1995).

The TNRCC received delegation of the NPDES program from EPA on September 14, 1998, and is authorized to implement the Texas Pollutant Discharge Elimination System (TPDES), the regulatory program to control discharges of pollutants to surface waters. The TPDES program covers all permitting, surveillance and inspection, public assistance, and enforcement regulatory processes associated with waste discharges into or adjacent to any water in the state. This includes discharges of waste from industry and municipal treatment works, and discharges of storm water associated with industrial activities, construction sites, and municipal separate storm sewer systems (MS4s).

No point source wastewater permits currently authorize the discharge of any legacy pollutant into any of the water bodies addressed by these TMDLs. Any necessary regulatory action concerning the discharge of legacy pollutants will be addressed through storm water requirements:

- TNRCC assumed jurisdiction and administration of the EPA Multi-Sector Storm Water General Permit for industrial activities on September 29, 2000. TNRCC is in the process of renewing that permit as TPDES General Permit No. TXRO5000.
- Discharges of storm water associated with construction projects covering five acres or more are currently regulated by EPA under the Phase I Construction Storm Water General Permit. TNRCC will assume jurisdiction and administration of the construction permit by July 7, 2003, and will develop a state permit for renewal.
- Discharges of storm water associated with construction projects one to five acres in size, or smaller than one acre if designated, will be regulated under Phase II of the storm water program. Phase II rules were published by EPA on December 8, 1999, and became effective on December 22, 1999. TNRCC must issue a Phase II Construction General Permit by December 9, 2002. Phase II construction sites must begin obtaining permit coverage within 90 days of permit issuance.
- Discharges of storm water associated with MS4s in cities and counties with populations greater than 100,000 are currently regulated by individual MS4 permits issued by EPA under Phase I of the storm water program. TNRCC will assume jurisdiction upon expiration of each MS4 permit. The City of Fort Worth is the only city in the watershed addressed by these TMDLs that is covered by an individual MS4 permit (No. TXS000901). The Fort Worth permit expires on November 30, 2001, and the City will apply for renewal with the TNRCC.
- Cities and counties with populations less than 100,000 will be regulated under the Phase II storm water rules. TNRCC must designate additional small MS4s, and must issue a Phase II MS4 permit by December 9, 2002. Small MS4s must obtain permit coverage within 90 days of permit issuance. Phase II MS4s will be required to identify BMPs, along with associated measurable goals and implementation schedules, for efforts such as the identification and elimination of illicit discharges, construction site runoff control, and post-construction storm water management in new development and redevelopment areas.

The TNRCC also has the regulatory authority to oversee the cleanup of sites contaminated with industrial and municipal hazardous and solid wastes, although no sites of this type are known to be contributing to the impairment in the water bodies considered in this implementation plan. In general, remediation and closures at solid and hazardous waste facilities must comply with the requirements of 30 TAC Chapter 335, which contains the Risk Reduction Standards, the state cleanup regulations that became effective in June 1993. Remediation and closures initially reported on or after May 1, 2000 must comply with the Texas Risk Reduction Program (TRRP) rules in 30 TAC Chapter 350.

Other State Agencies

The Texas Department of Agriculture (TDA) regulates the agricultural application of pesticides, as directed by Chapter 76 of the Texas Agriculture Code. Non-agricultural application of pesticides is regulated by the Structural Pest Control Board of Texas, as per the Structural Pest Control Act.

Municipalities

The City of Fort Worth has the legal authority to regulate pollutant discharges through the Fort Worth City Code, Chapter 12.5 (Environment Code). Article III (Storm Water Protection) of Chapter 12.5 is administered by the FWDEM, and is the section most applicable to any legacy pollutant releases. Article III prohibits unauthorized discharges to the City storm sewer system. FWDEM is authorized to inspect facilities and conduct sampling. It is a violation of Article III to discharge storm water associated with industrial or construction activities without applicable NPDES or TPDES permit coverage. Violation of a NPDES or TPDES storm water permit is also a violation of the City Environment Code. FWDEM has the authority to require modification of a facility's Storm Water Pollution Prevention Plan if it believes the plan does not comply with permit requirements. Article IV of Chapter 12.5 provides City staff with general inspection authority for all surface water quality matters.

Smaller cities within the Trinity River watershed generally have a city code provision that can be used to address unauthorized discharges. Many of these cities are subject to the Phase II storm water regulations.

Implementation Schedule

Several monitoring and evaluation projects are planned or underway as part of this implementation plan (see Table 2). Additional details of the various monitoring efforts are described in the Monitoring Plan section of this document.

Table 2. Implementation schedule for monitoring and evaluation of potential management measures.

Entity	Activity	Implementation Schedule
U.S. Geological Survey (USGS)	(1) Sediment core collection in three urban lakes	(1) Spring 2001
	(2) Suspended sediment sampling in urban lakes and river segment drainages	(2) Sampling devices are in place; Sampling to begin in Spring 2001
Texas Department of Health (TDH)	(1) Collection of fish for tissue analysis	(1) Trinity River sampling conducted in September 2000; Urban lakes sampling conducted in October 2000 (FWDEM) and March 2001
	(2) Laboratory analyses of fish tissue	(2) September and October 2000 analyses completed; March 2001 urban lakes analyses in progress
	(3) Reassessment of tissue contaminant risk	(3) Trinity River assessment in progress; Urban lakes assessment following receipt of data from both sampling rounds - probably late 2001 to mid-2002
City of Fort Worth Department of Environmental Management (FWDEM)	(1) Provide detailed watershed information to USGS for suspended sediment project	(1) Completed in January 2000
	(2) Collect fish from three urban lakes for tissue analysis (first sample of TDH project)	(2) Completed in October 2000
	(3) Modify Environmental Collection Center record-keeping to track receipt of chlordane and other legacy pollutants	(3) Computer hardware/software purchased in November 2000; Survey and tracking began in February 2001
	(4) Chlordane sampling at a representative urban storm water outfall	(4) Began in March 2001
	(5) Evaluation of potential BMPs	(5) Decision criteria for BMP evaluations currently being developed; BMP evaluations scheduled to begin in early 2002
Texas Natural Resource Conservation Commission (TNRCC)	Evaluation of results of the activities conducted by USGS, TDH, and FWDEM; Coordination and planning with FWDEM for any additional monitoring and/or BMP implementation; See Table 3 for details	Following completion of all scheduled activities and receipt of all resulting data - probably mid to late 2002; Interim meetings and evaluations will be conducted as appropriate; See Table 3 for details

The TNRCC and the U.S. Geological Survey (USGS) have provided funding for a joint investigation that involves comprehensive sediment coring and suspended sediment sampling of the affected water bodies. The quality assurance project plan (QAPP) for this project is currently under review. The major project activities, and the schedule for each, are as follows:

- Urban lakes sediment cores are scheduled for collection in Spring 2001.
- Suspended sediment sampling devices and associated flow gages have been installed and calibrated as described in the Monitoring Plan section of this document. Sample collection is anticipated to begin in Spring 2001.

The TDH has received funding from the TNRCC to conduct fish sampling and tissue analysis on a number of water bodies throughout the state during a two-year period that began in mid-2000. The impaired Trinity River segments and urban lakes are included in this project.

- The TDH collected fish from the Trinity River in September 2000. Tissue analyses have recently been completed. Assessment of both the September 2000 results and data collected in late 1998 is currently underway.
- The FWDEM provided personnel for collection and preparation of fish tissue samples, and nongrant funding for contaminant analyses, for the first phase of sampling in the urban lakes. Fish were collected in late October 2000. Tissue analyses are complete, and the results are discussed in the Reasonable Assurance of Success portion of this document. The TDH conducted the second phase of urban lakes sampling in early March 2001. Tissue analyses are in progress. The TDH will reassess tissue contaminant levels in the urban lakes when all analyses are complete.

As part of a $475,000 grant from the EPA, and as part of the Fort Worth storm water monitoring and management program, the FWDEM is investigating fish tissue contamination, potential pollutant inputs to the impaired water bodies, and the feasibility of BMPs to address any remaining pollutant inputs. Some of these activities are dependent upon the findings of portions of the USGS study outlined above. The major project activities and the schedule for each are as follows:

- Detailed watershed information was provided to the USGS in January 2000 for use in the USGS suspended sediment sampling and source analysis study.
- Fish were collected from the three urban lakes in late October 2000, as part of the TDH sampling effort (see above).
- Hand-held computers and software for use in ECC record-keeping were purchased in November 2000. A digital survey form was created in September 2000, and ECC staff were trained in early 2001. Tracking of the receipt of chlordane and other legacy pollutants began in February 2001.

- Storm water and sampling for chlordane characterization at a representative urban outfall in east Fort Worth began in March 2001, and will be performed six times during 2001.
- Evaluation of the potential BMPs is scheduled to begin in early 2002. Decision criteria for these evaluations are currently under development.

The TNRCC and the City of Fort Worth will further evaluate the need for, and effectiveness of, the various mitigation and remediation options, including site-specific natural attenuation, based on the results of the BMP evaluation, assessment of ECC records, and the results of the various monitoring efforts (see Table 3). Timetables for additional monitoring and/or the implementation of any BMPs, and estimates of the time necessary for restoration of the fish consumption uses, will be further developed as the results of the ongoing studies are known. Interim evaluations will be made as appropriate, with final evaluations to be performed following completion of all ongoing efforts, probably in mid- to late 2002. The following subsections outline a general approach (summarized in Table 3) to possible subsequent actions that will depend upon results of the efforts described above.

Historical Loading Trends

Contaminants in sediment degrade slowly, and may be present for long periods of time (Oliver *et al.* 1989; Rhee *et al.* 1993; Sokol *et al.* 1998; EPA 1999). Van Metre *et al.* (1998) analyzed sediment core samples from 11 reservoirs, and determined mean sediment half-lives of 7.7 to 17 years for chlordane, 13 $\pm$ 5.8 years for total DDT, and 9.5 $\pm$ 2.2 years for PCBs. Contaminant levels in lake sediment cores have shown good agreement with production and usage histories of the parent compounds, with peak concentrations appearing at the times of peak use (Ricci *et al.* 1983; Oliver *et al.* 1989; Van Metre and Callender 1997; Van Metre *et al.* 1998; Ging *et al.* 1999). Higher concentrations generally appeared deeper in the cores, indicating that input and accumulation were decreasing with time.

If historical trends determined from sediment cores indicate recent or continuing contaminant input to any of the Fort Worth urban lakes, additional investigation will be needed to isolate sources. Suspended sediment data and ECC tracking results will be evaluated to identify current source areas. Additional suspended sediment sampling will be performed, if necessary, to further isolate the source(s). If the USGS evaluations indicate unexpectedly large concentrations, the need for dredging will also be considered.

Concentrations of pesticide residues and PCBs in surface sediments collected from the urban lakes in May 1999 were less than the detection limits (TNRCC 2000). These results suggest that there has been no recent contaminant input to the lakes, and that any remaining contaminated sediments have been buried. Although residues can continue to persist in the deeper parts of sediment cores, burial by more recently deposited sediments may result in effective removal of the contaminants from bioavailability to aquatic life (Ricci *et al.* 1983).

Table 3. Evaluation outline for any subsequent actions found to be necessary based on the results of ongoing monitoring and related studies.
Any subsequent activities will be coordinated by TNRCC and FWDEM. See text for additional details.

Activity	Results	Subsequent Action
(1) Historical pollutant trends determined from urban lakes sediment cores (USGS)	(a) No substantial recent input - any existing pollutants in deeper layers of sediment (b) Pollutant concentration and depth in core suggests recent or continuing input	(a) Evaluate within framework of USGS conclusions - no additional action is likely to be necessary (b) Evaluate within framework of USGS conclusions and BMP evaluations: (i) Use suspended sediment data and ECC tracking results to identify current source(s) (see Activity 2 and 4) (ii) Evaluate need for dredging
(2) Current pollutant loading trends determined from suspended sediment sampling (USGS)	(a) No significant current input of legacy pollutants (b) Significant current loading of legacy pollutant(s) is detected	(a) No additional action necessary (b) (i) Use existing data and ECC tracking results to identify source area(s) to extent possible (ii) Plan and implement additional sampling as necessary to further isolate source(s) (iii) Address existing or potential source(s) with appropriate BMP(s) and/or regulatory action
(3) Fish tissue contaminant concentrations (TDH)	(a) Removal of consumption ban by TDH due to reduction of tissue contaminant concentrations (b) Consumption ban remains in effect, but trend in reduction of tissue contaminant concentrations is evident (c) No evidence of reduction in tissue contaminant concentrations based on samples collected in 2000-2006	(a) No action necessary other than follow-up tissue sampling five years after removal of the ban (b) (i) Continue tissue monitoring every five years to verify continuing contaminant reductions (ii) Conduct follow-up tissue monitoring five years after endpoint target is achieved and ban is removed (c) (i) Continue addressing pollutant sources and monitoring fish tissue (ii) Reevaluate TMDL time frames and need for additional approaches
(4) ECC legacy pollutant survey (FWDEM)	(a) No substantial receipt of legacy substances (b) Continued receipt of legacy substances	(a) No additional action necessary (b) Public education program (targeted to any source area that can be identified)

Current Pollutant Loading

Numerous studies have documented the long-term persistence of organochlorine pesticides and their degradation products in soil. Pesticide residue concentrations in soils can span several orders of magnitude, and are a reflection of application history and loss rates (Lichtenstein *et al.* 1971; Harner *et al.* 1999). Degradation rates of organochlorine residues are highly variable, and soil half-lives of as much as 20 to 35 years have been reported (Nash and Woolson 1967; Dimond and Owen 1996; Mattina *et al.* 1999).

The release of pollutants from undisturbed soils is not generally a major problem. Mattina *et al.* (1999) examined an experimental site 38 years after chlordane application, and found vertical and horizontal movement to be minimal. Bennett *et al.* (1974) observed little lateral movement of chlordane and dieldrin residues 21 years after application, except in areas that had experienced erosion. The primary method of transport of legacy pollutants into aquatic systems is by erosion of soil and attached contaminants (Munn and Gruber 1997).

If suspended sediment sampling data indicate continuing contaminant input to any of the affected water bodies, additional sampling will be performed as necessary to further isolate source areas. Additional suspended sediment sampling will be planned and performed through a contract with the USGS, with input and/or participation by the FWDEM. Identified sources will be addressed by the most appropriate BMPs (based on evaluations conducted by the FWDEM) and/or regulatory actions.

Fish Tissue Contaminant Concentrations

A large number of factors associated with fish physiology, environmental conditions, and the form of the contaminant have been found to influence contaminant elimination from fish tissue (see literature surveyed in TNRCC 2000). The time necessary for elimination is both long and variable. Schnoor (1981) calculated a dieldrin decrease of 15 percent per year in reservoir fish tissue. Half-lives for DDT, DDE, and PCBs in lake trout have been estimated at 9 to 10 years (see Borgmann and Whittle 1992; Van Metre *et al.* 1998). Long-term field studies have found that elimination rates are considerably longer than those measured in laboratory studies (de Boer *et al.* 1994; Delorme *et al.* 1999).

The endpoint target of these TMDLs is the reduction of fish tissue contaminant concentrations to levels that constitute an acceptable risk to fish consumers, allowing the TDH to remove the bans on fish consumption. If fish tissue data collected in 2000-2001 indicate that endpoint targets have been reached in a given water body, follow-up sampling will be conducted in 2006 to verify that tissue contaminants remain at acceptable levels. The TDH may choose to conduct additional monitoring in any of the water bodies at any time.

If fish tissue data collected in 2000-2001 indicate that endpoint targets have not yet been reached in a water body, it will be necessary to continue tissue monitoring. Additional tissue sampling may be the only step necessary if the tissue data indicate a clear trend in the reduction

of tissue contamination. Because the natural attenuation of legacy pollutants occurs gradually, collection and analysis of fish tissue on a five-year cycle beginning in 2006 should be adequate to track continuing declines and allow for periodic reassessment of consumption risk by the TDH. Tissue sampling will be performed by the TDH, or by another entity such as the FWDEM and/or the Trinity River Authority (TRA) through an arrangement with the TDH. Sampling will continue on this schedule until endpoint targets have been reached and the consumption bans removed. Follow-up sampling will be conducted approximately five years later to verify that tissue contaminants remain at acceptable levels. As in the above case, the TDH may choose to conduct additional monitoring in any of the water bodies at any time.

Decreases in fish tissue concentrations of organochlorine insecticides and PCBs have been observed where no major additional inputs are occurring (see Moore and Ramamoorthy 1984; Brown *et al*. 1985; Bremle and Larsson 1998). Available fish tissue data from the Fort Worth water bodies indicate that legacy pollutant concentrations are decreasing as a result of natural attenuation processes (see Reasonable Assurance of Success section of this document). If tissue samples collected in 2000-2006 indicate no reduction of contaminants in a water body, reevaluation of the TMDL approach will be required for that situation.

Environmental Collection Center Records

If Fort Worth ECC records indicate the continued receipt of chlordane or other legacy pollutants, some level of public education effort will be warranted to encourage the cessation of any continuing use of legacy substances and the proper disposal of any existing stocks. The effort can be targeted to specific neighborhoods if the data allow source determination on that level.

Monitoring After Additional Action

Subsequent remediation of source(s), implementation of BMPs, institutional controls, or other regulatory or enforcement activities will be dependent upon the nature of the source(s). Additional monitoring may be necessary to assess the adequacy of any of these additional efforts. The TNRCC and the FWDEM will cooperate in planning this assessment monitoring when a decision is made to take a particular action in a designated location. This monitoring may include fish tissue and/or suspended sediment sampling.

Restoration of Fish Consumption Use

The results of current monitoring efforts, and any subsequent need to implement one or more additional activities, will likely affect any estimates of the time necessary for restoration of the fish consumption use to these water bodies. Given the current knowledge of fish tissue contaminant concentrations and potential existing environmental reservoirs of legacy pollutants, restoration of the fish consumption use in these water bodies is expected within the next ten years.

Findings of the ongoing monitoring efforts and reassessment of tissue contaminant risk by the TDH may require revision of this estimate. The most recent urban lakes data suggest a time frame less than ten years for those water bodies. Although chlordane concentrations show evidence of a decline in Trinity River fish, concerns over PCB concentrations in fish tissue collected in 1998 and 2000 may result in an extension of the fish consumption ban on one or more of those segments (see Reasonable Assurance of Success section of this document). The time frame for restoration of the fish consumption use in the Trinity River may increase as a result.

Monitoring Plan

The TNRCC is continuing a variety of efforts to (1) determine if any current loading is occurring, (2) refine the estimates of any current loading, and (3) verify decreasing pollutant loading and tissue concentration trends. As noted previously in this document, the TNRCC and the USGS have provided funding for a joint investigation that is using a comprehensive sediment coring and suspended sediment sampling program to describe historical trends in the occurrence of legacy pollutants in the impacted segments of the Trinity River and the urban lakes. These efforts are designed to determine the existence and identity of any existing source of pollutants, and to estimate current loading rates of legacy pollutants. The USGS study includes the following major activities (Draft *Legacy Pollutants in Dallas-Fort Worth Urban Lakes and Rivers, FY2000-01 Project Proposal, 28 December 1999*; Draft Project QAPP):

- Historical trends in the occurrence of legacy pollutants will be determined from sediment cores collected from each of the urban lakes (see Van Metre and Callender 1997; Van Metre *et al.* 1998). Cores will be collected from three locations (downstream near dam, mid-lake, and upstream end) in each lake. The volume of existing lake sediment will be determined through collection of additional core samples and use of a sediment probe. An approximate mass balance on past contaminant loading to each lake will be determined, and the yield of each contaminant from the watershed will be calculated.
- The USGS will determine any current legacy pollutant loading trends to the urban lakes through sampling of incoming suspended sediment during four storm events. Automatic large-volume suspended sediment sampling devices and stream gages have been installed on the main creek channel immediately upstrem from each of the urban lakes. Flow-weighted composite samples will be collected when flow reaches a predetermined height, and will continue at predetermined time intervals over the storm hydrograph. A passive suspended sediment sampler has also been installed on a smaller creek that flows into Lake Como, where samples will be collected during four storm events.
- Five passive suspended sediment samplers have been installed on large urban storm water inflows into the Clear Fork Trinity River (Segment 0829). Three storm events

will be sampled to evaluate the occurrence of legacy pollutants, and to determine if sampling is needed at additional sites.

- Automatic sampling devices have been installed on three major tributaries to the West Fork Trinity River (Segment 0806) (see Figure 2). One sampler was installed at an existing stream gaging site on Sycamore Creek, where six discrete samples will be collected during each of two runoff events. Flow-weighted composite samples will be collected and analyzed for an additional three runoff events. Automatic samplers and flow gages were installed on Big Fossil Creek and Little Fossil Creek, where composite samples will be collected during four storm events. Passive suspended sediment samplers have been installed at two additional locations on Segment 0806, where a single sample will be collected during each of three storm events. The data will be used to determine the occurrence and loading of legacy pollutants at the tributary sites, and occurrence at the passive sampler sites.

Suspended sediment samples will be filtered, and the sediment analyzed for legacy pollutants. Suspended sediment sampling devices have been installed, and a project QAPP is currently under review. Sample collection is expected to begin in Spring 2001. The current contract for this project is scheduled to end on August 31, 2001. An extension may be necessary to allow adequate time for all planned sampling to be completed.

The TNRCC is cooperating with the TDH and the City of Fort Worth to monitor fish tissue in the impaired water bodies. Tissue monitoring is intended to better define the extent and severity of the impairments, establish spatial and temporal trends in fish tissue contamination, and monitor the reduction of tissue concentrations to levels that allow removal of the fish consumption bans. The TDH has received funding from the TNRCC to conduct fish tissue sampling on a number of water bodies throughout the State during a two-year period that began in mid-2000.

- Fish were collected from several locations within the impaired Trinity River segments in September 2000. Tissue analyses were recently completed. Assessment of both the September 2000 results and data collected in late 1998 is currently underway.
- The FWDEM provided personnel for collection and preparation of fish tissue samples, and nongrant funding for contaminant analyses, for the first phase of sampling in the urban lakes. Fish were collected in late October 2000. Tissue analyses are complete, and the results are discussed in the Reasonable Assurance of Success portion of this document. The TDH conducted the second phase of urban lakes sampling in early March 2001. Tissue analyses are in progress. The TDH will reassess tissue contaminant levels in the urban lakes when all analyses are complete.

As part of a grant from the EPA, and as part of the Fort Worth storm water monitoring and management program, the FWDEM is investigating tissue contamination levels and potential existing pollutant inputs to the impaired water bodies. The City study includes the following

activities (*Work Plan Summary - Mitigation Options for Urban Lakes Affected by Legacy Pollutants, FWDEM, January 2000*):

- The FWDEM provided personnel for collection and preparation of fish tissue samples from the three urban lakes, and nongrant funding for contaminant analyses, for the first phase of the TDH fish sampling project (see above). Fish samples for this portion of the project were collected in late October 2000.
- Based on the findings of the USGS work, the FWDEM may conduct additional suspended sediment sampling at the USGS sites or at additional sites to further isolate any pollutant source. In addition, samples of deposited sediments in selected storm drains may be collected to help identify areas to be used to help evaluate the effectiveness of BMPs (see Control Actions and Management Measures in this document). The FWDEM may also conduct soil sampling around selected homes built prior to the 1988 chlordane ban to determine if legacy pollutant reservoirs exist as a result of past application practices. This data will assist in the evaluation of the potential for pollutant transport during land disturbance during redevelopment, and assist in the evaluation of BMPs.
- The FWDEM is adding chlordane to the analyses conducted on storm water samples collected six times per year from an outfall near Eastern Hills High School, approximately 1.5 miles east of Fosdic Lake. The outfall is used as part of an ongoing storm water monitoring and characterization program, and drains an area that is primarily residential and public school land use. The information will assist in characterizing the chlordane content of runoff from a representative urban site, and may be useful in the evaluation of BMPs.
- The FWDEM has developed a project to study and track the receipt of chlordane and other legacy pollutants at the Fort Worth ECC. Records and a user survey will be used to identify, quantify, and track the receipt of legacy pollutants to determine the extent of any recent or current use.

The TNRCC and the City of Fort Worth will further evaluate the need for additional monitoring activities based on the results of the various ongoing studies. The necessary extent of any additional monitoring will be developed as the results of the TNRCC/ USGS, TDH, and FWDEM projects are known (see Implementation Schedule section of this document). The TDH may also choose to conduct additional fish tissue monitoring in any of the water bodies at any time.

- If sediment coring or suspended sediment sampling data indicate continuing contaminant input to a water body, additional suspended sediment sampling will be needed to isolate and delineate the source area(s). Additional sampling will be planned and performed through a contract with the USGS, with input and/or participation by the FWDEM.

- If fish tissue data collected in 2000-2001 indicate that endpoint targets have been reached in a given water body, follow-up sampling will be conducted in 2006 to verify that tissue contaminants remain at acceptable levels. Tissue sampling will be performed by the TDH, or by another entity such as the FWDEM and/or the TRA through an arrangement with the TDH.
- If fish tissue data collected in 2000-2001 indicate that endpoint targets have not yet been reached in a water body, additional tissue monitoring will be conducted on a five-year cycle beginning in 2006 to track contaminant declines and allow for periodic reassessment of consumption risk by the TDH. Tissue sampling will be performed by the TDH, or by another entity such as the FWDEM and/or the TRA through an arrangement with the TDH. Sampling will continue on this schedule until endpoint targets have been reached and the consumption ban removed. Follow-up sampling will be conducted approximately five years after removal of the consumption ban to verify that tissue contaminants remain at acceptable levels.
- Additional monitoring may be necessary to assess the adequacy of any subsequent source remediation, BMP implementation, or regulatory activities that are undertaken. This monitoring may include fish tissue and/or suspended sediment sampling, and will be coordinated with the FWDEM.

Reasonable Assurance of Success

Restrictions on the use of legacy pollutants generally have resulted in a slow but steady decline in environmental residues (Smith *et al.* 1988). Reconstructed contaminant trends in lake sediment cores have shown good agreement with production and usage histories of the parent compounds, with peak concentrations appearing at the times of peak use (Ricci *et al.* 1983; Oliver *et al.* 1989; Van Metre and Callender 1997; Van Metre *et al.* 1998; Ging *et al.* 1999). Higher concentrations generally appeared deeper in the cores, indicating that input and accumulation were decreasing with time. Although residues continue to persist in deeper parts of the cores, burial by more recently deposited sediments may result in effective removal of the contaminants from bioavailability to aquatic life (Ricci *et al.* 1983).

Decreases in fish and human tissue concentrations of organochlorine insecticides and PCBs have been observed where no major additional inputs are occurring (see Moore and Ramamoorthy 1984; Brown *et al.* 1985; Hovinga *et al.* 1992; Bremle and Larsson 1998; Schiff and Allen 2000). Reviews of tissue data collected from a variety of water bodies in northern Europe between 1967 and 1995 have found a significant decrease in organochlorine concentrations over time (Skåre *et al.* 1985; Bignert *et al.* 1998). Total DDT and PCB concentrations showed annual decreases of 6.2 to 12 percent and 3.6 to 13 percent, respectively over this time period. Fish tissue concentrations of total DDT, chlordane, and dieldrin have declined across the U.S. since uses of these substances were discontinued (Schmitt *et al.* 1990; USGS 2000). The DDE component of total DDT has increased as a result of continued degradation. Total chlordane levels were stable, although a shift from the

cis- to the *trans*- isomer between the mid-1970s and mid-1980s suggested a smaller influx of chlordane to the environment (Schmitt *et al.* 1990).

Declining tissue DDT and PCB concentrations have been reported in various locations and fish species in the Great Lakes (Scheider *et al.* 1998). Wszolek *et al.* (1979) found that DDE had decreased considerably from 1970 levels in a similar age group of fish. DDT concentrations in Lake Michigan and Lake Superior fish decreased steadily, to approximately 10 to 25 percent of 1969 levels by the late 1970s (see Bierman and Swain 1982). DDT and PCB concentrations in Lake Ontario spottail shiners in 1987 were significantly reduced from 1975 levels (Suns *et al.* 1991). Chlordane residues were near the detection limit in the shiner samples.

Total PCB concentrations in Lake Michigan fish declined, and then appeared to stabilize in the 1980s as a result of the large pools of PCBs that are being recycled in the environment (Stow *et al*. 1995). Modeling results indicate that PCBs in Lake Michigan salmonids will continue to decline very slowly over the next decade (Lamon *et al.* 1998). Lake Ontario lake trout PCB levels have been declining at a half-life of approximately ten years, although concentrations in two other species have not declined appreciably (see Borgmann and Whittle 1992). Less consistent trends in tissue PCB levels may be a reflection of the congener-specific nature of PCB metabolism and degradation. The pattern of decline in total PCBs may be dominated by declines in the less chlorinated congeners (Brown *et al.* 1985). In addition, strong oscillations in PCB levels influenced by food web interactions can be superimposed on a gradual decline (see Borgmann and Whittle 1992).

Continuing decreases in environmental legacy pollutant levels are expected, although the necessary time frame is subject to debate. In addition to degradation and biotransformation of compounds, there may also be a shift towards the atmosphere in the overall partitioning of some organochlorines (see Jones and de Voogt 1999; Gevao *et al.* 2000). Although residues may continue to persist in deeper sediments, burial by more recently deposited sediments may result in effective removal of the contaminants from bioavailability to aquatic life (Bopp *et al.* 1982; Ricci *et al.* 1983). Contaminants can also become so strongly attached to sediment particles over time that bioavailability may decline as a result. Severe extraction procedures used during analysis may not always reflect actual availability to biota (see Jones and de Voogt 1999).

Trinity River

Available sediment and fish tissue data from the Fort Worth water bodies indicate that legacy pollutant concentrations are decreasing as a result of natural attenuation processes. Chlordane concentrations in Trinity River sediment declined between 1974 and 1993 (see discussion in TNRCC 2000), thus removing a significant source of potentially bioavailable contamination. Surface sediment samples collected from the three urban lakes in May 1999 had concentrations of DDT, DDD, DDE, dieldrin, and seven PCB congeners less than the detection limits (0.0007 mg/kg for pesticides and 0.02 mg/kg for PCBs) in all three lakes (TNRCC 2000). The data suggest that there have been no recent contaminant inputs to the lakes, and that any remaining contaminated sediments are being buried, thus reducing bioavailability.

Fish tissue data collected from the impacted Trinity River segments by various entities is available for several dates and locations. These samples frequently consisted of a relatively small number of fish, and species collections most often included largemouth bass and/or one or more of the bottom-feeding common carp, smallmouth buffalo, and blue catfish. Fillet samples from individual fish were used by TDH for risk analysis, and are recommended for making decisions on consumption advisories and bans (EPA 1995). Mean contaminant levels for each sample date and location were calculated using the individual fish fillet data, to see if any trends were apparent in tissue concentrations. There is evidence of a decline in chlordane tissue concentrations along Segments 0829 and 0806 (Table 4), although the amount of data was generally limited.

Table 4. Mean and range of chlordane fish tissue (fillet) concentrations (mg/kg) through time at Trinity River locations in Fort Worth.
N = number of fish. nd = less than detection limit. na = not applicable. Raw data were obtained from Kleinsasser and Linam (1989), Texas Department of Health (*Fish Tissue Sampling Data 1970-1997* and unpublished 11/1998 data), and Texas Parks & Wildlife Department (unpublished data).

Sample Month/Year ===>			01-04/1988	10/1990	07/1996	11/1998
Segment	**Sample Location**		**Fish Tissue Concentration (mg/kg)**			
0829	Clear Fork Trinity at Purcey Drain	N Mean Range	1 0.780 ---	3 0.03 0.02-0.05	4 0.14 0.03-0.36	na
0806	West Fork Trinity between Beach Street and Riverside Drive	N Mean Range	na	na	na	10 0.13 nd-0.37
0806	West Fork Trinity at East Loop 820	N Mean Range	na	5 0.13 nd-0.28	3 0.03 nd-0.06	na

The most recently available data in Segment 0829 is from July 1996. The Purcey Street drain location in Segment 0829 shows a sharp decline from early 1988 (a single gizzard shad at 0.780 mg/kg) to the 1990 and 1996 sample means (0.03 and 0.14 mg/kg, respectively). Although the mean (0.14 mg/kg) and the maximum (0.36 mg/kg) in 1996 are greater than those of 1990 (0.03 and 0.05 mg/kg), all are less than the smallest TMDL endpoint target for chlordane in both Trinity River segments (0.50 mg/kg for children; TNRCC 2000). The Purcey street drain is the storm water outfall for much of downtown Fort Worth, and is located in the middle of the impacted portion of Segment 0829.

Sample collections near Loop 820 in Segment 0806 in 1990 and 1996 show a decline in the mean chlordane level from 0.13 to 0.03 mg/kg (Table 4). The maximum concentration also declined from 0.28 to 0.06 mg/kg. The samples consisted of five and three fish in 1990 and 1996, respectively, and included smallmouth buffalo, blue catfish, and a freshwater drum. A

more recent sample of ten fish was collected in late 1998 at a location between Beach Street and Riverside Drive, just east of downtown Fort Worth and upstream from the Loop 820 location. The mean and maximum chlordane concentrations (0.13 and 0.37 mg/kg, respectively) were similar to the 1990 Loop 820 values. All of these values are less than the smallest endpoint target for chlordane in both Trinity River segments (0.50 mg/kg for children; TNRCC 2000).

In January 2001, the TNRCC received a draft TDH risk assessment of tissue data from thirty fish collected at three sites along the Trinity River in November 1998 (TDH 2000). The three sample locations included the West Fork Trinity River at Riverside Drive, in Segment 0806 in east Fort Worth. The other sites lie within the impacted portion of two downstream segments (0841 and 0805). Chlordane concentrations ranged from less than the detection limit (0.01 mg/kg) to a maximum of 0.84 mg/kg. The average chlordane concentration (0.136 mg/kg) is less than the smallest TMDL endpoint target for chlordane in both Trinity River segments (TNRCC 2000).

The draft assessment (TDH 2000) states that the average concentrations of all contaminants (including chlordane) in fish collected in November 1998 were less than their respective cancer risk values. Concentrations of chlordane were also less than the noncarcinogenic risk level. Although the assessment does not propose to remove the fish consumption ban due to concerns associated with PCB concentrations, the data provide additional evidence of declining tissue chlordane concentrations as a result of natural attenuation. Preliminary data from the September 2000 sampling suggests a condition similar to that observed in 1998 (TDH staff, personal communication).

Urban Lakes

Fish tissue data is also available for the Fort Worth urban lakes for three to four dates between late 1994 and late 2000. Fish sample sizes from the urban lakes are generally larger than those in the Trinity River, particularly for samples collected in May 1999, providing more confidence in the apparent trends. Decreases in tissue contaminant concentrations through time are evident in all three lakes (see Table 5).

Sample data is available for Lake Como and Fosdic Lake from 1994, 1997, 1999, and 2000. Mean and maximum chlordane levels declined dramatically in Lake Como from 1994 (1.78 mg/kg mean and 2.90 mg/kg maximum) to 2000 (0.017 mg/kg mean and 0.03 mg/kg maximum). Similar decreases in mean and maximum values were observed for dieldrin, DDE, and PCBs (Table 5). Tissue concentrations of dieldrin, DDE, and seven PCB congeners were less than the detection limit in all Lake Como fish collected in October 2000.

Decreases in the mean and maximum chlordane, dieldrin, DDE, and PCB tissue concentrations are apparent across the four sample periods in Fosdic Lake (see Table 5). Mean chlordane declined from 0.350 to 0.004 mg/kg between 1994 and 1999. Confidence in this trend is supported by a May 1999 sample size of 18 fish (six largemouth bass, four redear sunfish, and

eight black bullhead). A downward trend is apparent for all contaminants. Tissue concentrations of dieldrin and seven PCB congeners were less than the detection limit in all Fosdic Lake fish collected in October 2000.

Table 5. Mean and range of contaminant fish tissue (fillet) concentrations (mg/kg) through time at three Fort Worth urban lakes.
N = number of fish. na = not applicable. Raw data were obtained from the Texas Department of Health (*Fish Tissue Sampling Data 1970-1997*) and the City of Fort Worth (unpublished data).

		Sample Month/Year				
		08/1994	04/1995	09/1997	05/1999	10/2000
Lake Como	N	4	na	5	7	5
Chlordane	Mean Range	1.78 1.00-2.90	na	0.665 0.371-0.849	0.02 0.01-0.04	0.017 <0.010-0.030
Dieldrin	Mean Range	0.074 0.034-0.160	na	0.05 0.017-0.129	0.03 0.01-0.06	<0.006 <0.006
DDE	Mean Range	0.107 0.085-0.130	na	0.002 <0.00005- 0.011	0.06 0.01-0.1	<0.005 <0.005
PCBs	Mean Range	0.220 0.150-0.340	na	na	0.23 <0.20-0.30	<0.040 <0.040
Fosdic Lake	N	1	na	6	18	5
Chlordane	Mean Range	0.350 na	na	0.165 0.032-0.437	0.004 <0.0004-0.01	0.037 0.024-0.060
Dieldrin	Mean Range	0.013 na	na	0.008 <0.0002-0.037	0.002 <0.001-0.006	<0.006 <0.006
DDE	Mean Range	0.054 na	na	0.008 <0.00005- 0.031	0.005 <0.0004-0.01	0.04 <0.050-0.062
PCBs	Mean Range	0.190 na	na	na	<0.04 <0.04	<0.040 <0.040
Echo Lake	N	na	8	na	12	5
PCBs	Mean Range	na	0.252 0.05-1.20	na	0.053 <0.04-0.21	<0.040 <0.040

Echo Lake was sampled in 1995, 1999, and 2000 (Table 5). The mean and maximum PCB concentrations decreased from 0.252 and 1.20 mg/kg, respectively in 1995, to less than 0.040 mg/kg in all Echo Lake fish collected in October 2000.

Current Investigations and Subsequent Action

The available evidence suggests that legacy pollutants are generally declining in both the surface sediments and the fish tissue of the affected water bodies. Continuing natural attenuation of these pollutants is expected via continuing degradation and metabolism of the contaminants, burial of contaminated sediment through natural sedimentation in the urban lakes, and scouring and redistribution of sediments in the river.

The TNRCC/USGS investigation is using a comprehensive sediment coring and suspended sediment sampling program to describe historical trends in the occurrence of legacy pollutants in the affected water bodies, and to determine the existence and identity of any existing source of pollutants (see Monitoring Plan section of this document for details). The use of sediment coring and high volume suspended sediment sampling and analysis has proven to be an effective approach to identifying and quantifying the source of legacy pollutants in other water bodies in the state, most recently in the Donna Reservoir and Canal system in south Texas.

In 1999 and 2000, the USGS and the TNRCC conducted a series of high volume suspended sediment sampling events in the Donna Canal, and collected sediment core samples from the Donna Reservoir (see *USGS Final Progress Memorandum: Investigation of PCBs on Suspended Sediment in Donna Canal, Texas, December 15, 2000*). The results yielded significant detections of PCBs in suspended sediment at specific sampling points in the canal. The PCBs in suspended sediment showed a decreasing trend in concentration in a downstream direction from the highest detectable PCB value. Through the combined use of sediment coring and suspended sediment analysis, the location of the source of PCBs in the Donna system was narrowed from within a total length of eight miles to a 75-meter reach of the canal.

If sediment coring and suspended sediment sampling identify a current source to any of the Fort Worth water bodies, implementation of one or more BMPs may be appropriate. Furthermore, delineation of potential source areas in a manner similar to that of the Donna Canal will help optimize the implementation of selected BMPs. Many of the BMP options being examined by the FWDEM have been successful in mitigating pollutant releases in situations similar to that in Fort Worth (NCTCOG 1993, 1999; WEF and ASCE 1998). Evaluation by the FWDEM will determine which will be most successful in this particular case should it be necessary to implement one or more of these measures. The City of Fort Worth storm water program provides a mechanism for implementing many of the potential BMPs . More drastic alternatives, such as dredging and/or the eradication of contaminated fish communities and restocking, have also been successful in restoring a fish consumption use (O'Meara *et al.* 2000); however, this approach is better justified at heavily contaminated sites impacted by point source discharges and major spills due to its expense and accompanying environmental concerns.

Measurable Outcomes

The following outcomes will denote the attainment of various implementation steps:

(1) Completion of urban lakes sediment core project
   (a) core sampling and laboratory analyses
   (b) data analysis and reconstruction of historical trends

(2) Completion of suspended sediment project
   (a) suspended sediment sampling and laboratory analyses
   (b) data analysis and evaluation of current pollutant loading

(3) Completion of initial fish tissue sampling

(4) Completion of reassessment of fish tissue risk by TDH

(5) Completion of Fort Worth ECC tracking study and data analysis

(6) Completion of BMP evaluations

(7) Completion of any additional suspended sediment sampling
   (a) planning/completion of sampling events and laboratory analyses
   (b) data analysis and evaluation of source areas

(8) Completion of additional fish tissue sampling at five-year intervals
   (a) sampling events and laboratory analyses
   (b) reassessment of fish tissue risk by TDH

(9) Planning and implementation of any necessary BMPs and/or regulatory strategies.

The most significant outcome for determining the success of the TMDLs and the implementation plan will be the removal of the fish consumption bans by the TDH. Interim outcomes that indicate progress towards this goal are:

- Continued reductions in fish tissue contaminant concentrations beyond those already observed,
- Reduction of fish tissue contaminant concentrations to a level that allows the TDH to modify a consumption ban by removing one or more contaminants, shift to an advisory for certain groups at greater risk, or limit the advisory to specific fish species, and
- Reduction of fish tissue pollutant concentrations to levels that meet the endpoint target concentrations and acceptable risk levels, but where the TDH has not yet removed the consumption ban.

The TDH has the authority and jurisdiction for the decision to issue, or to modify or remove, fish consumption bans and advisories. Subsequent risk assessments by the TDH may result in one or more of these options for the various water bodies addressed by this implementation plan. The ultimate endpoint goal for the affected water bodies is the protection of all groups and complete removal of the fish consumption bans.

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