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Implementation Plan for Clear Creek Chlordane TMDLs

For Segments 1101 and 1102

Prepared by the:
Strategic Assessment Division, TMDL Team

TEXAS NATURAL RESOURCE CONSERVATION COMMISSION

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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 can be effective and appropriate 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, depending on the nature of the entity's program and the procedures the entity follows.

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) the procedure TNRCC will use to develop 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;

[1] Control actions refer to point source pollutant reduction strategies, generally Texas Pollution Discharge Elimination System (TPDES) permits. Management measures refer to nonpoint source pollutant reduction strategies, generally voluntary best management practices.

(5) a statement of 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.

This implementation plan is designed to guide the achievement of reductions in concentrations of chlordane in fish tissue in Clear Creek 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.

Technical assistance in the form of published reports and consultations was provided by:

- the municipalities of League City, Friendswood, Pearland, and Webster
- the Seafood Safety Division of the Texas Department of Health
- the Galveston County Health District
- the Harris County Flood Control District, and
- the Houston-Galveston Area Council

This implementation plan was approved by the TNRCC on September 14, 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 ultimate 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 *Two Total Maximum Daily Loads for Chlordane in Clear Creek* (TNRCC 2000) are portions of the tidal and above tidal segments of Clear Creek in the San Jacinto-Brazos Coastal Basin (see Figure 1). These water bodies were included on the State of Texas 1998 and 1999 §303(d) lists as a result of the issuance of a fish consumption advisory by the Texas Department of Health (TDH) on November 18, 1993 (TDH 2001). TDH advised against consuming fish from Clear Creek upstream and west of State Highway 3. The fish consumption advisory was issued following determinations of unacceptable human health risk due to elevated tissue concentrations of chlordane and volatile organic chemicals including 1,2-dichloroethane and 1,1,2-trichloroethane. The impacted portions of Clear Creek and their watersheds lie within Harris, Galveston, Fort Bend, and Brazoria counties (see Figure 1). Within the context of this document, chlordane refers to technical chlordane

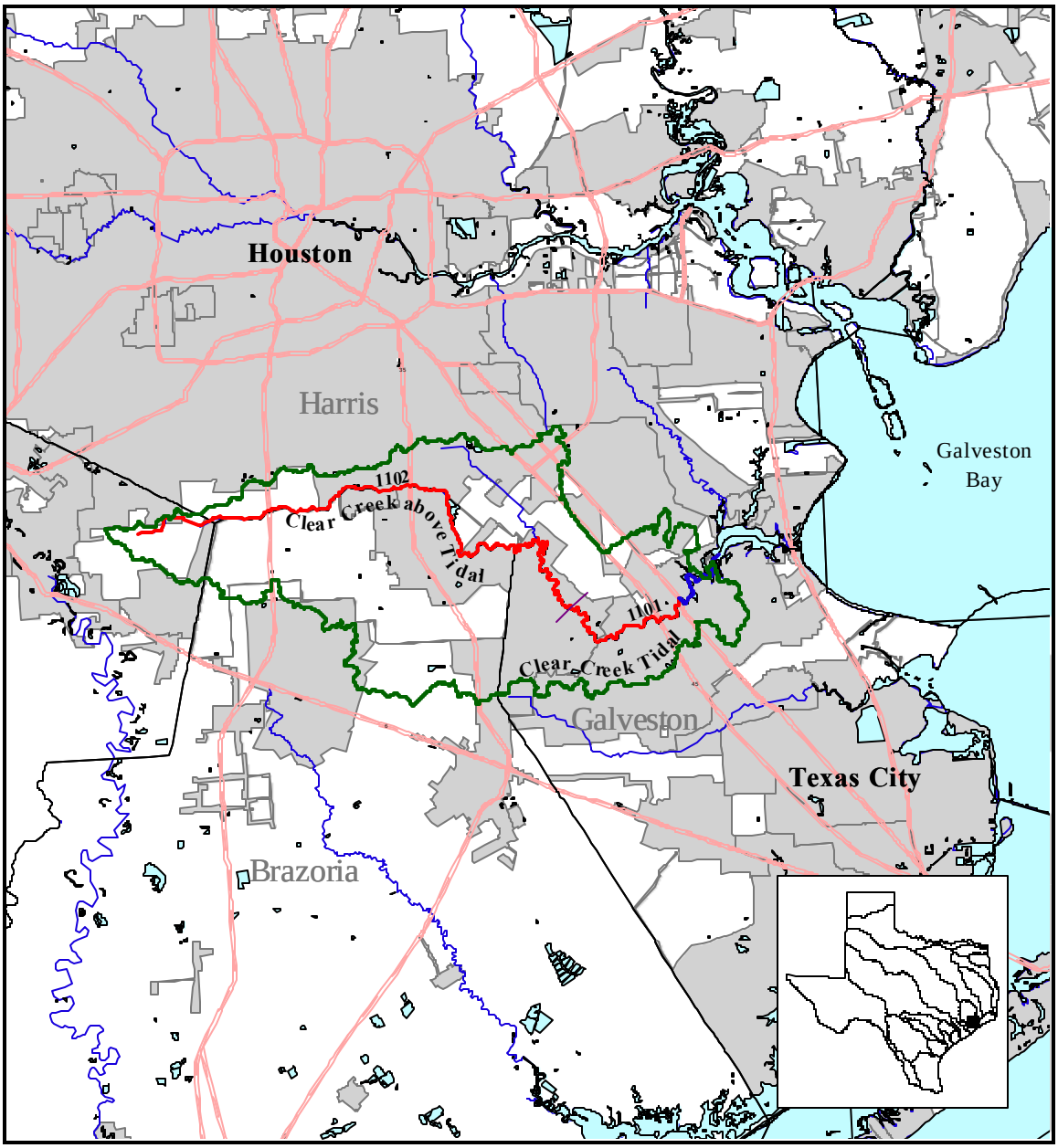

Figure 1. Study Area - Clear Creek Watershed

(CAS 12789-03-6), a mixture of chlorinated hydrocarbons including cis-chlordane, trans-chlordane, cis-nonachlor, trans-nonachlor, heptachlor, octachlordane, chlordene isomers, and other compounds.

Chlordane is a legacy pollutant, a term used to describe substances whose use has been banned or severely restricted by the U.S. Environmental Protection Agency (EPA). Because of their slow rate of decomposition, many of these substances frequently remain at elevated levels in the environment for many years after their widespread use has ended. No additional loading of legacy pollutants is allowed or expected due to the EPA restrictions. Gradual declines in environmental legacy pollutant concentrations occur as a result of natural attenuation processes.

Twenty-six domestic sewage treatment plants and two industrial facilities are currently permitted to discharge wastewater to Clear Creek. These dischargers are not considered to be significant sources of these compounds. Nonpoint sources of these compounds are considered to be the main contributors of chlordane in fish tissue in the tidal and above tidal segments of Clear Creek.

The TMDLs adopted for Clear Creek describe allowable loads of chlordane based on acceptable, risk-based fish tissue concentrations (TNRCC 2000a). 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 advisories on fish consumption (Table 1). The ultimate endpoint goal for the affected water bodies is the complete removal of the fish consumption advisories.

Table 1. Segments of Clear Creek listed on the 303(d) list due to chlordane concentrations in fish tissue and fish consumption advisory by the Texas Department of Health, and endpoint targets necessary to meet the fish consumption use.

Segment	**Primary Endpoint Target**
Clear Creek Tidal (1101)	≤ 1.17 mg/kg chlordane in fish tissue for adults ≤ 0.5 mg/kg chlordane in fish tissue for children
Clear Creek above Tidal (1102)	≤ 1.17 mg/kg chlordane in fish tissue for adults ≤ 0.5 mg/kg chlordane in fish tissue for children
All Water bodies	Removal of fish consumption advisories

Control Actions and Management Measures

Gradual declines in environmental legacy pollutant concentrations occur as a result of natural attenuation processes. Legacy pollutants in these 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. Additional loading of chlordane may also be the result of illicit use of this restricted pesticide within the Clear Creek watershed. However, illicit use of chlordane-based insecticides is believed to play a very minor role in its observed occurrence and illicit use is expected to cease completely due to chlordane's lack of availability as a banned pesticide. No authorized point source discharges of chlordane are allowed by law.

Available evidence suggests that chlordane concentrations are generally declining in fish tissue in several other watersheds in Texas and throughout the nation. Chlordane fish tissue concentrations in the Trinity and Nueces-Rio Grande Coastal Basins were found to be less than the TMDL endpoint target in recent sample collections (TNRCC 2000b and TNRCC 2000c; see Reasonable Assurance of Success section of this document). Continuing natural attenuation is expected via degradation and metabolism of remaining chlordane, and scouring and redistribution of sediments in Clear Creek.

Although tissue contaminant levels are expected to continue to decline through natural attenuation processes, investigations are planned to address any remaining pollutant loads to these water bodies. As part of an interagency agreement between the EPA and the United States Geological Survey (USGS), observed historical trends in chlordane occurrence in Clear Creek are being investigated to verify declining environmental concentrations in the watershed (see *Work Plan Summary -Historical Trends in Chlordane Occurrence in Clear Creek as Recorded in Bottom Sediments Deposited in Distributary Channels and Coastal Embayments Near the Confluence with Clear Lake, May, 2001*).

The cities in which these water bodies are located have storm water quality programs in place. These four cities are covered by individual Phase II storm water permits which will be issued by TNRCC (see Legal Authority section of this document). Various control actions and management measures have already been implemented under these local programs, and have likely reduced any remaining legacy pollutant input into Clear Creek. These include:

(1) erosion control requirements on construction sites, and
(2) routing of a significant portion of the storm water runoff to detention/retention impoundments before releasing it into Clear Creek, allowing for a certain amount of sedimentation of silt and debris.

Furthermore, as part of the preparation for implementation of Phase II storm water regulations, many of the municipalities in the Clear Creek watershed are working with the Houston-Galveston Area Council (HGAC) and the TNRCC's Galveston Bay Estuary Program to

implement additional measures related to the improvement of storm water quality. These include:

(1) formation of a storm water committees to oversee implementation of all aspects of Phase II storm water regulations
(2) implementation of public education programs addressing proper use and disposal of household chemicals

The TNRCC and local authorities will further evaluate the need for, and effectiveness of, the various mitigation and remediation efforts, including site-specific natural attenuation, based on the results of the EPA/USGS study. These evaluations will gauge the effectiveness of the various storm water control actions. Decisions concerning the need for, and implementation of, any additional control actions or management measures, including additional (best) management practices (BMPs) will be better 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. MS4 permittees 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.

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.

Implementation Schedule

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

The EPA has provided funding to the USGS for an investigation involving sediment coring in areas of the affected water bodies located near the confluence with Clear Lake. The objectives of the project are as follows:

- a more accurate characterization of chlordane occurrence in the Clear Creek watershed
- a qualitative assessment of current chlordane loading into Clear Creek; and
- the investigation of temporal trends in chlordane loading into Clear Creek

The major project activities, and the schedule for each, are as follows:

- site selection - Spring 2001;
- preparation of a Quality Assurance Project Plan - Spring/Summer 2001;
- collection of core samples - Summer 2001;
- analysis of core samples - Summer/Fall 2001; and
- reporting of data - December 2001

The TNRCC will base its assessment of the effectiveness of current mitigation efforts on the results of the investigation and on the results of the September 2000 TDH fish tissue collection and additional fish tissue sampling planned for 2005. The TNRCC will evaluate the need for, and potential effectiveness of, additional mitigation and remediation options, including management measures and/or institutional controls. The results of the USGS investigation and fish tissue monitoring will also be used to estimate site-specific rates of natural attenuation of chlordane in Clear Creek.

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

ENTITY	ACTIVITY	IMPLEMENTATION SCHEDULE
U.S. Geological Survey (USGS)	(1) Collection and evaluation of sediment cores collected in Clear Creek	(1) Summer/Fall 2001
Texas Department of Health (TDH)	(1) Collection of fish for tissue analysis (2) Reassessment of tissue contaminant risk	(1) Completed in September 2000 (2) Expected by October 2001
Texas Natural Resource Conservation Commission (TNRCC)	Evaluation of results of the activities conducted by USGS and TDH Coordination and planning with local authorities 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 early to mid 2002; Interim meetings and evaluations will be conducted as appropriate; See Table 3 for details

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 monitoring efforts are known. Interim evaluations will be made as appropriate, with final evaluations to be performed following completion of all planned and ongoing efforts, probably in early to mid 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.

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 the TNRCC and local authorities. See text for additional details.

ACTIVITY	RESULTS	SUBSEQUENT ACTION
(1) Historical pollutant trends determined from sediment cores (USGS)	(a) No substantial recent input - any existing pollutants in deeper layers of sediment	(a) Evaluate within framework of USGS conclusions - no additional action is likely to be necessary
	(b) Pollutant concentration and depth in core suggest recent or continuing input	(b) Evaluate within framework of USGS conclusions, initiate activities to identify current source(s), and evaluate potential BMPs and additional mitigation/remediation needs
(2) Fish tissue contaminant concentrations (TDH)	(a) Removal of consumption ban by TDH due to reduction of tissue contaminant concentrations	(a) No action necessary other than follow-up tissue sampling five years after removal of the ban
	(b) Consumption ban remains in effect, but trend in reduction of tissue contaminant concentrations is evident	(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) No evidence of reduction in tissue contaminant concentrations based on samples collected in 2000-2006	(c) (i) Continue addressing pollutant sources and monitoring fish tissue (ii) Reevaluate TMDL time frames and need for additional approaches

Historical Loading Trends

Contaminants present in sediments 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. 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). Higher concentrations generally appeared deeper in the cores, indicating that input and accumulation were decreasing with time.

If historical trends determined from the Clear Creek sediment cores indicate recent or continuing contaminant input and the results of recent fish tissue sampling by the TDH show concentrations

exceed the endpoint target concentrations specified in the adopted TMDLs, additional investigation will be needed to identify sources. Suspended sediment sampling will be performed, if necessary, to further isolate the source(s). If the USGS evaluations indicate unexpectedly large sediment concentrations, the need for dredging will also be evaluated. However, natural attenuation is expected to reduce contaminant concentrations, while ongoing sedimentation will continue to bury any remaining contaminated sediment in the depositional environments of the water course. Although residues can continue to persist in the deeper parts of the sediment column, burial by more recently deposited sediments may result in effective removal of the contaminants from bioavailability to aquatic life (Ricci *et al.* 1983).

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 the analysis of core samples collected in Clear Creek indicates continuing contaminant input to the affected water bodies, additional sampling will be performed as necessary to further investigate and isolate source areas. Suspended sediment sampling will be planned and performed through a contract with USGS, with input and/or participation by local authorities. Identified source areas will be addressed by the most appropriate management measures and/or institutional controls.

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 2000b). Long-term field studies have generally found that elimination rates are considerably longer than in 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 TDH to remove the bans on fish consumption. If the results of the fish tissue collection completed in September of 2000

indicate that endpoint targets have been reached in Clear Creek, follow-up sampling will be conducted in 2005 to verify that tissue contaminants remain at acceptable levels. However, the TDH may choose to conduct additional monitoring in Clear Creek at any time.

If fish tissue data collected in 2000-2005 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 2000 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 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 later to verify that tissue contaminants remain at acceptable levels. As in the above case, TDH may choose to conduct additional monitoring in any of the water bodies at any time.

Decreases in fish tissue concentrations of organochlorine insecticides have been observed where no major additional inputs are occurring (see Moore and Ramamoorthy 1984; Brown *et al.* 1985; Bremle and Larsson 1998). If tissue samples collected in 2000-2005 indicate no reduction of contaminants in a water body, reevaluation of the current TMDL approach will be required.

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. TNRCC and local authorities will cooperate in planning this assessment monitoring when a decision is made to take a particular action in a designated location.

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 current knowledge of fish tissue chlordane concentrations and potential existing environmental reservoirs of chlordane, restoration of the fish consumption use in Clear Creek is expected within the next ten years. Findings of the planned and ongoing monitoring efforts, and reassessment of tissue contaminant risk by TDH, may require revision of these estimates.

Monitoring Plan

As noted in previous sections of this document, the USEPA has provided funding to the USGS for an investigation that is using sediment coring to describe historical trends in the occurrence of legacy pollutants in Clear Creek to determine qualitatively if there are continuing sources of chlordane in the Clear Creek watershed and to estimate site-specific rates of natural attenuation of this pesticide. The study will use sampling approaches and protocols of the USGS National Water-Quality Assessment Program (NAWQA) Reconstructed Trends Study (Van Metre and Callender, 1997). The study will include the following activities:

- ***Site Selection***
  (1) A coring site will be selected that is likely to receive sediment input from as much of the Clear Creek watershed as possible given the additional criteria described below.
  (2) The coring location will be selected based on factors that enhance the likelihood of encountering appreciable, undisturbed, sequential sedimentation.
  (3) The coring location selected will minimized the effects of tidal influence on sedimentation, such as flow reversal and sediment dilution.

- ***Preparation of Quality Assurance Project Plan (QAPP)***
  (1) A QAPP will be prepared and submitted to USEPA for approval prior to the initiation of core sampling activities; protocols specified under EPA quality assurance document QA-R5 will be followed.

- ***Collection of Core Samples***
  (1) The cores will be collected with a 2-meter long piston corer and/or a 50-cm box corer to minimize sediment disturbance.
  (2) The cores will be sub-sampled in 1-5 cm increments depending on the total core sample depth

- ***Analysis of Core Samples***
  (1) Core sub-samples will be dated using Cs^{137} analysis and analyzed for chlorinated organic compounds and major and trace elements. First occurrence of and peaks in Cs^{137}, corroborated with peaks in lead and DDT, will be combined with sampling date to provide age-date markers in the core.

- ***Reporting of Data***
  (1) a data report containing sampling locations, tabulated data, and a graphic representation of the data will be submitted to the EPA and the TNRCC
  (2) the data report will contain a limited interpretation of the data as well as recommendations for any further work deemed necessary.

The TNRCC will cooperate with the TDH to monitor fish tissue in Clear Creek. 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 advisories. TDH received funding from TNRCC to conduct fish tissue sampling which was completed in September of 2000. TDH will reassess tissue contaminant levels in these water bodies when the results of the September 2000 sampling are established.

- Twenty fish were sampled, at three locations in Clear Creek in September of 2000.
- Fish tissue collected in September of 2000 were be analyzed in the Fall of 2000.
- The results of the tissue analyses will be evaluated and a re-assessment of risk to human health is scheduled to occur in the Summer of 2001.

The process described above for fish tissue collection, analysis, and assessment will be repeated within a five year time span to confirm results observed in 2000 and/or to re-assess the fish consumption impairment in Clear Creek.

The TNRCC and local authorities will further evaluate the need for additional monitoring activities based on the results of the various planned and ongoing studies. The necessary extent of any additional monitoring will be developed as the results of the EPA/USGS and TNRCC/TDH projects (see also Implementation Schedule section of this document). Additional monitoring can be planned in cooperation with individual cities, or through the regional storm water monitoring program coordinated by the HGAC, as appropriate. TDH may also choose to conduct additional fish tissue monitoring in any of the water bodies at any time.

- If sediment coring indicates continuing input of chlordane into Clear Creek, 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 USGS, with input and/or participation by local authorities.
- If fish tissue data collected in 2000 indicate that endpoint targets have been reached in a given water body, follow-up sampling will be conducted in 2005 to verify that tissue concentrations remain at acceptable levels. Tissue sampling will be performed by TDH, or by another entity through an arrangement with TDH.
- If fish tissue data collected in 2000 indicate that endpoint targets have not been reached in a water body, additional tissue monitoring will be conducted on a five-year cycle beginning in 2005 to track contaminant declines and allow for periodic reassessment of consumption risk by TDH. Tissue sampling will be performed by TDH, or by another entity through an arrangement with TDH. Sampling will continue on this schedule until endpoint targets have been reached and the consumption advisories are removed. Follow-up sampling will be conducted approximately five years after removal of the consumption advisories 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 local authorities.

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). 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 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). 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). 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). In Lake Ontario, chlordane residues were found to be near the detection limit in shiner samples (Suns *et al.* 1991).

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).

Planned Investigations and Subsequent Action

The EPA/USGS investigation will use sediment cores to describe historical trends in the occurrence of chlordane. The study will also attempt to determine the probability of any existing source of pollutants (see Monitoring Plan section of this document for details). The use of sediment coring has proven to be an effective approach to identifying temporal trends in pollutant occurrence in other

water bodies in the state of Texas (Town Lake in Austin, White Rock Lake in Dallas, and several urban lakes in Fort Worth).

If sediment coring indicates the probability of a significant continuing source of chlordane in the Clear Creek watershed, implementation of one or more BMPs may be appropriate. Furthermore, delineation of potential source areas through suspended sediment collection and analysis or other sampling techniques may help optimize the implementation of selected BMPs. Evaluation by the TNRCC and local governmental entities will assist in determining which BMPs may be most successful should it be necessary to implement one or more of these measures. Local storm water programs also provide 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 probably 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) Collection of core samples and completion of data analysis and reconstruction of historical trends from Clear Creek sediment cores and evaluation of current pollutant loading

(2) Completion of reassessment of fish tissue risk by TDH in 2001.

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

(4) Completion of additional sampling (suspended sediments or other methods)
   (a) planning/completion of sampling events and laboratory analyses
   (b) data analysis and evaluation of source areas

(5) Planning and implementation of any additional remediation activities, BMPs, and/or regulatory strategies as needed.

The most significant outcome for determining the success of the TMDLs and the implementation plan will be the removal of the fish consumption advisories by 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 TDH to modify a consumption advisory by removing some of the contaminants, or by shifting to an advisory for certain groups at greater risk, and

- Reduction of fish tissue contaminant concentrations to levels that meet the endpoint target concentrations and acceptable risk levels, but where TDH has not yet removed the consumption advisory.

TDH has the authority and jurisdiction for the decision to issue or remove fish consumption bans and advisories. Subsequent risk assessments by TDH may result in no change to an advisory, removal of the advisory, or a shift to an advisory for certain groups at greater risk. The ultimate endpoint goal for the affected water bodies is the protection of all groups from contaminant exposure via consumption of fish and the complete removal of the fish consumption advisories from Clear Creek.

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