PART 1: DECLARATION FOR THE RECORD OF DECISION

A. Site Name and Location

Lower Roanoke River Area-Operable Unit 2
Domtar Paper Company, LLC (Domtar) (formerly Weyerhaeuser Company) Site
Martin County, North Carolina
USEPA ID # NCD991278540

B. Statement of Basis and Purpose

This decision document presents the selected remedial action for the Lower Roanoke River Area of the Domtar (formerly Weyerhaeuser) Site, Martin County, North Carolina, chosen in accordance with the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) and, to the extent practicable, the National Contingency Plan (NCP). This decision is based on the administrative record file for this Site.

The State of North Carolina concurs with the selected remedy.

C. Assessment of the Site

The response action selected in this Record of Decision is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

D. Description of the Selected Remedy

The Domtar (formerly Weyerhaeuser) Site is comprised of four areas of concern (Operable Units or OUs) which were investigated in separate studies. The four areas are Landfill No. 1 (OU1), Former Chlorine Plant (OU3), Welch Creek (OU4), and the Lower Roanoke River (OU2). The ROD for Landfill No. 1 was issued in June 2002 and cleanup activities were completed in January 2006. The ROD for the Former Chlorine Plant was issued in September 2003 and cleanup activities were completed in August 2006. Both Landfill No. 1 and the Former Chlorine Plant are currently undergoing operation and maintenance activities. The ROD for Welch Creek was signed in September 2007.

This remedy provides additional documentation of the ongoing natural recovery in the Lower Roanoke River Area of the Domtar (formerly Weyerhaeuser) Site. EPA has determined that monitored natural recovery is sufficient given that the concentrations of the site related contaminants are already below the EPA's general dioxin clean-up level of 1 ppb and within the range of the calculated clean-up goals for dioxin and mercury.

The anticipated MNR monitoring program consists of three rounds of confirmatory core sampling, annual dioxin sampling for comparison to the North Carolina surface water ARAR, fish tissue monitoring, and annual review of local habitat conditions from documented sources.

The purpose of the additional data collection activities is to provide multiple lines of evidence for evaluating the remedy effectiveness during the first two 5-year reviews. The final sampling program will be subject to agency review and approval during the RD/RA process.

The major components of the monitored natural recovery program include:

- For the first 5 years, three species of fish (catfish, bluegills, and bass) will be collected annually, if possible. After 5 years, the monitoring will be reduced to bluegill and bass only on a biannual basis. Fish samples will be collected at two locations in the LRR OU-2 (the same two locations where the NPDES fish fillet monitoring is conducted) and one reference location.
- Catfish fillet samples will be analyzed for dioxin to continue the trend analyses from the NPDES program.
- Whole bluegills and bass will be analyzed for dioxin and mercury to assess concentration trends and confirm the conceptual model that mercury in fish tissue is not site related.
- Collect five fine-layer core samples at four stations in the LRR OU-2 and one upstream of Warren Neck Creek. Analyze approximately nine subsamples in the top 4 to 6 inches for dioxin. Collect samples at years 1, 4, and 9 and then reassess the need for additional sampling.
- Sediment sampling for mercury as part of year 1 monitoring (the need for additional mercury sediment monitoring to be determined)
- Collect three 1-liter surface water samples for dioxin analysis annually (coincident with fish tissue monitoring locations and schedule).
- Annually inspect fish advisory signs (coincident with fish tissue monitoring locations and schedule).
- Annually review reports on local habitat conditions such as USACE summaries of dam releases, NC DENR water quality monitoring summaries, and overviews of severe weather conditions (*e.g.*, hurricanes or extended droughts) that could adversely impact biota habitats.
- Existing fish consumption advisory

E. Statutory Determinations

The selected remedy is protective of human health and the environment, complies with federal and state requirements that are legally applicable or relevant and appropriate to the remedial action, and is cost-effective.

Based on the information currently available, USEPA believes that the Preferred Alternative provides the best balance of tradeoffs among the other alternatives with respect to the balancing and modifying criteria. EPA expects the Preferred Alternative to satisfy the following statutory requirements of CERCLA 121 (b), which include that the alternative would be protective of human health and the environment, would comply with ARARs, would be cost effective, and would utilize permanent solutions.

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure (as signified by the existing fish consumption advisory) a statutory review will be conducted within five years after initiation of remedial action to ensure that the remedy is, or will be, protective of human health and the environment. The purpose of the additional data collection activities associated with this remedy is to provide multiple lines of evidence for evaluation of the remedy effectiveness during the first two five- year reviews.

F. ROD Data Certification

The following information is included in the Decision Summary section of this Record of Decision. Additional information can be found in the Administrative Record file for this Site.

- Chemicals of concern and their respective concentrations (pp. 25, 31, 40, 80)
- Baseline risk represented by the chemicals of concern (pp. 70-71, 86-88)
- Cleanup levels established for chemicals of concern and the basis for these levels (p.113)
- Current and reasonably anticipated future land use assumptions (p. 47)
- Potential land and surface water use that will be available at the site as a result of the Selected Remedy (p. 112)
- Established capital, annual operation and maintenance (O&M), and total present worth costs, discount rate, and the number of years over which the remedy cost estimates are projected (p.113)
- Key factors that led to selecting the remedy (p. 109)

G. Authorizing Signature

Franklin E. Hill, Director
Superfund Division

9/24/08
Date

PART 2: THE DECISION SUMMARY

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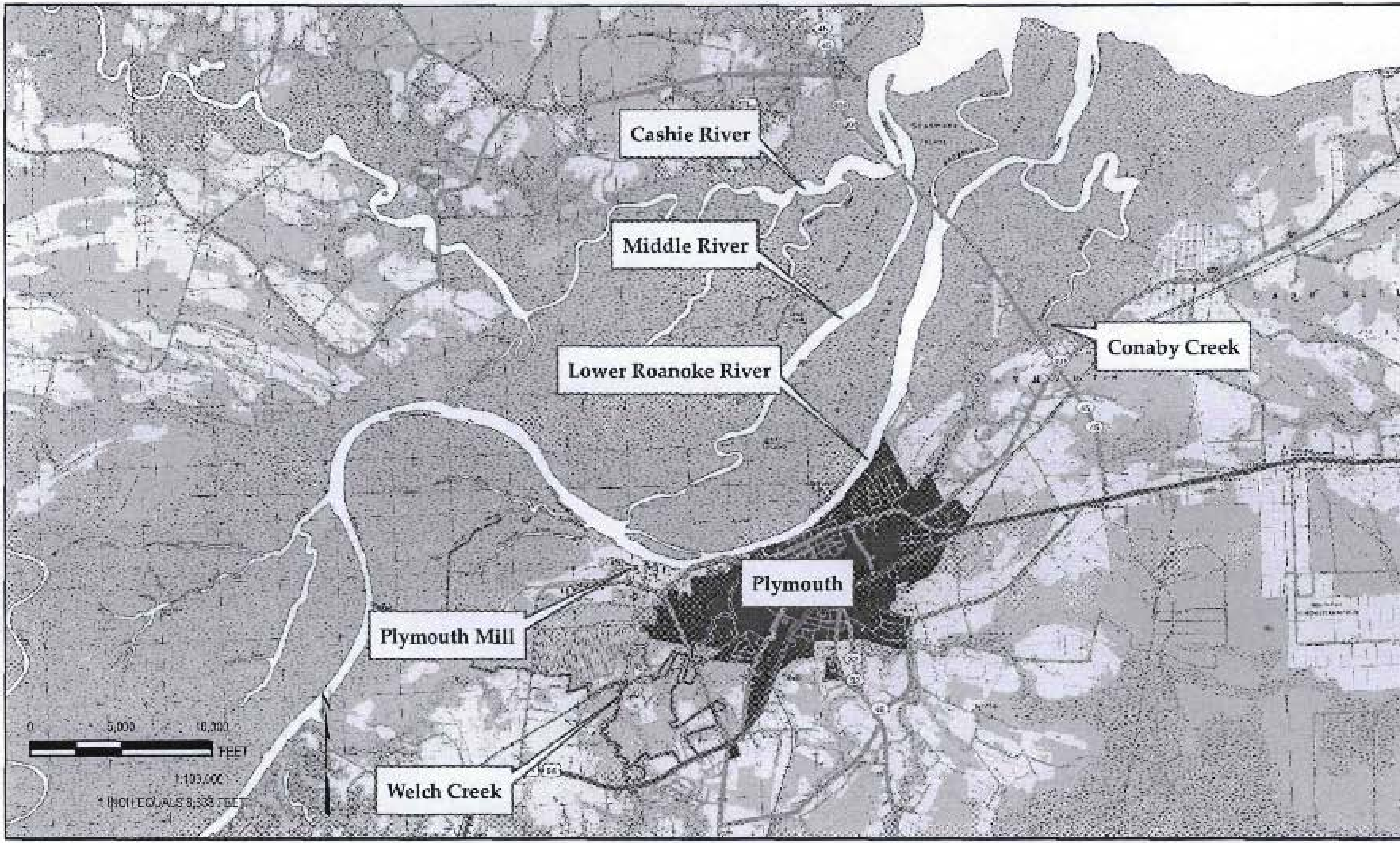
Appendices

A. Site Name, Location and Description

The Domtar Paper Company, LLC (formerly Weyerhaeuser Company) facility (Site) is an active wood and paper products manufacturing facility employing approximately 700 people. The Site is located just outside of the city limits of Plymouth, Martin County, North Carolina, and has been assigned CERCLIS Site ID No. NCD991278540. The Site location is shown on Figure A-1. The USEPA has the enforcement lead at the Site, with support from the North Carolina Department of Environment and Natural Resources (NC DENR). The USEPA plans to negotiate a Consent Decree with the Responsible Party to conduct and pay for the cleanup at the Site. Work on the Site was initiated by the USEPA. The USEPA completed the Remedial Investigation (RI) Report, the Baseline Human Health Risk Assessment (HHRA) and the Baseline Ecological Risk Assessment (BERA) for Operable Unit 2, the Lower Roanoke River. In 2005, the USEPA requested that Weyerhaeuser complete a Feasibility Study (FS) for Operable Unit 2. This FS work was continued by Domtar[1], the current owner of the pulp and paper operations at the Site.

Current operations at the Site include the production of fine paper. Weyerhaeuser acquired the facility in 1957, after merging with the Kieckhefer-Eddy Corporation, which began operation at the site in 1937. Weyerhaeuser operated the facility from 1957 until 2007. The facility, now owned and operated by Domtar, is located on approximately 2,400 acres, about 1.5 miles west of the town of Plymouth. The Roanoke River originates in Virginia and flows generally southeast into Albemarle Sound, North Carolina. The lower portion of the river, referred to as the Lower Roanoke River (LRR), extends from the discharge below the Roanoke Rapids Dam approximately 138 miles to Albemarle Sound. The LRR Operable Unit 2 (LRR OU2) area is located between Martin and Washington Counties in eastern North Carolina and consists of 14.3 miles of the river from a point upstream of the Plymouth Mill facility to the Albemarle Sound. The average flow in the river is approximately 8,000 cubic feet per second (cfs) and the river is surrounded by extensive coastal wetlands.

[1] Domtar Paper Company, LLC took ownership of the pulp and paper operations at the Plymouth Mill and assumed related environmental obligations from Weyerhaeuser Company on March 7, 2007. Previous required reports for this CERCLA Site were submitted by Weyerhaeuser. For continuity, references to the facility owner of the Plymouth Mill, are cited as Domtar (formerly Weyerhaeuser) in the remainder of this Record of Decision.



DOMTAR
MARTIN COUNTY, NORTH CAROLINA
LOWER ROANOKE RIVER - O.U.-2

LOWER ROANOKE RIVER
AND SURROUNDING AREA

DATE: AUG 2008

FIGURE A-1

B. Site History and Enforcement Activities

The facility has been used for pulp and paper production since 1937 and, at different times, treated wastewater from the operation was discharged into either Welch Creek or the Lower Roanoke River. Wastewater effluent associated with bleached pulp was discharged directly to the Lower Roanoke River by the original owner from approximately 1937 to 1956. Due to the hydrologic setting and stable sediment conditions, wastewater solids have accumulated at the bottom of Welch Creek, which is a tributary to the Lower Roanoke River system. In 1988, the Mill's permitted wastewater treatment plant discharge was permanently rerouted into the Lower Roanoke River. Subsequently, the facility upgraded their bleaching process from free chlorine to chlorine dioxide. This modification has been demonstrated at other facilities to eliminate or significantly reduce formation of dioxin congeners, specifically 2,3,7,8 TCDD. This upgrade was initiated in 1992 and completed in 1994.

In-plant waste control improvements were implemented in 1957 when Weyerhaeuser acquired the facility from the Kieckhefer-Eddy Company. A 12-acre spray pond and two retention ponds were later constructed. Beginning in 1968, the wastewater was subject to treatment in a series of on-site wastewater treatment ponds that currently consist of primary settling ponds, an aeration basin, and a large serpentine-shaped retention pond. From 1968 to 1987, wastewater was discharged to Welch Creek from an outfall located 2.3 miles upstream from the confluence (the post-1970 outfall), also shown on Figure B-1. The discharges to Welch Creek were permitted by the State of North Carolina in 1969. Since 1975, wastewater discharges from the Plymouth Mill were regulated by National Pollutant Discharge Elimination System (NPDES) permits. Since 1988, treated wastewater from the pulp and paper processes and other site facilities has been permitted to directly discharge into the Roanoke River approximately ½ mile downstream from the facility. The most recent NPDES permit is effective for the period from March 1, 2006, until February 28, 2011.

A Special Notice Letter was sent to Weyerhaeuser by the USEPA on November 19, 1997, notifying them of potential liability, as defined by Section 107 (a) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended, that Weyerhaeuser may have incurred with respect to the Site. The Special Notice Letter outlined multiple areas on, and adjacent to, the facility property which, following initial investigation by the USEPA and NC DENR, were considered to have caused a release or the threat of a release of hazardous substances, pollutants or contaminants. The four areas (operable units) defined for this Site are: 1) Landfill No. 1 Area; 2) Lower Roanoke River; 3) Former Chlorine Plant Area; 4) Welch Creek. After negotiations between the USEPA and Weyerhaeuser, an Administrative Order by Consent (AOC) was signed by both parties on March 24, 1998. The RI/FS for the Landfill No. 1 Area, Former Chlorine Plant Area, and Welch Creek were covered under the terms of the AOC and the attached Statement of Work (SOW). The Roanoke River RI was conducted separately by the USEPA using Superfund funding. At the request of USEPA, the FS for the Roanoke River was prepared by Weyerhaeuser and then completed by Domtar.


0 500 1,000 2,000
FEET
N
PRE-1970
OUTFALL
POST-1970
OUTFALL
NORTH CAROLINA
WELCH CREEK AREA
LEGEND
TRANSECTS
GENERAL TRANSECT
MASTER TRANSECT
PROPERTY BDRY.
DOMTAR (FORMERLY WEYERHAEUSER)
MARTIN COUNTY, NORTH CAROLINA
WELCH CREEK - OU-4
BRIDGES AND WETLAND CONDITIONS
AUG 2008

FIGURE B-1

C. Community Participation

Pursuant to CERCLA Sections 113(k)(2)(B)(i-v) and 117, the RI/FS Reports and the Proposed Plan for the Site were released to the public for comment on July 17, 2008. These documents were made available to the public in the administrative record located in an information repository maintained at the USEPA Docket Room in Region IV and at the Washington County Public Library in Plymouth, North Carolina.

The notice of the availability of these documents was published in the Roanoke Beacon, Plymouth North Carolina, in July 2008. A pubic comment period on the documents was held from July 12 to August 11, 2008. A copy of the notice and the Proposed Plan fact sheet were mailed to the Site mailing list which contains names of community members and interested parties. In addition, a public meeting was held on July 17, 2008. At this meeting, representatives from the USEPA answered questions about the Site and the remedial alternatives under consideration. EPA did not receive any written or verbal comments other than the verbal comments provided at the public meeting. As a result, it was not necessary to prepare a Responsiveness Summary.

Other community relations activities for OU2 or OU4 included:

- Development of a community relations plan.
- A RI kick-off public meeting held in the community on March 23, 1999.
- Issuance of a fact sheet on the RI/FS process and progress in March 1999 and January 2001.
- Issuance of a fact sheet regarding status of all operable units in April 2005.
- Issuance of a fact sheet on the Proposed Plan for OU4 in August 2007.
- Issuance of a fact sheet on the Proposed Plan for OU2 in July 2008.
- Informed citizens of the Technical Assistance Grant and Community Advisory Group program (literature placed in repository).

D. Scope and Role of Operable Unit within Site Strategy

Because of the geographic separation of the three on-site areas along with the LRR and the differences in the type of contamination present and the media impacted, individual RI/FS reports have been prepared for each of the three on-site areas identified in the AOC. USEPA's contractor prepared the RI report for the LRR. Domtar prepared the FS for the LRR. The operable unit designations given to each area are:

- Operable Unit 1: Landfill No. 1 Area
- Operable Unit 2: Lower Roanoke River
- Operable Unit 3: Former Chlorine Plant
- Operable Unit 4: Welch Creek.

These focused investigations were conducted in order to streamline the investigation and remedy selection process. The USEPA has already selected remedies and issued separate RODs in 2001, 2003, and 2007 for Operable Units 1, 3, and 4, respectively. Operable Units 3 and 4 address areas on-site that had potential to impact the Lower Roanoke River. More specifically, the remedy for Operable Unit 3 provides containment of groundwater containing low levels of mercury that could migrate to the Lower Roanoke River. Operable Unit 4 provides for a thin layer sand cap over dioxin contaminated sediments in Welch Creek, a tributary of the Lower Roanoke River, and long term monitoring and maintenance of the cap. The sand cap will reduce or eliminate the potential for contaminants from Welch Creek to be transported via surface water flow to the Lower Roanoke River or nearby wetlands. Operable Unit 2 is the final operable unit for the Site.

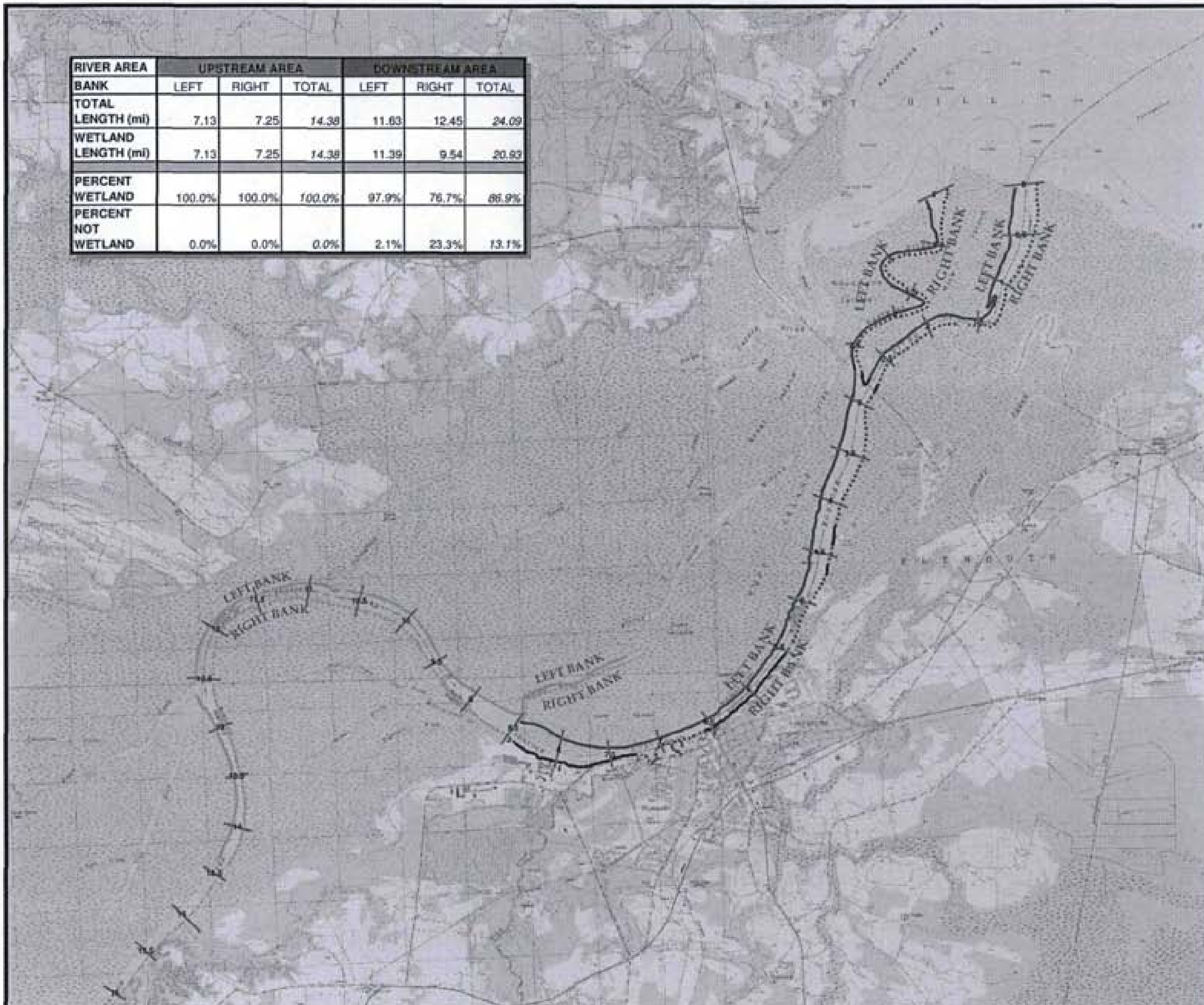
E. Site Characteristics

1. Site Setting

The Roanoke River is approximately 410 miles long, originating in Virginia, and flowing generally southeast across the Blue Ridge Mountains and into Albemarle Sound, North Carolina. A comprehensive flood-control and hydroelectric-power project was initiated in the middle portion of the basin (Miles 138 to 179) beginning in the early 1950s. A total of six dams and associated reservoirs have been constructed on the river and its tributaries for flood control, power generation, and recreational use. Thus, the flow in the Roanoke River is highly regulated. Three of these reservoirs (Lake Gaston, Kerr Lake, and Roanoke Rapids Lake) are constructed along the Virginia/North Carolina border. The lower portion of the river below the Roanoke Rapids Dam extends approximately 138 miles to Albemarle Sound. This section of the Roanoke River from Roanoke Rapids Dam to the confluence with Albemarle Sound ranges from 300 to 900 feet wide, with measured flows at the Dam ranging from 750 to 37,700 cfs with an average of 8,100 cfs. (USGS, 2003). Since the completion of the flood control and hydroelectric project in the early 1960s, the peak flows in the Roanoke River have been significantly attenuated. Prior to 1960, the annual peak flow frequently exceeded 100,000 cfs and had an average peak flow of 79,000 cfs. Since 1960, the average annual peak flow is held close to 20,000 cfs. This river is one of five major brownwater ecosystems in the Southeast, containing the largest intact and least-disturbed bottomland hardwood forest ecosystem remaining in the mid-Atlantic region. In general, the drainage basin for the Lower Roanoke River is comprised of flat, low-lying terrain typical of the Tidewater region within the Coastal Plain Physiographic Province of North Carolina with 5 to 15 feet of relief. The majority of the lower river system (below the Roanoke Rapids Dam) is included in Subbasin 09 of the Roanoke River basin within the coastal plain eco-region of North Carolina (NC DENR, 2001). Along the lower portions of the Roanoke River, most of the land in the basin is forested (71 percent), and the river and tributaries are bordered by extensive floodplain forests.

In the LRR OU-2, wetlands dominate the shoreline of over 90 percent of the banks (see Figure E-1). Water level and inundation of wetlands along the Lower Roanoke River are affected by river flow and tidal fluctuations (lunar and wind-driven) in Albemarle Sound. In terms of water quality, NC DENR (2001) indicated no major water chemistry problems in the Lower Roanoke River based on samples collected monthly from sites on the Roanoke River above and below the town of Plymouth (Mile 6), with the exception of elevated ammonia nitrogen at the downstream site. The water quality issue that has received substantial attention over the past decade is episodic periods of low dissolved oxygen (DO). In fact, the NC DENR (2006) reported more than 10 percent of DO measurements along the Lower Roanoke River were less than the desired level of 5 mg/L. A major contributing factor to low DO levels in the Lower Roanoke River is drainage from floodplain swamps associated with local storm events and the water release pattern from upstream dams for flood control and power generation operations. Floodplain swamps have naturally low DO content in surface waters.

RIVER AREA	UPSTREAM AREA			DOWNSTREAM AREA		
BANK	LEFT	RIGHT	TOTAL	LEFT	RIGHT	TOTAL
TOTAL LENGTH (mi)	7.13	7.25	14.38	11.63	12.45	24.09
WETLAND LENGTH (mi)	7.13	7.25	14.38	11.39	9.54	20.93
PERCENT WETLAND	100.0%	100.0%	100.0%	97.9%	76.7%	86.9%
PERCENT NOT WETLAND	0.0%	0.0%	0.0%	2.1%	23.3%	13.1%



LEGEND

- GROUP 1
- GROUP 2
- AREA OF NON-WETLAND COVER
- RIVER MILE MARKERS

NOTES

1. BASE MAP FROM USGS TOPOGRAPHIC QUADRANGLES: PLYMOUTH EAST (1974, PHOTO REV. 1980), PLYMOUTH WEST (1979, PHOTO REV. 1980), WESTOVER (1974, PHOTO REV. 1980), WOODARD (1979, PHOTO REV. 1980).

0 5,000 10,000 FEET

1" EQUALS 5,000'

DOMTAR
MARTIN COUNTY, NORTH CAROLINA
LOWER ROANOKE RIVER - O.U. - 2

LOWER ROANOKE RIVER BANK
PERCENT WETLAND

AUG 2008

FIGURE E-1

When these swamp areas are flooded and the water recedes into the river, the low DO content water contributes to fish kills that have occurred during certain storm events (NC DENR, 2001). In addition, low flows associated with drought conditions can provide conditions that allow salt water intrusion into the lower areas of the Roanoke River as far west as Warren Neck Creek (*i.e.*, upstream of the Mill).

Most of the surrounding area consists of dense, forested wetlands and swamps. To the south, the river flows adjacent to the Town of Plymouth, the Georgia-Pacific Hardwood Sawmill Site, and the Domtar facility. The LRR OU-2 is entirely within the Coastal Plain Physiographic Province of North Carolina. The lower river is characterized by numerous meanders that have been incised into the swamp and forested floodplain. The eastern end of the river has been drowned by the current sea level. In the Lower Roanoke River channel, sands dominate the center of the channel and mud dominates the flanks of the channel. Peat deposits dominate the adjacent wetland forest and swamp. The river channel has not meandered in the recent past and is not actively meandering. In addition, due to the upstream dams, there is no active bed load being transported downstream. Accumulation of the inorganic mud along the flanks is a result of the absence of floods (due to the dams) that would normally periodically flush the fine-grained material.

The flow dynamics of the Lower Roanoke River are complex due to tidal fluctuations (0.5 feet), flow partitioning among several channels (*e.g.*, Middle River and Eastmost River), the influence of coastal wetlands, the rising sea level that "drowns" the lower river channel, natural storm events, and most importantly, the dam-controlled and regulated flow of the river system. As discussed later, this tidal river setting results in a net depositional environment for sediment, which contributes to the natural recovery of the ecosystem.

The climate of the area is characterized by warm summers and mild winters. The average annual temperature is 65°F. Precipitation in the area averages 51 inches annually, with the heaviest rains typically occurring in the summer months.

2. Hydrology and Water Quality

Short- and long-term variations in river flow along the Lower Roanoke River are controlled by releases from a total of six dams. The three mid-river dams near the Virginia/North Carolina border are used to generate hydroelectric power for the region and manage flood waters. This flow control is expected to continue into the foreseeable future since the Kerr Lake Dam, located in Virginia was re-licensed in 2005 with a 40-year license time span. Flow management practices have been identified as the most significant factor impacting the fishery in the Lower Roanoke River by both regulators (NC DENR) and interested parties (Nature Conservancy, 2005) Local stakeholders have stressed the importance of water management and the associated impact on DO as critical to understanding and maintaining the overall health of the Lower Roanoke River area. A collection of private and public groups continue to cooperatively address water management in the Lower Roanoke River to improve or maintain the overall health of both the river and the associated wetlands.

The importance of the Roanoke River flows to ecosystem health has been progressively understood over the past two decades. Rulifson and Manooch (1993) summarized an extensive evaluation of the flow needs for the lower portions of the Roanoke River watershed based on work by a committee of representatives of state and federal agencies and local universities. The result of their efforts was a modified spring flow regime to support striped bass recovery. In terms of water quality, the association between water management operations and DO concentrations is illustrated by an extensive fish kill that occurred in July and August 1995 along the middle portions of the Lower Roanoke River (near Mile 60) as a result of floodplain drainage from swamps. The fish kill followed an extended period of inundation of floodplain swamps during flood control operations and resulted in modification of flow management procedures at upstream dams to progressively lower river flow (NC DENR, 2001). Even with the refined release pattern, monitoring of DO concentrations along the lower river have shown a consistent pattern of downstream depletion from Roanoke Rapids dam to Albemarle Sound. The NC DENR reported more than 10 percent of DO measurements along the Lower Roanoke River were less than the desired level of 5 mg/L. Coincident with decreased DO concentrations, the Nature Conservancy has also expressed concern over prolonged flooding of wetland forests during the growing season through the current flood control management prescription.

3. Regional Geology and Hydrogeology

The geology in the region generally consists of a wedge of clastic sediment and marine limestone that thickens from west to east. The sediment consists of sand, silt, and clay. The sand is deposited in poorly connected bodies that may have only a limited horizontal and vertical extent. However, on a regional scale, differences in the frequency of occurrence and the interconnection of the sand bodies are sufficient enough to distinguish regional aquifers from regional aquitards. Specific geologic and hydrogeologic units are summarized as follows:

- Quaternary-age Surficial Aquifer: consists of fine sand, silt, clay, and peat that form a unit of less than 50 feet in thickness. The annual ground water recharge through the native soil is estimated to range from 0.4 foot, where silt and clay predominate, to 1.7 feet, where sand is predominantly at the ground surface. Ground water from the Coastal Plain aquifers discharges into these shallower (*i.e.*, more recently deposited) stream alluvial systems.
- Yorktown Confining Unit: consists of predominately of clay and sandy clay with occasional beds of fine sand or shells and a reported thickness of 40 feet in the Plymouth, North Carolina, area. The Roanoke River, draining all of Martin County, has cut into the Yorktown Formation.
- Yorktown Aquifer: consists of fine sand, silty and clayey sand, and clay with shells and shell beds with 70 percent sand in the Plymouth, North Carolina, area. The hydraulic conductivity of the Yorktown aquifer averages 2×10^{-4} ft/s. The annual recharge to the aquifer is estimated to be less than 0.2 foot on a regional scale. In the Tidewater region, where the site is located, ground water flows into the Yorktown aquifer from the underlying Pungo River Formation.
- Pungo River Formation: confining unit composed of 90 percent Miocene-age clay and averages 55 feet in thickness.
- Pungo River Aquifer: consists of marine-deposited fine-to medium-grained sand with a high phosphate content and is only about 10 feet thick near Plymouth, North Carolina.

- Castle Hayne Confining Unit (where present) and the Eocence-age Castle Hayne Aquifer: consists of limestone, sandy marl, and fine to coarse limey sand. The elevation of the aquifer below Plymouth, North Carolina, is reported to be about -130 feet. The aquifer is as much as 1,200 feet thick in areas of North Carolina and about 100 feet thick below Plymouth. This is the most productive aquifer in North Carolina, with an average hydraulic conductivity of 6.5×10^{-4} ft/s. Production tests of Plymouth Facility water supply wells in this formation indicated an average hydraulic conductivity of 6.5×10^{-4} ft/s. Recharge to the aquifer is on the order of 0.05 foot on a regional basis. The hydraulic head in the aquifer near Plymouth, North Carolina, in the early 1900s was -1 foot.
- Five or more other confining/aquifer units have been identified below Plymouth, North Carolina, that are of little relevance because the Castle Hayne Aquifer is the regional water supply aquifer below the Site.

4. Area Ground Water Use

The majority of the Plymouth Facility process water is obtained from the Lower Roanoke River. Facility water use is supplemented by deep on-site potable water supply wells. These water supply wells and other private wells in the vicinity draw water from depths of 100 to 200 feet below ground surface, thus utilizing the Castle Hayne Aquifer. Groundwater is the sole source of potable water in the area. The Lower Roanoke River, including the Albemarle Sound, is not suitable as a water supply source. Most residences in the vicinity receive their potable water from the city of Plymouth water system. The system obtains its water from four wells located approximately 2.2 miles from the Plymouth Mill. Residents who do not obtain their water from the city use private wells. The private well nearest the Plymouth Mill is 1.1 miles to the south. This well is approximately 160 feet deep and likely completed in the Castle Hayne aquifer.

5. Remedial Investigation and Supplemental Field Work

The data and information that form the basis for the site characterization come from a RI and BERA investigation conducted by USEPA, USFWS studies, voluntary supplemental data collection activities conducted by Weyerhaeuser in 1999 through 2001, and additional site-specific data collection activities and science-based meeting discussions that have been subsequently conducted. The RI field activities on the LRR were completed in 2001 followed by preparation of both the RI Report and the BERA.

Summary of RI Activities

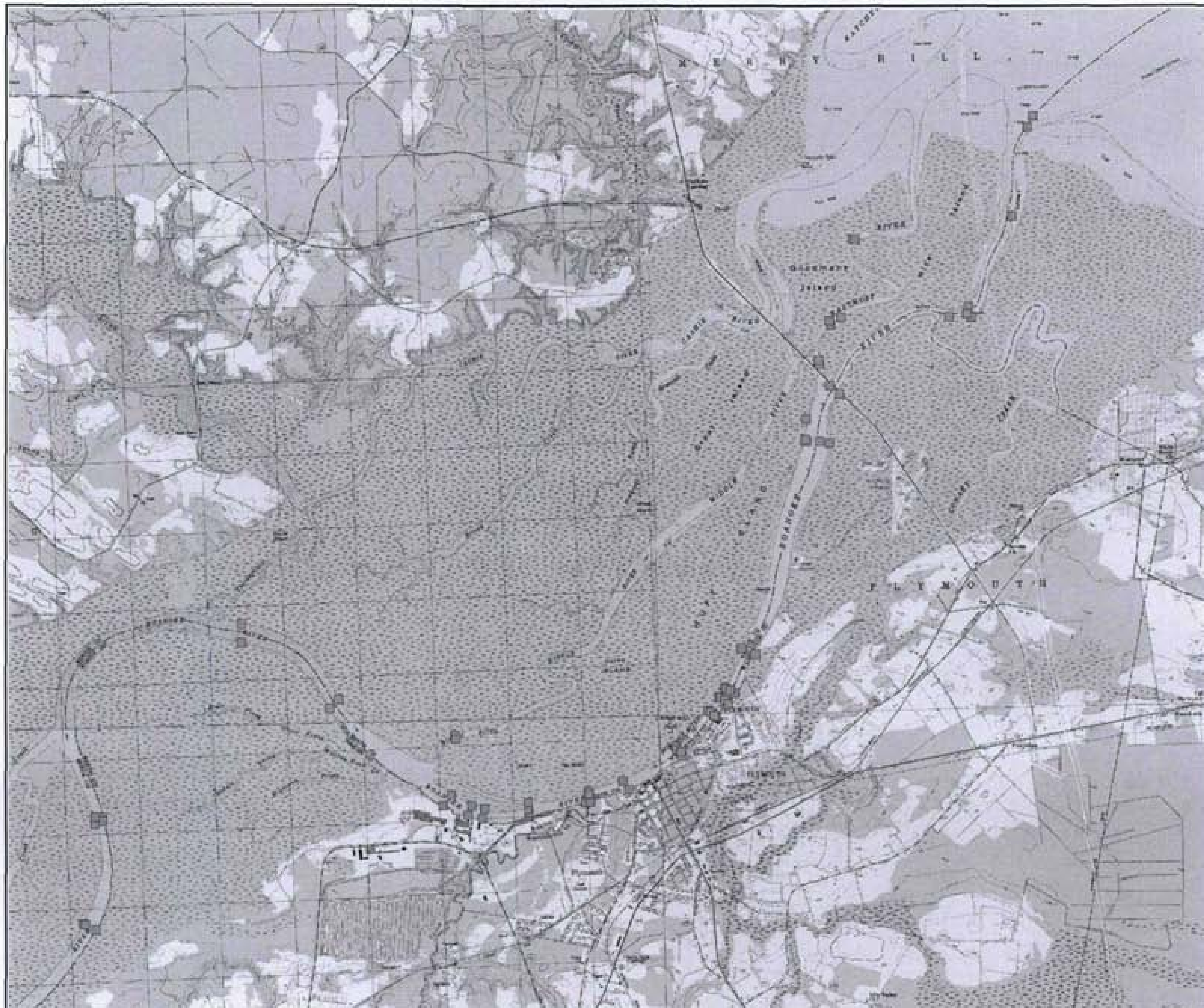
The USEPA contracted with CDM Federal Programs to conduct the RI/FS of the Roanoke River study area. The purpose of the RI was to gather data and information in order to characterize site conditions in the LRR OU-2, determine the nature and extent of the contamination, and to assess human health and ecological risks. In the initial phase, a preliminary site assessment was performed. The RI consisted of six field sampling/ data collection events for collection of environmental media. In addition, several agencies were contracted by the USEPA to help evaluate specific aspects of the Roanoke River system. The U.S. Army Corps of Engineers (USACE) Water Experiment Station was contracted to conduct hydrodynamic modeling and fate and transport modeling of the river system.

The United States Geologic Survey (USGS) was contracted by the USEPA to collect hydrologic measurements for use in the USACE models. In addition, Lockheed Martin Technology Services performed a dioxin fingerprinting analysis on sediments, soils and surface water collected during the RI. Table E-1 summarizes the sampling events conducted as part of the RI. Table E-2 summarizes the biota sampling activities conducted as part of the RI.

Table E-1
Environmental Media Sampling Summary during LRR RI Activities

Sampling Date and Event	Sampling Objectives	Samples Collected	Sample Locations	Sample Analysis
March 1999 Sampling Reconnaissance	**Preliminary sediment and wetland soil chemical analysis and to determine if target aquatic species were present.**	**Twelve river sediment and wetland soil samples**	**Four transects along the LRR from the Mill to the Albemarle Sound**	**Metals, extractable organic compounds, pesticides/PCBs and dioxins**
Sampling Assessment Visit- May 1999	**To identify sedimentation/depositional locations were representative samples could be collected and to test potential sampling devices for effectiveness.**	**NA**	**NA**	**NA**
August 1999 and June 2000 Sampling Events	**Sediment, wetland soil, and biota samples were collected during these events for the RI.**	Sediment Samples: **Sixty-nine sediment samples (some from multiple depths at the same location) were collected at depositional environments.** **Sixteen background sediment samples were collected.**	**Thirty-five sample locations (Figure E-2) several along the river in the vicinity of the Plymouth Mill and Georgia Pacific site to the Albemarle Sound, five locations in the Eastmost River and two in the Middle River.**	**Dioxins/furans, TAL metals, SVOCs, pesticides and PCBs.** **August 1999 samples were also analyzed for VOCs and total organic matter. June 2000 samples were analyzed for total organic carbon.**
		Wetland Soil Samples: **eight wetland soil samples were collected in August 1999 and six in 2000.**	**Eleven locations (Figure E-3) in the Roanoke River, two locations in the Eastmost River and one in the**	**Sample were collected from a depth of 0 to 6 inches and analyzed for dioxins/furans, TAL metals,**

Sampling Date and Event	Sampling Objectives	Samples Collected	Sample Locations	Sample Analysis
		Three reference wetland soil samples were collected.	Middle River.	SVOCs, Pesticides, PCBs and TOC. August 1999 samples were also analyzed for VOCs.
February/March 2001	Surface Water Sampling	Surface Water Grab Samples were collected from eight locations.	Sample locations included one at the mouth of the Chowan River, one upstream of Plymouth Mill, two in Welch Creek, two downstream of Mill and one in the Eastmost River and one in the Middle River.	Analyzed for TCL constituents including VOCs and SVOCs, pesticides, PCBs, dioxins/ furans, and TAL metals.
		High Volume Surface Water Samples were collected from eight locations.		Analyzed for dioxins/furans, Suspended sediment concentration analysis, water quality parameters.
June 2000	Sediment Toxicity and Bioaccumulation Testing	Sediment samples were collected from four locations plus one reference and represented a concentration gradient based on 1999 data.	Sediment samples were collected from location 433, 434, 435 436, and 449 (reference).	*Hyalella azteca* sediment toxicity testing *Lumbriculus variegates* toxicity and bioaccumulation
	Wetland Soil Toxicity Testing	Wetland soil samples were collected from three locations plus one reference and represented a concentration gradient based on 1999 data.	Wetland soil samples were collected from 314, 315, 311, and 317 (reference).	*Eisenia foetida* soil toxicity and bioaccumulation testing.



LEGEND

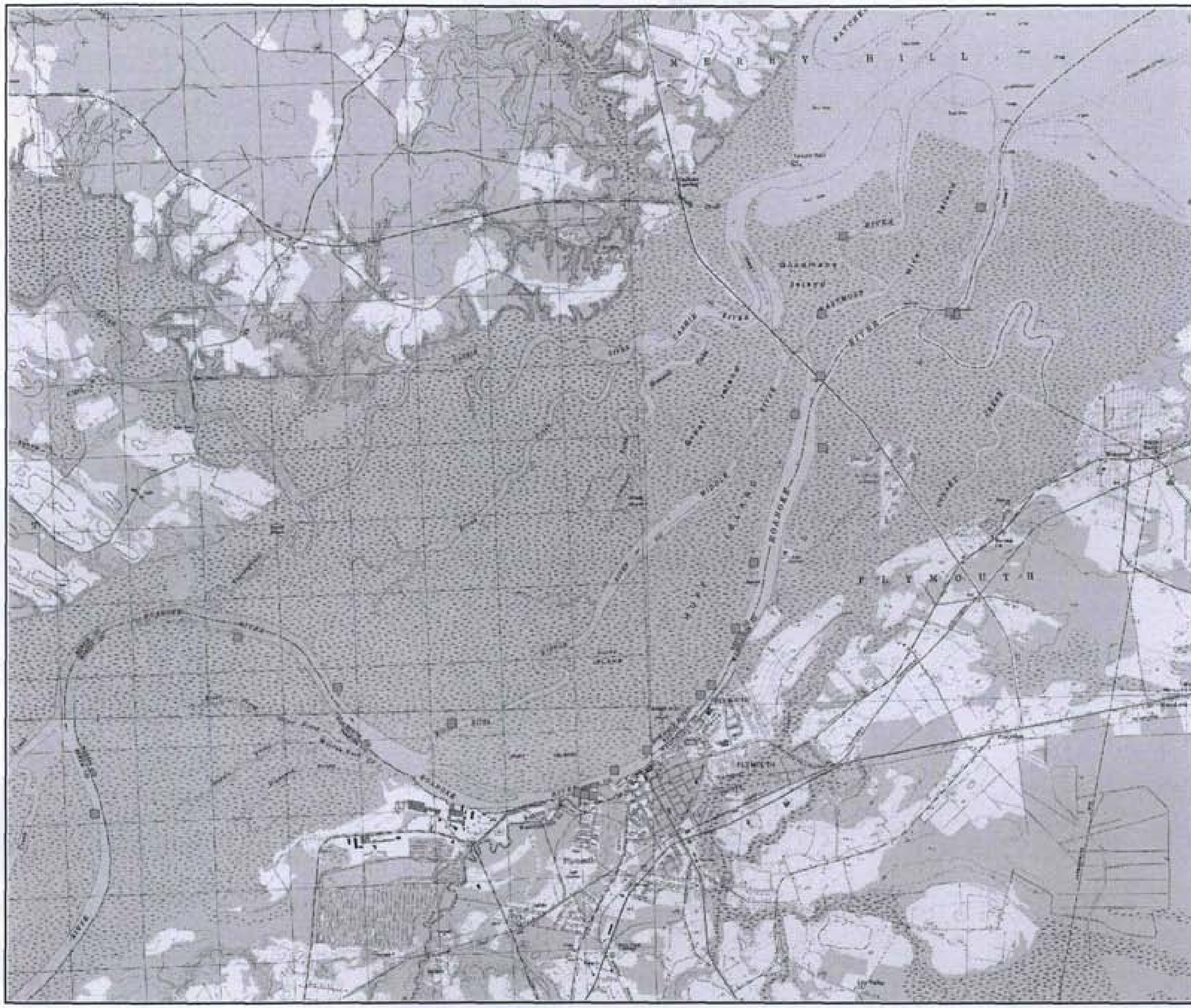
■ US EPA SAMPLES

N

0 1,000 2,000 FEET

PROJECT:	DOMTAR COMPANY MARTIN COUNTY, NORTH CAROLINA LOWER ROANOKE RIVER - O.U.-2
SHEET TITLE:	SEDIMENT SAMPLE LOCATIONS IN THE REMEDIAL INVESTIGATION

FIGURE E-2



LEGEND

USEPA Wetland Sample Locations

0 1,000 2,000 FEET

1" EQUALS 2,018'

1:24,221

PROJECT: DOMTAR COMPANY
MARTIN COUNTY, NORTH CAROLINA
LOWER ROANOKE RIVER - O.U.-2

SHEET TITLE: WETLAND SOIL SAMPLE LOCATIONS IN THE REMEDIAL INVESTIGATION

FIGURE E-3

Table E-2
Biota Sampling Summary During LRR RI Activities in August 1999 and June 2000

Media Type	Species	Number (Location)	Analytes
Fish Tissue	**Gamefish (largemouth Bass)**	**Nine locations (405, 407, 419, 432 [reference], 434, 435, 436, 440 [Eastmost], and 449 [reference])**	**Fish collected in 1999 were processed for whole body analysis and fish collected in 2000 were fillet in the field and both fillets and carcasses were analyzed for dioxins/furans, TAL metals, pesticides, PCBs and SVOCs and percent lipids.** **Fillet samples from white and yellow catfish samples at location 440 did not have sufficient sample mass for SVOC analysis and pesticide/PCB data was rejected by laboratory data validators.**
	Bottom feeders (yellow and white catfish)	**Four locations 434, 435, 436, 440 (Eastmost), 449 (reference)**	
	Forage Fish (bluegill, largemouth bass, sunfish)	**Sunfish locations: 407, 419, 432 (reference)** **Bluegill locations: 434, 435, 440 (Eastmost), 436, and 449 (reference).**	
Clams	***Corbicula***	**Six composite samples and one individual clam were collected. Locations include 433 (Albemarle Sound), 434 and 435, 440 (Eastmost) 436, 440 (reference)**	**Dioxins/furans, TAL metals, pesticides, and percent lipids. Pesticides/PCB data was rejected by data validators. There was insufficient sample mass for SVOC analysis. The individual corbicula sample was collected at location 435 and analyzed for dioxins/furans only.**
	Rangia	**Two composite samples**	**Dioxins and furans only.**
Frogs		**Five locations (402, 405, 407, 419 and 432 (reference)**	

Samples collected during the RI investigation were assigned an eight digit alpha-numeric sample descriptor in the form of RR-XXX-YYY. The prefix RR (Roanoke River) was used on the sample designations. The XXX represents a three digit alpha numeric sample number corresponding to the sample collection location. The samples were numbered as follows:

XXX	Description
301-399	**Wetland soil**
401-499	**Roanoke River Sample**
601-699	**Duplicate wetland sample**
701-799	**Duplicate river sample**
801-*899	**Rinseate blank wetlands sample**
901-999	**Rinseate blank river sample**

The duplicates can be identified as the regular sample plus 300. The rinseate blank samples are identified as the regular sample plus 400.

The YYY represents the next two or three letters which indicate the sample matrix as specified below:

YYY	Description
SDP	**Sediment for parameter analysis**
SDT	**Sediment for toxicity evaluation**
SOP	**Soil for parameter analysis**
SOT	**Soil for toxicity evaluation**
FIC	**Fish, channel catfish, carp, sucker or other benthic species**
FIR	**Fish- Redear sunfish or bluegill**
MAC	**Macroinvertebrate, clam**
ERB	**Equipment Rinseate blank**
OBF	**Other biota, frog**

Supplemental Investigations and Information

NPDES Permit Required Fish Analysis

The most recent fish dioxin NPDES study dated March 2008 includes fish samples collected in 2007 and summarizes the results of analyses conducted since 1989. The study is intended to monitor the current concentrations and the changes in dioxin levels in fish subsequent to reductions of dioxin in effluent sources.

For fish collected during 2007 from Roanoke River and Albemarle Sound stations, total TEQs for all 17 congeners calculated using WHO TEFs (excluding non-detect samples) ranged from 0.10 to 3.31 ppt in channel catfish and from 0.0 to 0.95 ppt in white catfish. Blue catfish were used for one composite in the Roanoke River (RR-15) due to the lack of channel and white catfish. For samples from Welch Creek, concentrations of 2, 3, 7, 8-TCDD were 0.10 and 0.25 ppt for two white catfish samples and 0.09 ppt for bluegill; while total TEQs (WHO TEFs) were 0.13 and 0.25 ppt for white catfish samples and 0.09 ppt for bluegill.

When all congeners were taken into account, average TEQs (WHO TEFs) for all catfish were below 1.5 ppt for all eight stations in 2007, seven of which were below 0.75 ppt. Also, 21 of 22 fish samples contained dioxin TEQ that was less than 1.5 ppt.

The overall average of all stations downstream of the mill outfall, excluding Welch Creek (RR-MD, RR-15, CR-17, AS-M1, AS-32, and AS-BB), was 0.5 ppt. Five sites (RR-WI, RR-15, CR-17, AS-32, AS-BB) have had average total TEQs less than 3.0 ppt for at the last three years or more. Interpreting year-to-year changes in average fish dioxin TEQ at individual stations has a number of confounding factors, which include variation in catfish size and species collected (channel catfish levels higher than white catfish) and potential fish mobility associated with extreme drought (2002, 2007), high flows and anoxia (2003). Overall, the long-term database for NPDES-required monitoring of fish dioxin concentrations in the Roanoke River and Albemarle Sound supports a conclusion of continued general decline in dioxin and furan concentrations in catfish. Data from the March 2008 NPDES monitoring report showing the variation in average catfish 2, 3, 7, 8-TCDD/F TEQ values (ppt) by location and year are included in Attachment 2.

USFWS Reproduction Studies

The USFWS conducted a series of studies on the reproductive health of various avian species in the LRR area from 1992 to 2003. These studies focused on evaluating the relationship between dioxin concentrations and various indicators of reproductive success for herons, wood ducks, and osprey. Two of the studies specifically focused on wood ducks in the Lower Roanoke River and Welch Creek wetlands. In the studies, no relationship was found between concentrations of dioxin in eggs and reproductive performance even though literature based screening-level benchmarks were exceeded.

> **Wood Duck Study** – The phased wood duck study (1993 to 1995 and then 2002 to 2003) indicated that dioxin TEQ levels in eggs had decreased over time, reflecting decreasing levels of available dioxin in the area. Geometric mean wood duck egg TEQs (6 pg/g) were 5-times less than those measured at this site a decade earlier. The congener profiles, lack of contamination in reference site eggs, and decline in concentrations following mill cessation of molecular chlorine bleaching indicated that local wood duck egg contamination reflects paper mill impacts. There was no definitive evidence of adverse impacts from current PCDD and PCDF contamination. Wood duck productivity, as measured by cutch size and percent hatch, was high compared to other sites; the percent hatch had a wide range in Welch Creek, the

Roanoke River, and Eastmost River (0 to 100), but the median and average percent hatch for these areas is normal. Mercury, TCDD, TCDF, and TEQs were not significantly correlated with percent hatch.

The study also included analysis of mercury in eggs. Mercury concentrations were significantly greater in eggs from the nests of the Roanoke River basin sites compared to the reference site. However, while greater than reference site concentrations, the maximum concentration of 0.14 u.g/g fresh wet weight from a nest box on Welch Creek is well below adverse effects thresholds.

Heron Study – In the early 1990s, the effects of dioxin on a heron rookery were studied by Beeman, et al., 1993. Two colonies were located approximately 32 km (20 miles) upriver of the Weyerhaeuser facility and within the feeding range of great blue herons. In the study, concentrations of dioxin measured in the heron eggs were not elevated above screening levels and there were no observed effects on clutch size, hatch rate, or eggshell thickness.

Osprey Study – The USFWS summarized in 1996 their evaluation of reproductive productivity along with dioxin and mercury concentrations for osprey in Western Albemarle Sound. The study objectives included determining PCDD and PCDF burdens in osprey eggs from Western Albemarle Sound, mercury burdens in Western Albemarle Sound osprey eggs, and comparing productivity of Western Albemarle Sound osprey eggs to ospreys breeding at a reference site. From 1992 to 1995, occupied nests were inspected for clutch size hatchling success and fledgling success. The concentrations of dioxin and mercury were measured in six egg samples each from the Albemarle Sound and a control area. The author concluded that, "there was no significant relationship between western Albemarle Sound osprey reproductive performance and TEQs or mercury." Although the TCDD TEQs exceeded avian effects thresholds, osprey productivity was not appreciably different from a nearby reference area. Finally, the study reported that mercury concentrations in osprey eggs from Western Albemarle Sound were consistently lower than levels believed to impair avian reproduction.

Wildlife Surveys

Supplemental surveys of wildlife and vegetation were conducted and evaluated by Weyerhaeuser to better assess the Lower Roanoke River wetland conditions upstream and downstream of the Weyerhaeuser facility. Species observed during the site-specific avian and vegetation habitat surveys are consistent with literature-based expectations for the region. Nine of the bank locations were upstream of the Weyerhaeuser facility and eight bank survey points were downstream of the site. Five survey locations were located further inland. The results of the survey concluded that there was no evidence of site- related differences between the locations surveyed upstream and downstream of the Weyerhaeuser facility.

Additional independent bird surveys were reviewed to update the understanding of current wetland conditions. Sallabanks, et al. (2000) investigated breeding bird abundance in bottomland hardwood forest along the lower reaches of the Roanoke River. The primary habitats identified and utilized for this investigation consisted of levee forest and swamp forest areas. The authors identified the different dominant and mid-story tree species for each of the primary habitats. Avian species identified in this study included permanent residents, short-distance migrants, Neotropical migrants and forest-interior and area-sensitive species. The authors concluded that the Roanoke River bottomland acts as an effective reserve for both common and uncommon birds expected in the area.

The results of these wildlife surveys depict the Lower Roanoke River wetlands as a healthy, natural environment consistent with other site-specific studies. The wildlife survey results are consistent with independent assessments of the functionality of the Lower Roanoke River areas wetlands conducted by the North Carolina Division of Coastal Management (NC DCM) and the Nature Conservancy.

Weyerhaeuser Supplemental Studies

The supplemental data and information that support the site characterization come from a series of science-based meeting discussions, a voluntary investigation conducted by Weyerhaeuser in 1999 and 2000 and additional site-specific data collection activities conducted by agencies independent of USEPA and Weyerhaeuser. In parallel to data collection by the USEPA for the LRR RI, Weyerhaeuser prepared and executed a separate work plan for collection of supplemental sediment, wetland, and biological data to enhance the assessment of site conditions. The data were collected, managed, and validated by Weyerhaeuser in a manner consistent with the USEPA-approved Remedial Investigation and Feasibility Study Quality Assurance Project Plan, and site-specific work plans (RMT and Beak International, 2001). Sampling stations were co-located with LRR OU-2 samples collected in the USEPA-led RI study. The separate reports that contained the results from these supplemental investigations, along with an integrative summary, were provided to the USEPA in 2002. The information from these supplemental reports was not incorporated into the existing LRR RI and BERA reports. A separate LRR Site Conceptual Model Memorandum was prepared by Weyerhaeuser that integrates the supplemental data and applicable new information in a manner consistent with the iterative process for data collection on contaminated sediment sites.

Then, in 2003, after the RI and BERA for Welch Creek were approved and the LRR RI and BERA were being completed, Weyerhaeuser and the USEPA discussed the best mechanisms for advancing the FS process for both operable units. Both parties agreed that an interactive approach to evaluation of technical issues was desirable and agreed to concurrent facilitated meetings to address technical issues and streamline the process for preparation of the FS reports for both operable units. Additional discussion of each source of information follows.

Summary of Supplemental LRR Data Collection Results

Supplemental data were collected by Weyerhaeuser to support evaluation of current site conditions in the LRR FS. A summary of these reports follow:

- **Fine-Layer Coring Evaluation** – Supplemental sediment cores were collected at five locations down to a depth of 2.75 feet below the sediment surface and sectioned into fine-layers as small as 1.5 centimeters (0.05 foot). Sediment samples were tested for dioxin, mercury, copper, iron, aluminum, TOC, and grain size. The COC data confirmed a clear pattern of new sediment deposition. The highest concentrations of dioxin were buried 6 to 24 centimeters (0.2 to 0.8 feet) below the sediment surface. Therefore, these data provide consistent reinforcement to the modeling conclusion that there is natural deposition of new sediment along the Lower Roanoke River system.
- **Sediment Quality Triad Study** – To augment USEPA's toxicity data, Weyerhaeuser conducted a sediment quality triad (SQT) assessment (chemistry, toxicity, and benthic community surveys) at 14 locations along the Lower Roanoke River (four upstream locations and ten downstream locations). The objective of the SQT tests was to assess a possible relationship between chemical COCs (dioxin and mercury) and health of the benthic invertebrate populations. A secondary objective of the SQT was to provide a more extensive data set from which to evaluate potential sediment toxicity. The SQT sediment toxicity testing indicated minimal differences for sampling locations downstream of the Plymouth Mill from upstream reference locations. For the *Hyalella azteca* tests, there were no significant differences between the laboratory control samples tested and the 14 Lower Roanoke River samples. When comparing downstream samples individually to the pooled upstream reference, differences of small magnitude were noted for survival at RR-SD-08R (76% vs. 84 to 92%) and growth at RR-SD-06L (0.066 mg vs. 0.072 to 0.086 mg) that were statistically significant. Site-specific data from the supplemental SQT assessment indicated that the surficial sediments in the Lower Roanoke River are not adversely impacting the benthic macroinvertebrate population in the Lower Roanoke River system.
- **Wildlife and Vegetation Survey** – Avian and vegetation habitat surveys were conducted at 17 locations along the banks of the Lower Roanoke River and five locations further inland. Species observed in the surveys are consistent with literature-based expectations for the region. Furthermore, there was no evidence of differences between locations surveyed upstream and downstream of Plymouth Mill. These survey results are consistent with other site-specific information that assessed these wetland habitats as thriving and affirm the conclusion that these Lower Roanoke River wetland areas support the types of healthy wildlife and vegetation populations expected to be present in this type of habitat.

The Facilitated Meeting Process

The primary purpose of the facilitated meeting process was to engage stakeholders in discussions related to specific technical issues associated with sediment remediation in Welch Creek and, to a somewhat lesser degree, LRR OU-2. These discussions included topics such as remedy goals, RAOs, and technology evaluations which encompass a sound science approach. The five meetings conducted from August 2003 to April 2004 were attended by these parties as well as a professional technical facilitator. The stakeholder meeting discussions and follow-on action item activities resulted in a number of agreements that impacted the remedy selection process for LRR OU-2.

The agreements reached that impact the identification and evaluation of remedial alternatives, as well as remedy selection for the LRR OU-2 include the following:

- **Bioactive Layer for Sediment** – Defined as the top 5 centimeters of sediment for Welch Creek based on literature and local scientific experts. While the bioactive layer thickness was not explicitly defined for the LRR OU-2 by the stakeholders, the concept of a bioactive sediment layer as an important medium for the bioavailability of constituents of concern (COCs) applies to the LRR OU-2 as well. Available literature (Reible, et al., 1996) indicates that the bioactive layer is likely the top 5 to 10 centimeters for the Lower Roanoke River.
- **Striped Bass Habitat and Fishery** – The stakeholders, with input from the Wildlife Resource Commission, acknowledged that Welch Creek does not have its own population of striped bass, but rather, individual bass using Welch Creek are part of the Roanoke River-Albemarle Sound population. The Roanoke River-Albemarle Sound population of striped bass has been effectively managed by North Carolina and the fishery was declared restored in 1997. North Carolina's focus is to protect habitat for striped bass in the Roanoke River and to maintain the health of this fishery. This stakeholder concern is critical for the identification and evaluation of appropriate remedial technologies and alternatives for the LRR OU-2.
- **Stable Sediment Conditions in Welch Creek** – The USACE has determined that the sediment deposits are stable throughout Welch Creek with the possible exception of the midstream reach (MT-7 to GT-15). In addition, the USACE has concluded that there is limited increased potential for future sediment mobilization, if the upland drainage basin of Welch Creek were developed. The stable sediment conditions in Welch Creek are a factor in assessing the effectiveness of on-going deposition in the LRR.
- **Comparative Risk Evaluation Framework for Remedial Alternatives** – The USEPA and stakeholders agreed that a comparative risk evaluation framework for remedial alternatives is appropriate in the FS. Consistent with the eleven sediment management principles (OSWER Directive 9285.6-08) and the nine FS evaluation criteria (OSWER Directive 9355.3-01), this framework will be used to compare the risk reduction (over time) and environmental benefit that is anticipated for the remedial alternatives. A comparative risk and environmental benefit evaluation was performed in the LRR FS.
- **Remedial Action Objectives (RAOs)** – Final RAOs were developed by the USEPA and other stakeholders for Welch Creek. These RAOs considered the desired outcomes for Welch Creek and LRR OU-2, as expressed by the USEPA, United States Fish and Wildlife Services (USFWS), National Oceanic and Atmospheric Administration (NOAA), and NC DENR. The final agreed-upon RAOs for Welch Creek form the starting point for development of the RAOs for the LRR OU-2. The USEPA and stakeholder group acknowledged the following criteria in the final development of RAOs:
    - Balance between short-term adverse impacts and long-term benefits
    - Desire for a successful remedy – technically and perceptually
    - Consideration of site materials and setting
    - Timely implementation of remedial action
    - Avoidance of significant revisions to approach or action

These criteria were used to develop the LRR OU-2 RAOs presented in Section I.

- **Reaction to Welch Creek Pilot Studies** - An expanded group of stakeholders was also assembled to provide input on the design of the Welch Creek pilot studies. State representatives with specific interests related to the local fisheries provided valuable input regarding the need to protect the recovered striped bass fishery and not disturb the recovery that had occurred in the river system. As a result of their input, the Welch Creek pilot studies included a mini scale test to ensure that the engineering controls would limit possible releases from capping tests and the dredging pilot test was eliminated from the program.

6. Contaminant Distribution

The characterization of the nature and extent of contamination in the Lower Roanoke River operable unit was focused on wetland soil and sediments/surface water using the various data sources previously described.

a. Wetland Soil

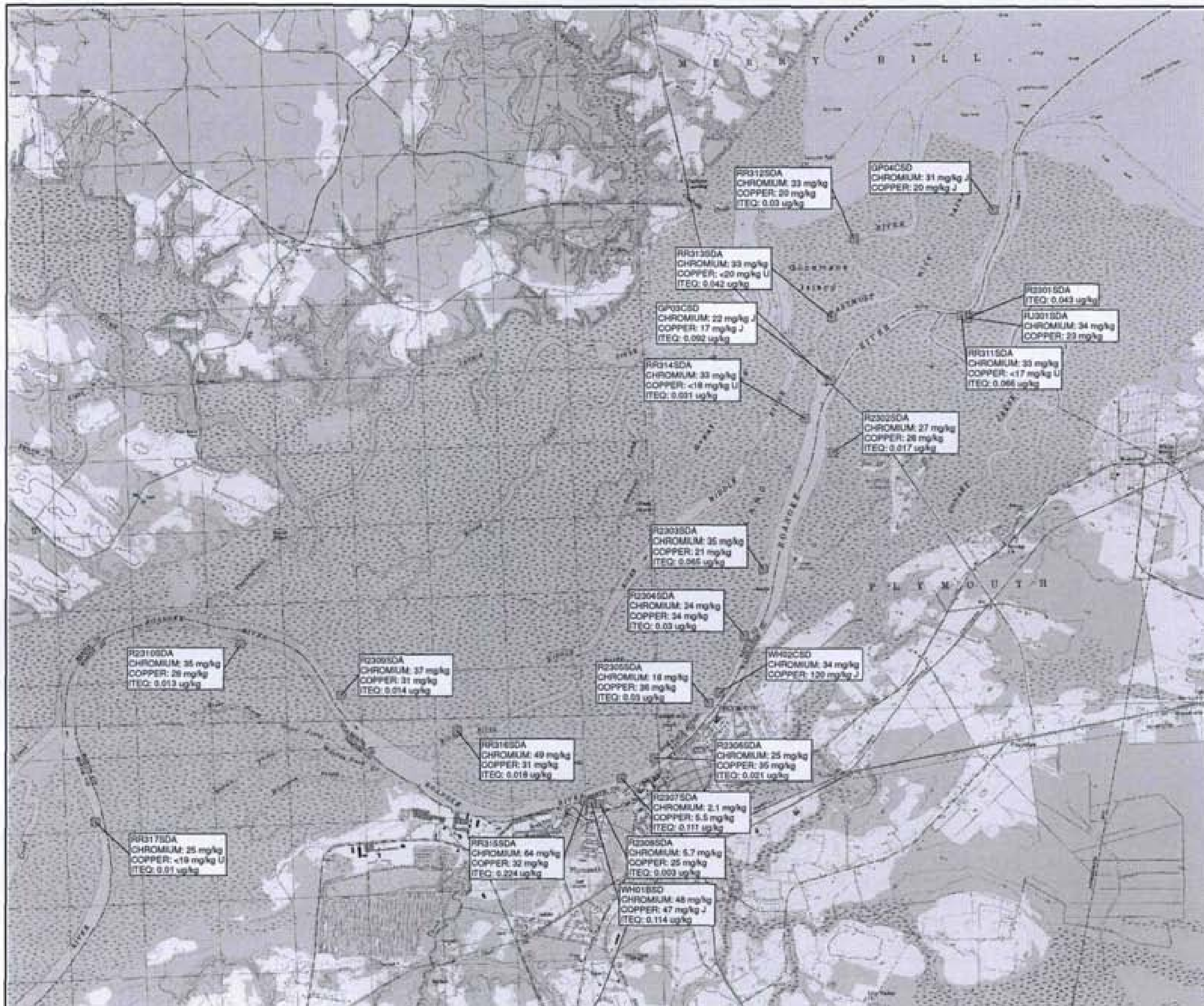
During the LRR RI activities conducted by USEPA's contractor CDM, wetland soil samples were collected at 17 locations (thirteen downstream and four upstream of the Mill). All samples were collected from the top 6 inches of soil and from specific near bank locations "based on observed conditions indicating that the areas is one in which sediment is likely to accumulate." . Analyses were performed for identified COCs as well as selected additional analytes. COCs for wetlands soil were initially identified in the Ecological Risk Problem Formulation as pentachlorophenol, polychlorinated biphenyls (PCBs), copper, chromium and dioxin/furan. Based upon human health and BERA considerations, this list was revised in the approved LRR RI to include copper, chromium, arsenic and dioxin/furans. The list was again narrowed to exclude arsenic from remedial goal option (RGO) development since arsenic was not a final wetland soil COC in the human health risk assessment. Final COC concentration ranges for both reference and downstream wetland soil samples are summarized in Table E-3 and shown on Figure E-4. Note: due to collection of wetland soil samples from near-bank areas immediately adjacent to the riverbed, these results are considered to be biased high.

Table E-3
Comparison of Wetland Soil COC Results to Comparison Criteria and LOAEL-Based RGOs

Parameter	Location (relative to the Plymouth Mill)	Range	Average and Number of Samples	Comparison Criterion (from LRR RI Table 4-8)	LOAEL based RGO in Soil	Number of Samples Above Criterion/Lowest RGO
Chromium (conc. in mg/kg)	Upstream	25 to 37	32.3 (N = 3)	65 mg/kg	559 to 239,000 mg/kg	Comparison Criterion – Zero
	Downstream	2 to 64	30.6 (N = 18)			RGO (559 mg/kg) – Zero
Copper (conc. in mg/kg)	Upstream	9.5 to 31	22.17 (N = 3)	44 mg/kg	101 to 2,660 mg/kg	Comparison Criterion – Two
	Downstream	5.5 to 120	28.89 (N = 18)			RGO (101 mg/kg) – One
Dioxin as I-TEQ (conc. in ug/kg)	Upstream	0.0097 to 0.014	0.0121 (N = 3)	0.023 ug/kg	0.180 to 5.16 ug/kg	Comparison Criterion – Twelve
	Downstream	0.003 to 0.224	0.059 (N = 16)			RGO (0.310 I- TEQ ug/kg) – Zero RGO (0.180 ug/kg Avian –TEQ) – Seven

Notes:
1. Includes all available data collected by USEPA or Weyerhaeuser from top 6 inches of wetland soil.
2. For metals with no-detect, one-half the detection limit was used.
3. Dioxin reported as I-TEQ.
4. If dioxin congener not-detect, one-tenth the detection limit was used.
5. Number of samples includes replicates/duplicates.

Comparison to RGOs - The LOAEL-based RGO has been used for the comparison of sample results in the on-site Operable Units (Landfill No. 1, Former Chlorine Plant, and Welch Creek). Table E-3 also includes the LOAEL based and human health based RGOs identified in the LRR RI. Consistent with additional information provided in the LRR FS, neither copper nor chromium are detected consistently in wetland soil or are quantified at elevated concentrations that support final selection as a site related COC for wetland purposes. Dioxin concentrations in wetland soil are well below the EPA's general dioxin clean-up level of 1 ppb for protection of human health and the environment and within the overall range of the calculated clean-up goals, depending upon the particular endpoint. More specifically, dioxin concentrations in wetland soil are within the overall range of the LOAEL-based RGOs for various receptors. However, the concentrations did exceed the LOAEL-based RGO concentrations calculated for avian receptors in seven of sixteen downstream locations. As stated in the LRR BERA uncertainty analysis, the conservative food chain model assumptions and data from biased sample locations tend to overestimate risk.



LEGEND

USEPA Wetland Sample Locations

PROJECT: **DOMTAR COMPANY**
MARTIN COUNTY, NORTH CAROLINA
LOWER ROANOKE RIVER - O.U.-2

SHEET TITLE: **WETLAND SOIL COC CONCENTRATIONS**

FIGURE E-4

Observed Wetland Conditions - Since North Carolina assesses wetland conditions based upon functionality without specific chemical standards, wetland conditions were also evaluated considering the conclusions of the North Carolina Coastal Region Evaluation of Wetland Significance (NC-CREWS) program instituted by the NC DCM. Wetland scientists conduct on-location visits to gather functional data on 39 parameters for each wetland evaluated, synthesize the information using Geographic Information System (GIS) software, group the parameters into three main wetland functions: Water Quality Functions, Wildlife Habitat Functions, and Hydrology Functions and then assign scores to each function. After consideration of the various factors a rating level was assigned to reflect the following functionality (NC-CREWS, 2005):

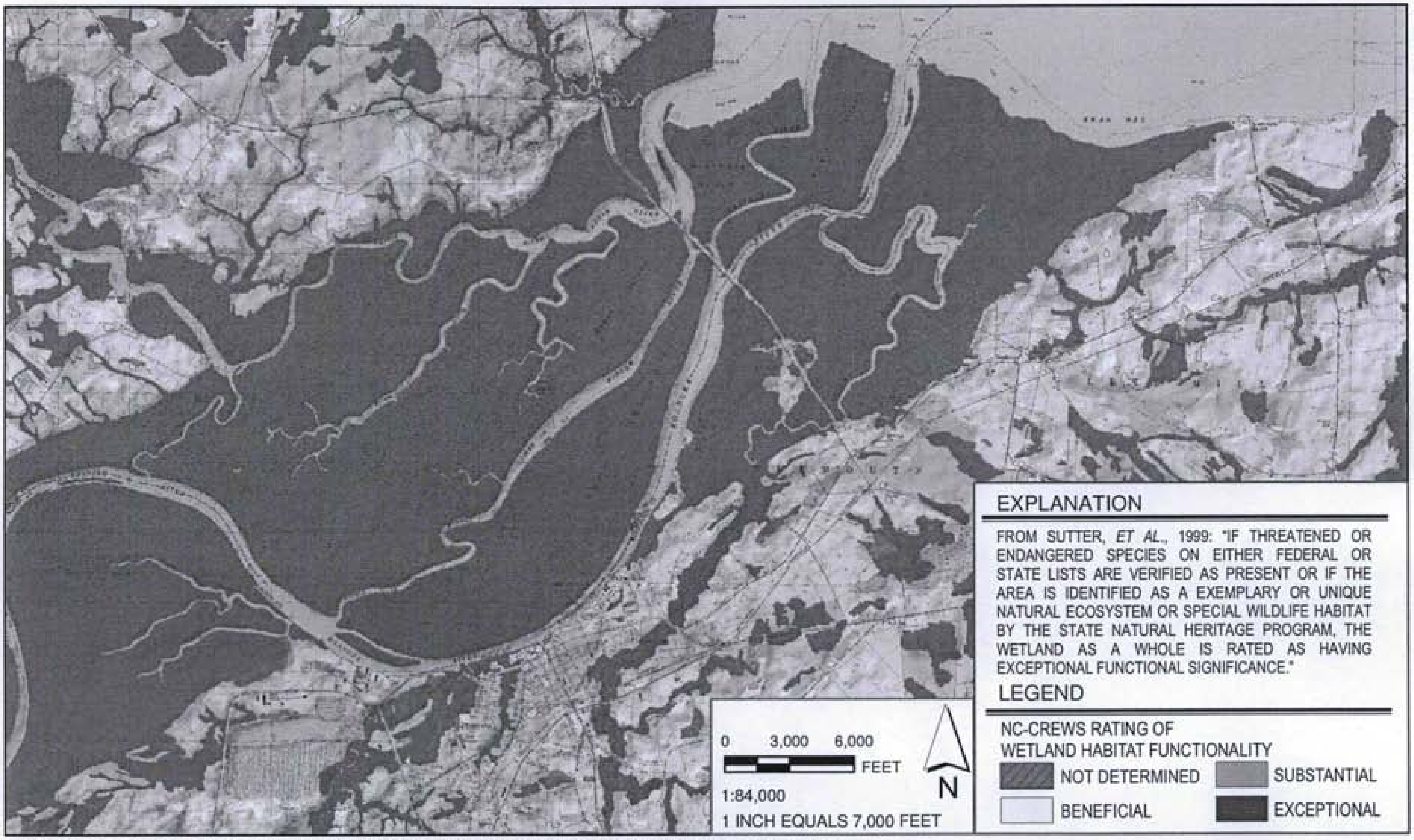
- Beneficial Significance - indicates that a wetland performs the three main functions at below normal levels or not at all.
- Substantial Significance – indicates that a wetland performs the three main functions at normal or slightly above normal levels.
- Exceptional Significance – indicates that a wetland performs the three main functions at well above normal levels.

Most of the near-by wetland areas associated with the Lower Roanoke River were rated as a mixture of Substantial Significance or Exceptional Significance based on the NC-CREWS reflecting their exceptional value and overall healthy condition. A map of these areas is included as Figure E-5.

b. Sediments

Sediment COCs were identified in the LRR RI as dioxin/furans, total mercury, and copper. In addition to the sediment data collected for the LRR RI, sediment data was also collected by the responsible party as part of supplemental studies to assess biological impacts through a sediment triad assessment and to evaluate potential sediment burial through fine-layer core sampling.

All data from both studies were included with the exception of sample number R2419TXA. There was some uncertainty associated with this data point regarding its quality and representativeness. The data for sample R2419TXA was specifically evaluated as an outlier due to concentrations differences 5 to 15 times higher than three nearby samples; did not contain congener patterns consistent with the on-site sources and was flagged during data validation. Finally, there were also noted inconsistencies with mercury and copper results from



BASE MAP FROM USGS 7.5 MINUTE QUADRANGLES: PLYMOUTH WEST (1979, REVISED 1980) AND HOKE (1978, REVISED 1980).

NC-CREWS
WETLAND HABITAT FUNCTIONALITY
LOWER ROANOKE RIVER WETLANDS

DOMTAR
MARTIN COUNTY, NORTH CAROLINA
LOWER ROANOKE RIVER - O.U. - 2

AUG 2008

FIGURE E-5

this location. Thus, this single data point was replaced by other nearby data to more accurately characterize the site for all approved sediment evaluations.

Concentrations of Mercury and Copper in Sediment

For all retained sediment samples, there were a limited number of detected concentrations for copper and mercury and the sediment concentration patterns were inconsistent with distance from the Mill. These metals data was more fully evaluated to assess the implications of these metals on risk and remedy selection.

For copper in sediment:

- Concentrations of copper in sediment samples are generally consistent with the comparison criterion (results from upstream reference sampling locations) that was intended to distinguish between site-related impacts and background concentrations.
- For copper, only one downstream sample (out of 70) and one upstream sample (out of 19) exceeded the comparison criterion and no samples exceeded LOAEL-based RGOs.
- Copper concentrations in the LRR OU-2 system were shown to be highly correlated with the background mineral components (aluminum and iron) of sediments.

These results support a risk management decision to not further address copper as a COC for remedy selection.

For mercury in sediment:

- The Former Chlorine Plant remedial actions have reduced the potential for residual mercury movement into the LRR OU-2 by isolating mercury present in the on-site subsurface soils. The Former Chlorine Plant remedy construction was completed in August 2006.
- Measured mercury concentrations in surficial sediments up and downstream of the Plymouth Mill are similar in that limited samples from both up and downstream reaches exceed reference criteria. Furthermore, there was no discernable pattern of mercury deposition in sediment with distance from the Plymouth Mill.
- National, regional, and local data that quantify historic and current concentrations of mercury in rainfall confirm that atmospheric deposition of mercury represents an on-going source of mercury to the lands and waters of eastern North Carolina, with coal-fired utilities as the likely primary emission sources. Thus, this on-going source of mercury to the environment must be recognized, especially given the site setting and surrounding wetlands that facilitate mercury methylation.
- Fish tissue mercury concentrations in the LRR OU-2 and Welch Creek are consistent with statewide and regional mercury concentrations in upper trophic level fish.

These actions and data support a conclusion that mercury concentrations observed in shallow sediment and wetland soil, as well as fish tissue in eastern North Carolina, is a regional concern caused by widespread, on-going input of mercury. Thus, mercury is not considered an actionable site-specific COC that needs to be addressed directly in the LRR FS. Instead, longer term fish tissue monitoring with comparison to local and regional background data as part of a remedial alternative is one approach to confirming this conclusion consistent with the iterative process for the management of contaminated sediment sites.

Concentrations of Dioxins in Sediment

Sediment samples were collected for analysis of various COCs including dioxin at 15 locations upstream and 55 locations downstream of the Mill. A map of dioxin concentrations in shallow sediment (defined as the top 6 inches or approximately 15 centimeters) is presented as Figure E-6. The bioactive layer of surficial sediment for the LRR OU-2 is estimated to be 5 to 10 centimeters. In evaluating potential risk to environment and recovery of the system, the concentration of dioxin found in this "bioavailable" surficial layer is a key factor. This figure includes sediment data collected during the LRR RI sampling along with shallow sediment data from 23 additional locations. Two different sampling techniques were applied to obtain these 23 samples. Fourteen samples were collected using Ponar samplers during the SQT evaluation while nine samples were collected by a coring device (five fine-layer and four sectioned as a single sample from the upper 15 centimeters [6 inches]).

The surface concentrations of dioxin are all below the LOAEL based RGO of 0.180 ug/kg. There were no major concentration trends other than sediment samples collected downstream of the mouth of Welch Creek more frequently contained I-TEQ dioxin levels above the background comparison criteria of 0.028 ug/kg. In addition, slightly higher I-TEQ dioxin concentrations were measured in samples collected near the confluence of Welch Creek and the Lower Roanoke River as well as from several locations immediately up and downstream of the confluence with the Eastmost River.

Table E-4 presents a compilation and comparison of USEPA and Weyerhaeuser data sets addressing dioxin concentrations in surface sediments for use in this LRR FS.

Table E-4
Summary of Updated Shallow Sediment Dioxin Data

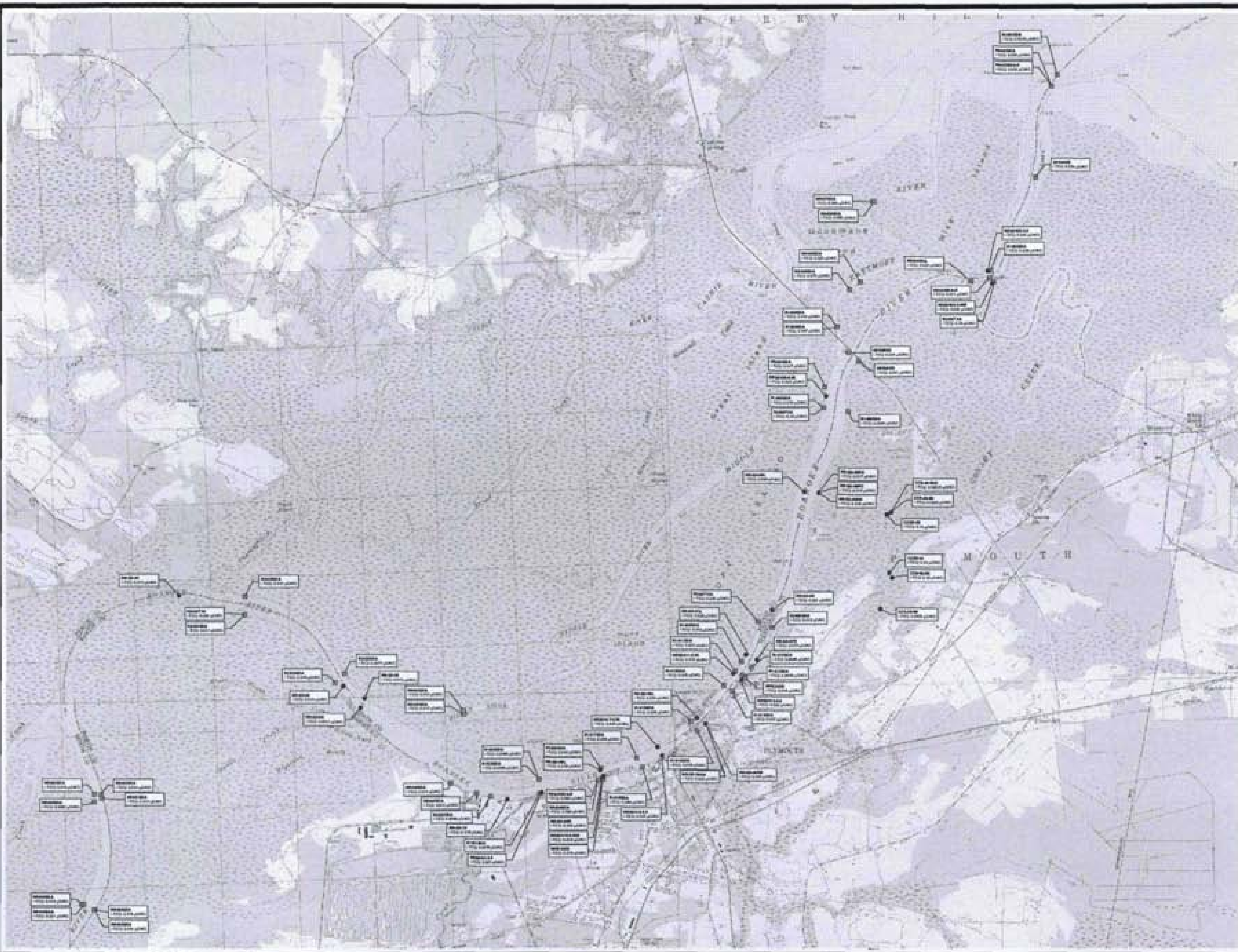
Location	Party Collecting Data	Range (ng/kg)	Number	Average (ng/kg) and [Standard Deviation]	No. Over Comparison Criterion from LRR RI Table 4-4: 28 ng/kg	No. Over LOAEL Based RGO from LRR RI Table 6-2: 180 to 2890 ng/kg (5)
Reference (Upstream)	USEPA	7.3 to 21	15	15 [3.8]	0	0
	Weyerhaeuser	1.7 to 13	4	9.4 [5.3]	0	0
	Combined Data	1.7 to 21	19	13.5 [4.6]	0	0
Downstream	USEPA	2.9 to 178	43	38 [39]	20	0
	Weyerhaeuser	15 to 72	23	29 [14]	8	0
	Combined Data	2.9 to 178	66	35 [33]	28	0

Notes:

1. All sample data from 0 to 15 centimeters (0 to 6 inches).
2. Dioxin reported as I-TEQ.
3. Duplicate samples counted in total number. There were zero duplicate pairs upstream and three pairs downstream.
4. The sample R2419TXA contained a dioxin concentration of 430 ng/kg. This sample was not considered representative and was not included in this table based upon the rationale summarized in the text and further described in Appendix E, Evaluation of R2419TXA Sample as a Possible Outlier.
5. LOAEL based on mammalian TEQ (comparable to I-TEQ).
6. If congener not detected, one-tenth of the detection limit is used.

The two data sets are generally similar as suggested by the similarity in average concentrations calculated for each data set individually. The slightly lower average developed from the Weyerhaeuser supplemental data is likely due to a larger number of samples collected in the top few centimeters where new clean sediment is accumulating. USEPA's data also have a wider range and associated standard deviation, but only two shallow sediment samples contained quantified dioxin I-TEQ concentrations above 100 ng/kg.

Figure E-7 provides a comparison of surface area weighted average sediment concentrations (SWAC) for shallow sediments upstream and downstream of the Mill. The SWAC is a calculation method used to compare sediment concentrations across different areas or over time



LEGEND

I-TEQ SURFACE SEDIMENT SAMPLES

- ● WEYERHAEUSER SAMPLES
- ▣ US EPA SAMPLES

NOTES

1. ALL VALUES ARE CALCULATED USING THE INTERNATIONAL TEQs.
2. ALL TEQ VALUES USE 1/10TH OF THE DETECTION LIMIT FOR NO-DETECTS.

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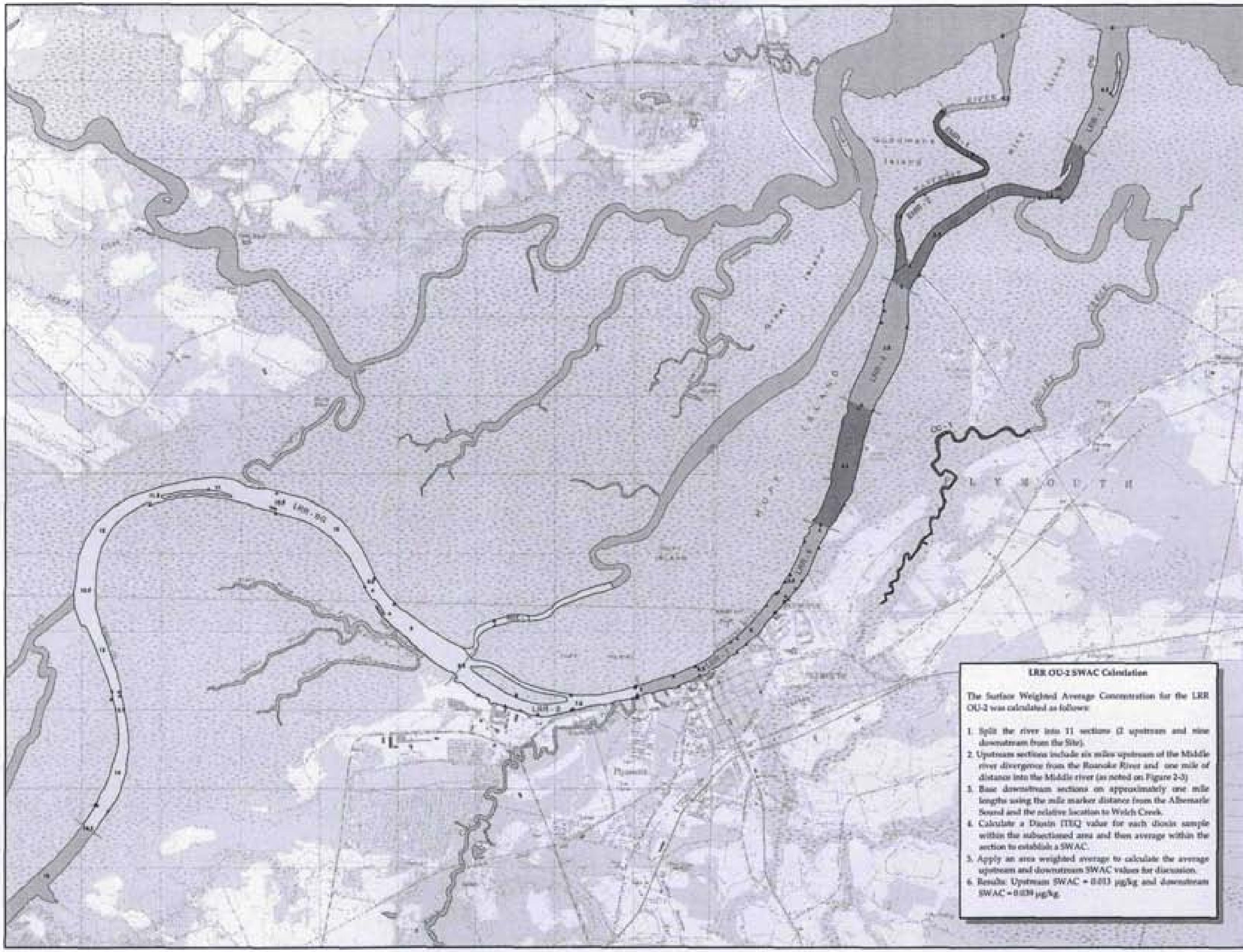
LOWER ROANOKE RIVER - O.U. 2

I-TEQ, SURFACE SEDIMENT SAMPLES
LOWER ROANOKE RIVER

FIGURE E-6



LRR OU-2 SWAC Calculation

The Surface Weighted Average Concentration for the LRR OU-2 was calculated as follows:

1. Split the river into 11 sections (2 upstream and nine downstream from the Site).
2. Upstream sections include six miles upstream of the Middle river divergence from the Roanoke River and one mile of distance into the Middle river (as noted on Figure 2-3)
3. Base downstream sections on approximately one mile lengths using the mile marker distance from the Albemarle Sound and the relative location to Welch Creek.
4. Calculate a Dioxin ITEQ value for each dioxin sample within the subsectioned area and then average within the section to establish a SWAC.
5. Apply an area weighted average to calculate the average upstream and downstream SWAC values for discussion.
6. Results: Upstream SWAC = 0.013 µg/kg and downstream SWAC = 0.039 µg/kg.

LEGEND

▲ SURFICIAL SEDIMENT TEQ LOCATIONS

RIVER MILE MARKERS

SWAC CALCULATION AREAS - AVERAGE TEQ (µg/Kg)

- < 0.028
- 0.028 - 0.040
- 0.040 - 0.050
- > 0.050

OTHER RIVER / SOUND AREAS (NO SWAC CALCULATIONS)

NOTES

1. ALL VALUES ARE CALCULATED USING THE INTERNATIONAL TEQs.
2. ALL TEQ VALUES USE 1/10TH OF THE DETECTION LIMIT FOR NO-DETECTS.
3. SURFACE AREA WEIGHTED I-TEQ VALUES CALCULATED AS THE SUM OF THE PRODUCTS OF AVERAGE SAMPLE VALUES FOR EACH STREAM AREA AND ITS RESPECTIVE AREA DIVIDED BY THE TOTAL AREA FOR ALL ANALYZED SECTIONS IN THE RESPECTIVE UNITS.

LOCATION	SWAC UNIT	AVERAGE I-TEQ (µg/Kg)	SAMPLE COUNT	SURFACE AREA WEIGHTED I-TEQ (µg/Kg)
UPSTREAM	LRR_BG	0.013	17	0.013
	MR_1	0.016	2	
DOWN-STREAM	LRR_8	0.026	15	0.039
	LRR_7	0.025	10	
	LRR_6	0.028	14	
	LRR_5	0.048	1	
	LRR_4	0.039	6	
	LRR_3	0.042	5	
	LRR_2	0.050	6	
	LRR_1	0.034	1	
	EMR_2	0.046	4	
	EMR_1	0.073	2	
CONABY CREEK	CC_1	0.077	6	0.077

0 1,000 2,000 4,000 FEET

1 INCH EQUALS 3,971 FEET

1:47,651

N

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SURFACE AREA WEIGHTED AVERAGE CONCENTRATION
LOWER ROANOKE RIVER

FIGURE E-7

for sediment sites and can be used for comparison to targeted clean-up concentrations. The resultant overall downstream SWAC of 0.039 ug/kg I-TEQ is above the upstream calculated SWAC of 0.013 ug/kg but is well below the LOAEL based RGO of 0.180 ug/kg and only slightly greater than the comparison criterion of 0.028 ug/kg. Calculated SWAC levels by mile are shown in Figure E-7 and reveal that lower surficial dioxin concentrations are present in areas where the river is wider, suggesting a greater rate of deposition in areas with larger cross-section and associated lower water velocity. The data confirm an on-going depositional environment which shows lower concentrations of dioxin in the bioactive layer than deeper in the sediment profile.

c. Concentrations in Surface Water

Eight surface water samples were collected during the LRR RI activities. The sample locations include one at the mouth of the Chowan River, one upstream of the Mill, two on Welch Creek, one on the Middle River, and three between the Mill and Albemarle Sound. At all locations, samples were collected using two sampling methods. Grab samples were collected for comparison to state water quality standards using 1-liter sample containers consistent with EPA Method 1613B. This method is specified by reference to 40 CFR Part 136 in the North Carolina Surface Water and Wetland Standards (15A NCAC 02B.0103). Specifically, the administrative code specifies that analytical procedures to determine conformity with standards follow USEPA's standard procedures, so the grab samples were collected consistent with Region 4 SOPs. In addition to dioxin, surface water grab samples were also analyzed for TCL constituents and TAL metals. To further evaluate dioxin concentrations, a separate high volume sample was collected at each location over approximately 8 hours with a total volume of 750 liters pumped through three filters and a resin bed. The stated purpose of the high volume samples was to determine the nature and extent of dioxin contamination and provide information for the ecological risk assessment.

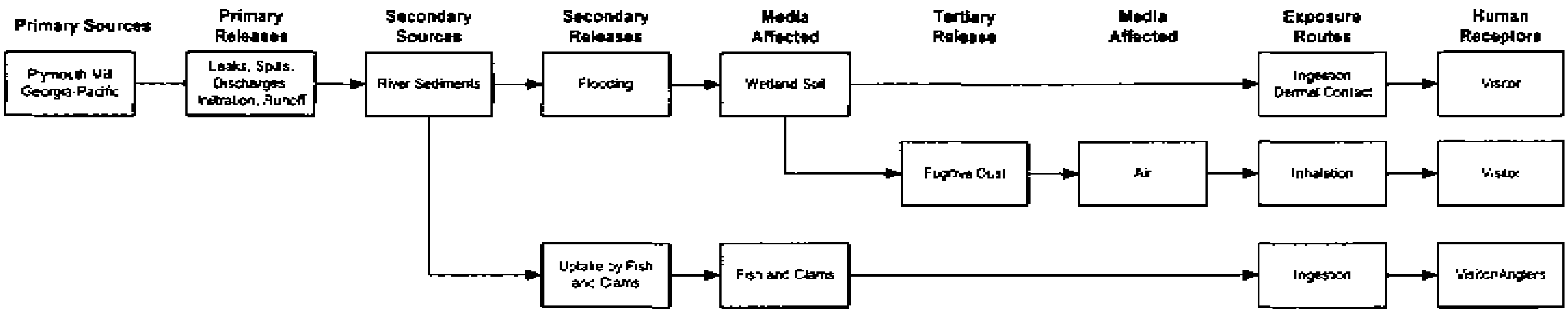
The results of the grab sample analyses were compared to North Carolina surface water standards. For all eight samples, there were no detectable TCL compounds and no standard exceedances for TAL metals, except iron in one location. Some dioxin congeners were detected in surface water grab samples, but not 2,3,7,8-TCDD which is the regulated congener. The high volume samples were analyzed by dissolved fraction and filter size fraction. As expected additional dioxin congeners (including dissolved 2,3,7,8-TCDD at one location) were quantified above the lower detection limits. In general, the concentrations and numbers of dioxin congeners were greater in downstream sample locations. However, the I-TEQ dioxin concentrations measured using the high volume method were all below 1 part per quadrillion with the highest concentrations detected within Welch Creek. The highest dioxin TEQ concentration in the Lower Roanoke River downstream of the Mill was 0.2 parts per quadrillion. This data supports a conclusion that there is minimal movement of dioxin through the water column within the Lower Roanoke River.

7. Site Conceptual Model

The Human Health and Ecological Site Conceptual Models for the Lower Roanoke River was developed during the work planning activities and the Ecological Site Conceptual Model continued to be refined through the FS process. The preliminary Site Conceptual Models based on characteristics of the contaminated media, the COPCs for each affected environmental medium, and the migration and transport potential of the constituents to potential receptor was included in the RI Work Plan and formed the basis for the investigation and risk assessment for the Lower Roanoke River.

The human health site conceptual model is included as Figure E-8. The ecological site conceptual model for the Lower Roanoke River adjacent wetlands was focused and reviewed with development of a modified version in the Lower Roanoke River FS. The revised ecological Site Conceptual Model (Figure E-9) integrated the input from the facilitated meeting stakeholders, supplemental data, published literature, and other sources and provided a more visual illustration of the potential ecological risk and sediment migration pathways than the previous version.

The refined ecological Site Conceptual Model in the approved Lower Roanoke River FS focuses on dioxin as a primary COC since on-going air deposition sources of mercury cannot be controlled by a sediment remedy. The final refined ecological Site Conceptual Model forms the basis for the evaluation of remedial alternatives.



NOTE: Human Health site conceptual model not revised from the CDM Baseline Risk Assessment for Human Health Lower Roanoke River Study, North Carolina (Figure 4-1). Further assessment did not warrant revisions to the model however, the uncertainty and risk assumptions were reassessed.

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HUMAN HEALTH SITE CONCEPTUAL MODEL

FIGURE E-8

F. Contaminant Fate and Transport

This section of the ROD addresses the potential routes of contaminant migration through various media in the LRR OU-2 as well as the implications of other site conditions and supplemental investigations on contaminant fate and transport. The assessment is based upon the results of the various data collection activities and independent studies and utilizes the updated site conceptual model to identify critical migration pathways.

Potential routes of contaminant migration identified for the Lower Roanoke River are:

- Contaminant migration to the Lower Roanoke River from Welch Creek
- Surface water migration
- Atmospheric transport/deposition
- Contaminant migration from the sediment into the surface water
- Background sources

1. Contaminant Migration to the Lower Roanoke River from Welch Creek

The potential for on going sources to the Roanoke River was assessed in two ways. First the congener fingerprints of dioxin in sediment were evaluated to identify current or historic sources and then the significance of the contribution was evaluated. Dioxin fingerprinting activities were performed to assess congener patterns up and downstream of Welch Creek. The analyst identified patterns consistent with by-products from bleaching used in paper making operations in downstream sediments and concluded that wastewater discharges from the Mill were a likely source. In order to evaluate the both the amount and significance of this historic source and assess the potential for on-going transport of COPCs, including dioxin, from the Welch Creek basin, a whole water sampling program was implemented during the Welch Creek remedial investigation. Additional details on the sampling program and results are discussed in the Welch Creek FS and summarized in the Welch Creek ROD. The results of the whole water sampling indicate that there is relatively little on-going migration of solids in the Welch Creek system as a result of storm surge events. The maximum concentration of total suspended solids in Welch Creek water was 47 mg/L and the duration of the elevated concentrations was only several hours. Since dioxin has extremely low solubility and will be transported through solids migration, this data was used to calculate an annualized loading for comparison to upstream sources. The results show that the annualized loading from Welch Creek baseflow and average annual flow events represents approximately 0.83 to 1.34 percent of the total Roanoke River loading. This information confirmed the modeling conclusions that the sediments in Welch Creek were not migrating under most hydrological conditions. This information supported selection of a thin layer capping remedy for Welch Creek. This remedy will be constructed within the next few years and once completed will further reduce the residual contributions of dioxin from this historic source.

2. Surface Water Migration (High Volume Water Sampling)

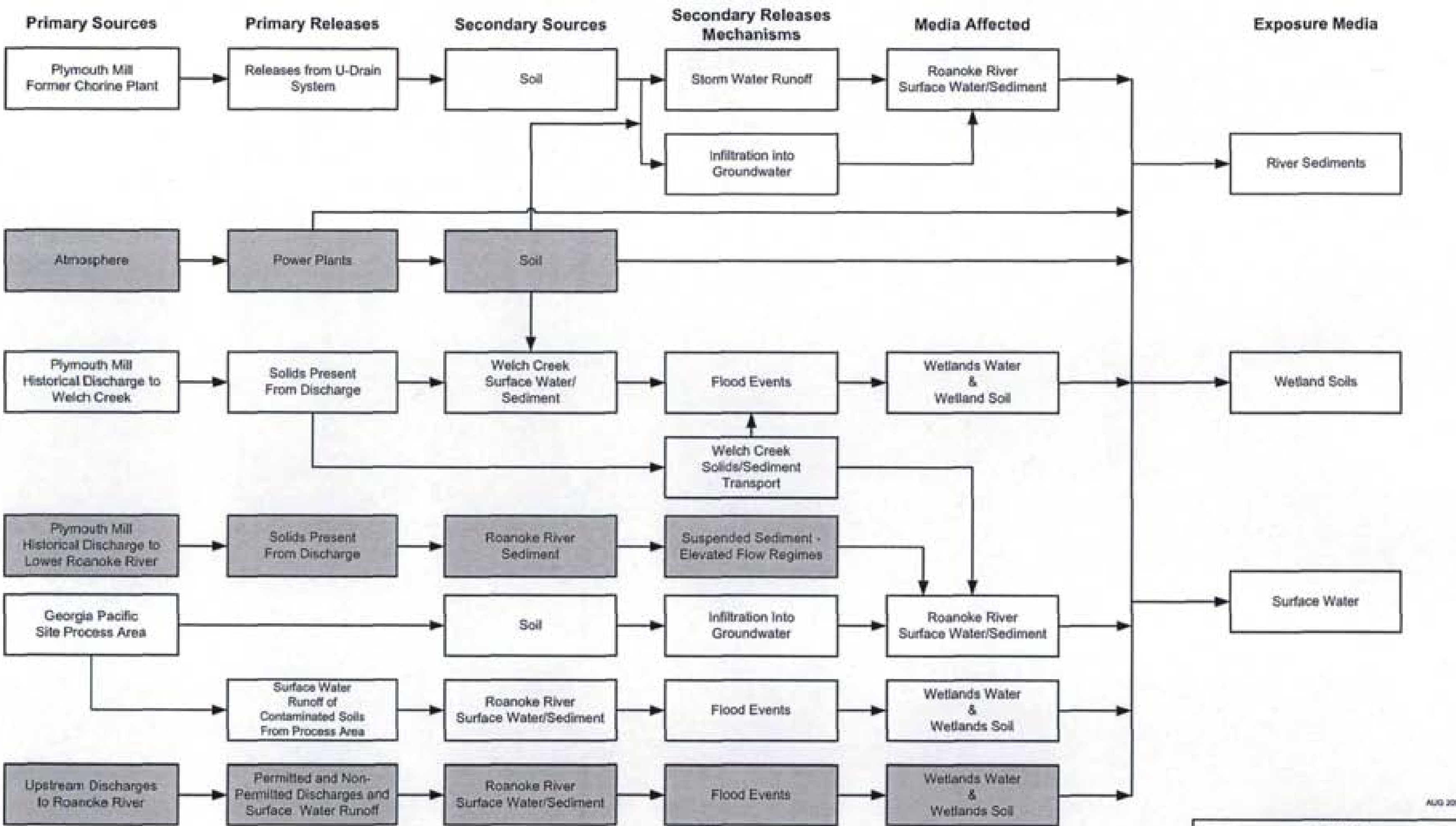
Since the concentrations of dioxin are below the detection limit of the regulatory specified analytical method for dioxin (detection limit was established by the laboratory to be 0.02 ng/L [ppt] or 20 part per quadrillion), eight high volume (750 liter) surface water samples were collected, the water pumped through special filters and resins and then the filters and resins were analyzed for dioxin. Application of this investigation tool lowered the detection limit to 8.7 fg/L (part per quintillion) and the results were used to help evaluate the nature and extent of dioxin contamination and to provide information for the ecological risk assessment. The eight sample locations include one at the mouth of the Chowan River, one upstream of the Plymouth Mill, two on Welch Creek, one on the Middle River, and three between the Mill and Albemarle Sound. As expected, additional dioxin congeners (including dissolved 2,3,7,8-TCDD at one location) were quantified when there were lower detection limits. In general, the concentrations and numbers of detected dioxin congeners were greater in locations downstream of Welch Creek. However, the I-TEQ dioxin concentrations measured using the high volume method were all below 1 part per quadrillion with the highest concentrations detected within Welch Creek. The highest dioxin TEQ concentration in the Lower Roanoke River downstream of the Mill was 0.2 parts per quadrillion. This data supports a conclusion that there is minimal movement of dioxin through the water column within the Lower Roanoke River.

3. Atmospheric Transport/Deposition

The Site Conceptual Model (Figure E-9) identifies atmospheric deposition of various COCs, including both dioxin and mercury, as a contributing pathway for media concentrations along the Lower Roanoke River. For the LRR site, the effects of atmospheric deposition of dioxin were assessed by considering upstream and downstream dioxin fish tissue concentrations as well as dioxin concentrations and congener patterns in the water column.

In contrast, further assessment of the implications of atmospheric mercury is merited since mercury is recognized to be a widespread problem and has been measured in sediments, wetlands soils and fish at comparable concentrations upstream and downstream of the facility. A description of the potential sources of mercury was included in the LRR FS. A brief list of these sources is included below.

- **Atmospheric sources and fish tissue concentrations of mercury.** Atmospheric deposition of mercury has been widely studied due to widespread public concern and scientific interest. National and regional data as well as local data support the conclusion that atmospheric deposition of mercury represents an ongoing and dominant source of mercury throughout the eastern portion of the United States and eastern North Carolina. It has also been determined that mercury fish tissue concentrations in eastern North Carolina were strongly correlated to atmospheric mercury sources. In eastern North Carolina, fish advisories are in place for several species east of Interstate 85, and regulators specifically attribute these advisories to coal fired utility boilers. Mercury fish tissue data collected locally, in nearby states, and regionally confirms that the concentrations of mercury in fish from the Lower Roanoke River are comparable to other waterbodies throughout the region.
- **Atmospheric deposition in terrestrial ecosystems.** Although much of the research has focused on mercury impacts to fish, terrestrial systems are also impacted by airborne mercury deposition. Research documents that forests, including wetlands, may sequester as much as four times more mercury than is present in precipitation. Once deposited on the landscape, these researchers have



NOTES:
1. Adapted from LRR BERA Figure 5-1
2. Light Blue Shaded Boxes indicate figure changes
3. The refined SCM addresses current site conditions

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REFINED ECOLOGICAL
SITE CONCEPTUAL MODEL

FIGURE E-9

also determined that terrestrial environments continue to act as secondary sources of mercury to adjacent waterways. Furthermore, the amount of mercury that remains sequestered in a soil sample matrix is proportional to the organic content of the sample.

- **Assessment of potential site-related mercury sources.** Since the Former Chlorine Plant (FCP) was an identified source of mercury in the preliminary Ecological Site Conceptual Model presented in the LRR RI, both current and historic site-related sources of mercury were further evaluated as part of the LRR FS to determine if there were significant ongoing contributions from the Plymouth Mill to be considered in the refined Ecological Site Conceptual Model. Based upon calculations in the approved FCP RI, current sources of mercury from groundwater migration represent a range of 0.002 to 0.2% of total contributions of mercury to the Lower Roanoke River. This limited contribution is targeted to be reduced up to 99% through remediation of the FCP unit (completed in 2006). In addition, mercury associated with past releases from the FCP have been isolated by several feet of natural sediment deposits. Similarly, the average measured annual deposition of water borne sediments in wetlands along the lower reaches of the Roanoke River (~ 1.8 to 2.0 cm/yr, Peet, et al., 2005) will have buried any historic site related mercury in wetlands soil. The FCP was eliminated as an on-going source of mercury in the refined ecological site conceptual model, while on-going atmospheric source supports the elimination of mercury as a site-related COC in surface soils and sediment.

Measured concentrations of mercury in both sediments and wetland soils reflect variability and uncertainty from sampling approaches and analytical procedures but remain consistent with an on-going atmospheric source of mercury to the system. The ranges in mercury upstream and downstream of the Weyerhaeuser facility are summarized in Table F-1. The difference between upstream and downstream concentrations can be attributed to the higher organic content in the downstream wetland soils, which was twice the organic content of upstream soils.

Table F-1
Concentrations of Mercury and Organic Carbon in Sediments and Wetland Soil

	Range[1] (mg/kg)	Average[2] (mg/kg)	Number of NDs	Standard Deviation	Avg. Organic Content[3] (mg/kg)
Wetland Soil – Upstream	<0.25 to 0.52	0.249	3/4	0.182	21,900
Wetland Soil – Downstream	< 0.11 to 0.74	0.316	12/17	0.218	42,160
Sediment (0-6 in) - Upstream	<0.15 to 1.4	0.262	7/15	0.352	17,200
Sediment (0-6 in) – Downstream	<0.07 to 1.6	0.214	28/41	0.283	15,930

Notes:

1) The calculated comparison criterion developed for mercury was 0.32 in wetland soil but did not include the wetland soil sample from the Middle River (RR316SDA – 0.52 mg/kg). The comparison criterion for mercury in sediment was 0.68 mg/kg.
2) Average includes ½ the detection limit for non-detected results.

3) Although sufficient data are not available for wetlands samples to develop a formal relationship between mercury and TOC, a regression analysis for the five quantified mercury results in sediment had an R2 value of 0.929.

Sediment mercury concentrations were also frequently below the method detection limits for mercury. For samples where mercury was detected, the average concentrations of both mercury and organic carbon were essentially the same both upstream and downstream of the Plymouth Mill. The overall consistency in mercury sediment data across the entire LRR study area supports a conclusion that there is a uniform source of mercury affecting both upstream and downstream sites. This observation is consistent with the dominant importance of uncontrolled atmospheric sources of mercury.

4. Migration Potential of Lower Roanoke River Sediment

Assessment of sediment migration potential provides critical information for use in remedy evaluation and selection. The evaluation of migration potential of the Lower Roanoke River sediment was primarily based upon the USACE hydrological modeling of the Lower Roanoke River supplemented by independent studies of the river environment (*e.g.*, Riggs, etc.) and the fine layer sediment coring data that allowed physical confirmation of site conditions. All of these lines of evidence confirm that the Lower Roanoke River is a system that provides a long-term stable environment for sediment.

Geologic Assessment of the Lower Roanoke River System

The conceptual model of the Lower Roanoke River developed by Riggs (1996) characterizes the lower reaches of the Roanoke River as not actively meandering since the series of dams was constructed from the early 1950s through the 1960s in the middle portion of the basin. The construction of these dams substantially reduced bed load transport in the system. According to modeling work commissioned by the USEPA and conducted by the USACE (Scott, 2001), the LRR OU-2 is a non-erosional environment that accumulates fine sediment under many flow conditions. Based on the results of sediment strength testing and stream flow modeling, the USACE concluded that the LRR OU-2 "historic sediment deposits are most likely stable, with sediment transport in the system consisting of fines transported to the Roanoke from tributaries. Some bed movement may occur at higher flows, but significant bed load and suspended load are unlikely, even at the highest flows" (Scott, 2001). Riggs (1996) indicates the current sediment loading to the Lower Roanoke River would be primarily from portions of the drainage basin downstream of Roanoke Rapids dam.

Detailed United States Army Corps of Engineers Evaluation

A study designed by the USACE to evaluate transport of suspended material in the Lower Roanoke River (*i.e.*, assess the potential for deposition and/or transport of silt, clay, and organic material already in suspension in the Roanoke River), and evaluate sediment stability and potential transport concluded that the potential for deposition of suspended sediment reaching the Lower Roanoke River from upstream sources and tributaries was a direct function of river flow.

The USACE study included characterization of the strength of sediments to resist erosion (*i.e.*, shear strength) and predictions of shear stress (*e.g.*, the force of flowing water over sediments) along the

LRR. The lower portion of the Roanoke River is in a coastal setting with broad floodplains. The peak bed shear is associated with a storm that produces a storm surge up the river with a significant outflow as the water quickly recedes. The USACE modeled six different flow regimes projected for the LRR in the Plymouth area. The different flows modeled were 5,000 cfs, 9,000 cfs, 15,000 cfs, and 20,000 cfs at steady state conditions and 2,500 cfs and 9,000 cfs at hurricane conditions. The 2,500 cfs hurricane event was based on observed conditions during Hurricane Dennis. The maximum historical flow since installation of the dam translates to about 20,000 cfs at Williamston. According to the USACE, only at this highest flow does the model indicate any potential for bed movement. Thus, significant bed load and suspended load was considered unlikely, even at the highest flows. In cases where shear stress exceeds the shear strength of sediments, erosion of sediments is likely to occur. Based on the results of the sediment testing and the stream flow modeling, the Scott study (2001) concluded that the LRR "historic sediment deposits are most likely stable, with sediment transport in the system consisting of fines transported to the Roanoke from tributaries. Some bed movement may occur at higher flows, but significant bed load and suspended load are unlikely, even at the highest flows." The author further concluded that areas of sediment with the highest concentration of COCs are "generally natural depositional areas that will not be affected by the range of flows in the Roanoke."

The USACE performed another study to evaluate transport of suspended material along the Roanoke River (Scott, 2002). This study evaluated the potential for deposition and/or transport of silt, clay, and organic material already in suspension in the LRR. Since the initial modeling study showed sediment along the LRR to be stable, resuspension (*i.e.*, erosion) of the in-place sediment deposits was not considered in this follow-up study. To put these findings in context with the Roanoke River System, the actual flow rates measured by the USGS at the Roanoke Rapids dam, since 1960 were assessed. The study conclusions and the relationship to the Roanoke River flow conditions were:

- River flows <3,800 cfs – Depositional setting with no erosion potential (34.7% of the flow)
- River flows from 3,800 to 6,600 cfs – Transitional with no erosion potential (18.1% of the flow)
- River Flows >6,600 cfs – Transport with unlikely erosion potential (47.2% of the flow)

Thus there is no potential for erosion 53.8% of the time and unlikely potential for erosion 47.2% of the time. The key conclusion for supporting remedy evaluations is that erosion is unlikely to occur for any of the observed flow regime. Thus, the Lower Roanoke River presents a depositional and non-erosional environment where sediments will accumulate and once deposited remain in place, effectively covering the existing sediment deposits.

Implications from Supplemental Coring Investigation

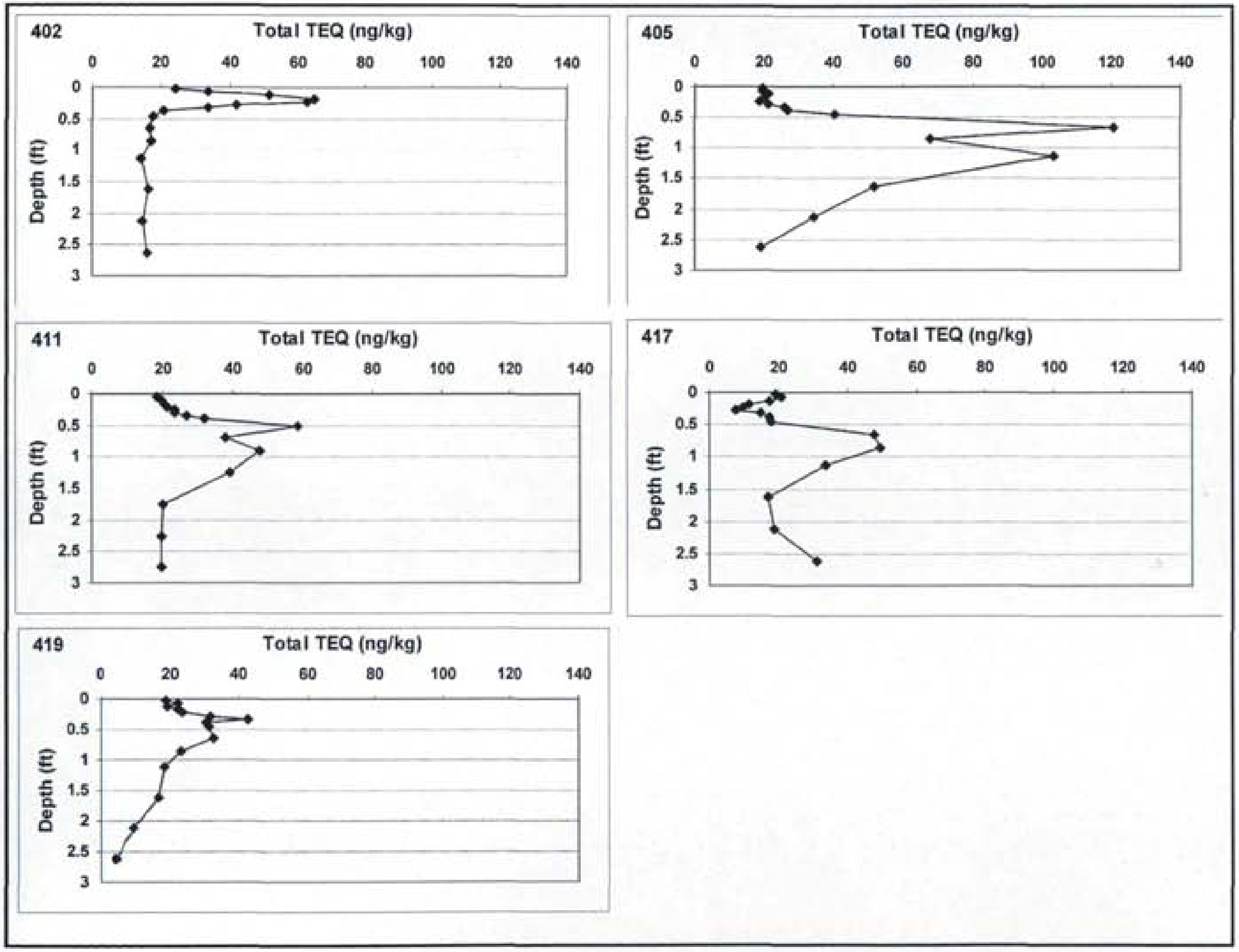
The predicted natural deposition of sediment with low COC concentrations was difficult to observe in the sediment cores collected by the USEPA during the RI activities due to the relatively coarse 15 centimeters

(0.5 foot) sampling interval. Therefore, supplemental core samples were collected by Weyerhaeuser to better understand site-specific spatial deposition pattern. This coring study included bathymetric profiles and collection of sediment cores at nine locations, five of which were fine-layer cores (generally subsections of 1.5 centimeters to a depth of 15 centimeters). These supplemental sediment cores were collected after Hurricane Floyd, a 500-year recurrence interval precipitation event. These cores provide an "empirical record" of COCs with depth that reflects the past and current conditions at the site.

A clear pattern of sediment deposition was observed based on the bathymetry measurements and the geochemical and physical characteristics of stratigraphy core samples. Four distinct sediment types were identified that are consistent with changes in the origin of sediment and river hydrology characterized by Riggs (1996). The most recent deposit, termed Lowland Mud for this study, is derived primarily from drainage areas located below the Roanoke Rapids dam (Mile 138), which includes agricultural land and extensive forested swamps. Flood control measures implemented at Kerr reservoir and rising sea levels have enhanced the deposition of fine-grained and organic rich sediment.

The chemical analysis of these samples allowed further assessment of the effectiveness of the depositing sediment layer to lower concentrations in the surficial bioactive zone. The supplemental fine-layer cores collected at five locations extended 2.75 feet below the sediment surface, with sample increments as small as 1.5 centimeters (0.05 foot). Sediment samples were analyzed for dioxin, mercury, copper, iron, aluminum, TOC, and grain size. The COC data confirmed a clear pattern of new sediment deposition. Figure F-1 in the LRR FS presents the dioxin concentrations (as I-TEQ) with depth for the five core locations. The highest concentrations of dioxin were buried 6 to 24 centimeters (0.2 to 0.8 feet) below the sediment surface. Therefore, these data provide consistent reinforcement to the modeling conclusion that there is active deposition of new sediment along the Lower Roanoke River and that the cleaner deposited material remains above the older deposits even after extreme hurricane events. Although specific analysis to allow dating of the deposits was not completed, the fine-layer profiles with depth of dioxin TEQs provide a clear empirical record that dioxin-containing sediments are being buried by cleaner sediments. This finding is significant since the sediment bioactive layer (where benthic organisms are active) is likely to consist of the top 5 to 10 centimeters (2 to 4 inches) in LRR OU-2.

The sediment depositional patterns for potentially site-related metals (mercury and chromium) were also evaluated. The surficial sediment mercury concentrations throughout the river are similar to, or less than, the USEPA comparison concentration that was defined as the concentration used to differentiate site-related impacts (0.68 mg/kg). The results from this study also support the conclusion that copper is not a site-related COC. This suggests that sediment copper in LRR OU-2 is associated with background minerals. Background concentrations are further discussed in the following paragraphs.



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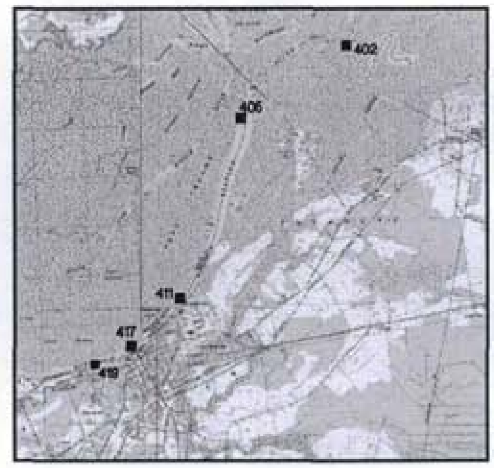
TOTAL TEQ CONCENTRATION (ng/kg)



SAMPLE POINT LOCATOR MAP

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LOWER ROANOKE RIVER - O.U. 2

FINE LAYER CORING
TOTAL TEQ SEDIMENT CONCENTRATIONS WITH DEPTH

FIGURE F-1

5. Background Concentrations

For the LRR area, both copper and chromium were included as preliminary constituents of concern and evaluated in the human health and ecological risk assessments. As per guidance, identification of COPCs precedes an evaluation of background concentrations. Site and background conditions were compared to help evaluate alternatives and support appropriate remedy decisions. In the LRR RI, comparison concentrations of COCs were established during the LRR RI to distinguish between those constituents that were site-related and those characteristic of the region from all sources. Comparison concentrations used were twice the average concentration of reference sites. Table F-2 and Table F-3 present the range of measured concentrations of copper and chromium in Lower Roanoke River sediments and wetland soils, respectively, along with the background comparison criteria.

Table F-2
Concentration (mg/kg) Ranges of Copper and Chromium in Lower Roanoke River Sediment

	Comparison Criteria from RI Table 4-4	Range Measured (average)	Number of Samples Over Comparison Criteria
Chromium (mg/kg)	74.8	14 to 54 (36.7)	0/41
Copper(mg/kg)	49	11 to 70 (27.5)	1/41

Notes:
1. Average includes ½ the detection limit for non-detected results.
2. Samples included in comparison are from the top six inches of sediment at all locations at and downstream of the site.

Concentrations of copper and chromium in sediment samples are generally consistent with the comparison criteria that were intended to distinguish between site-related impacts and background concentrations. Only one sample for copper exceeded the comparison criterion (out of 41) while chromium was below the comparison criterion in all sediment samples. Further, copper concentrations in the Lower Roanoke River system were shown to be highly correlated with the background mineral components (aluminum and iron) of sediments. This evaluation supports the conclusion that the presence of copper and chromium in Lower Roanoke River sediments is not site related.

Table F-3
Concentration (mg/kg) Ranges of Copper and Chromium in Lower Roanoke River Wetland Soil

	Comparison Criteria from RI Table 4-8	Range Measured (average)	Number of Samples Over Comparison Criteria
Chromium (mg/kg)	64.7	2.1 to 64 (29.5)	0/17
Copper (mg/kg)	44.3	5.5 to 120 (28.8)	2/17

Notes:

1. Average calculated based upon detected concentrations and half of the detection limit for non-detected results

Data on copper and chromium concentrations in wetland soils are more limited but follow the same general pattern as river sediments. For the 17 samples collected, measured concentrations of copper and chromium were generally within the range of background. For copper, two wetland samples were above the comparison criterion while no samples exceed the comparison criterion for chromium. Further, the only sample substantially different from the comparison criterion for copper (120 vs. 44.3 mg/kg) occurred along the north side of the river, about three miles downstream from the Plymouth Mill. Based upon the limited number of concentrations that exceed the comparison criteria and the locations of those samples, there does not appear to be a relationship to any site-related source.

G. Current and Potential Future Land and Resources Uses

Current land use in the area is primarily conservancy with low impact recreational uses of the properties. The lower Roanoke River area is used frequently for eco-tourism including boating, paddling and recreational fishing. The City of Plymouth, downstream of the Domtar Mill, continues to enhance its waterfront and support various fishing tournaments and river related tourist activities. Drinking water is not obtained from the surface water of the Roanoke River on the Mill property or downstream of the Mill.

There are a few residents located along tributaries to the Lower Roanoke River; however, most of area along the main channel of the river consists of dense, forested wetlands and swamps. Thus, there is limited development outside of the Mill and the City of Plymouth. Residential development is not expected to expand within the forested wetlands adjacent to the Roanoke River since much of the area is owned by various conservancy groups and carefully regulated through the NC DCM who are responsible for implementing the Coastal Area Management Act. Shallow groundwater in the vicinity of the Mill area is not currently used, and is not expected to be used, as a potable water source due to quality and yield limitations. However, the State of North Carolina considers all groundwater to be potentially potable.

A state-issued dioxin fish consumption advisory remains in effect for bottom-feeding fish in the Lower Roanoke River. Significant improvements in the dioxin fish tissue concentrations have resulted in the removal of the fish consumption advisory for game fish in the Lower Roanoke River.

H. Summary of Site Risks

The baseline HHRA and the BERA present the results of comprehensive deterministic risk assessments that address potential threats to public health and the environment posed by OU-2 under current and future conditions assuming that no remedial actions take place. Using the collected data and the Site Conceptual Model, these risk assessments help identify contaminants and exposure pathways that need to be addressed by the remedial action.

1. The Baseline Human Health Risk Assessment

The baseline HHRA consists of the following sections: identification of chemicals of potential concern; exposure assessment; toxicity assessment; and, risk characterization. A summary of each section is presented below.

a. Chemicals of Potential Concern (COPCs)

The first step involved in the human health risk assessment process is selection of COPCs. The COPC selection identifies site-related chemicals that are present at concentrations that could result in potential adverse effects on human health. The COPCs are eventually reduced to a smaller list of chemicals of concern (COCs) that emphasize the contaminants that are the most significant contributors to calculated potential risk.

For the purpose of the baseline risk assessment, COPCs for human health, as shown in Table H-1, include the following:

- Wetland soil: Dioxin TEQ, and three metals
- Fish: Dioxin TEQ, selected PAHs and pesticides, and two metals
- Clams: Dioxin TEQ and two PAHs

The highest number of COPCs was associated with the whole catfish consumption scenario.

b. Exposure Assessment

The second step of the risk assessment process, the Exposure Assessment, involves identifying the human populations that may be exposed to COPCs in environmental media and the routes by which they may be exposed. The exposure assessment is finalized with the estimate of the daily dose of COPCs to which receptors may be exposed.

The objective of the exposure assessment is to estimate the type and magnitude of potential exposures to COPCs in environmental media associated with the Lower Roanoke River. The exposure assessment for the Lower Roanoke River follows the guidance in Risk Assessment Guidance for Superfund (RAGS) (USEPA, 1989) and addresses the following:

- Characterization of the exposure setting
- Identification of migration and exposure pathways
- Quantification of exposure

Table H-1
Chemicals of Potential Concern for Human Health

Wetland Soil Contaminants of Potential Concern		
Dioxin TEQ		
Arsenic Chromium Manganese		
Catfish Contaminants of Potential Concern		
Dioxin TEQ		
Chromium Manganese		
Benzo(a)anthracene Benzo(k)Fluoranthene Chrysene Dibenzo(a,h)anthracene		
4,4-DDD 4,4-DDE 4,4-DDT	Aldrin Alpha-BHC Dieldrin	Heptachlor
Gamefish Contaminants of Potential Concern		
Dioxin TEQ		
Aluminum Chromium		
4,4-DDD 4,4-DDE 4,4-DDT	Aldrin Alpha-BHC	Trans-nonachlor
Clam Contaminants of Potential Concern		
Dioxin TEQ		
Benzo(a)anthracene Chrysene		

Characterization of Exposure Setting

The location and setting of the Lower Roanoke River was presented in Sections A and E. As a component of characterizing the exposure setting for the Lower Roanoke River, potential human receptors and their expected types of exposure to the constituents present at the site were identified for current and future land use scenarios. Completed exposure pathways are the means by which potentially exposed populations (receptors) come into contact with site-related COPCs. The potentially completed exposure pathways evaluated for potential human receptors in the LRR OU-2 Risk Assessment were as follows:

- Current and future exposure of site visitors to COPCs in wetland soil
- Current and future exposure of anglers and site visitors to COPCs by ingestion of affected fish and clams

Identification of Migration and Exposure Pathways

The Lower Roanoke River area conceptual site model (see Figure E-9) is based on characterization of waste sources, the COPC for each affected environmental medium, and the migration and transport potential of this constituent to potential receptors.

An exposure pathway is the means by which a constituent moves from a source to a receptor. A completed exposure pathway has the following elements:

1. **Constituent Source** - The primary sources of constituents of concern in the environmental media of the Lower Roanoke River are air deposition, the upstream point source discharges and run-off into the river, and historical Plymouth Mill wastewater discharges. Elevated near shore wetland soil concentration levels were attributed to flood events and thus also associated with the both upstream sources and historical mill discharges
2. **Constituent Release and Environmental Transport Mechanism** - The potential constituent release and transport pathways relevant to human health in the Lower Roanoke River are as follows:
   - Sediment migration within the Lower Roanoke River and into adjacent wetlands
   - Partitioning of site-related constituents from sediment to surface water or wetland water
3. **Potential Exposure Routes and Pathways** - Completed exposure pathways are the means by which potentially exposed populations (receptors) come into contact with COPCs. The completed exposure pathways evaluated under current and future land use scenarios for potential human receptors in the Lower Roanoke River and the exposure routes were as follows:
   - Anglers exposure to COPCs in wetland soil and affected fish
     - Incidental ingestion of wetland soil
     - Dermal contact from wetland soil and

- Particulate inhalation of wetland soil
- Ingestion of affected fish and clams

– Site Visitor exposure to COPCs in wetland soil
  - Incidental ingestion of wetland soil
  - Dermal contact with wetland soil, and
  - Particulate inhalation of wetland soil

Quantification of Exposure

The potential exposure to site-related COPCs for each receptor is represented by a chronic daily intake (CDI). The CDI for an individual receptor is estimated from the exposure point concentration of each COPC in each environmental medium.

Exposure Point Concentration

Consistent with Region 4 Supplemental Guidance (USEPA, 1996), the exposure point concentrations used for estimating CDIs are the lesser of the maximum concentration for each COPC or the 95 percent upper confidence limit (95 percent UCL) of the mean concentration assuming a log-normal distribution of the data set. A value equivalent to one-half the quantitation limit was used in the 95 percent UCL exposure point concentration calculations for constituents reported as not detected. The EPCs for various scenarios are noted in Table H-2. The associated exposure assumptions are listed in Table H-3.

CDI

A CDI is the exposure expressed as the mass of a substance contacted per unit body weight per unit time, averaged over a period of years. The CDIs for COPCs in the Lower Roanoke River were calculated to represent the reasonable maximum exposure (RME). The RME doses are defined as the "maximum exposure that is reasonably expected to occur at the site" (USEPA, 1989). Several variables that determine the exposure dose for the RME are based on high end (typically 90^{th} percentile or greater) estimates. The RME CDI for any given constituent results from a multiplication of these selected 90th or greater percentile variables. The multiplication of the variables therefore represents a high-end value and a conservative estimate of the actual exposure dose.

c. Toxicity Assessment

There are two purposes of the toxicity assessment: first, to review available information on the potential adverse effects that may result from exposure to the COPC; and second, to quantify the relationship between exposure to these constituents and the likelihood of potential health effects. Toxicity reference values (TRVs) for the COPCs were taken from Integrated Risk Information System (IRIS) and the Health Effect Assessment Summary Table (HEAST).

Table H-2
Exposure Point Concentrations Summary
Reasonable Maximum Exposure
Lower Roanoke River Study

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Soil/Air

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean [1]	95% UCL of Log-Transformed Data	Maximum Concentration/ Qualifier [2]		Exposure Point Concentration			
							Value	Units	Statistic [3]	Rationale
Wetland	Dioxin TEQ	mg/kg	0.00005	0.00012	0.00022	J	0.00012	mg/kg	UCL-T	Reg IV Guidance
	Arsenic	mg/kg	2.7	4.5	7.0	-	4.5	mg/kg	UCL-T	Reg IV Guidance
	Chromium	mg/kg	30.6	55.8	64.0	-	55.8	mg/kg	UCL-T	Reg IV Guidance
	Manganese	mg/kg	454	1,056	1,200	-	1,056	mg/kg	UCL-T	Reg IV Guidance

Footnotes:

1. Arithmetic mean calculated using one-half the sample quantitation limit for non-detects. Calculated in this way, the mean can be greater than the maximum
2. "J" is estimated value and "-" is a result that did not require qualification.
3. 95% UCL of Log-transformed Data (95% UCL-T)

Dioxin TEQ - Toxic Equivalent Value of 2,3,7,8-Tetrachlorodibenzodioxin

CDM.

Table B-2 (cont.)
Exposure Point Concentrations Summary
Reasonable Maximum Exposure
Lower Roanoke River Study

Scenario Timeframe: Current/Future
Medium: Catfish
Exposure Medium: Catfish (Filet)

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean [1]	95% UCL of Log-Transformed Data	Maximum Concentration/ Qualifier [2]		Exposure Point Concentration			
							Value	Units	Statistic [3]	Rationale
Meat	4,4'-DDD (p,p'-DDD)	mg/kg	0.013	31.78	0.006	N	0.006	mg/kg	Maximum	Reg IV Guidance
	4,4'-DDE (p,p'-DDE)	mg/kg	0.020	0.05	0.024	-	0.024	mg/kg	Maximum	Reg IV Guidance
	4,4'-DDT (p,p'-DDT)	mg/kg	0.004	12.17	0.009	N	0.009	mg/kg	Maximum	Reg IV Guidance
	Aldrin	mg/kg	0.001	0.36	0.001	JN	0.001	mg/kg	Maximum	Reg IV Guidance
	Dioxin TEQ	mg/kg	1E-06	NA	1.8E-06	J	1.8E-06	mg/kg	Maximum	Reg IV Guidance
	Chromium	mg/kg	0.1	0.7	0.2	-	0.2	mg/kg	Maximum	Reg IV Guidance

Footnotes:

1. Arithmetic mean calculated using one-half the sample quantitation limit for non-detects.
Calculated in this way, the mean can be greater than the maximum detected concentration.

2. "J" is estimated value, "N" is presumptive evidence, and "-" is a result that did not require qualification.

3. Maximum detected value

Dioxin TEQ - Toxic Equivalent Value of 2,3,7,8-Tetrachlorodibenzodioxin

Table H-2 (cont.)
Exposure Point Concentrations Summary
Reasonable Maximum Exposure
Lower Roanoke River Study

Scenario Timeframe: Current/Future
Medium: Catfish
Exposure Medium: Catfish (Whole)

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean [1]	95% UCL of Log-Transformed Data	Maximum Concentration/ Qualifier [2]		Exposure Point Concentration			
							Value	Units	Statistic [3]	Rationale
Meal	Benzo(a)anthracene	mg/kg	0.178	12	0.061	-	0.061	mg/kg	Maximum	Reg IV Guidance
	Benzo(k)fluoranthene	mg/kg	0.177	34	0.071	J	0.071	mg/kg	Maximum	Reg IV Guidance
	Chrysene	mg/kg	0.186	30	0.130	J	0.130	mg/kg	Maximum	Reg IV Guidance
	Dibenzo(a,h)anthracene	mg/kg	0.197	15	0.200	J	0.200	mg/kg	Maximum	Reg IV Guidance
	4,4'-DDD (p,p'-DDD)	mg/kg	0.014	0.117	0.035	N	0.035	mg/kg	Maximum	Reg IV Guidance
	4,4'-DDE (p,p'-DDE)	mg/kg	0.024	0.069	0.067	-	0.067	mg/kg	Maximum	Reg IV Guidance
	4,4'-DDT (p,p'-DDT)	mg/kg	0.009	0.093	0.020	N	0.020	mg/kg	Maximum	Reg IV Guidance
	Aldrin	mg/kg	0.002	0.030	0.001	JN	0.001	mg/kg	Maximum	Reg IV Guidance
	Alpha-BHC	mg/kg	0.003	0.055	0.007	-	0.007	mg/kg	Maximum	Reg IV Guidance
	Dieldrin	mg/kg	0.002	0.011	0.002	J	0.002	mg/kg	Maximum	Reg IV Guidance
	Heptachlor	mg/kg	0.002	0.019	0.002	J	0.002	mg/kg	Maximum	Reg IV Guidance
	Dioxin TEQ	mg/kg	2.5E-06	8.7E-05	4.5E-06	-	4.5E-06	mg/kg	Maximum	Reg IV Guidance
	Chromium	mg/kg	0.3	0.8	0.5	-	0.5	mg/kg	Maximum	Reg IV Guidance
	Manganese	mg/kg	6.1	602	21	-	21	mg/kg	Maximum	Reg IV Guidance

Footnotes:

1. Arithmetic mean calculated using one-half the sample quantitation limit for non-detects.
Calculated in this way, the mean can be greater than the maximum detected concentration.

2. "J" is estimated value, "N" is presumptive evidence, and "-" is a result that did not require qualification.

3. Maximum detected value

Dioxin TEQ - Toxic Equivalent Value of 2,3,7,8-Tetrachlorodibenzodioxin

CDM

Table H-2 (cont.)
Exposure Point Concentrations Summary
Reasonable Maximum Exposure
Lower Roanoke River Study

Scenario Timeframe: Current/Future
Medium: Game Fish
Exposure Medium: Game Fish (Filet)

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean [1]	95% UCL of Log Transformed Data	Maximum Concentration/ Qualifier [2]		Exposure Point Concentration			
							Value	Units	Statistic [3]	Rationale
Meal	4,4'-DDE (p,p'-DDE)	mg/kg	0.017	1.8	0.052	-	0.052	mg/kg	Maximum	Reg IV Guidance
	Dioxin TEQ	mg/kg	1.6E-06	NA	1.6E-06	-	1.6E-06	mg/kg	Maximum	Reg IV Guidance
	Chromium	mg/kg	0.2	0.4	0.3	-	0.3	mg/kg	Maximum	Reg IV Guidance

Footnotes:

1. Arithmetic mean calculated using one-half the sample quantitation limit for non-detects.
Calculated in this way, the mean can be greater than the maximum detected concentration.

2. "J" is estimated value, "N" is presumptive evidence, and "-" is a result that did not require qualification.

3. Maximum detected value

Dioxin TEQ - Toxic Equivalent Value of 2,3,7,8-Tetrachlorodibenzodioxin

Table H-2 (cont

Exposure Point Concentrations Summary
Reasonable Maximum Exposure
Lower Roanoke River Study

Scenario Timeframe: Current/Future
Medium: Clam
Exposure Medium: Clam

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean [1]	95% UCL of Log-Transformed Data	Maximum Concentration/ Qualifier [2]		Exposure Point Concentration			
							Value	Units	Statistic [3]	Rationale
Meal	Benzo(a)anthracene	mg/kg	0.023	2.3	0.055	J	0.055	mg/kg	Maximum	Reg IV Guidance
	Chrysene	mg/kg	0.022	2.1	0.052	J	0.052	mg/kg	Maximum	Reg IV Guidance
	Dioxin TEQ	mg/kg	2.8E-07	3.7E-06	3.6E-07	-	3.6E-07	mg/kg	Maximum	Reg IV Guidance

Footnotes:

1. Arithmetic mean calculated using one-half the sample quantitation limit for non-detects. Calculated in this way, the mean can be greater than the maximum detected concentration.
2. "J" is estimated value and "-" is a result that did not require qualification.
3. Maximum detected value

Dioxin TEQ - Toxic Equivalent Value of 2,3,7,8-Tetrachlorodibenzodioxin

Table H-2 (cont.)
Exposure Point Concentrations Summary
Reasonable Maximum Exposure
Lower Roanoke River Study

Scenario Timeframe: Current/Future
Medium: Game Fish
Exposure Medium: Game Fish (Whole)

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean[1]	95% UCL of Log Transformed Data	Maximum Concentration/ Qualifier[2]		Exposure Point Concentration			
							Value	Units	Statistic[3]	Rationale
Meat	4,4'-DDD (p,p'-DDD)	mg/kg	0.006	0.056	0.009	J	0.009	mg/kg	Maximum	Reg IV Guidance
	4,4'-DDE (p,p'-DDE)	mg/kg	0.020	0.175	0.052	-	0.052	mg/kg	Maximum	Reg IV Guidance
	4,4'-DDT (p,p'-DDT)	mg/kg	0.005	0.029	0.003	JN	0.003	mg/kg	Maximum	Reg IV Guidance
	Aldrin	mg/kg	0.003	0.057	0.003	-	0.003	mg/kg	Maximum	Reg IV Guidance
	Alpha-BHC	mg/kg	0.003	0.048	0.005	N	0.005	mg/kg	Maximum	Reg IV Guidance
	Trans-Nonachlor	mg/kg	0.01	0.039	0.013	J	0.013	mg/kg	Maximum	Reg IV Guidance
	Dioxin TEQ	mg/kg	4.3E-06	1.5E-05	6.5E-06	-	6.5E-06	mg/kg	Maximum	Reg IV Guidance
	Aluminum	mg/kg	89	7,917	680	-	680	mg/kg	Maximum	Reg IV Guidance
	Chromium	mg/kg	0.4	1.0	0.7	-	0.7	mg/kg	Maximum	Reg IV Guidance

Footnotes:

1. Arithmetic mean calculated using one-half the sample quantitation limit for non-detects.
Calculated in this way, the mean can be greater than the maximum detected concentration.

2. "J" is estimated value, "N" is presumptive evidence, and "-" is a result that did not require qualification.

3. Maximum detected value

Dioxin TEQ - Toxic Equivalent Value of 2,3,7,8-Tetrachlorodibenzodioxin

Table H-3
Values Used for Daily Intake Calculations
Lower Roanoke River Study

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Soil/Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/Model Name
Ingestion	Trespasser/ Visitor	Adolescent	Wetland	CS	chemical concentration in soil	See Table 3	mg/kg	See Table 3	Chronic daily intake = CS x IR_s x CF x FI x EF x ED x 1/BW x 1/AT
				IR_s	ingestion rate (oral)	100	mg/day	Judgment	
				CF	conversion factor	0.000001	kg/mg	--	
				FI	fraction ingested from source	1	unitless	Judgment	
				EF	exposure frequency	50	days/year	Judgment	
				ED	exposure duration	10	years	EPA 1995	
				BW	body weight	45	kg	EPA 1995	
				AT-C	averaging time (cancer)	25550	days	EPA 1989	
				AT-N	averaging time (non-cancer)	3650	days	EPA 1989	
Dermal	Trespasser/ Visitor	Adolescent	Wetland	CS	chemical concentration in soil	See Table 3	mg/kg	See Table 3	Chronic daily intake = CS x CF x SA x AF x ABS x EF x ED x 1/BW x 1/AT
				SA	exposed skin surface area	5800	cm^2/day	EPA 1997	
				AF	adherence factor	1	mg/cm^2	EPA 1995	
				ABS	absorption factor	Chem. Spec.	unitless	EPA 1995	
				EF	exposure frequency	50	days/year	Judgment	
				ED	exposure duration	10	years	EPA 1995	
				CF	conversion factor	0.000001	kg/mg	--	
				BW	body weight	45	kg	EPA 1995	
				AT-C	averaging time (cancer)	25550	days	EPA 1989	
				AT-N	averaging time (non-cancer)	3650	days	EPA 1989	
Inhalation	Trespasser/ Visitor	Adolescent	Wetland	CS	chemical concentration in soil	See Table 3	mg/kg	See Table 3	Chronic daily intake = CS x IR_i x ED x EF x (1/PEF) x 1/BW x 1/AT
				IR_i	inhalation rate	17	m^3/day	EPA 1997	
				PEF	particulate emissions factor	1.32E+09	m^3/kg	EPA 1991b	
				EF	exposure frequency	50	days/year	Judgment	
				ED	exposure duration	10	years	EPA 1995	
				BW	body weight	45	kg	EPA 1995	
				AT-C	averaging time (cancer)	25550	days	EPA 1989	
				AT-N	averaging time (non-cancer)	3650	days	EPA 1989	

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U.S. EPA. 1991a. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors," OSWER Directive 9285.6-03, March 25.

U.S. EPA. 1991b. Human Health Evaluation Manual, Part B: Development of Risk-Based Preliminary Remediation Goals," OSWER Directive 9285.7-01B, December 13.

U.S. EPA. 1995. "Supplemental Guidance to RAGS: Region 4 Bulletins. Human Health Risk Assessment." November.

U.S. EPA. 1997. Exposure Factors Handbook, Volume I, General Factors. Prepared by the Office of Research and Development, August.

Table H-3 (CONT.)
Values Used for Daily Intake Calculations
Lower Roanoke River Study

Scenario Timeframe: Current/Future
Medium: Fish and Clams
Exposure Medium: Fish and Clams

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/Model Name
Ingestion	Trespasser/ Visitor	Adolescent	Meal	CS	chemical concentration in fish or clams	See Table 3	mg/kg	See Table 3	Chronic daily intake = CS x IR x CF x FI x EF x ED x 1/BW x 1/AT
				IR	ingestion rate	326	g/meal	EPA 1997	
				CF	conversion factor	0.001	kg/g	--	
				FI	fraction ingested from source	1	unitless	Judgment	
				EF	exposure frequency	50	meals/year	Judgment	
				ED	exposure duration	10	years	EPA 1995	
				BW	body weight	45	kg	EPA 1995	
				AT-C	averaging time (cancer)	25550	days	EPA 1989	
				AT-N	averaging time (non-cancer)	10950	days	EPA 1989	
Ingestion	Angler	Adult	Meal	CS	chemical concentration in fish or clams	See Table 3	mg/kg	See Table 3	Chronic daily intake = CS x IR x CF x FI x EF x ED x 1/BW x 1/AT
				IR	ingestion rate	25	g/day	EPA 1997	
				CF	conversion factor	0.001	kg/g	--	
				FI	fraction ingested from source	1	unitless	Judgment	
				EF	exposure frequency	365	days/year	EPA 1997	
				ED	exposure duration	30	years	EPA 1991	
				BW	body weight	70	kg	EPA 1995	
				AT-C	averaging time (cancer)	25550	days	EPA 1989	
				AT-N	averaging time (non-cancer)	10950	days	EPA 1989	

U.S. EPA. 1989. Risk Assessment Guidance for Superfund: Human Health Evaluation Manual (Part A) December. Appendix A.
U.S. EPA. 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors." OSWER Directive 9285.6-03, March 25.
U.S. EPA. 1995. "Supplemental Guidance to RAGS: Region 4 Bulletins. Human Health Risk Assessment." November.
U.S. EPA. 1997. Exposure Factors Handbook, Volume 1, General Factors. Prepared by the Office of Research and Development, August.

Toxicity Information for Non-carcinogenic Effects

The USEPA's preferred (USEPA, 1996) toxicity value for evaluating non-carcinogenic effects resulting from chemical exposure is the chronic reference dose (RfD). The chronic RfD is an estimate of a daily exposure level for the human population (including sensitive populations) that should not cause an appreciable risk of harmful effects during a lifetime of exposure. Oral RfDs (RfDO) are published exposure dose estimates derived from ingestion-based studies. RfDO values were used to estimate the potential hazards associated with the incidental ingestion pathway and with modification, the dermal contact pathway. Inhalation RfDs (RfDI) are published exposure dose estimates derived from inhalation based studies and were used to estimate the potential hazard for the inhalation pathway. Tables H-4a and H-4b present a summary of the available quantitative toxicity information for COCs for non-carcinogenic effects to be used in the estimation of hazard through incidental ingestion, dermal contact, and inhalation exposure pathways.

Toxicity Information for Carcinogenic Effects

Toxicity values for constituents with potential carcinogenic effects are expressed as slope factors (SF). The slope factor is the upper bound estimate of the probability of a response per unit intake of a chemical over a lifetime. It is the value used to define the probability of an individual developing cancer as a result of exposure to a particular level of a potential carcinogen.

Oral slope factors (SFo) are published exposure dose estimates derived from ingestion based studies. SFo values were used to estimate the potential hazards associated with the incidental ingestion pathway and with modification, the dermal contact pathway. Inhalation slope factors (SFI) are published exposure dose estimates derived from inhalation based studies and were used to estimate the potential hazard for the inhalation pathway. Table H-5a and Table H-5b also show the USEPA Weight of Evidence (WOE) for each of the COPCs that are considered by the USEPA to be potential carcinogenic compounds. WOE is a classification system for characterizing the extent to which the available data indicate that an agent is a human carcinogen. Group A chemicals are listed as "known human carcinogenic compounds" by the USEPA. Group B1 chemicals are listed as "probable human carcinogenic compounds" based on limited evidence of carcinogenicity in humans. Group B2 chemicals are called "probable human carcinogenic compounds" based on evidence of carcinogenicity in animals; human evidence is inadequate. Group C chemicals are "possible human carcinogenic compounds" based on limited evidence of carcinogenicity in animals; human evidence is inadequate. Group D chemicals are not classifiable as to human carcinogenicity. Group E chemicals show no evidence of carcinogenicity in humans.

Table H-4a
Non-Cancer Toxicity Data – Oral/Dermal
Lower Roanoke River Study

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD		Absorption Efficiency (for Dermal)[1]	Dermal RfD [2,3]		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfD: Target Organ(s)	
		Value	Units		Value	Units			Source(s)	Date(s)
Benzo(a)anthracene	Chronic	NA	mg/kg/day	100%	NA	mg/kg/day	NA	NA	IRIS	5/5/1998
Benzo(k)fluoranthene	Chronic	NA	mg/kg/day	100%	NA	mg/kg/day	NA	NA	IRIS	5/5/1998
Chrysene	Chronic	NA	mg/kg/day	100%	NA	mg/kg/day	NA	NA	IRIS	5/5/1998
Dibenzo(a,h)anthracene	Chronic	NA	mg/kg/day	100%	NA	mg/kg/day	NA	NA	IRIS	5/5/1998
4,4'-DDD (p,p'-DDD)	Chronic	NA	mg/kg/day	100%	NA	mg/kg/day	NA	NA	IRIS	8/22/1988
4,4'-DDE (p,p'-DDE)	Chronic	NA	mg/kg/day	100%	NA	mg/kg/day	NA	NA	IRIS	8/22/1988
4,4'-DDT (p,p'-DDT)	Chronic	5E-04	mg/kg/day	100%	5E-04	mg/kg/day	Liver	100	IRIS	2/1/1996
Aldrin	Chronic	3E-05	mg/kg/day	100%	3E-05	mg/kg/day	Liver	1000	IRIS	3/1/1988
Alpha-BHC	Chronic	NA	mg/kg/day	100%	NA	mg/kg/day	NA	NA	IRIS	7/1/1993
Dieldrin	Chronic	5E-05	mg/kg/day	100%	5E-05	mg/kg/day	Liver	100	IRIS	8/1/1990
Heptachlor	Chronic	5E-04	mg/kg/day	100%	5E-04	mg/kg/day	Liver	300	IRIS	3/1/1991
Trans-Nonachlor	Chronic	5E-04	mg/kg/day	100%	5E-04	mg/kg/day	Liver	300	IRIS	2/7/1988
Dioxin TEQ	Chronic	NA	mg/kg/day	100%	NA	mg/kg/day	NA	NA	IRIS	5/5/1998
Aluminum	Chronic	1E+00	mg/kg/day	20%	2E-01	mg/kg/day	CNS (Neurotoxicity)	100	NCEA	8/13/1999
Arsenic	Chronic	3E-04	mg/kg/day	100%	3E-04	mg/kg/day	Skin	3	IRIS	11/15/1990
Chromium VI	Chronic	3E-03	mg/kg/day	20%	6E-04	mg/kg/day	None reported	900	IRIS	4/28/1998
Manganese (soil)[4]	Chronic	7E-02	mg/kg/day	5%	4E-03	mg/kg/day	CNS	3	R4 EPA	1995

Notes:

1. ATSDR toxicological profiles consulted. When absorption efficiency exceeded 50% in the toxicological profile, EPA Region IV policy is to default to 100% (EPA 1999d). Where no data were available, the following defaults were used: 20% inorganics, 50% semivolatiles, 80% volatiles.

2. EPA 1989a. Risk Assessment Guidance for Superfund. Human Health Evaluation Manual (Part A) December. Appendix A

3. Equation used for derivation: RfD x oral to dermal adjustment factor

4. The RfDo for manganese in IRIS is 1.4E-1 mg/kg/day based on the NOAEL of 10 mg/day. For soil exposure, Region IV policy is to subtract the average daily dietary exposure (5 mg/day) from the NOAEL to determine a "soil" RfDo. When this is done, a "soil" RfDo of7E-2 mg/kg/day results.

Acronyms:

ATSDR - Agency for Toxic Substances and Disease Registry
IRIS - Integrated Risk Information System
HEAST - Health Effects Assessment Summary Tables
NCEA - National Center for Environmental Assessment
RfD - Reference dose
unk - Unknown
NA - Not applicable
TEQ - Toxic Equivalent Value of 2,3,7,8-Tetrachlorodibenzodioxin

Table H-4b
Non-Cancer Toxicity Data -- Inhalation
Lower Roanoke River Study

Chemical of Potential Concern	Chronic/ Subchronic	Inhalation RfC		Adjusted RfD [1]		Primary Target Organ	Combined Uncertainty/ Modifying Factors	RfC: Target Organ(s)	
		Values	Units	Values	Units			Source(s)	Date(s)
Benzo(a)anthracene	NA	NA	NA	NA	NA	NA	NA	NA	5/5/1998
Benzo(k)fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA	5/5/1998
Chrysene	NA	NA	NA	NA	NA	NA	NA	NA	5/5/1998
Dibenzo(a,h)anthracene	NA	NA	NA	NA	NA	NA	NA	NA	5/5/1998
4,4'-DDD (p,p'-DDD)	NA	NA	NA	NA	NA	NA	NA	NA	8/22/1988
4,4'-DDE (p,p'-DDE)	NA	NA	NA	NA	NA	NA	NA	NA	8/22/1988
4,4'-DDT (p,p'-DDT)	NA	NA	NA	NA	NA	NA	NA	NA	2/1/1996
Aldrin	NA	NA	NA	NA	NA	NA	NA	NA	3/1/1988
Alpha-BHC	NA	NA	NA	NA	NA	NA	NA	NA	7/1/1993
Dieldrin	NA	NA	NA	NA	NA	NA	NA	NA	9/1/1990
Heptachlor	NA	NA	NA	NA	NA	NA	NA	NA	3/1/1991
Trans-Nonachlor	Chronic	7E-04	mg/m3	2E-04	mg/kg/day	Liver	1000	IRIS	2/7/1998
Dioxin TEQ	NA	NA	NA	NA	NA	NA	NA	NA	5/5/1998
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	8/13/1999
Arsenic	NA	NA	NA	NA	NA	NA	NA	NA	11/15/1990
Chromium	Chronic	1E-04	mg/m3	3E-05	mg/kg/day	Lung	300	IRIS	4/28/1998
Manganese (soil)	NA	5E-05	mg/m^3	1.4E-05	mg/kg/day	CNS	1000	IRIS	1995

Notes:

1. Equation used for derivation: RfC divided by 70 kg (assumed human body weight) multiplied by 20 m^3/day (assumed human intake rate).

Acronyms:

IRIS - Integrated Risk Information System

HEAST - Health Effects Assessment Summary Tables

NCEA - National Center for Environmental Assessment

RfC - Reference concentration

RfD - Reference dose

CNS - Central nervous system

NA - Not applicable

Table H-5a
Cancer Toxicity Data – Oral/Dermal
Lower Roanoke River Study

Chemical of Potential Concern	Oral Cancer Slope Factor		Absorption Efficiency (for Dermal)	Adjusted Cancer Slope Factor (for Dermal) [1,3]		Weight of Evidence/ Cancer Guideline Description [4,5]	Oral CSF: Absorption Efficiency	
	Value	Units		Value	Units		Source(s)	Date(s)
Benzo(a)anthracene	7.3E-01	$(mg/kg/day)^{-1}$	100%	7.3E-01	$(mg/kg/day)^{-1}$	B2	R4 EPA	1995
Benzo(k)fluoranthene	7.3E-01	$(mg/kg/day)^{-1}$	100%	7.3E-01	$(mg/kg/day)^{-1}$	B2	R4 EPA	1995
Chrysene	7.3E-03	$(mg/kg/day)^{-1}$	100%	7.3E-03	$(mg/kg/day)^{-1}$	B2	R4 EPA	1995
Dibenzo(a,h)anthracene	7.3E+00	$(mg/kg/day)^{-1}$	100%	7.3E+00	$(mg/kg/day)^{-1}$	B2	R4 EPA	1995
4,4'-DDD (p,p'-DDD)	2.4E-01	$(mg/kg/day)^{-1}$	100%	2.4E-01	$(mg/kg/day)^{-1}$	B2	IRIS	8/22/1988
4,4'-DDE (p,p'-DDE)	3.4E-01	$(mg/kg/day)^{-1}$	100%	3.4E-01	$(mg/kg/day)^{-1}$	B2	IRIS	8/22/1988
4,4'-DDT (p,p'-DDT)	3.4E-01	$(mg/kg/day)^{-1}$	100%	3.4E-01	$(mg/kg/day)^{-1}$	B2	IRIS	5/1/1991
Aldrin	1.7E+01	$(mg/kg/day)^{-1}$	100%	1.7E+01	$(mg/kg/day)^{-1}$	B2	IRIS	7/1/1993
Alpha-BHC	6.3E+00	$(mg/kg/day)^{-1}$	100%	6.3E+00	$(mg/kg/day)^{-1}$	B2	IRIS	7/1/1993
Dieldrin	1.6E+01	$(mg/kg/day)^{-1}$	100%	1.6E+01	$(mg/kg/day)^{-1}$	B2	IRIS	7/1/1993
Heptachlor	4.5E+00	$(mg/kg/day)^{-1}$	100%	4.5E+00	$(mg/kg/day)^{-1}$	B2	IRIS	7/1/1993
Trans-Nonachlor	3.5E-01	$(mg/kg/day)^{-1}$	100%	3.5E-01	$(mg/kg/day)^{-1}$	B2	IRIS	2/7/1998
Dioxin TEQ	1.5E+05	$(mg/kg/day)^{-1}$	100%	1.5E+05	$(mg/kg/day)^{-1}$	B2	HEAST	1995
Aluminum	NA	$(mg/kg/day)^{-1}$	20%	NA	$(mg/kg/day)^{-1}$	D	NA	NA
Arsenic	1.5E+00	$(mg/kg/day)^{-1}$	100%	1.5E+00	$(mg/kg/day)^{-1}$	A	IRIS	2/3/1994
Chromium	NA	$(mg/kg/day)^{-1}$	NA	NA	$(mg/kg/day)^{-1}$	D	IRIS	4/28/1998
Manganese (soil) [6]	NA	$(mg/kg/day)^{-1}$	NA	NA	$(mg/kg/day)^{-1}$	D	IRIS	5/25/1988

Notes:

1. ATSDR toxicological profiles consulted. When absorption efficiency exceeded 50% in the toxicological profile, EPA Region IV policy is to default to 100% (EPA 1999d). Where no data were available, the following defaults were used: 20% inorganics, 50% semivolatiles, 80% volatiles.
2. EPA 1989a. Risk Assessment Guidance for Superfund: Human Health Evaluation Manual (Part A) December, Appendix A.
3. Equation used for derivation: CSF divided by oral to dermal adjustment factor
4. Weight of Evidence:
   Known/Likely
   Cannot be Determined
   Not Likely
5. EPA Group:
   A - Human carcinogen
   B1 - Probable human carcinogen - indicates that limited human data are available
   B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans
   C - Possible human carcinogen
   D - Not classifiable as a human carcinogen
   E - Evidence of noncarcinogenicity
   NE - Not evaluated

Acronyms:
ATSDR - Agency for Toxic Substances and Disease Registry
IRIS - Integrated Risk Information System
HEAST - Health Effects Assessment Summary Tables
CSF - Cancer Slope Factor
NA - Not applicable
TEQ - Toxic Equivalent Value of 2,3,7,8-Tetrachlorodibenzodioxin

Table H-5b
Cancer Toxicity Data – Inhalation
Lower Roanoke River Study

Chemical of Potential Concern	Unit Risk		Adjustment [1]	Inhalation Cancer Slope Factor		Weight of Evidence/ Cancer Guideline Description [2,3]	Source(s)	Date(s)
	Value	Units		Value	Units			
Benzo(a)anthracene	8.8E-02	mg/m^3	3.5	3.1E-01	(mg/kg/day)$^{-1}$	B2	R4 EPA	1995
Benzo(k)fluoranthene	8.8E-02	mg/m^3	3.5	3.1E-01	(mg/kg/day)$^{-1}$	B2	R4 EPA	1995
Chrysene	8.8E-04	mg/m^3	3.5	3.1E-03	(mg/kg/day)$^{-1}$	B2	R4 EPA	1995
Dibenzo(a,h)anthracene	8.8E-01	mg/m^3	3.5	3.1E+00	(mg/kg/day)$^{-1}$	B2	R4 EPA	1995
4,4'-DDD (p,p'-DDD)	NA	NA	NA	NA	NA	NE	IRIS	8/22/1988
4,4'-DDE (p,p'-DDE)	NA	NA	NA	NA	NA	NE	IRIS	8/22/1988
4,4'-DDT (p,p'-DDT)	9.7E-05	ug/m^3	3500	3.4E-01	(mg/kg/day)$^{-1}$	B2	IRIS	5/1/1991
Aldrin	4.9E-03	ug/m^3	3500	1.7E+01	(mg/kg/day)$^{-1}$	B2	IRIS	7/1/1993
Alpha-BHC	1.8E-03	ug/m^3	3500	6.3E+00	(mg/kg/day)$^{-1}$	B2	IRIS	7/1/1993
Dieldrin	4.6E-03	ug/m^3	3500	1.6E+01	(mg/kg/day)$^{-1}$	B2	IRIS	7/1/1993
Heptachlor	1.3E-03	ug/m^3	3500	4.6E+00	(mg/kg/day)$^{-1}$	B2	IRIS	7/1/1993
Trans-Nonachlor	1.0E-04	ug/m^3	3500	3.5E-01	(mg/kg/day)$^{-1}$	B2	IRIS	2/7/1998
Dioxin TEQ	3.3E-05	pg/m^3	3.5E+09	1.2E+05	(mg/kg/day)$^{-1}$	B2	HEAST	1995
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	4.3E-03	ug/m^3	3500	1.5E+01	(mg/kg/day)$^{-1}$	A	IRIS	2/3/1994
Chromium	1.2E-02	ug/m^3	3500	4.2E+01	(mg/kg/day)$^{-1}$	A	IRIS	4/28/1998
Manganese (soil)	NA	NA	NA	NA	NA	D	IRIS	5/25/1988

Notes:

1. Adjustment: 70 kg (assumed human body weight) divided by 20 m^3/day (assumed human intake rate) multiplied by 1,000 ug/mg.

2. Weight of Evidence:
   Known/Likely
   Cannot be Determined
   Not Likely
3. EPA Group:
   A - Human carcinogen
   B1 - Probable human carcinogen - indicates that limited human data are available
   B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans
   C - Possible human carcinogen
   D - Not classifiable as a human carcinogen
   E - Evidence of noncarcinogenicity
   W - Withdrawn; Agency position pending
   NE - Not evaluated

Surrogates:
Chlordane used for trans-nonachlor
Chromium VI used for chromium

Acronyms:

ATSDR - Agency for Toxic Substances and Disease Registry

IRIS - Integrated Risk Information System

HEAST - Health Effects Assessment Summary Tables

TEQ - Toxic Equivalent Value of 2,3,7,8-Tetrachlorodibenzodioxin

Absorbed Doses

Reference doses and slope factors are typically calculated based on toxicity testing that involves ingestion of the constituent being evaluated. For the dermal route of exposure, toxicity values that are expressed as an administered dose must be adjusted to reflect an absorbed dose. To utilize oral toxicity values (RfDO or SFO) in estimation of hazard associated with dermal contact exposures, it is necessary to apply a dermal correction factor to the RfDOs (or SFOs) when they are used in the evaluation of absorbed intake values. For compounds that have poor oral absorption efficiencies, the dermally adjusted RfD would be expected to be lower and the dermally-adjusted SF would be expected to be higher. Consistent with guidance, appropriate published data on oral absorption of specific chemicals should be used to make the administered/ absorbed dose adjustment, where available. The individual Agency for Toxic Substance and Disease Registry (ATSDR) Toxicological Profiles were utilized as the source of the chemical- specific absorption efficiencies, where available. For the COPCs used in the LRR OU-2 human health risk assessment calculations, the absorption factor was 100% except for aluminum which was adjusted to 20% per Region 4 guidance.

d. Human Health Exposure and Risk Calculations

In the baseline risk characterization, the results of the toxicity and exposure assessments are summarized and integrated into quantitative and qualitative expressions of potential risk for carcinogenic compounds and into a HI for non-carcinogenic compounds. The baseline risk characterization presents the RME for baseline site conditions in the absence of additional site controls or remediation. It should also be noted that the risk calculations were based upon fish tissue concentrations that were measured in 2000 and 2001. Since the fish tissue trends continue to show generally a slow decline, the calculated risks based upon the RME include additional conservatism and an unanticipated safety factor. In the 2007 NPDES fish sampling event, a total of 22 composite fish samples from 7 locations were analyzed for dioxin. In these composites, 19 of 22 samples contained dioxin TEQ less than 1 ppt; 2 samples were less than 1.5 ppt, and one sample had 3.3 ppt. A dioxin concentration of 3 ppt in tissue is the basis for fish consumption advisories issued by the NC Dept. of Health. The consumption advisory based on dioxin remains in effect for bottom fish such as catfish and carp and will remain in effect until similar results are achieved for two or more years in a row.

Non-carcinogenic Hazard

The potential for non-carcinogenic effects is evaluated by comparing an exposure level over a specified time period (*e.g.*, life-time) with a reference dose (RfD) derived for a similar exposure period. A RfD represents a level that an individual may be exposed to that is not expected to cause any deleterious effect. The ratio of exposure to toxicity is called a hazard quotient (HQ). An HQ<1 indicates that a receptor's dose of a single contaminant is less than the RfD, and that toxic non- carcinogenic effects from that chemical are unlikely. The Hazard Index (HI) is generated by adding the HQs for all chemicals of concern that affect the same target organ (e.g., liver) or that act through the same mechanism of action within a medium or across all media to which a given individual may reasonably be exposed. An HI<1 indicates that, based on the sum of all HQs from different contaminants and exposure routes, toxic non carcinogenic effects from all contaminants are unlikely. An HI >1 indicates that site-related exposures may present a risk to human health.

The HQ is calculated as follows:

Non-cancer HQ = CDI/RfD

Where: CDI = chronic daily intake
RfD = reference dose

CDI and RfD are expressed in the same units and represent the same exposure period (e.g., chronic, sub-chronic, or short-term). Non- carcinogenic hazard for each individual receptor pathway which was modeled in the risk assessment as presented in the following sections.

Site Visitors

The wetlands adjacent to the LRR OU-2 are remote; however, they were assumed to be theoretically accessible to site visitor who may consume fish caught in the LRR, despite a fish consumption advisory. Separate assessments were made for consumption of catfish, gamefish, and clams. The HI for the site visitor is summarized below.

Wetland soils and Catfish: Non carcinogenic hazards are not expected based on a HI of 0.2. For comparison, non carcinogenic hazards for a site visitor exposed to wetland soil and ingesting whole body catfish resulted in a HI of 0.7 for this scenario.

Wetland soils and Gamefish: Non carcinogenic hazards are not expected for ingestion of gamefish and wetland soils based on a HI of 0.2. For comparison, noncarcinogenic hazards for a site visitor exposed to wetland soil and ingesting whole body gamefish resulted in a HI of 1 for this scenario.

Wetland soils and Clams: Non carcinogenic hazards are not expected for ingestion of clams and wetland soils based on a HI of 0.09.

Anglers

Fish consumption advisories exist on the LRR OU-2 for consumption of catfish, however, for conservative evaluations, separate assessments were made for consumption of catfish, gamefish and clams. The HIs for the angler exposure scenario are summarized below.

Catfish: Non carcinogenic hazards are not expected for ingestion of catfish filets based on a HI of 0.05. For comparison, non carcinogenic hazards for an angler ingesting whole body catfish resulted in a HI of 0.2.

Gamefish: Non carcinogenic hazards are not expected for ingestion of gamefish filets based on a HI of 0.2. For comparison, non carcinogenic hazards for an angler ingesting whole body gamefish resulted in a HI of 0.4.

Clams: Calculation of the non-cancer hazards is not applicable because none of the COPCs has an RfD.

Carcinogenic Risk

For carcinogens, risks are generally expressed as the incremental probability of an individual's developing cancer over a lifetime as a result of exposure to the carcinogen. Excess lifetime cancer risk is calculated from the following equation:

Risk = CDI x SF

Where: risk = a unit less probability (*e.g.*, 2×10^{-5}) of an individual's developing cancer
CDI = chronic daily intake averaged over 70 years (mg/kg-day)
SF = slope factor, expressed as (mg/kg-day) -1.

These risks are probabilities that are expressed in scientific notation (*e.g.*, 10^{-6}). An excess lifetime cancer risk of 1×10^{-6} indicates that an individual experiencing the reasonable maximum exposure estimate has a 1 in 1,000,000 chance of developing cancer as a result of site-related exposure. This is referred to as an "excess lifetime cancer risk" because it would be in addition to the risks of cancer individuals face from other causes such as smoking or exposure to too much sun. The chances of an individual's developing cancer from all other causes have been estimated to be as high as one in three. The USEPA's acceptable risk range for excess lifetime cancer risk from site-related exposure is 10^{-4} to 10^{-6}. Carcinogenic risk for each individual receptor pathway which was modeled in the risk assessment as presented in the following sections.

Site Visitors

Wetland soils and Catfish: The total incremental lifetime carcinogenic risk estimate of a site visitor exposed to wetland soil and ingesting catfish fillets is 4 x 10^{-5}, which is within USEPA's acceptable risk range of 1 x 10^{-4} to 1 x 10^{-6}. For comparison, cancer risk for a site visitor exposed to wetland soil and ingesting whole body catfish is 3 x 10^{-4}, which is above the USEPA acceptable risk range.

Wetland soils and Gamefish: The total incremental lifetime carcinogenic risk estimate of a site visitor exposed to wetland soil and ingesting gamefish fillets is 4 x 10^{-5}, which is within USEPA's acceptable risk range of 1 x 10^{-4} to 1 x 10^{-6}. For comparison, carcinogenic risk for a site visitor exposed to wetland soil and ingesting whole body gamefish is 2 x 10^{-4}, which is above the USEPA target risk range. The majority of the excess risk estimate is attributable to the dioxin TEQ concentration in whole body game fish.

Wetland soils and Clams: The total incremental lifetime carcinogenic risk estimate of a site visitor exposed to wetland soil and ingesting clams is 2 x 10^{-5}, which is within USEPA's acceptable risk range of 1 x 10^{-4} to 1 x 10^{-6}.

Anglers

Catfish: The total incremental lifetime carcinogenic risk estimate of an angler ingesting catfish fillets is 5 x 10^{-5}, which is within USEPA's acceptable risk range of 1 x 10^{-4} to 1 x 10^{-6}. For comparison, cancer risk for an angler ingesting whole body catfish is 4 x 10^{-4}.

Gamefish: The total incremental lifetime carcinogenic risk estimate of an angler exposed ingesting gamefish fillets is 4 x 10^{-5}, which is within USEPA's acceptable risk range of 1 x 10^{-4} to 1 x 10^{-6}. For comparison, cancer risk for an angler ingesting whole body gamefish is 2 x 10^{-4}, which is above the USEPA target risk range. The majority of the excess risk estimate is attributable to the dioxin TEQ concentration in whole body game fish.

Clams: The total incremental lifetime carcinogenic risk estimate of an angler ingesting clams is 1 x 10^{-5}, which is within USEPA's acceptable risk range of 1 x 10^{-4} to 1 x 10^{-6}.

e. Summary of Risk Characterization

The non-carcinogenic HIs and the incremental carcinogenic risk for each media and receptor are presented in Table H-6 for the RME. The total HIs derived for the site visitor and angler under the different dietary scenarios, were less than 1.0, with the exception of the site visitor ingesting wetland soil and whole body gamefish (HI=1). In that scenario, aluminum contributed a HI of 0.7. A HI below 1.0 indicates that these receptors are not expected to experience adverse non-carcinogenic health effects under the exposure evaluated.

The LRR HHRA (CDM, 2003b) evaluated potential human health risk associated with a site visitor exposed to wetland soils and consuming fish. Dioxin in consumed fish represented the majority of the calculated risk. Dibenzo(a,h)anthracene also contributes to the calculated risk for the scenarios involving the consumption of whole catfish. It should be noted that dibenzo(a,h)anthracene was detected in just one of ten fish samples.

For site visitors consuming fish fillets, the calculated potential incremental lifetime cancer risk was 4×10^{-5} which is within USEPA's target range for Superfund sites or 1×10^{-4} to 1×10^{-6}. In contrast, the modeled scenario presented in the LRR RI for the site visitor consuming the whole fish (as in fish stew), results in an estimated incremental lifetime cancer risk of 2×10^{-4}, above USEPA's target range. The uncertainty discussion addressing exposure assessment

Table H-6
Hazard and Incremental Risk Summary by Media for Reasonable Maximum Exposure Current/Future Scenario

RECEPTOR/ MEDIA OF CONCERN	LOWER ROANOKE RIVER HAZARD	LOWER ROANOKE RIVER INCREMENTAL RISK
	REASONABLE MAXIMUM EXPOSURE	REASONABLE MAXIMUM EXPOSURE
Trespasser/Visitor		
Wetland Soil	0.09	**2.0×10^{-6}**
Catfish Fillet	0.1	4.0×10^{-5}
Total Receptor Risk	0.2	**4.0×10^{-5}**
Trespasser/Visitor		
Wetland Soil	0.09	2.0×10^{-6}
Whole Catfish	0.6	3.0×10^{-4}
Total Receptor Risk	0.7	**3.0×10^{-4}**
Trespasser/Visitor		
Wetland Soil	0.09	2.6×10^{-6}
Gamefish Fillet	0.09	4.0×10^{-5}
Total Receptor Risk	**0.2**	**4.0×10^{-5}**
Trespasser/Visitor		
Wetland Soil	0.09	2.0×10^{-6}
Whole Gamefish	**1**	2.0×10^{-4}
Total Receptor Risk	**1**	**2.0×10^{-4}**
Trespasser/Visitor		
Wetland Soil	0.09	2.0×10^{-6}
Clams	NA	2.0×10^{-5}
Total Receptor Risk	**0.09**	**2.0×10^{-5}**
Angler		
Catfish Fillet	0.05	5.0×10^{-5}
Total Receptor Risk	**0.05**	**5.0×10^{-5}**
Angler		
Whole Catfish	0.2	4.0×10^{-4}
Total Receptor Risk	**0.2**	**4.0×10^{-4}**

Table H-6
Hazard and Incremental Risk Summary by Media for
Reasonable Maximum Exposure Current/Future Scenario

RECEPTOR/ MEDIA OF CONCERN	LOWER ROANOKE RIVER HAZARD	LOWER ROANOKE RIVER INCREMENTAL RISK
	REASONABLE MAXIMUM EXPOSURE	REASONABLE MAXIMUM EXPOSURE
Angler		
Gamefish Fillet	0.03	4.0×10^{-5}
Total Receptor Risk	**0.03**	$\mathbf{4.0 \times 10^{-5}}$
Angler		
Whole Gamefish	0.4	2.0×10^{-4}
Total Receptor Risk	**0.4**	$\mathbf{2.0 \times 10^{-4}}$
Angler		
Clams	NA	1.0×10^{-5}
Total Receptor Risk	**NA**	$\mathbf{1.0 \times 10^{-5}}$

acknowledges that the risk assessment incorporated conservative assumptions into the exposure assessment and thus, results in an overestimation of risk. The uncertainty section states that human exposure to fish may be overestimated in the LRR BRA-HH due to incorporation of whole fish data into the dietary model. For consistency with criteria used to establish fish advisories in North Carolina and more common risk assessment practice, protective risk management decisions are more typically based upon consumption of fish fillets.

Finally, on-going fish tissue monitoring for dioxin continued to show a slow downward trend. Thus, calculated risks based upon past data may overestimate the current exposures.

f. Uncertainty Analysis

The primary goal of the uncertainty analysis is to provide a discussion of the key assumptions made in the risk assessment that may significantly influence the estimate of potential risk. A discussion of the sources of uncertainty contributing to the potential risk and the associated effects (overestimation or underestimation of risk) of these factors as presented in the Human Health Risk Assessment.

In the absence of empirical- or site-specific data, assumptions are developed based on best estimates of exposure or dose-response relationships. To assist in the development of these estimates, the USEPA (1989, 1991) recommends the use of guidelines and standard factors in risk assessments conducted under CERCLA. The use of these standard factors is intended to promote consistency among risk assessments where assumptions must be made. Although the use of standard factors undoubtedly promotes comparability, their usefulness in accurately predicting potential risk is directly related to their applicability to the actual site-specific conditions.

The potential non carcinogenic hazard and carcinogenic risk estimates for the site are based on a number of assumptions that incorporate varying degrees of uncertainty resulting from many sources, including the following:

- Assumptions in the selection of exposure pathways and scenarios.
- Assumptions in the toxicity information relied upon.
- Assumptions on the data quality.

Several factors introduced in the risk assessment may contribute to the uncertainty of the potential risk estimates, including the following:

- Sampling concentrated in areas at the site believed to be affected by constituents (biased sampling) is likely to overestimate exposure.
- Use of environmental data qualified as estimated potentially biases the actual value low or high.
- Using toxicity values with low confidence ratings and high uncertainty factors could potentially overestimate the risk calculated.
- Using toxicity values that are largely based on animal studies and extrapolated to humans could potentially overestimate or underestimate the risk calculated.
- Not quantitatively evaluating constituents that do not have toxicity data may underestimate actual risk.
- Not quantitatively evaluating synergistic or cumulative toxicity effect associated with the co-occurrence of COPCs in environmental media may underestimate actual risk.
- Compounding conservative assumptions in the risk assessment yield extremely conservative (overestimated) potential risk estimates.
- Assuming constituents present in the stream sediment have a significant tendency to desorb from the soil and pass through the skin is likely to overestimate exposure.
- Using 95 percent UCL and maximum concentrations is likely to overestimate intakes since actual exposure is probably at lower concentrations.

Several factors were identified in the risk assessment as factors that may contribute to the uncertainty of the potential risk estimates. An uncertainty analysis was included in the risk assessment.. A brief summary of the key assumptions and uncertainties is included below.

Exposure Assessment

There are numerous assumptions made in the exposure assessment, including the selection of exposure routes, scenarios, and factors (*e.g.*, contact rates, exposure frequency, body weight) used to estimate exposure doses. The RME was used to develop exposure doses and is defined as the "maximum exposure that is reasonably expected to occur at the site

(USEPA, 1989)." Several variables that determine the exposure dose for the RME are based on high-end (typically 90th percentile or greater) estimates. These variables include exposure concentrations, intake rate, exposure frequency, exposure duration and fraction ingested.

Therefore, the calculated RME dose for any given constituent, which results from a multiplication of these selected variables, represents a high-end value and a conservative estimate of the actual exposure dose. The use of this exposure dose, coupled with conservative estimates of toxicity, will yield a potential risk result that represents a high-end estimate of the likelihood of non-carcinogenic effects. The exposure assessment in the LRR BERA included the following uncertainties:

- The use of conservative assumptions may result in an overestimate of risk.
- Exposure to fish may be overestimated. The data sets for catfish and gamefish include both fillets and carcasses. Inclusion of whole body results may overestimate risk for site visitors and anglers who consume only the fillet.
- Clams were obtained during the investigation to evaluate potential impacts to ecological receptors. The assumption that humans would consume clams may not be valid.
- Site visitors and anglers may have direct contact with surface water. Risks were not quantified for exposure to surface water because the risk were assumed to be negligible.

Toxicity Assessment

In order for a potential risk to be present, both exposure to the COC and toxicity at the predicted exposure levels must exist. The toxicological uncertainties primarily relate to the methodology by which carcinogenic and non-carcinogenic criteria (*i.e.*, CSFs and Rfds) are developed. The toxicity values developed by the USEPA are designed to represent a conservative position, may not reflect the current scientific consensus, and in most instances, will result in an overestimation of potential hazards. In addition, there is considerable scientific debate regarding the nature of dioxin toxicity. In light of the uncertainty associated with the health effects of dioxin TEQ exposures, the CSF relied upon may overestimate or underestimate actual cancer risk.

The assumptions of the exposure assessment are conservative, and in general, result in overestimates of exposure. In the face of uncertainties, the assumptions of the exposure assessment are purposely conservative (high-end). This conservative risk and hazard estimate approach, dealing with uncertainties for exposure, conforms to USEPA guidance provided in RAGS (USEPA, 1989).

Data Quality Uncertainties

Several of the pesticide results were qualified with a presumptive "N" qualifier, indicating that presumptive rather than positive evidence of contamination. Use of this data is discouraged due to the greater uncertainty introduced into the assessment. Although this data was included in the risk assessment, none of the pesticides attributed to the overall risk.

g. Constituent of Concern Determination

Constituents of concern (COCs) are the COPCs that significantly contribute to a pathway in a current or future land use scenario for either site visitor or angler that either exceeds a 1×10^{-4} cumulative site cancer risk; or exceeds a non-carcinogenic HI of 1.

Generally, a 1×10^{-4} cumulative site risk level and an HI of 1 are guides for potential use as remediation "triggers." The exact level used as the "trigger" is at the discretion of the risk manager. Constituents are considered as significant contributors to risk and therefore included as COCs if their individual carcinogenic risk contribution is greater than 1×10^{-6} and their noncarcinogenic HQ is greater than 0.1. No total receptor risks exceed the 1×10^{-4} cumulative site risk level, assuming ingestion of fish filets. Although no total receptor risk exceeds the 1×10^{-4} cumulative site risk level, dioxin TEQ (USEPA, 1989 and WHO, 1997) exceeds individual carcinogenic risk contribution of greater than 1×10^{-6} for the evaluated receptors.

Under the current and future use exposure scenario for the site visitor, dioxin in wetland soil was the only COC. Dioxin, PAHs and organochlorine pesticides were COCs associated with the wholebody fish scenarios. The carcinogenic risk was within the acceptable risk range for the fillet consumption scenarios. RGOs were not calculated for fish. Policy based dioxin cleanup goals for soil range from 1 to 20 ug/kg as I-TEQ. The highest wetland soil concentration for dioxin was 0.22 ug/kg I-TEQ, which was below the cleanup goal range. As stated previously, human exposure to fish may be overestimated in the LRR BRA-HH due to incorporation of whole fish data into the dietary model. For consistency with criteria used to establish fish advisories in North Carolina and more common risk assessment practice, protective risk management decisions are more typically based upon consumption of fish fillets.

2. The Baseline Ecological Risk Assessment (BERA)

A BERA report was prepared concurrently with the RI report for the LRR which documents biological data gathering and ecological risk characterization activities. The data gathering included analysis of forage materials and prey items for COPCs in support of exposure modeling to evaluate potential effects in upper trophic level endpoints using conservative assumptions. Sediment and wetland soil toxicity tests were also conducted. Additional site-specific information was collected by USFWS and Weyerhaeuser and was incorporated into the FS as part of the continued refinement of the ecological site conceptual model. A brief summary of the risk assessment components is presented below.

a. Problem Formulation

The problem formulation step focused on the defined project objectives and incorporated the existing ecological information to arrive at a conceptual model that could be tested. As part of the problem formulation step, the site-related ecosystem was characterized, the site-related COPC and assessment endpoints were identified, and a preliminary conceptual model was formulated. The conceptual model serves as the foundation for the subsequent ecological study design and BERA. The preliminary ecological conceptual site model for the Lower Roanoke River was further refined as part of the FS. The refined ecological conceptual site model is presented in Figure E-9.

Conceptual Migration and Exposure Model

The ecological migration and exposure model identifies exposure pathways via surface water, sediments wetland soil and prey items containing chemicals that may affect the Lower Roanoke River ecosystem. Consistent with Sediment Management Principles Guidance (Principle 4), the ecological site conceptual models was refined based upon new available information. In this effort, the existing LRR OU-2 site conceptual models were reviewed based upon the supplemental data and information presented in the FS. Refinements were made when there were significant issues that needed to be considered to resolve contradictions among different lines of evidence. The ecological site conceptual model was modified to include atmospheric deposition as a source of mercury to the river and wetland ecosystem. Background contributions of COCs from upstream sources have also been added to the site conceptual model since in many instances measured COPCs were present within the range of the comparison criteria developed from background sampling and thus could not be specifically attributed to site related activities. Potential primary receptors identified in the preliminary and refined site conceptual model include benthic macroinvertebrates and fish. Predator species are exposed to COPCs primarily through the ingestion of prey and forage species (macroinvertebrates and fish) that may have sequestered dioxins and mercury in their lipid and muscle tissue. It is primarily by this mechanism that bioaccumulative constituents are transferred to the members of the upper trophic levels of an ecosystem.

Potential pathways for environmental receptors for the LRR OU-2 are as follows:

- Soil invertebrates which may be exposed to site related COPCs in surface water and wetland soil through ingestion, respiration and dermal contact.
- Benthic invertebrate communities, which may be exposed to site-related COPCs in surface water and sediment through ingestion, respiration, and dermal contact.
- Fish communities, which may be exposed to site-related COPCs in affected prey items, surface water and sediment through ingestion, respiration, and dermal contact.
- Terrestrial biota, which may be directly exposed to COPCs in surface water and wetland soil through ingestion or dermal contact.
- Avian biota, which may be exposed to surface water and wetland soil through ingestion and dermal contact.
- Terrestrial and avian receptors, which may also be exposed to contaminants through the ingestion of affected fish and invertebrates and incidental sediment.

Assessment and Measurement Endpoints

Assessment endpoints representing stream-adapted aquatic and terrestrial ecosystems were selected for evaluation of Lower Roanoke River and its environs. Assessment endpoints were selected with consideration for ecological effects to both the aquatic and terrestrial ecosystem components, which result from direct exposure to COPCs in surface water and sediments and from transfer through dietary exposure interactions.

Assessment endpoints were selected to focus primarily on upper trophic level receptors in consideration of the bioaccumulative properties of selected COPCs (dioxin/furans, PCBs, mercury and selenium). Upper trophic level mammalian and avian receptors may be exposed to site-related COPCs through ingestion of forage materials (plants, terrestrial/wetland invertebrates, and small mammals) that have accumulated COPCs in tissues or through incidental ingestion of affected environmental media. For ecological risk assessments, actual measurement of impacts to whole site-specific animal communities and populations and any associated habitats is difficult in part due to the complex interactions both within and between the animal communities and populations that compose an ecosystem and the likely absence of community or population based toxicological data for the site-specific assessment endpoints. As such, measurement endpoints are chosen to represent the assessment endpoints.

Assessment endpoints identified for Lower Roanoke River and its adjacent wetlands include the following:

- Assessment Endpoint 1: Protection of soil invertebrates
- Assessment Endpoint 2: Protection of worm-eating birds
- Assessment Endpoint 3: Protection of insectivorous mammals
- Assessment Endpoint 4: Protection of insectivorous birds
- Assessment Endpoint 5: Protection of benthic macroinvertebrate communities
- Assessment Endpoint 6: Protection of fish communities
- Assessment Endpoint 7: Protection of omnivorous bird communities
- Assessment Endpoint 8: Protection of carnivorous/piscivorous bird communities
- Assessment Endpoint 9: Protection of omnivorous mammal communities

Measurement endpoints were selected to conservatively estimate the effects to the upper trophic levels of the different biotic communities that compose the ecosystem of the Lower Roanoke River. Measurement endpoints are quantitative expressions of observed or measured biological responses to stressors relevant to selected assessment endpoints. Measurement endpoints relied upon in the BERA are as follows:

- Comparison of observed wetland soil analytical data to literature based benchmark values that are protective of survival, growth, and reproduction of soil invertebrates.

- Comparison of observed sediment analytical data to literature based benchmark values that are protective of benthic macroinvertebrates.
- Comparison of observed surface water analytical data to literature based benchmark values that are protective of aquatic life.
- Aquatic macroinvertebrate toxicity testing performed in the laboratory on sediments collected from the Lower Roanoke River to evaluate toxicity to *Hyalella azteca*.
- Earthworm toxicity testing performed in the laboratory on wetland soils collected from the Lower Roanoke River to evaluate toxicity to *Eisenia foetida*.
- Bioaccumulation testing using *Lumbriculus variegates* and *Eisenia foetida* were used in food chain modeling for emergent aquatic insects and soil invertebrates, respectively.
- Food –chain modeling was used to evaluate risks to upper trophic level birds and mammals. The measurement endpoint for each of the upper trophic level assessment endpoints involves comparison of modeled dietary intakes for each ecological COPC to chronic toxicity thresholds.

Table H-7 presents data gathering conducted in support of the measurement endpoints for the Lower Roanoke River.

b. Ecological Chemicals of Potential Concern

Preliminary direct ecological COPCs were selected by comparing the maximum detected concentration of each constituent to the appropriate USEPA Region 4 ecological screening value for each media tested. The COPCs were further refined based on dietary exposure modeling for the selected upper trophic endpoint receptors which was performed in the Screening Ecological Risk Assessment. The ecological COPCs for each environmental media in the Lower Roanoke River are shown in Table H-8.

c. Biological Tissue Characterizations

Tissue samples of fish, clams, and benthic invertebrates were collected for analysis from the Lower Roanoke River in order to provide modeled COPC concentrations in forage species for dietary exposure model inputs. The exposure point concentrations used in the BERA dietary exposure modeling, which were derived from the biological tissue sampling results, are presented in Table H-9.

d. Exposure Characterization

Both direct and modeled exposure characterization was conducted in the ecological risk assessment.

Direct Effects Characterization

Direct exposures occur when the ecological receptor is directly exposed to a COPC in environmental media through ingestion, inhalation or dermal exposure. Risk from direct exposure to river sediments and surface water were evaluated for benthic macroinvertebrates

Table H-7: Summary of Assessment and Measurement Endpoints

ASSESSMENT ENDPOINT	MEASUREMENT ENDPOINT
1. Protection of the fish communities	– Chemical analysis of fish tissue
	– Fish tissue benchmark value comparison
	– Chemical analysis of surface water
	– Surface water benchmark value comparison
2. Protection of the benthic macroinvertebrate communities	– Chemical analysis of river sediments
	– Sediment benchmark value comparison
	– Aquatic macroinvertebrate toxicity test using *Hyalella azteca* and *Lumbriculus variegates* toxicity and bioaccumulation bioassay
	– Chemical analysis of surface water
	– Surface water benchmark value comparison
3. Protection of soil invertebrates	– Chemical analysis of wetland soils
	– Soil benchmark value comparison
	– Earthworm toxicity testing using *Eisenia foetida*
4. Protection of worm –eating birds	– Chemical analysis of wetland soils
	– Soil benchmark value comparison
	– Food chain model
	– Chemical analysis of surface water
5. Protection of insectivorous birds	– Aquatic worm tissue data using *Lumbriculus variegates* as a surrogate for aquatic emergent insects
	– Chemical analysis of sediments
	– Chemical analysis of surface water
	– Food chain model
6. Protection of omnivorous birds	– Chemical analysis of prey tissue concentrations
	– Chemical analysis of sediments
	– Chemical analysis of surface water
	– Food chain model
7. Protection of carnivorous/piscivorous birds	– Chemical analysis of prey tissue concentrations
	– Chemical analysis of wetland soil
	– Chemical analysis of surface water
	– Food chain model
8. Protection of insectivorous mammals	– Earthworm data using *Eisenia foetida*
	– Chemical analysis of wetland soil
	– Chemical analysis of surface water
	– Food chain model
9. Protection of omnivorous mammals	– Chemical analysis of sediments and wetland soil
	– Chemical analysis of prey tissue concentrations
	– Chemical analysis of surface water
	– Food chain model

Table H-8
Ecological COPCs for the Lower Roanoke River

SUBAREA/MEDIA OF CONCERN	ECOLOGICAL CONSTITUENTS OF POTENTIAL CONCERN	
Sediment	Dioxin/Furans Copper	Total Mercury
Wetland Soils	Dioxin/Furans Pentachlorophenol Total Mercury	Chromium Copper
Surface Water	Dioxin/Furans	

Table H-9
Exposure Point Concentrations Used in Ecological Dietary Exposure Modeling for the Lower Roanoke River

Number of Samples	Constituent of Concern	Mean Concentration (dry weight, mg/kg)	95% UCL Concentration (dry weight, mg/kg)	Maximum Concentration (dry weight, mg/kg)
Downstream Sample Locations River Sediments				
n=41	Chromium	36.44	40.53	53
n=41	Copper	27.44	30.32	70
n=51	Mercury	0.23	0.3	1.6
n=38	Avian Dioxin TEQ	0.00008	0.0002	0.00004
n=38	Fish Dioxin TEQ	0.00002	0.00004	0.00002
n=38	Mammal Dioxin TEQ	0.00003	0.00004	0.00002
Reference Sample Locations River Sediment				
n=8	Chromium	37.38	42..35	47
n=8	Copper	24.5	28.18	35
n=8	Mercury	0.34	0.98	1.4
n=8	Avian Dioxin TEQ	0.000007	0.00001	0.00002
n=8	Fish Dioxin TEQ	0.000004	0.000006	0.000009
n=8	Mammal Dioxin TEQ	0.000007	0.00001	0.00001
Downstream Wetland Soil Sample Locations				
n=18	Chromium	30.6	55.16	64
n=18	Copper	28.89	43	120
n=18	Mercury	0.33	0.54	0.74
n=16	Avian Dioxin TEQ	0.0001	0.0007	0.0008
n=16	Fish Dioxin TEQ	0.00005	0.0001	0.0002
n=16	Mammal Dioxin TEQ	0.00005	0.0001	0.0002
Reference Wetland Soil Sample Locations				
n=3	Chromium	32.33	54.14	37
n=3	Copper	22.17	1024.95	31
n=3	Mercury	0.16	0.25	0.18
n=3	Avian Dioxin TEQ	0.000005	0.00001	0.000007
n=3	Fish Dioxin TEQ	0.000004	0.000005	0.000004
n=3	Mammal Dioxin TEQ	0.000006	0.000008	0.000007
Downstream Surface Water Exposure Point Concentrations (mg/L)				
n=5	Chromium	0.002	0.008	0.004
n=5	Copper	0.001	0.002	0.002
n=5	Mercury	0.00005	Not calculated	0.00005

Table H-9
Exposure Point Concentrations Used in Ecological Dietary Exposure Modeling for the Lower Roanoke River

Number of Samples	Constituent of Concern	Mean Concentration (dry weight, mg/kg)	95% UCL Concentration (dry weight, mg/kg)	Maximum Concentration (dry weight, mg/kg)
n=5	Avian Dioxin TEQ	1.73E-10	5.7E-9	6.18E-10
n=5	Fish Dioxin TEQ	1.97E-10	0.00000002	7.18E-10
n=5	Mammal Dioxin TEQ	2.5E-10	7E-9	8.67E-10
Reference Surface Water Exposure Point Concentrations (mg/L)				
n=1	Chromium	0.002	Not calculated	0.002
n=1	Copper	0.001	Not calculated	0.001
n=1	Mercury	0.00005	Not calculated	0.00005
n=1	Avian Dioxin TEQ	2.2E-11	Not calculated	2.2E-11
n=1	Fish Dioxin TEQ	1.5E-11	Not calculated	1.5E-11
n=1	Mammal Dioxin TEQ	2.8E-11	Not calculated	2.8E-11
Downstream Sample Locations Earthworm Tissue				
n=3	Chromium	0.8	1.84	1
n=3	Copper	1.63	2.27	1.9
n=3	Mercury	0.07	Not calculated	0.07
n=3	Avian Dioxin TEQ	0.000009	437.68	0.00002
n=3	Fish Dioxin TEQ	0.000003	0.002	0.000005
n=3	Mammal Dioxin TEQ	0.000003	0.004	0.000006
Reference Sample Locations Earthworm Tissue				
n=1	Chromium	0.71	Not calculated	0.71
n=1	Copper	4.2	Not calculated	4.2
n=1	Mercury	0.03	Not calculated	0.03
n=1	Avian Dioxin TEQ	0.000001	Not calculated	0.000001
n=1	Fish Dioxin TEQ	0.000001	Not calculated	0.000001
n=1	Mammal Dioxin TEQ	0.000001	Not calculated	0.000001
Downstream Sample Locations Aquatic Worm Tissue				
n=4	Chromium	1.1	3.72	1.8
n=4	Copper	1.75	3.69	2.7
n=4	Mercury	0.02	0.15	0.03
n=4	Avian Dioxin TEQ	0.000008	0.008	0.00002
n=4	Fish Dioxin TEQ	0.000002	0.00003	0.000005
n=4	Mammal Dioxin TEQ	0.000002	0.00006	0.000005
Reference Sample Locations Aquatic Worm Tissue				

Table H-9
Exposure Point Concentrations Used in Ecological Dietary Exposure Modeling for the Lower Roanoke River

Number of Samples	Constituent of Concern	Mean Concentration (dry weight, mg/kg)	95% UCL Concentration (dry weight, mg/kg)	Maximum Concentration (dry weight, mg/kg)
n=1	Chromium	6.8	Not calculated	6.8
n=1	Copper	1.2	Not calculated	1.2
n=1	Mercury	0.01	Not calculated	0.01
n=1	Avian Dioxin TEQ	Not calculated	Not calculated	Not calculated
n=1	Fish Dioxin TEQ	Not calculated	Not calculated	Not calculated
n=1	Mammal Dioxin TEQ	Not calculated	Not calculated	Not calculated
Downstream Sample Locations Fish Tissue				
n=19	Chromium	0.29	0.44	0.73
n=18	Copper	0.54	0.91	2.05
n=18	Mercury	0.33	1.96	1.24
n=22	Avian Dioxin TEQ	0.000005	0.000008	0.00003
n=22	Fish Dioxin TEQ.	0.000003	0.000005	0.00002
n=22	Mammal Dioxin TEQ	0.000003	0.000005	0.00002
Reference Sample Locations Fish Tissue				
n=5	Chromium	0.29	1.27	0.43
n=5	Copper	0.39	0.71	0.57
n=5	Mercury	0.32	7025.3	0.98
n=3	Avian Dioxin TEQ	0.000004	0.00002	0.000006
n=3	Fish Dioxin TEQ	0.000003	0.000006	0.000004
n=3	Mammal Dioxin TEQ	0.000003	0.000007	0.000004
Downstream Sample Locations Bivalve Tissue				
n=5	Chromium	0.39	0.6	0.57
n=5	Copper	6.18	9.19	8.4
n=3	Mercury	0.03	Not calculated	0.02
n=7	Avian Dioxin TEQ	0.000003	0.000005	0.000005
n=7	Fish Dioxin TEQ	0.000002	0.000002	0.000002
n=7	Mammal Dioxin TEQ	0.000002	0.000002	0.000002
Reference Sample Locations Bivalve Tissue				
n=1	Chromium	0.92	Not calculated	0.92
n=1	Copper	7.3	Not calculated	7.3
n=1	Mercury	0.02	Not calculated	0.02
n=1	Avian Dioxin TEQ	0.000003	Not calculated	0.000003

Table H-9
Exposure Point Concentrations Used in Ecological Dietary Exposure Modeling for the Lower Roanoke River

Number of Samples	Constituent of Concern	Mean Concentration (dry weight, mg/kg)	95% UCL Concentration (dry weight, mg/kg)	Maximum Concentration (dry weight, mg/kg)
n=1	Fish Dioxin TEQ	0.000002	Not calculated	0.000002
n=1	Mammal Dioxin TEQ	0.000002	Not calculated	0.000002
Downstream Sample Locations Frog Tissue				
n=4	Chromium	0.18	Not calculated	0.18
n=4	Copper	2	Not calculated	2
n=4	Mercury	0.02	Not calculated	0.02
n=4	Avian Dioxin TEQ	0.000001	Not calculated	0.000001
n=4	Fish Dioxin TEQ	0.000001	Not calculated	0.000001
n=4	Mammal Dioxin TEQ	0.000001	Not calculated	0.000001
Reference Sample Locations Frog Tissue				
n=1	Chromium	0.28	Not calculated	0.28
n=1	Copper	1.8	Not calculated	1.8
n=1	Mercury	0.02	Not calculated	0.02
n=1	Avian Dioxin TEQ	0.000001	Not calculated	0.000001
n=1	Fish Dioxin TEQ	0.000001	Not calculated	0.000001
n=1	Mammal Dioxin TEQ	0.000001	Not calculated	0.000001

Mean and maximum values are used in the food chain models. 95% UCL was only for comparison.

and fish, and risks from direct exposure to wetland soils is evaluated for soil invertebrates. The exposure point concentration (maximum quantified concentration) was compared to conservative literature based benchmarks.

Modeled Risk Characterization

The risk characterization step of the ecological assessment relies on the integration of data on exposure and effects to arrive at findings and conclusions relative to risks posed to the selected ecological receptors. The result of this modeled characterization determines whether there are potential unacceptable risks posed to ecological receptors by site-related constituents. Consistent with USEPA guidance (USEPA, 1997), the ecological risk characterization relies on the Hazard Quotient (HQ) method as an indicator of the risks posed to the ecological endpoint.

The HQ method compares an estimated exposure level or daily dose to reference values (TRVs) for each modeled ecological COPC under consideration. The BERA for the Lower Roanoke River incorporated a conservative approach to HQ estimation based on the dietary exposure modeling for upper trophic level receptors by comparing the estimated daily dose to conservative NOAEL and LOAEL based TRVs.

The general approach to exposure characterization in the BERA was based on multiple lines of evidence to evaluate ecological risks. The lines of evidence presented in the BERA vary by assessment endpoint. Additional lines of evidence from independent and supplemental investigations were incorporated into the updated ecological site conditions in the FS. Exposure can be expressed as the temporal and spatial co-occurrence (*i.e.*, contact) of stressors (*i.e.*, COPCs) with the ecological receptors of an ecosystem (USEPA, 1992). Within the context of an ecological risk assessment, the estimation of exposure focuses on the measurement endpoints that represent the variety of species within the site-related ecosystem.

The effects characterization for each assessment endpoint as presented in the BERA is summarized below.

- **Assessment Endpoint No. 1: Protection of Soil Invertebrates.** Measurement endpoints for this assessment endpoints include analytical data from wetland soils. Risk to soil invertebrates were evaluated by comparison of wetland soil concentrations to soil benchmark values developed to be protective of soil invertebrates and by toxicity tests to earthworms using site-specific wetland soils.
- **Assessment Endpoint No. 2: Protection of Worm-Eating Birds.** There were three types of data collected for evaluation of this exposure endpoint: chemical analysis of wetland soils and surface water and earthworm tissue analysis from a bioaccumulation bioassay. The data was incorporated into a dietary exposure model to evaluate risk to worm eating birds. The American robin was selected as a representative species.
- **Assessment Endpoint No. 3: Protection of Insectivorous Mammals.** There were three types of data collected for evaluation of this exposure endpoint: chemical analysis of wetland soils and surface water and earthworm tissue analysis from a bioaccumulation bioassay. The data was incorporated into a dietary exposure model to evaluate risk to insectivorous mammals. The short-tailed shrew was selected as a representative species.
- **Assessment Endpoint No. 4: Protection of Insectivorous Birds.** There were three types of data collected for evaluation of this exposure endpoint: chemical analysis of river sediments and surface water and benthic macroinvertebrate tissue analysis from a bioaccumulation bioassay. The data was incorporated into a dietary exposure model to evaluate risk to insectivorous birds. The barn swallow was selected as a representative species.
- **Assessment Endpoint No. 5: Protection of Benthic Macroinvertebrates.** Measurement endpoints for this assessment endpoints include analytical data from sediments. Risk to benthic invertebrates were evaluated by comparison of sediment concentrations to a range of benchmark values developed to be protective of aquatic organisms and by toxicity tests to *Hyalella azteca* using site-specific sediments.
- **Assessment Endpoint No. 6: Protection of Fish.** Three types of data were collected for evaluation of exposure to this endpoint: chemical analysis of sediments, fish tissue, and surface water. Risk was evaluated by comparison of fish tissue concentrations to

risk based fish tissue benchmarks in the literature. Surface water concentrations were compared to the State of North Carolina's Water Quality Standards, along with NOECs and LOECs obtained from literature sources. The redear sunfish, bluegill and largemouth bass were selected as representative species.

- **Assessment Endpoint No. 7: Protection of Omnivorous Birds.** There were six types of data collected for evaluation of this exposure endpoint: chemical analysis of sediments and surface water along with chemical analysis of fish, bivalves, and frogs, and benthic macroinvertebrate tissue analysis from a bioaccumulation bioassay. The data was incorporated into a dietary exposure model to evaluate risk to omnivorous birds. The wood duck was selected as a representative species.
- **Assessment Endpoint No. 8: Protection of Carnivorous/Piscivorous Birds.** There were five types of data collected for evaluation of this exposure endpoint: chemical analysis of sediments and surface water, along with chemical analysis of fish and benthic macroinvertebrate tissue analysis from a bioaccumulation bioassay. The data was incorporated into a dietary exposure model to evaluate risk to carnivorous/piscivorous birds. The green heron and osprey were selected as representative species for this assessment endpoint.
- **Assessment Endpoint No. 9: Protection of Omnivorous Mammals.** There were several types of data collected for evaluation of this exposure endpoint: chemical analysis of sediments, wetland soils and surface water, along with chemical analysis of fish and clams and soil invertebrate and benthic macroinvertebrate tissue analysis from bioaccumulation bioassays. The data was incorporated into a dietary exposure model to evaluate risk to carnivorous/ piscivorous mammals. The raccoon and river otter were selected as representative species for this assessment endpoint.

Table H-10 presents a summary of the risk results for assessment endpoints. For the Lower Roanoke River, COCs identified from dietary exposure modeling, based on at least one estimated HQ greater than 1.0, were dioxin TEQ, chromium, copper, and mercury.

Table H-10
Summary of Risk Assessment Results by Assessment Endpoint

Assessment Endpoint No. 1: Protection of Soil Invertebrates		
COC	**Mean HQ**	**Maximum HQ**
Chromium	76	160
Copper	0.55	2.4
Dioxins/Furans	NA	1.1
Toxicity test results	Results from the *Eisenia foetida* toxicity tests indicate no acute mortality to soil invertebrates from exposure to site contaminants in wetland soils.	
Assessment Endpoint No. 2: Protection of Worm-eating Birds		
American Robin		
COC	**Mean HQ**	**Maximum HQ**
Chromium- NOAEL-based	0.6	0.92
Chromium- LOAEL- based	0.06	0.09
Copper- NOAEL –based	0.08	0.14
Copper-LOAEL-based	0.06	0.1
Mercury-NOAEL-based	29	31.5
Mercury-LOAEL-based	2.9	3.15
Dioxins/Furans- NOAEL-based	14.2	36.2
Dioxins/Furans- LOAEL-based	1.42	3.62
Assessment Endpoint No. 3: Protection of Insectivorous Mammals		
Short-tailed Shrew		
COC	**Mean HQ**	**Maximum HQ**
Chromium- NOAEL-based	0.04	0.06
Chromium- LOAEL- based	0.004	0.006
Copper- NOAEL –based	0.26	0.52
Copper-LOAEL-based	0/13	0.26
Mercury-NOAEL-based	1.6	1.85
Mercury-LOAEL-based	0.28	0.33
Dioxins/Furans- NOAEL-based	2.6	6.81
Dioxins/Furans- LOAEL-based	0.26	0.68
Assessment Endpoint No. 4: Protection of Insectivorous Birds		
Barn Swallow		
COC	**Mean HQ**	**Maximum HQ**
Chromium- NOAEL-based	0.33	0.53
Chromium- LOAEL- based	0.03	0.05
Copper- NOAEL –based	0.04	0.06
Copper-LOAEL-based	0.03	0.05
Mercury-NOAEL-based	3.87	8.18
Mercury-LOAEL-based	0.39	0.82

Table H-10
Summary of Risk Assessment Results by Assessment Endpoint

Dioxins/Furans- NOAEL-based	5.47	15.02	
Dioxins/Furans- LOAEL-based	0.55	1.5	
Assessment Endpoint No. 5: Protection of Benthic Macroinvertebrates			
COC	**Maximum HQ using Effects Range Low**	**Maximum HQ using Effects Range Median**	**Maximum HQ using Region 4 Sediment Benchmark**
Copper	2	0.2	NA
Mercury	11	2	NA
Dioxins/Furans	NA	NA	68
Toxicity Test Results	Results of *Hyalella azteca* indicated in reduced survival at one location, results of *Lumbriculus variegates* indicated no acute mortality		
Assessment Endpoint No. 6: Protection of Fish			
COC	Does the maximum exceed Tissue Residue-based benchmark		
Copper-	No		
Mercury	Yes		
Dioxins/Furans	Yes		
Do site COC concentrations in surface water exceed literature based NOEC and LOEC surface water values for fish?	No		
Does the site COC concentrations exceed the NC surface water standard for dioxin?	Yes		
Assessment Endpoint No. 7: Protection of Omnivorous Birds			
Wood Duck			
COC	**Mean HQ**	**Maximum HQ**	
Chromium- NOAEL-based	0.11	0.17	
Chromium- LOAEL- based	0.01	0.02	
Copper- NOAEL –based	0.01	0.02	
Copper-LOAEL-based	0.008	0.01	
Mercury-NOAEL-based	1.12	2.86	
Mercury-LOAEL-based	0.11	0.29	
Dioxins/Furans- NOAEL-based	1.56	4.51	
Dioxins/Furans- LOAEL-based	0.16	0.45	

Table H-10
Summary of Risk Assessment Results by Assessment Endpoint

Assessment Endpoint No. 8: Protection of Carnivorous/Piscivorous Birds		
COC	**Mean HQ**	**Maximum HQ**
Osprey		
Chromium- NOAEL-based	0.02	0.04
Chromium- LOAEL- based	0.002	0.004
Copper- NOAEL –based	0.002	0.009
Copper-LOAEL-based	0.002	0.007
Mercury-NOAEL-based	13.86	52.29
Mercury-LOAEL-based	1.39	2.23
Dioxins/Furans- NOAEL-based	0.75	3.92
Dioxins/Furans- LOAEL-based	0.08	0.39
Green Heron		
Chromium- NOAEL-based	0.06	0.09
Chromium- LOAEL- based	0.006	0.009
Copper- NOAEL –based	0.01	0.02
Copper-LOAEL-based	0.007	0.01
Mercury-NOAEL-based	7.03	26.27
Mercury-LOAEL-based	0.7	2.53
Dioxins/Furans- NOAEL-based	1.04	3.7
Dioxins/Furans- LOAEL-based	0.1	0.37
Assessment Endpoint No. 9: Protection of Omnivorous Mammals		
COC	**Mean HQ**	**Maximum HQ**
Raccoon		
Chromium- NOAEL-based	0.01	0.02
Chromium- LOAEL- based	0.001	0.002
Copper- NOAEL –based	0.15	0.26
Copper-LOAEL-based	0.08	0.11
Mercury-NOAEL-based	1.08	3.37
Mercury-LOAEL-based	0.19	0.59
Dioxins/Furans- NOAEL-based	0.82	2.79
Dioxins/Furans- LOAEL-based	0.08	0.28
River Otter		
Chromium- NOAEL-based	0.02	0.03
Chromium- LOAEL- based	0.002	0.003
Copper- NOAEL –based	0.12	0.27
Copper-LOAEL-based	0.06	0.13
Mercury-NOAEL-based	3.47	13.07
Mercury-LOAEL-based	0.61	2.31
Dioxins/Furans- NOAEL-based	1.27	6.61
Dioxins/Furans- LOAEL-based	0.13	0.66

e. Uncertainty Analysis

The primary goal of the uncertainty analysis is to provide a discussion of the key assumptions made in the risk assessment that significantly influence the estimate of risk. The ecological risk estimates for the site is based on a number of assumptions that incorporate varying degrees of uncertainty resulting from many sources. The ecological risk characterization for the upper trophic level species presented in the BERA relies on a deterministic "HQ" method (*i.e.*, point estimates of risk derived from ratios of modeled exposure concentrations and toxicity reference values believed to be potentially harmful to organisms). Such screening-level data and models are designed to be conservative, to minimize the possibility that any potential adverse effects are missed in the risk assessment. The deterministic methods generally overstate the actual effects of chemicals at most sites, focus too narrowly on individual versus population effects, and limit appropriate reflection of variability and uncertainty inherent in the natural system. As an example, for each endpoint species evaluated, the conservative exposure scenarios presented in the risk assessment compound conservative dietary assumptions, namely, maximum ingestion rate and minimum body weight, to yield a conservative (overestimated) exposure estimate (on a dose per body weight basis). In reality, both these critical dietary exposure variables are proportional to each other and are likely represented in a normal distribution in the ecosystem.

Additional uncertainties discussed in the BERA are summarized below.

Uncertainties Associated with Refinement of COPCs

On source of uncertainty in the refinement of COPC process is where comparison to benchmark values found in the literature may result in an under or overestimate of risk. A second source of uncertainty exists in the refinement where a COPC is not detected and no screening benchmark is available for comparison. This may underestimate risk however it is anticipated that risk from these constituents would be negligible.

Uncertainties Associated with Characterization of Effects

Media-specific toxicity data are the primary source of uncertainty in the effects analysis. Factors contributing to uncertainty include extrapolations between species or responses and extrapolation of laboratory test species versus free living species. Extrapolations between taxa, chemicals and responses are commonly used where data are limited. Extrapolations may over or underestimate risk. In addition to toxicity data, effects data used to assess risk to invertebrates may overestimate or underestimate risk. Site specific toxicity tests and bioaccumulation bioassay interpretations and use of the results may result in an under or overestimate of risk.

Uncertainties Associated with Estimates of Exposure

Major sources of uncertainty in estimating exposures to ecological receptors include the concentrations used to represent the magnitude and distribution of contamination in each media. The biased sampling and reliance on maximum or 95% upper confidence limit data may overestimate actual site risks. Data interpolation is necessary an acceptable with limited data sets. The conservative exposure parameters relied upon in the risk evaluation did not likely result in an underestimate of risk.

Uncertainties Associated with Selection of Assessment Endpoints

In evaluating the potential for adverse effects from exposure to site related contaminants, there are multiple species that are likely to be exposed to different degrees and to respond differently to the same contaminant. The selection of assessment endpoints focused the risk assessment on the ecosystem components that are most likely to be adversely affected by site related constituents.

Uncertainties Associated with Measurement Endpoints

Uncertainty associated with using depurated earthworm tissue was mitigated by inclusion of an incidental soil ingestion in the food chain model. The soil and sediment sample locations for toxicity testing were selected along a contaminant gradient, thereby mitigating uncertainties associated with a limited sample size.

Uncertainties Associated with Estimation of Risks

Benchmark values, toxicity tests and food chain model components all have associated uncertainties. The use of conservative exposure assumptions likely does not result in an underestimate of risk. Uncertainties in toxicity/exposure-response were bracketed by calculating hazard quotients using both the NOAEL and the LOAEL.

f. Risk Assessment Conclusions

The LRR BERA evaluated nine assessment endpoints using published screening criteria, food chain modeling, and some site-specific toxicity tests. As a result of the dietary uptake assumptions and screening levels selected for comparison, the BERA concluded that there was potential excess risk for all assessment endpoints. A summary of these conclusions from the BERA by assessment end point is included in Table H-11.

Table H-11
Summary of LRR BERA Risk Conclusions

Media of Concern	Applicable Assessment Endpoints	Basis for Risk Assessment Conclusion	Comment
Wetlands	Soil Invertebrates	Maximum exceeded screening level for copper, chromium and dioxin. Average exceeded screening level for chromium	Reference locations also showed risk for chromium
	Worm eating Birds (Robin)	Food Chain modeling exceeded LOAELs and NOAELs for mercury and dioxin (Maximums and Averages)	Reference locations also showed risk for both dioxin and mercury
	Insectivorous Mammals (Shrew)	Food Chain modeling exceeded NOAELs for mercury and dioxin (Maximums and Averages)	---
Sediment	Insectivorous Birds (Swallow)	Food Chain modeling exceeded NOAELs for mercury and dioxin (Maximums and Averages)	---
	Benthic macroinvertebrates	Maximum exceeded screening level for copper and mercury Possible acute mortality in one sample	---
	Omnivorous birds (Wood Duck)	Food Chain modeling exceeded NOAELs for mercury and dioxin (Maximums and Averages)	---
	Piscivorous Birds (Osprey and Heron)	Food Chain modeling exceeded NOAELs for mercury (Maximum and Average) and dioxin (Maximum)	---
	Omnivorous mammal (Raccoon/Otter)	Food Chain modeling exceeded NOAELs for mercury and dioxin (Maximums and Averages)	---
Surface Water	Fish	Tissue dioxin concentrations exceeded literature values. Comparison to human health surface water standard showed exceedance	Comparison to water quality thresholds for fish did not show excess risk

An essential component of the risk conclusions presented in the LRR BERA is the level of protectiveness incorporated into the risk analysis. The risk assessment approach was to apply conservative assumptions that protect unidentified sensitive species that may be present on site. As noted in the uncertainty section of the risk assessment, the intent was to reduce the possibility that conclusions of 'no risk' could be reached when an adverse threat exists. The level of protectiveness, as reflected in the assumptions applied to the risk calculations, is one of many factors to be considered by the risk manager as remedial alternatives are evaluated. As has been noted in other sections of this ROD, additional lines of evidence have been considered to make final risk management decisions.

g. Preliminary Ecological Remedial Goal Options (RGOs)

One of the objectives for the ecological risk assessment activities for the LRR OU-2 was to provide the information necessary to support risk management decisions concerning the practical need for, and the extent of remedial actions in the LRR OU-2. Preliminary numerical RGOs were established for LRR media reflecting ecological exposure considerations for the populations resulting in a modeled HQ greater than 1.0. Based on the results of the modeled ecological risk characterization, dioxin/furans, copper, chromium and mercury are appropriate for consideration in risk-based decision making for the LRR OU-2.

The RGO represents a specific media concentration that is modeled to not exceed a HQ of 1.0. Inherent in this calculation is the assumption that the concentration of a COC in a specific medium actually produces the hazard in the endpoint. It is also assumed that the relationship between concentration and hazard is linear. In interpretation of the modeled HQs as a potential indicator of ecosystem effects, higher weighting was assigned to LOAEL-based HQs, and subsequently the LOAEL-based RGOs. Preliminary RGOs are presented in Table H- 12. When the RAOs can be used to establish an appropriate approach to performance monitoring, RGOs may not be necessary.

Table H-12
Summary of Remedial Goal Options (RGOs)

COC	Receptor	NOAEL-Based RGO – soils (mg/kg)	LOAEL-Based RGO – soils (mg/kg)	Mean Reference Area Wetland Soil Concentrations (mg/kg)	NOAEL-Based RGO - sediments (mg/kg)	LOAEL-Based RGO - sediments (mg/kg)	Mean Reference Area Sediment Concentrations (mg/kg)
Mercury	robin	0.02	0.22	0.33	NA	NA	0.23
	shrew	0.36	2.05		NA	NA	
	wood duck	NA	NA		0.27	2.76	
	heron	NA	NA		0.04	0.37	
	otter	NA	NA		0.07	0.42	
	swallow	NA	NA		0.08	0.83	
	raccoon	6.88	453		1.28	453	
	osprey	NA	NA		0.02	0.19	
Chromium	robin	59.9	599	30.6	NA	NA	36.44
	shrew	946	9,460		NA	NA	
	wood duck	NA	NA		163	1,638	
	heron	NA	NA		340	3,406	
	otter	NA	NA		2,070	20,699	
	swallow	NA	NA		47.7	477	
	raccoon	23,900	239,000		27,200	239,000	
	osprey	NA	NA		2,180	21,804	
Copper	robin	146	192	28.9	NA	NA	27.44
	shrew	50.6	101.2		NA	NA	
	wood duck	NA	NA		3,002	3,948	
	heron	NA	NA		3,192	4,197	
	otter	NA	NA		217	435	
	swallow	NA	NA		918	1,207	
	raccoon	1310	2660		988	2,660	
	osprey	NA	NA		11,507	15,133	

Table H-12
Summary of Remedial Goal Options (RGOs)

COC	Receptor	NOAEL-Based RGO – soils (mg/kg)	LOAEL-Based RGO – soils (mg/kg)	Mean Reference Area Wetland Soil Concentrations (mg/kg)	NOAEL-Based RGO - sediments (mg/kg)	LOAEL-Based RGO - sediments (mg/kg)	Mean Reference Area Sediment Concentrations (mg/kg)
Dioxins/furans	robin	1.08E-5	1.08E-4	Total TEQs for: Bird 1.4E-04 Fish 4.7E-05 Mammal 5.5E-05	NA	NA	Total TEQs for: Bird 8.3E-05 Fish 3.7E-05 Mammal 4.2E-05
	shrew	3.1E-5	3.1E-4		NA	NA	
	wood duck	NA	NA		6.9E-5	6.9E-4	
	heron	NA	NA		8.0E-5	8.0E-4	
	otter	NA	NA		1.8E-5	1.8E-4	
	swallow	NA	NA		2.0E-5	2.0E-4	
	raccoon	0.000516	0.00516		2.9E-4	2.9E-3	
	osprey	NA	NA		9.7E-5	9.7E-4	
Sediment RGO based on CRV in fish tissue (mg/kg)	Fish	0.000299					
Surface Water RGO based on Channel Catfish (mg/L)	Fish	4.74E-09					
Surface Water RGO Based on Shortnose Sturgeon (mg/L)	Fish	4.74E-10					

Notes:

Reference area concentrations were derived as described in the Draft Final Remedial Investigation Report, Lower Roanoke River (CDM 2002):

Reference area concentrations for wetland soils represent two times the average concentration from locations 309, 310, and 317.

Reference area concentrations for river sediments represent the 90th percent upper confidence limit on the arithmetic mean (U90) concentration from locations 449, 450, 451, 452, 453, 454, 455, and 456. The U90 was calculated using the formula: X+Z(s/n^(▯)). The value for Z was obtained from a Standard Normal Table.

Dioxin TEQs on this table were calculated according to the World Health Organization method (Van den Berg et al. 1998), while the dioxin TEQs in the RI were calculated according to the International method (EPA 1989).

Reference area concentrations provided in the RI report are entitled "Comparison Criteria from Reference Area Sediments or Wetland Soils."

I. Remedial Action Objectives

Remedial Action Objectives (RAOs) for the Lower Roanoke River were developed based on the requirements of the National Contingency Plan (40 CFR §300.430[e][2][i]), which defines remedial action objectives as a listing of the COCs and media of concern, potential exposure pathways and remediation goals. Specifically, RAOs form the basis of remedial alternatives development and comparison of various management options to reduce risk, and to maintain acceptable levels of risk posed at the site. The RAOs for LRR OU-2 were developed and presented in the LRR FS. The overall purpose of the RAOs is to define what it is that the remedy is supposed to achieve in order for it to be considered a success. Remedy failures can result from technical problems, or by not meeting stakeholders' expectations for the remedy. Consistent with the Principles for Managing Contaminated Sediment Risks (OSWER Directive 9285.6-08, USEPA 2002a), the principle of early involvement by the stakeholders was followed to define the basis for the Welch Creek RAOs which were relied upon for development of the RAOs for the LRR OU-2. The RAOs for LRR OU-2 are very similar to those developed for Welch Creek and. The RAOs developed for LRR OU-2 include goals for the protection of human health and the environment. When the RAOs can be used to establish an appropriate approach to performance monitoring, RGOs may not be necessary. The LRR OU-2 RAOs will be used to provide input into remedy evaluation and long-term performance monitoring. These RAOs are presented and discussed below.

Human Health Remedial Action Objectives

- Maintain acceptable levels of potential risk to site-specific human receptors.
- Maintain surface water concentrations at or below surface water standards, to the extent practicable.
- Continue progress toward removal of remaining fish consumption advisory in Lower Roanoke River.

Ecological Remedial Action Objectives

- Protect the habitat of LRR OU-2 to maintain the health of local populations and communities of biota.
- Reduce the dioxin concentrations in whole fish tissues over time, to the extent practicable.
- Minimize the adverse effects of remediation activities on the existing aquatic environment and/or wetland habitat, to the extent practicable.
- Protection of the striped bass fishery and habitat.

Application of Remedial Goal Options

The site-specific information supporting healthy current site habitat conditions, a recovered striped bass fishery and evidence of natural recovery in the system was considered for application of the RAOs along with evaluation of remedial alternatives. LRR OU-2 RAOs will have a critical role in remedy performance monitoring and evaluation of remedy success for LRR OU-2 as well as Welch Creek. Relying on RAOs for remedy performance evaluation is consistent with an adaptive management approach for sediment sites. Multiple lines of evidence and field observations will be relied upon for evaluating remedy success in LRR OU-2.

On-going Role of Remedial Action Objectives

The RAOs establish the framework for the development and comparison of remedial alternatives, including the overall environmental benefit achieved by a remedy. The protection of human health and the environment and compliance with ARARs serve as the primary threshold criteria for remedy selection by the USEPA. The LRR OU-2 RAOs help to define what "protection of human health and the environment" means to the USEPA and interested stakeholders. In addition, the LRR OU-2 RAOs acknowledge the importance of existing habitats for the wildlife and fisheries associated with this ecosystem. The remedy implementation in both the short-term and long-term should not create more adverse environmental impacts than beneficial results.

RAOs also provide the basis upon which to develop and then refine a long term performance monitoring program shaped around the clearly identified goals. Specific aspects of the LRR OU-2 RAOs, in conjunction with the site conceptual model, will be used to identify the type of sampling and general comparison criteria that will be integrated into the performance monitoring plan.

J. Description of Alternatives

As required in the NCP, remedial technologies were screened for effectiveness, implementability and cost. After screening, the following technologies were retained for assembly into alternatives:

- No Action,
- Institutional and Engineering Controls,
- Fish Tissue Monitoring, and
- Monitored Natural Recovery (MNR).

Three alternatives were then assembled integrating all of the technologies to provide a range of effectiveness and cost.

Description of Individual Alternatives

Alternative 1: No Action

No Action provides a baseline alternative for evaluation of the other alternatives. This alternative is included in the FS, as required by the NCP.

- The Lower Roanoke River fish tissue consumption advisory for dioxins will continue until tissue concentrations are below applicable thresholds.
- No remedial action or additional monitoring is included in the No Action Alternative

Total Capital Costs	$ 0
O&M Costs (Present Worth):	$ 0
Contingency Costs:	$ 0
Total Present Worth Costs:	$ 0
Duration to Finish Construction:	Immediate

Alternative 2: Limited Action with Fish Tissue Monitoring

Limited action with fish tissue monitoring consists of monitoring fish tissue concentrations as the system naturally recovers.

- No treatment or containment technologies.
- The Lower Roanoke River fish tissue consumption advisory for dioxins will continue until tissue concentrations are below applicable thresholds.
- Operation and maintenance is not required as no remedy is implemented.
- Long-term monitoring will be implemented in the LRR OU-2. The monitoring plan would focus on evaluating fish tissue trends.

Indirect Costs	$366,000 to $439,200
Performance Monitoring Costs (Present Worth):	$561,000 to $717,500
Total Present Worth Costs:	$927,400 to $1,156,000

Duration to Finish Construction: Immediate

Alternative 3: Monitored Natural Recovery

Monitored natural recovery is a limited response action monitored sediment remedy which relies on natural attenuation processes to achieve the site-specific remedial action objectives, as compared to more active remedial approaches. This alternative consists of monitoring sediment, surface water and fish tissue concentrations as the system naturally recovers.

- No treatment or containment technologies.
- The Lower Roanoke River fish tissue consumption advisory for dioxins will continue until tissue concentrations are below applicable thresholds.
- Operation and maintenance is not required as no remedy is implemented.
- Long-term monitoring will be implemented in the Lower Roanoke River. The monitoring plan would focus on evaluating fish tissue trends, sediment and surface water concentrations, and the health of the local habitat.

Indirect Costs	\$390,000 to \$468,000
Performance Monitoring Costs (Present Worth):	\$1,220,700 to \$1,491,800
Total Present Worth Costs:	\$1,610,700 to \$1,959,800
Duration to Finish Construction:	Immediate

K. Summary of Comparative Analysis of Alternatives

In this section, each alternative is assessed using nine evaluation criteria required under the NCP (NCP§300.430 (f)(5)(i)). Comparison of the alternatives with respect to these evaluation criteria are presented in summary form in the text of this section and in 6-3 of the FS. In addition to this comparison, consistency of the remedial alternatives to principles defined in two applicable OSWER directives was considered along with a Relative Environmental Benefit Evaluation (REBE). The REBE reflects Section 7.4 of the Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (USEPA, 2005) which encourages comparison of net risk reduction between alternatives as part of the decision making process. The REBE approach combined this concept with direction from the stakeholders to qualitatively consider relative risk. A summary of these comparisons are also included in this section of the ROD. This multi-pronged approach is designed to provide sufficient information to adequately compare the alternatives, aid in the selection of an appropriate remedy for the Site, and demonstrate satisfaction of the statutory requirements.

1. Comparison to NCP Criteria

Each alternative is evaluated in terms of its ability to:

- Provide overall protection of human health and the environment.
- Attain ARARs or provide grounds for invoking a waiver.
- Use permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable.
- Satisfy the preference for treatment that reduces toxicity, mobility, or volume of the hazardous substances, pollutants and contaminants as a principal element.
- Be completed in a timely manner.
- Be implemented with the least amount of negative effects.
- Be cost-effective.
- Be acceptable to the State.
- Be acceptable to the Public.

The nine evaluation criteria required to address the above CERCLA requirements serve as the basis for conducting the detailed analysis. The comparison for each evaluation criteria is presented in the following paragraphs.

Overall Protection of Human Health and the Environment

Alternative 1 is required for consideration by the NCP. No action presumes that no monitoring occurs but the fish advisory remains in place, providing protection to human health, but do no address potential ecological risk or assess remedy effectiveness. Alternative 2 has limited monitoring of fish tissue and will allow analysis of contaminant levels in fish tissue, supporting protection of human health. However, fish tissue concentrations and remedy effectiveness are not always directly related. Alternative 3 will provide both long- and short-term protection to human health by confirming remedy effectiveness. Sediment sampling will confirm stable, depositional environment that controls exposure pathways. Fish tissue monitoring program will also assess improvement in ecological protection. Monitoring of burial rates may provide information needed to estimate time to achieve RAOs.

Compliance with ARARs

Section 121(d) of CERCLA and NCP §300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate federal and state requirements, standards, criteria, and limitations, which are collectively referred to as "ARARs," unless such ARARs are waived under CERCLA Section 121(d)(4).

Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal or state environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well-suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate.

To-Be-Considered Requirements (TBCs) are federal and state environmental and public health agency criteria, advisories, guidance, and proposed standards that are not legally enforceable but contain information that is useful in carrying out, or in determining the level of protectiveness of, selected remedies. TBCs are meant to compliment the use of ARARs, not to compete with or replace them. Because TBCs are not ARARS, their identification and use are not mandatory. Where no ARARs address a particular situation at a CERCLA site, or the existing ARARs do not ensure sufficient protectiveness, the TBC advisory, criteria or guidelines should be used to evaluate alternative remedial actions.

Compliance with ARARs addresses whether a remedy will meet all of the applicable or relevant and appropriate requirements of federal and state environmental statutes, or provides a basis for invoking a waiver. There is one chemical-specific applicable requirement, the Surface Water Quality Standard for 2,3,7,8-TCDD. All alternatives provide long-term improvements to surface water quality as natural burial takes place and will result in no surface water quality standard exceedances.

Long-Term Effectiveness

Alternative 1 (No Action) would not be effective immediately, however, natural process will result in burial of contaminated sediment. The maintenance of the existing fish advisory is assumed under Alternative 1. Alternative 2 (fish tissue monitoring) is not effective immediately; however, natural process will result in burial of contaminated sediment. Fish tissue monitoring provided information to stakeholders for use in continual assessment of current and historical trends but may not provide a reliable assessment of the effectiveness of RAOs. Alternative 3 (MNR) is not considered effective immediately; however, natural process will result in burial of contaminated sediment. A proper monitoring program provides sediment information along with fish and water data to allow an estimate of time to meet RAOs.

Reduce Toxicity, Mobility, or Volume

None of the alternatives have a treatment component, and therefore, are all considered comparable. Reduction of mobility may be achieved in all alternatives through natural burial, but sediment is already stable. Reduction in volume is not achieved in the alternatives.

Short Term Effectiveness

There are no adverse effects from Alternatives 1, 2, and 3. All three alternatives are based upon natural deposition and have the same short-term effectiveness.

Implementability

There are no adverse implementation issues for the three Alternatives. No action is the easiest to implement.

Cost

Detailed cost estimates were prepared for each alternative and included in the FS report. The detailed cost estimates include total capital cost (both direct and indirect), and O&M costs for implementing each alternative. Cost estimates for the alternatives were prepared primarily based on professional experience and information supplied by external sources. The estimated present worth of the remedial alternatives was based on a discount rate of 7 percent, which is typical per current USEPA guidance on cost estimation (USEPA, 2000).

Total capital costs are those expenditures required to initiate and implement a remedial action. Both direct and indirect costs are considered in the development of capital costs. Direct costs include construction costs or expenditures for equipment, labor, and materials required to implement the remedial action. Indirect costs consist of engineering, permitting, supervising, and other outside services required to implement the remedial action. Certain contingencies have also been included in the cost estimates to account for unknowns, since the FS contains only conceptual designs.

Performance monitoring and O&M cost estimates were converted to present worth values using a discount rate of 7 percent and a 30-year post-closure period. Therefore, the total present worth of an alternative was the sum of the total capital cost and the present worth of the performance monitoring and O&M costs.

Typically, the "study estimates" made during the FS are expected to provide an accuracy of +50 percent to -30 percent (USEPA, 2000). Final costs would depend on actual labor and material costs, actual site conditions, market conditions, final project scope, engineering between the FS and final design, final project schedule, productivity, and other variable factors. As a result, the final costs could vary from the estimates presented in this report. However, most of these factors should not affect the relative cost differences between alternatives.

Alternative 1 has the lowest costs since no additional action or monitoring is performed. Alternative 2 consists of limited fish tissue monitoring only and has the next lowest cost. Alternative 3, monitored natural recovery consists of additional monitoring and has the highest total capital cost.

State Acceptance
The State of North Carolina, as represented by the NCDENR, has been the support agency during the Remedial Investigation and Focused Feasibility Study (RI/FFS) process for the Site. In accordance with 40 C.F.R. § 300.430, NCDENR as the support agency, has provided input during this process by reviewing major documents in the Administrative Record. The NCDENR Division of Waste Management ("the State") concurs with the selected remedy.

Community Acceptance
EPA held a public meeting to discuss the proposed remedy on July 17, 2008. Citizens that expressed opinions during the meeting were encouraged by the improving conditions and were generally supportive of the proposal for monitored natural recovery. The public comment period was held from July 12 to August 11, 2008. There were no comments received during the comment period other than those expressed at the public meeting. EPA believes that the community accepts the remedy.

2. Consistency with Sediment Management Principles

The second comparison completed for the three alternatives was consideration of how consistent these remedial approaches were to the eleven sediment management principles. Figure K-1 identifies the various principles and indicates a relative ranking for the principles for each alternative. The Tier 1 consideration memo, which is part of the administrative record, provides a greater discussion of these sediment management principles for the LRR.

3. Relative Environmental Benefit Evaluation

Table K-1 expands on the short and long term effectiveness criteria by presenting a ranking by seventeen site-specific factors which represent a relative environmental benefit evaluation. Seventeen site-specific factors were developed to assess the potential relative risks and benefits associated with implementing each technology within the LRR operable unit. The individual factors were specifically focused on issues related to protection of human exposure, risk and habitat use, ecological exposure, risk and habitat impacts, and ARAR compliance. This comparative assessment provides a method to contrast the secondary environmental effects of the different remedial technologies. Other questions and factors could also be identified and compared as well, as long as each technology is ranked using similar criteria. These comparisons provide a simplified method for ranking and comparing the identified effects. Each of the questions is ranked based upon relative benefit or adverse effect using five rankings as follows:

0 = Neutral effect

+ = Beneficial effect

++ = Greater beneficial effect

- = Adverse effect

-- = Greater adverse effect

To compare technologies over all factors, the total number of beneficial or positive scores (*i.e.*, "+") and adverse or negative scores (*i.e.*, "-") are summed.

Table K-3

Relative Environmental Benefit Evaluation of LRR OU-2 Alternatives

REMEDIAL ALTERNATIVE NUMBER			1		2		3	
NCP REMEDY SELECTION CRITERIA	THRESHOLD CRITERION	ENVIRONMENTAL FACTORS TO CONSIDER FOR REMEDY IMPLEMENTATION	NO ACTION		LIMITED ACTION WITH FISH TISSUE MONITORING		MONITORED NATURAL RECOVERY (MNR)	
Overall Protectiveness of Human Health and the Environment	**Human Exposure, Risk, and Habitat Use**	**Will remedy implementation enhance control of the contaminant exposure pathways (i.e., surficial sediment concentrations and bioavailability of dioxin) in the river?**	O	No action does not include maintenance of institutional controls. Potential exposure pathways will eventually be controlled through natural attenuation processes.	+	Potential exposure pathways are expected to be controlled by maintenance of institutional controls (fish consumption advisory signs) and through natural recovery processes.	+	Potential exposure pathways are expected to be controlled by maintenance of institutional controls (fish consumption advisory signs) and through natural recovery processes.
		What effect is the remedy likely to have on the dioxin fish consumption advisory?	O	The dioxin fish advisory for bottom-feeding fish is likely to stay in effect for sometime with no action.	+	The dioxin fish consumption advisory for bottom-feeding fish is likely to stay in effect for sometime, but will be evaluated through fish tissue monitoring.	+	The dioxin fish consumption advisory for bottom-feeding fish is likely to stay in effect for sometime, but progress will be evaluated through MNR monitoring.
		Will remedy implementation result in reduced exposure to organic contaminants, and subsequent potential for human exposure?	–	No action will not measure a reduction in exposure to organic contaminants, and subsequent potential for human exposure. Natural deposition is likely to reduce exposure to organic contaminants in a reasonable timeframe. Natural deposition is not evaluated under No Action.	O	Limited action includes fish tissue monitoring to identify any changes in risk. Natural deposition is likely to reduce exposure to organic contaminants in a reasonable timeframe.	+	Limited action includes fish tissue monitoring to identify any changes in risk and sediment sampling to confirm depositional rate. MNR is likely to reduce exposure to organic contaminants in a reasonable timeframe. Monitoring will quantify risk and trigger review as appropriate to minimize any risk
		Will remedy implementation result in increased exposure to on-site workers?	O	No effect	O	No effect.	O	No effect
		Will remedy implementation present physical hazards (increased truck traffic) to the surrounding community?	O	No effect.	O	No effect	O	No effect.
		Will remedy implementation limit boating access to Roanoke River?	O	No effect	O	No effect.	O	No effect

Notes:

O = neutral or no effect

— = adverse effect

+ = beneficial effect

— — = greater adverse effect

+ + = greater beneficial effect

Table K-1 (continued)
Relative Environmental Benefit Evaluation of LRR OU-2 Alternatives

REMEDIAL ALTERNATIVE NUMBER			1		2		3	
NCP REMEDY SELECTION CRITERIA	THRESHOLD CRITERION	ENVIRONMENTAL FACTORS TO CONSIDER FOR REMEDY IMPLEMENTATION	NO ACTION		LIMITED ACTION WITH FISH TISSUE MONITORING		MONITORED NATURAL RECOVERY (MNR)	
Overall Protection of Human Health and the Environment	Ecological Exposure, Risk, and Habitat Impacts	**Will remedy implementation enhance control of the contaminant exposure pathways (i.e., surficial sediment concentration and bioavailability of dioxin) in the river?**	O	No action will not enhance control of contaminant exposure pathways, and subsequent exposure of benthic organisms.	O	Limited action will not enhance control of contaminant exposure pathways, and subsequent exposure of benthic organisms.	O	MNR will not enhance control of contaminant exposure pathways and subsequent exposure of benthic organisms.
		Will remedy implementation adversely effect critical habitat factors for the striped bass fishery (flow requirements, dissolved oxygen, temperature, specific conductance, suspended solids)?	O	No adverse change is expected for the striped bass habitat or fishery with no action.	O	No adverse change is expected for the striped bass habitat or fishery with limited action and fish tissue monitoring.	O	No adverse change is expected for the striped bass habitat and fishery with MNR.
		Will remedy implementation maintain or enhance the aquatic habitat?	+	No action will maintain the aquatic habitat.	+	Limited action will maintain the aquatic habitat.	+ +	MNR will enhance the aquatic habitat and provides monitoring information to evaluate progress.
		Will remedy implementation maintain or enhance the surrounding wetlands habitat?	O	No adverse effect.	O	No adverse effect.	O	No adverse effect.
		Will remedy implementation alter the benthic community?	O	No adverse effect.	O	No adverse effect.	O	No adverse effect.
		What is the potential impact of groundwater flow on remedy?	O	Rates of groundwater flow are low and are not likely to transport contaminants to the bioavailable layer of sediment.	O	Rates of groundwater flow are low and are not likely to transport contaminants to the bioavailable layer of sediment.	O	Rates of groundwater flow are low and are not likely to transport contaminants to the bioavailable layer of sediment.
		Will remedy implementation reduce the potential for sediment resuspension?	O	No effect.	O	No effect.	O	No effect.
		Will remedy implementation preserve the wood debris habitat?	+	No action will preserve the wood debris habitat.	+	Limited action will preserve the wood debris habitat.	+	MNR will preserve the wood debris habitat.
		Will remedy implementation adversely affect water quality (dissolved oxygen, turbidity, total suspended solids)?	+	No adverse effect.	+	No adverse effect.	+	No adverse effect.

Notes

O = neutral or no effect

– = adverse effect
+ = beneficial effect

– – = greater adverse effect
+ + = greater beneficial effect

Table K-/ (continued)

Relative Environmental Benefit Evaluation of LRR OU-2 Alternatives

REMEDIAL ALTERNATIVE NUMBER			1		2		3	
NCP REMEDY SELECTION CRITERIA	THRESHOLD CRITERION	ENVIRONMENTAL FACTORS TO CONSIDER FOR REMEDY IMPLEMENTATION	NO ACTION		LIMITED ACTION WITH FISH TISSUE MONITORING		MONITORED NATURAL RECOVERY (MNR)	
Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)	ARAR Compliance	Will remedy achieve surface water quality standard for 2,3,7,8-TCDD?	O	No current ARAR exceedances	O	No current ARAR exceedances	O	No current ARAR exceedances
		Will remedy maintain coastal wetlands functionality?	+ +	No action will maintain coastal wetlands functionality.	+ +	Limited action will maintain wetlands functionality.	+ +	MNR will maintain wetlands functionality.

	1	2	3
Total Beneficial Effects (Total Number of Pluses)	+5	+7	+9
Total Adverse Effects (Total Number of Minuses)	-1	0	0

Notes:

O = neutral or no effect

— = adverse effect + = beneficial effect

— — = greater adverse effect + + = greater beneficial effect

SEDIMENT RISK MANAGEMENT PRINCIPLES

1. Control Sources Early

2. Involve the Community Early and Often

3. Coordinated with States, Local Governments, Tribes, and Natural Resource Trustees (Including Stakeholder Discussions)

4. Develop and Refine a Conceptual Model that Considers Sediment Stability

5. Use an Iterative Approach in a Risk-Based Framework

6. Carefully Evaluate the Assumptions and Uncertainties Associated with Site Characterization Data and Site Models

7. Select Site-specific, Project-specific, and Sediment-specific Risk Management Approaches that will Achieve Risk-based Goals.

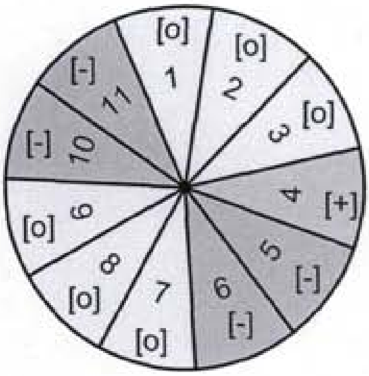
8. Ensure that Sediment Cleanup Levels are Clearly Tied to Risk Management Goals

9. Maximize the Effectiveness of Institutional Controls and Recognize their Limitations

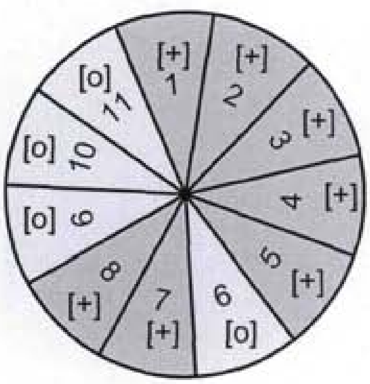
10. Design Remedies to Minimize Short-term Risks while Achieving Long-term Protection

11. Monitor During and After Sediment Remediation to Assess and Document Remedy Effectiveness

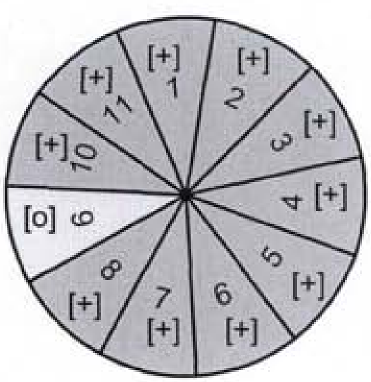
Alternative No. 1
No Action



Alternative No. 2
Limited Action with Fish Tissue Monitoring



Alternative No. 3
Monitored Natural Recovery (MNR)



Negative	Neutral	Positive
[-]	[o]	[+]

DOMTAR
MARTIN COUNTY, NORTH CAROLINA
LOWER ROANOKE RIVER - O.U.-2

COMPARISON OF THE RISK MANAGEMENT PRINCIPLES FOR EACH ALTERNATIVE

FIGURE K- 1

L. Principal Threat Wastes

The NCP establishes an expectation that the USEPA will use treatment to address principle threats posed by a site whenever practicable (NCP Section 300.430(a)(1)(iii)(A). Identifying principal threat waste combines concepts of both hazard and risk. In general, principal threat wastes are those source materials considered to be highly toxic or highly mobile, which generally cannot be contained in a reliable manner or would present a significant risk to human health or the environment should exposure occur. For the LRR sediments, the concentrations of both mercury and dioxin, primary COCs present in LRR, are within a range of calculated clean-up levels in both wetland soils and sediment established in the BERA and, for dioxin, are also below the USEPA's general dioxin cleanup level of 1 ppb. There is little risk to human receptors and limited risk to biological receptors based upon site specific data. Furthermore, for both fish and birds, the concentration trends are downward. These factors along with the low potential for migration or erosion of even slightly impacted sediment indicate that these materials do not meet the definition of a principal threat waste. Therefore, there are no principal threat wastes for this operable unit.

M. The Selected Remedy

1. Rationale for the Selected Remedy

The Selected Remedy is Alternative 3: Monitored Natural Recovery for the Lower Roanoke River. This remedy includes appropriate long term monitoring to further document improving conditions in the study area.

The risk management decision for this operable unit considers several lines of evidence. The consumption of whole fish by people results in a potential risk that slightly exceeds the 10-4 risk level. However, consumption of fish filet is considered the typical assumption for to evaluate human risk. Calculating human risk based on consumption of whole fish may overstate the risk and thus is a conservative assumption. Also, there are potential risks to some ecological receptors such as birds or mammals that ingest contaminants from fish, sediment, or wetland soil as noted in the ecological risk assessment.

These considerations are tempered by several other lines of evidence. The only other remaining potential source of dioxin to the LRR ecosystem is the sediment of Welch Creek, a tributary to the LRR. Welch Creek sediment contains higher levels of dioxin that that found in sediment in the LRR. A remedy was selected in September 2007 for Welch Creek that includes a thin layer sand cap over sediment in the upstream reach and long term monitoring and maintenance. The sand cap will reduce or eliminate the potential for contaminated Welch Creek sediment to be transported via surface water flow to the Lower Roanoke River or nearby wetlands. Other contaminant sources at the Domtar mill have been addressed through other regulatory actions or other Superfund cleanups at the Site. Also, dioxin concentrations in sediment and wetland soil associated with the LRR are already well below EPA's policy cleanup goal of 1 ppb for protection of human health and the environment. The dioxin concentrations are also generally within or below a range of calculated cleanup goals for sediment or wetland soil as presented in the ecological risk assessment. There are clear downward trends of dioxin levels in fish since the mid 1990's as noted in the annual fish sampling performed pursuant to the mill's NPDES permit. The USFWS has noted a five fold decline in dioxin levels in wood duck eggs within a similar timeframe. These declines are most likely related to more stringent wastewater discharge standards that were implemented at the Mill in the early 1990's.

However, there is a fish consumption advisory (issued by the State of North Carolina) based on dioxin in bottom dwelling fish like catfish and carp. EPA's 2005 Contaminated Sediment Remediation Guidance (OSWER 9355.0-85) suggests that if fish consumption advisories are necessary to control risks, a no-action decision for sediment is not appropriate, even if the advisories are already in place. Dioxin concentrations in catfish have been dropping, so it is anticipated that the fish consumption advisory will be further modified at some point in the future. A similar advisory based on dioxin in sport fish was lifted in 2001.

Mercury concentrations in shallow sediment and wetland soil are within or below a range of calculated cleanup goals. Higher levels of mercury in river sediment adjacent to the mill are covered by approximately six feet of cleaner sediment. Airborne deposition of mercury from other sources is an ongoing regional issue and may contribute to the levels of mercury in shallow sediment and fish.

The long term monitoring planned for this remedy will build upon the ongoing annual fish sampling and will also add further sediment sampling to document the deposition of cleaner sediment in this area and surface water sampling to confirm compliance with surface water standards.

2. Description of the Selected Remedy

The anticipated MNR monitoring program as noted in the FS consists of three rounds of confirmatory core sampling, annual dioxin sampling for comparison to the North Carolina surface water ARAR, fish tissue monitoring, and annual review of local habitat conditions from documented sources. The purpose of the additional data collection activities is to provide multiple lines of evidence for evaluating the remedy effectiveness during the first two 5-year reviews. The final sampling program will be subject to agency review and approval during the RD/RA process.

Specific sampling/inspection and review components include:

- For the first 5 years, three species of fish (catfish, bluegills, and bass) will be collected annually, if possible. After 5 years, the monitoring will be reduced to bluegill and bass only on a biannual basis. Fish samples will be collected at two locations in the LRR OU-2 (the same two locations where the NPDES fish fillet monitoring is conducted) and one reference location.
- Catfish fillet samples will be analyzed for dioxin to continue the trend analyses from the NPDES program.
- Whole bluegills and bass will be analyzed for dioxin and mercury to assess concentration trends and confirm the conceptual model that mercury in fish tissue is not site related.
- Collect five fine-layer core samples at four stations in the LRR OU-2 and one upstream of Warren Neck Creek. Analyze approximately nine subsamples in the top 4 to 6 inches for dioxin. Collect samples at years 1, 4, and 9 and then reassess the need for additional sampling.
- Sediment sampling for mercury as part of year 1 monitoring (the need for additional mercury sediment monitoring to be determined)
- Collect three 1-liter surface water samples for dioxin analysis annually (coincident with fish tissue monitoring locations and schedule).
- Annually inspect fish advisory signs (coincident with fish tissue monitoring locations and schedule).
- Annually review reports on local habitat conditions such as USACE summaries of dam releases, NC DENR water quality monitoring summaries, and overviews of severe weather conditions (*e.g.*, hurricanes or extended droughts) that could adversely impact biota habitats.

Institutional Controls

EPA Institutional Controls (ICs) guidance (EPA 2000) recommends four specific factors be considered when documenting the ICs to be implemented at a Site: Objective, Mechanism, Timing and Responsibility. The following is a listing of these factors relative to the Lower Roanoke River.

1. **Objective:** The objectives of the ICs are to prevent or reduce potential human consumption of contaminated fish.
2. **Mechanism:** The remedy includes ICs to achieve the objectives noted above. ICs are non-engineered instruments, such as administrative and/or legal controls, that help to minimize and/or manage the potential for human exposure to contamination and/or protect the integrity of a remedy. The following are general explanations of the four categories of IC mechanisms available for use followed by those controls to be used for the Domtar Site:

   - *Proprietary Controls* - These controls are based on State law and use a variety of tools to prohibit activities that may compromise the effectiveness of the remedy or restrict activities or future uses of resources that may result in unacceptable risk to human health or the environment. They may also be used to provide site access for operation and maintenance activities. The most common examples of proprietary controls are easements and covenants.
   - *Governmental Controls* - These controls impose land or resource restrictions using the authority of an existing unit of government. Typical examples of governmental controls include zoning, building codes, drilling permit requirements and State or local groundwater use regulations.
   - *Enforcement and Permit Tools with IC Components* - These types of legal tools include orders, permits, and consent decrees. These instruments may be issued unilaterally or negotiated to compel a party to limit certain site activities as well as ensure the performance of affirmative obligations (e.g., to monitor and report on an IC's effectiveness).
   - *Informational Devices* - These tools provide information or notification about whether a remedy is operating as designed and/or that residual or contained contamination may remain on-site. Typical information devices include State registries, deed notices, and advisories.

For the Domtar Site, Institutional Controls will include the following:

Government Control – The State of North Carolina Department of Health and Human Services, Division of Public Health, Epidemiology Section issues fish consumption advisories. The fish consumption advisories will remain in place until State standards have been met. The current fish consumption advisory notes that catfish and carp from waters near the site may contain low levels of dioxins. Women of childbearing age and children should not eat any catfish or carp from this area until further notice. All other persons should eat no more than one meal per month of catfish and carp from this area. The North Carolina State Health Director uses a concentration of 3×10^{-6} mg/kg total dioxins in fish tissues for issuing fish consumption advisories.

3. **Timing:** The Institutional Controls must be described in the Remedial Design (RD) and the Operations and Maintenance (O&M) Plan. These controls must stay in place as long as the remedy remains in place. Fish consumption advisories will remain in effect until the protective levels established by the State for fish tissue have been met.

Responsibility: USEPA is responsible for monitoring (e.g., in O&M Report, in IC Implementation Report, during the 5 year reviews, etc.) the implementation and effectiveness of the ICs. The State of North Carolina will be responsible for determining if and when the fish consumption advisories can be lifted or modified.

3. Summary of the Estimated Remedy Costs

The selected remedy has a present worth cost of approximately $ 9.6 million which includes construction and maintenance/monitoring as shown in Table M-1.

ITEM DESCRIPTION	UNITS	QTY	UNIT PRICE $	PRESENT WORTH $
Institutional Controls (inspection/maintenance of fish advisory signage)	year	30	$10,320	$154,900
Predictive Modeling	each	1	$44,000	$44,000
Water monitoring	year	30		$36,300
Fine Layer Sediment Sampling	year	3	$91,770	$212,000
Fish tissue Monitoring (annual/biannual)	year	17	$63,900	$514,700
Review of local habitat conditions	year	6	$96,900	$82,500
Annual reporting (annual/biannual)	year	17	$59,525	$115,700
5-year review support	year	6	$57,625	$83,000
Subtotal				$1,243,100
contingency 20%				$248,700
total capital costs				$1,491,800
Project Management/Meetings				$174,000
RD/RA negotiations				$36,000
RD and Work plans				$120,000
EPA oversight				$60,000
Subtotal				$390,000
contingency 20%				$78,000
				$468,000
Total Present Worth Costs				$1,959,800
Note: While monitoring costs are projected over 30 years, some events would occur on a combination of annual and bi-annual frequency resulting in a total # of events that is less than 30.				

4. Expected Outcomes of the Selected Remedy

The more stringent wastewater discharge requirements implemented in the 1990's in combination with natural recovery are expected to further reduce contaminant concentrations in fish. In turn, that will reduce potential risks to people as signified by the current fish consumption advisory.

1. Available Use after Clean-up

It is anticipated that ultimately there will be fewer restrictions on fish consumption as contaminant levels continue to decrease.

2. Final Clean-up Levels

One goal of the remedy is to continue progress towards, and ultimately lift or modify, the existing fish consumption advisory based on dioxin. The existing State of North Carolina fish consumption advisory is based upon a dioxin level of 3 ppt in fish tissue.

3. Anticipated Environmental and Ecological Benefits

Potential risks to environmental receptors will be further reduced due to lower concentrations of contaminants in the river sediment.

N. Statutory Determinations

Protection of Human Health and the Environment

The selected remedy will adequately protect human health and the environment through natural recovery with appropriate monitoring to document declining contaminant levels in fish. Fish consumption advisories issued by the State of North Carolina will remain in effect until contaminant concentrations in fish have achieved levels established by the State.

Compliance with Applicable or Relevant and Appropriate Requirements

The Federal and State ARARs that are relevant to the Site and the Selected Remedy are presented in the following Tables N-1 through N-3.

Table N-1
Applicable or Relevant and Appropriate Provisions of the following Standards, Requirements, Criteria, or Limitations (Chemical-Specific)

CONSTITUENT OF CONCERN	NORTH CAROLINA SURFACE WATER QUALITY STANDARD (µg/L)	CITATION	COMMENT
Dioxin congener 2,3,7,8-TCDD only – Total Concentrations	1.4×10^{-8}	Title 15A NCAC Subchapter 2B.0200, 2B.0208.	The North Carolina 2B standard establishes numerical goals for the protection of surface water quality. Applicable (1-liter sample volumes).

Table N-2
Applicable or Relevant and Appropriate Provisions of the following Standards, Requirements, Criteria, or Limitations (Location-Specific)

STANDARD, REQUIREMENTS, OR LIMITATION	CITATION	DESCRIPTION
Area affecting coastal area waters	North Carolina CAMA (NCGS Chapter 113 A, Article 7)	Establishes criteria for protection, preservation, and conservation of coastal areas. Relevant appropriate for activities that occur on Washington County side of Creek. Relevant and appropriate.
North Carolina Coastal Management	Title 15A NCAC Chapter 7	Protects natural resources and manages development in high hazard areas to achieve quality coastal waters. Provides public access for recreation and redevelop of urban waterfronts. Assures that the public and local governments have a say in coastal decision making and assist in developing a plan for and managing living marine resources. Relevant appropriate for activities that occur on Washington County side of Creek. Relevant and appropriate.
North Carolina Wetlands Protection	Title 15A NCAC Chapter 2B.0202	Provides definition of "functional wetland" and requires protection of wetland resources to maintain functionality standard. Applicable.
Flood Plain Management		
Flood Plain Management	40 CFR 6, Appendix A, 10 CFR 1022	In 100-year flood plains, actions must be taken to reduce the risk of flood loss, minimize the impact of floods on human safety, and restore and preserve the natural and beneficial values of flood plains. Applicable.
	40 CFR 122	In areas that potentially erode or release sediment, controls and best management practices are to be used to control runoff from construction activities. Applicable.
Environmental Protection		
Endangered Species Act	16 USC 1531, 50 CFR Part 200, 50 CFR Part 402	Requires action to conserve endangered species within critical habitats on which endangered species depend and includes consultation with Department of the Interior. The U.S. Fish and Wildlife Service has determined that the only federally protected species under Service jurisdiction that is likely to occur in the project area is the bald eagle. Applicable.

STANDARD, REQUIREMENTS, OR LIMITATION	CITATION	DESCRIPTION
Coastal Zone Management Act	16 USC 1451	Requires action to conserve endangered species within critical habitats on which endangered species depend and includes consultation with the Department of Interior. Relevant and appropriate.

Table N-3
Applicable or Relevant and Appropriate Provisions of the following Standards, Requirements, Criteria, or Limitations (Action-Specific)

STANDARD, REQUIREMENT, OR LIMITATION	CITATION	DESCRIPTION
Surface Water Protection		
Classification and water quality standards applicable to surface water and wetlands in North Carolina	Title 15A NCAC Subchapter 2B.0100 and .0200	Establishes a series of numerical standards for surface water and functional standards for wetland quality. Applicable.
Air Quality Protection		
Environmental Protection		
Water and Air Resources Statute	NCGS Chapter 143 Article 21	A public policy of the State to maintain, protect, and enhance water quality within North Carolina. Potentially applicable.
Oil Pollution and Hazardous Substances Control Act	NCGS Chapter 143 Article 21A	Establishes criteria for protecting the land and the waters over which this State has jurisdiction from pollution by oil, oil products, oil by-products, and other hazardous substances. Potentially applicable.
Sedimentation Pollution Control Act	NCGS Chapter 113A Article 4, 15A NCAC 4	Requirements for control of erosion and sedimentation of streams, lakes and other waters of North Carolina. Potentially applicable.
Worker Safety		
Worker Health and Safety	29 CFR 1920.120	Training, personnel protection, medical monitoring and other health and safety requirements for employees engaged in hazardous waste site operations. Applicable.

STANDARD, REQUIREMENT, OR LIMITATION	CITATION	DESCRIPTION
Worker Safety	29 CFR 1926	Standards for general construction. Applicable
Clean Water Act		
Rivers and Harbors Act of 1889	33 USC 403	Requires permit for structures or work in or affecting navigable waters. Potentially applicable.

(1) Permits are not required for actions that occur on site. Substantive requirements of ARARs will be met

To Be Considered (TBC) Information

In addition to ARARs, there is To Be Considered (TBC) information. TBC items are not legally enforceable requirements, but should be considered during the development and implementation of the remedial action. A list of potential TBC information for Welch Creek includes the following:

- NC DENR – Department of Health and Human Services (DHHS) fish consumption advisory for dioxin
- Clean Water Act Section 303d, watershed planning with respect to waters not meeting water quality standards and requirement to develop total maximum daily loads (TMDL) for pollutants for which standards not being achieved (*e.g.,* mercury)
- Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites (OSWER Directive 9285.6-08, USEPA, 2002)
- USEPA Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (EPA-540-R-05-012, December 2005)
- Ecological Risk Assessment and Risk Management Principles (OSWER Directive 9285.7-28P, USEPA)
- Substantive requirements of local permits and ordinances

Cost Effectiveness

This section explains how the Selected Remedy meets the statutory requirement that all Superfund remedies be cost-effective. A cost-effective remedy in the Superfund program is one whose "costs are proportional to its overall effectiveness" (NCP §300.430(f)(1)(ii)(D)). The "overall effectiveness" is determined by evaluating the following three of the five balancing criteria used in the detailed analysis of alternatives: (1) Long-term effectiveness and permanence; (2) Reduction in toxicity, mobility and volume (TMV) through treatment; and, (3) Short-term effectiveness. "Overall effectiveness is then compared to cost" to determine whether a remedy is cost-effective (NCP §300.430(f)(1)(ii)(D)).

The selected remedy is considered cost effective because it reduces potential impacts to human health and the environment through natural recovery and associated monitoring; no active measures are necessary.

Utilization of Permanent Solutions and Alternative Treatment (or Resource Recovery) Technologies to the Maximum Extent Practicable (MEP)

The use of treatment technologies is not necessary given the low levels of contaminants and improving long term trends noted in environmental receptors like fish and wood ducks.

Preference for Treatment as a Principal Element

As noted above and in other sections of this ROD, contaminant levels and conditions in the study area do not indicate the need for a treatment component to the remedy.

Five-Year Requirements

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining onsite above levels that allow for unlimited use and unrestricted exposure (as signified by the existing fish consumption advisory), a review will be conducted every five years after construction completion at the Site to ensure that the remedy is, or will be, protective of human health and the environment.

O. Documentation of Significant Changes from Preferred Alternative of Proposed Plan

The Proposed Plan for the Lower Roanoke River at the Domtar (formerly Weyerhaeuser) Site was mailed to the community around July 9, 2008. The public comment period was from July 12, 2008, to August 11, 2008. The Proposed Plan identified Alternative 3 (monitored natural recovery) as the Preferred Alternative for remediation. EPA did not receive any written or verbal comments other than the verbal comments provided at the public meeting. Responses to such comments are included in the public meeting transcript. As a result, it was not necessary to prepare a separate Responsiveness Summary. EPA has determined that no significant changes to the remedy, as originally identified in the Proposed Plan, are necessary or appropriate. The transcript of the Proposed Plan Public Meeting is attached as Appendix A.

APPENDIX A: PUBLIC MEETING TRANSCRIPT

Copy of Transcript

U.S. EPA PUBLIC MEETING

SUPERFUND PROPOSED PLAN
DOMTAR (FORMERLY WEYERHAEUSER) SITE
LOWER ROANOKE RIVER

July 17, 2008
7:08 p.m.

First Baptist Church
309 Washington Street
Plymouth, North Carolina 27862

BOBBIE G. NEWMAN-COURT REPORTER

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Facsimile: 404.495.0766

2700 Centennial Tower
101 Marietta Street
Atlanta,GA 30303

APPEARANCE:

MEETING MODERATOR - MR. RANDY BRYANT
REMEDIAL PROJECT MANAGER
NORTH SITE MANAGEMENT BRANCH
U.S. ENVIRONMENTAL PROTECTION AGENCY
61 FORSYTH STREET, SOUTHWEST
11TH FLOOR - NSMB
ATLANTA, GEORGIA 30303

COURT REPORTER - BOBBIE G. NEWMAN

U.S. EPA PUBLIC MEETING

July 17, 2008

COURT REPORTER NOTE: The public meeting convened at 7:08 p.m. in the Fellowship Hall of the First Baptist Church, Plymouth, North Carolina.

MR. RANDY BRYANT: Well, folks, I think I'll just go ahead and get started. It's getting close to ten after; it's probably sufficient time to go ahead and get started. My name is Randy Bryant, and I'm with the U.S. EPA. We have a regional office in Atlanta. And I'm here tonight to talk to you about the studies that we've been doing associated with Domtar and the adjacent Lower Roanoke River.

Just a couple of housekeeping notes. I think you saw the sign-in sheet. I'd appreciate it if you'd sign in. You don't have to, but I'd appreciate it if you did. Bobbie is our court reporter. She'll be making a transcript of the meeting tonight so that if you have particular questions or comments she can record those. What I plan to do is just go through a brief presentation, and I'll hit the highlights. And that may answer some of your questions, but then we'll have a question-and-answer session at the end. And at that point, what I'll probably do is move the mike out a little bit and, if you would, just speak into the mike and state your name. That way it will be easier for Bobbie as she's doing her transcript. All right. Well, let me just go ahead and get started here.

I've already mentioned, while we're here, we're going to talk about the studies that we've done for the Lower Roanoke River as related to the Domtar mill. (Uses slide presentation to accompany narration.) A little bit about the background and history, some of the site studies that we've done, a few of the alternatives that we've looked at, what we think is the preferred alternative, and then some idea of the schedule when it comes after the selection of an alternative. And then, like I said, we'll have some time for questions and comments.

I'll go ahead and start out with the punch line. You know the reason we're here, what we found out from doing these studies over the years, and also incorporating results from studies from U.S. Fish & Wildlife Service or from the annual fish monitoring that's been done. There's been a significant decline in contaminant concentrations in fish and other receptors over the last 10 to 15 years. Back in -- around 1992-1994, that time period, paper mills had to tighten up on their discharge standards, produce less dioxin. And, you know, they did that at this mill. And it's been a significant factor in improving or dropping those concentrations in fish. It's been a pretty significant decline, like I said, over the last 10 or 15 years.

The contaminant levels, particularly dioxin in sediment, are already low enough, you know, that they're below either EPA's policy cleanup number for dioxin or even the calculated cleanup numbers that we came up with.

We're planning just to do some additional monitoring to make sure that these improvements continue, just to have further documentation that it is proceeding as we expected. And we don't need to do a cleanup for the river sediment or the wetland soil.

Just briefly, I work in a particular section at EPA; it's Superfund. It deals with the release of hazardous substances in the environment, and normally it's dealing with historical issues, you know, like when you have an operating mill. There are other regulations that deal with their current discharges and stuff, but Superfund looks more at the historic issues and that's what we've been doing here. Under Superfund, the companies that owned or operated the facility are required to do the associated studies and cleanups, under EPA oversight.

When you do your studies, you're really looking at four basic questions: what are the contaminants, where are they, is there any risk associated with that, and what are you going to do about it. And then, based on those studies, EPA issues a Proposed Plan, which we've done. We have copies of the Proposed Plan on the table (indicating). I'm wondering how many of you got these in the mail because we sent them out in the mail to our mailing list. (A show of hands.) Okay. All right. And we're in the middle of the comment period -- or actually early in the comment period. The comment period just started back on the 12th of July and it'll run through August 11. It will consider the public comments we get during that time, and then we'll make a final decision in what's called a Record of Decision. It's just a summary of the studies that have been done and a decision document signed off by upper management. And then, once the ROD is done, then you just work on planning for -- and actually you're doing the remedy. And, in this case, you're just talking about a monitoring remedy.

And just a real brief site history. Like I said, this is the Roanoke River study associated with what used to be called the Weyerhaeuser mill. It is now Domtar. The mill has been in operation for almost seventy years. It used to do fine paper and fluff; now it is focused on fine paper. Weyerhaeuser owned it for almost 50 years, up until 2007. And then in 2007, parts of Weyerhaeuser merged with parts of Domtar to create Domtar Paper Company, which now owns this mill.

We've done several Superfund projects out here. This is actually the last of four. We call them Operable Units (OUs) but that's just, you know, separate projects. Operable

Unit 1 (OU1) was the old landfill. OU3 was the former chlorine plant. Both of those were on the mill property. OU4 is Welch Creek, which we talked about last summer; some of you-all may have come to the meeting for that one. And OU2 is the Lower Roanoke River.

And just maybe a brief word about OU4. When we came here the last time, we were talking about the Proposed Plan for OU4. You know, we had finalized the decision in the Record of Decision. We sent a little notice to let you know that. And then -- since then, we've been working on a Consent Decree, which is just the legal document that provides for Domtar to do the work. And Domtar has recently signed that; EPA has an internal process of just doing its final approval and sending it off to DOJ. But, we've certainly made progress on that; you know, Domtar has stepped up and signed that Consent Decree.

The study area is about 14 miles of the river going downstream to the mouth at the Albemarle Sound. And you all know, I mean, the land and the area, you know, aside from -- from Plymouth is mostly forest. There's a lot of wetlands along the banks of the river. It's a good size river; it's about 500 feet wide, you know, here in the vicinity of the mill, and typical flow in the river is about 6,600 cubic feet per second. And something else I'm sure you all are aware of, it's a noted striped bass fishery.

Wastewater, you know, from the paper mill has been discharged, you know, to the river, from back in the early years from '37 to '57 and then 1988 to the present. Since '69, that discharge has been under permit, and the mill has a current permit. And, as I mentioned before, the paper bleaching process was changed back in the early to mid 90's, and that's been a contributing factor, or a significant factor, to the declining dioxin concentrations in fish.

And this (indicating slide) is just a figure to give you an idea; the darker area in the middle is the town of Plymouth. This little green shading gives you a general idea of the location of the mill, and the red line down the length of the Roanoke River gives you an idea of the extent of the study area. You can see it went several miles upstream from the mill and also downstream to Albemarle Sound. And just a couple of photos. This is looking downstream at the area near the town of Plymouth. And then another photo just to give you an idea of the conditions there along the river bank. In this figure, and with all these figures, you'll find them -- if you wanted to look further at the reports, they are in the library. But this figure just shows you the -- the areas where samples have been taken during the different studies. The green is land; you can see that the blue is the water and the yellow, and blue dots represent locations where sediment samples are collected -- just to give you some idea of the extent of the area that we worked in.

So, what is it that we found? Two main things. Dioxin is the main thing associated with the mill. Mercury had some association with the mill due to historical operations, though the mercury that we see in shallow sediment is probably, unfortunately, more associated with airborne deposition, meaning it comes from other sources across the state or even possibly from other states. The airborne deposition of mercury is a -- is a region-wide problem. But, for these contaminants, we are really focused on the shallow sediment in the river, the sediments that -- the receptors, or the -- the low end of the food chain, are more likely to come in contact with, and that's the upper six inches. And with -- the dioxin concentrations range from, you can see here, 0.029 to 0.170 parts per billion, and then mercury range from 0.7 to 1.6. And again, this is the shallow sediment, zero to six inches. You have somewhat higher concentrations with dioxin with depth. You have an area adjacent to the mill where you have higher concentrations in the sediment, but that's at depths like at six feet below. So, you've got clear sediment covering those higher levels of mercury that are adjacent to the mill. And it's those higher levels of mercury that are like six feet below that are probably the more associated with the mill.

Because they used to have a chlorine plant, and initially they had chlor-alkali cells, which utilized mercury to produce chlorine. In wetland soil, you can also detect some dioxin and mercury, but again, the levels are pretty low. You can see the range of values there. That's also noted in the table in the proposed plan facts sheet.

In addition to the data we collected, there was also a second round of sediment sampling. And what they did was take even smaller cuts. Like, when we would take a sample, it would be zero to six inches. And in -- in supplemental sampling, they took very fine samples -- and the idea's to see if they could get a better handle on the amount of fresh sediment that was being laid down. And that's harder to get from a zero to six-inch sample, but if you can do it in smaller, little slices, it's a little easier to see. And that is suggesting that you do have some additional sediment coming in and covering even the lower levels of dioxin that are present.

We also had some help from the Corps of Engineers. You know, they did some modeling for us. And their modeling indicated that the river bottom is not particularly prone to erosion. That's a good thing. So, even the stuff that we have, we won't expect to see erosion coming in along the river bed itself and moving it further.

And the fish -- like I mentioned and as you probably well know, there's a dioxin fish advisory for just the bottom-dwelling fish, like catfish and carp. It was lifted for sport fish way back in 2001. And the level in the catfish has been dropping, and they've dropped pretty dramatically, a factor of 10 or more since about 15 years ago. And, in the limited sampling that we did with mercury in fish, you can still see that in -- in catfish and also in some of the large-mouth bass. Now, there is statewide directions or fish advisories, particularly related to mercury, and, as I mentioned, that's more associated with airborne deposition. If you need more information or are curious about that, I have a -- a website with me. And the main thing about the State fish advisory, they just give you some suggestions on fish to avoid, to avoid a high level of mercury. Again, though, that's more of a -- a regional issue rather than just something that's specific to the lower Roanoke.

We figured out what the contaminants were, where they were and then it's a question of, you know, does it pose a risk. And the sediment or wetland soil doesn't pose a risk for people. And the consumption of a fish fillet, at least from a risk assessment perspective that we calculated, doesn't pose a risk. But you have to be aware that there is that State fish advisory, which you should follow, which says that you should limit your intake of those bottom dwellers.

And, as I mentioned at the beginning, the levels that we see in sediment and wetland soil are below EPA's cleanup policy number of 1.0 part per billion (ppb) for dioxin, and are also within or below the range of calculated values that we presented in the risk assessment. And again, those are documents that are available in the library if you wish to see those. And the mercury and wetland soil, that's also within the range of calculated cleanup goals.

I mentioned the declining levels of dioxin in fish. There's also been a decline in wood duck eggs based on a study that the Fish and Wildlife Service has been doing. They've been looking at the wood duck eggs and the concentration of dioxin over a period of years. And since the mid-1990s, there's been almost a fivefold decrease in dioxin concentration. And so that's just another line of evidence, something else for me to consider as I'm trying to weigh the various data and -- and arrive at an appropriate course of action.

We talked about the fish sampling. And I've mentioned that they have to do annual fish sampling anyway in association with their discharge permit. And in the most recent sampling, there're very encouraging results. They had 22 fish samples, and 21 of those had less than one-half part per trillion of dioxin (ppt), and keep in mind that the fish advisory is based on a level of three parts per trillion.

So, for the most recent sample results, almost all of them were below that number. Now, that doesn't mean there'll be an immediate change in the fish advisory because you'll want to see this repeated over a period of a few years. And that is up to the State; that's a State fish advisory, and they'll modify that when they see fit, based on seeing some more repetition of results similar to what they saw in the most recent report.

So we're left with -- you know, we've evaluated where it is, what it is, what kind of risk there was. There really isn't much except for the fact that what's embodied by the fish advisory. So, we thought, well, what exactly do we need to do; what would you do? And we looked at a few alternatives (listed on slide) and they're basically just variations on the degree of monitoring that you would do. And we always look at a "no action" alternative to serve as a baseline for comparison. If this existing fish advisory would remain in place, that that's all that would be associated with Alternative 1, which we call "no action."

And then, Alternative 2 is "limited monitoring," which would build upon the monitoring they have to do anyway, and we would add some whole fish sampling and also pick up some mercury analysis. Now, if you run this over, doing this on an annual basis over 30 years, you're looking at a floor of $1,000,000 for that alternative -- if you had to do it for

30 years.

Alternative 3, we're calling it "monitored natural recovery." Again, it's just building on; it's adding additional layers of testing to verify what we think is the most appropriate thing. And what this adds, in addition to the fish sampling, is two more rounds of the fine interval, you know, those real thin layer sediment sampling, and also annual surface water sampling. And again, if you run this out 30 years, you're looking at about 1.9 million dollars, if we had to continue over 30 years. This alternative is what we would prefer to do. You know, we're scientists, engineers; we like to have lots of data to confirm what we think is happening. And we think it's appropriate, you know, for some of the reasons I've discussed already. I'm not going to go through those again. And I think I've covered this about mercury -- and deep mercury next to the mill is more associated with Domtar at the mill. The low levels that we see in shallow sediment are most likely the result of airborne deposition.

We are looking at different alternatives, just different criteria that we use to try to judge between them. I will go through these just simply so that you're familiar with them: Protection of human health and the environment in compliance with the laws. And then, we have these balancing criteria that you can see, including long-term effectiveness, reduction of toxicity through treatment, implementability, costs. And then we also have consideration of the State's position and also community concerns.

Now with the alternatives we have here, the situation we have here, you know, we don't need to do much beyond monitoring. In other sites where I worked on where you have greater risks, you might have more variety of alternatives that involve a different or variety of techniques, so you get to have more interplay along those criteria. Here, we just need monitoring alternatives. Really, what you're looking at the difference in again is just the level of sampling and documentation that you do, and, you know, the associated costs with that.

That's it in a nutshell. The comment period is going to run through August 11. Like I said, EPA will review the comments and make a final decision, and we'll represent that in a Record of Decision, which we would hope to sign in September or October of this year. And that will also include responses and any comments that we get. And during the latter part of 2008-2009, we negotiate another Consent Decree that we just do specifically with the monitoring for the Lower Roanoke River. It would be similar to the Consent Decree that they're doing for the Welch Creek remedy. And, if things move along pretty well, we may be in a position that we can have the monitoring plans reviewed and finalized during late 2009 and then set an appropriate start time to get going with that.

And just to emphasize why we think this is the most appropriate way to go. Any of the sources at the mill have been addressed, particularly going back even before the Superfund Program became involved. This goes back to them changing the discharge standards back in the early '90s. It's really made a difference. We've seen a decline in fish. We've seen a decline in the wood duck eggs, you know, based on studies from other agencies. And the contaminant levels that we have in shallow sediment are already within acceptable levels, and they don't warrant cleanup. You have additional sediment, cleaner sediment, being brought into the area and laid down. And, as you can imagine, sediment coming in from further upstream is being deposited as it moves closer to the sound. And we are certainly going to collect enough data from a monitoring program to confirm some of the points that we have been seeing to make sure that we continue to see that decline in fish concentrations, and also additional fine core sediment sampling to document the rate at which cleaner sediment is being deposited within the area.

The fact sheet has contact information, and also is noted here (on the slide), to call us, write us, send us an e-mail. And again, I'm Randy Bryant, I'm the project manager. I'm supposed to make sense of the various studies and kind of come up with an appropriate course of action, and then ultimately, though, it's not a final decision until the Division Director of Superfund signs off on the decision.

All right, with that I'll open it up for questions or comments. Give me just a second, I'll move the mike to make it a little easier for you-all to step up if you have any. If you don't, then that's fine, but let me just move this for your convenience. And again, if you have a specific comment you want to make, if you would just state your name to make it easier for the court reporter to make the (transcript).

MR. CHRIS SMITH: Do you want us to step up to the microphone or speak from right where we're at?

MR. BRYANT: I think she'd prefer you step up to the microphone.

MR. SMITH: My name is Chris Smith and I'm a resident of Roper and a life-long resident of Washington County. I've spent my share of time on the river and experiencing the beauty of Washington County and what the waterways have to offer. When I received the document in the mail, I read through it and to me it was pretty good news. We finally get the facts and data that show that things were improving the health of the river. You know, there were some problems in the past, let's say from past sins, but they seemed to be healing themself. And one of the points I want to make is that you've got facts and data there that support that. And so I think it is very important to keep monitoring the river, obtaining this data. I mean, it's almost like a thermometer if you take the temperature of the river. You know, it's an indicator to help the river and the fact that -- that there's a healing process going on with the existing conditions. Again, there's facts and data, and I won't harp on that because I want to bring up another point that it wasn't quite a few years ago but, you know, we need the economic development in this area, not just this county, but Martin County and just all the Northeast tier. And, they talked about an ethanol plant on the river, and the environmentalists' battle cry back then, it was that, You can't let the barges go up the river; it's going to stir up sediment. So, you know, there was the emotional part to it, them saying it's going to stir up sediment, you know, where it might or it might not. Is that a real issue? There were no facts and data to back that up, but yet it stirred up fear. It would rally all the environmentalists to help stop the permitting process for that ethanol plant. And what I want to propose to you, to make this part of this study or another study, is to let's put to bed that fear of barges going up the river stirring up sediment. One of the partners in this venture here will be the Corps of Engineers. If they send barges up the river, they have to snag the river anyway to, you know, make it safe for navigation. And, I would like to see a study where let's take the worst conditions, when you've got low river flows and let the barge go upriver, sample, do your sediment samples, water column samples, turbidity and whatever other tests you do, to see if -- if it is a real issue or not, if the prop wash is actually stirring up sediment. If it is stirring up sediment, is the sediment that's being stirred up, is it of concern? So that we have some facts and data that the next time somebody comes along who wants to propose some type of economic development opportunity for this region such as some type of industrial plant or something that's going to require barging, whether it's wood products coming down the river, or -- or ethanol or fuel oil going up to Williamston somewhere -- or Jamesville. Just -- we need facts and data so that, if some opportunity presents itself again like that, you can say, well, here's the stuff and you know that's not a valid argument because we've proven that prop wash does not disturb the sediment enough to cause any kind of environmental concern. That's the end of that discussion on that issue. That's the point I want to make on that. But, I'll go back again. I do like what was written there (indicates fact sheet) and I'll do my best -- I do think I'd like to support the Alternative (3) like you suggested there in your document. To me, this is one of the more positive meetings that I have attended because of the results that are showing on that document that

I received. Thank you for your time.

MR. BRYANT: Thank you.

MR. BRIAN ROTH: Good evening. I'm Brian Roth. I'm the Mayor of Plymouth. Actually, I've just got a lot of questions.

MR. BRYANT: Okay.

MR. ROTH: And so -- I don't know how you want to handle all these, but the first one I was actually with Mr. Beswick. It is -- the studies that are being proposed, will they give us -- when I'm say "us," I'm talking about "us" as society -- data that can be used to identify whether there would be a churning -- a sediment churning issue for barges or traffic going up and down the river in the future, or is the type of data you're collecting unrelated to that type of analysis?

MR. BRYANT: The data that we would collect as part of the long-term monitoring -- the results would have to help. It would depend -- I mean, I'm not sure just how deep an effect would be from prop wash but, at a minimum, the data that we collect would give you an idea of the additional sediment that's been laid down over the last few years. It would give you an idea of how -- how quickly that's building up. And then, it should be fairly simple to go from, Okay, it's this thick now, you know, and then factor in how much you would expect to get from your prop wash. So, you should be able to use that data to give you some greater comfort about that issue.

MR. ROTH: In this handout that you had, and I read what you sent in the mail. I received mine and thank you for sending that.

MR. BRYANT: Uh-huh.

MR. ROTH: It talks about testing at a reference location. How does that -- I assume you're testing fish at a reference location. How does that play in -- how does that have meaning?

MR. BRYANT: That just means you go further upstream to make sure that you're not in the area that's been impacted by past discharges. Like, you know, when we did our condition study, you know we went, I think it was about five miles upstream to get what would be more of a background area that was -- had, you know, little or no impact from, you know, discharges. And, usually, you need to have a reference location whenever you're doing one of these studies that serves as a basis of comparison.

MR. ROTH: I'm going to tell you that I'm not a fisherman --

MR. BRYANT: Uh-huh.

MR. ROTH: -- so, I don't know what types or what species migrate and so on. But, in my thought process, it would be hard to find a reference location. You'd have to go essentially quite a -- quite a distance -- and I don't know what "quite a distance" definition that is -- to find a reference location of fish migrating, fish not contaminated in the Lower Roanoke River, went upstream five miles and using that same fish as a reference point or data point. I'm not sure you are doing that, but I'll leave that to the experts.

MR. BRYANT: Yeah, and what we'll do -- I mean, I was thinking a little bit more about sediment samples myself -- at least in that response. But what we'll do is, when we get to the point where we're ready to have -- to put together a monitoring plan, then we'll just -- we'll consult with Fish and Wildlife and NOAA and North Carolina DENR.

MR. ROTH: The other question I've got is, how much sediment is being laid each year on the bottom of the river. How fast does it collect? I'm sure it depends on which side of the river you are at and environmental factors.

MR. BRYANT: That I'm not real sure about. That's one reason that we'd want to have a couple of rounds of some additional sampling, and we can measure the increase relative to what we did during our first study. But, I mean, I don't think I have a good answer for you for the rate of accumulation right now.

MR. ROTH: Would that come out of the study?

MR. BRYANT: Yeah, the data that would --

MR. ROTH: These people, would they be tracking sediment data?

MR. BRYANT: Yeah, the data they generate should help answer that question about how quickly you're getting additional sediment.

MR. ROTH: Would the -- let me mention, you did a great job on your presentation, but it's hard as a layperson looking at all the numbers and so on that's on the charts. Catfish, carp, how -- how far along are they to being clean, meeting your criteria? When I say clean, I understand not totally clean probably but to meet the criteria.

MR. BRYANT: Okay. Well, based on the 2008 annual fish sample report, virtually all the fish satisfied that. But, in order for the fish advisory to be modified, the State, I'm sure, is going to want to see that similar pattern or result repeated probably for two or three years in a row. So, at a minimum, I'm thinking it's going to be a few more years before they modify the fish advisory; but since that's the State's fish advisory, you know, we'll leave it to them about when they think it's appropriate to modify it. But I would say, just based on the fact that the most recent results were really good, you know, we should be getting close to the time when they can modify that.

MR. ROTH: As far as, you know, any other wildlife, are there any wildlife species for the eggs? Are they -- do

they exceed the limits right now -- any other species?
MR. BRYANT: With -- like the wood duck eggs?
MR. ROTH: Yes.
MR. BRYANT: It's not so much like there's a standard published that, you know, like, Thou shalt not have more than such and such in eggs. The main thing to take from that is that there's been a significant decline, and it's gotten to the point where they wouldn't expect to see any kind of impacts on wood ducks or -- or similar birds of that level. Now, we didn't test like every species that's out there because that's beyond what we can do. We picked some that, you know, can be representative, to give you some idea.
MR. ROTH: So, what I'm hearing is all of the fish are below EPA's standard. Is that right -- all the species have declined, based on the '08 data --
MR. BRYANT: No. That was --
MR. ROTH: -- the advisory still in place?
MR. BRYANT: That was specific for like bottom feeders, like catfish. There are several varieties of catfish that they were able to catch. And, with sport fishing, that -- that fish advisory was lifted for dioxin back in '01.
MR. ROTH: Right. So again, to go back to my question. Are there any species of fish that don't meet EPA standards?

MR. BRYANT: Well, again, this goes back to -- actually we have the State advisory, and I would just stick with the State advisory for now. Even with the good things that we see, stick with the -- the existing advisory, you know, monitoring the intake of the bottom dwellers.

MR. ROTH: And other than that, I just wanted to state on the record that both Weyerhaeuser and Domtar are extremely important to our community and we appreciate them as good neighbors, and they've been very good to us over the years. We also rely on the health and well-being of the Roanoke River as well, and that's also extremely important to our local economy because of the sport fishing and hunting and other wildlife that's out there. So, I think from the community's perspective, it's been a pretty good marriage. And with our industrial complexes around the area and balancing that with the wildlife and the environment, we appreciate the work that you-all are doing and certainly appreciate Domtar, formerly Weyerhaeuser, and all of your efforts. It's been a long-going process, and it's costing money, but I don't to see anyone hurt in the process either. And, other than that, as far as the various alternatives --

MR. BRYANT: Uh-huh.

MR. ROTH: -- I'm certainly not qualified to say which one should be selected. I will leave that to the experts, but I do encourage everybody to come together and find a good solution at the end. Everybody will benefit from it. Thank you.

MR. BRYANT: Thank you. If we don't have any others (comments), we can just go ahead and wrap it up. I know everybody is -- I don't know if people got to eat before they came here or not, so. I appreciate you-all coming out. You have my contact information if you have questions that come up in the future. And I again appreciate your time this evening. And with that, we'll call it a day. Thank you.

*****THE PUBLIC MEETING CONCLUDED AT 7:45 P.M.*****

C-E-R-T-I-F-I-C-A-T-I-O-N

STATE OF NORTH CAROLINA)

COUNTY OF PITT)

I, BOBBIE G. NEWMAN, A COURT REPORTER AND NOTARY PUBLIC IN AND FOR THE AFORESAID COUNTY AND STATE, DO HEREBY CERTIFY THAT THE FOREGOING PAGES ARE AN ACCURATE TRANSCRIPT OF THE U.S. EPA PUBLIC MEETING, WHICH WAS TAKEN BY ME BY STENOMASK, AND TRANSCRIBED UNDER MY DIRECT SUPERVISION.

I FURTHER CERTIFY THAT THE DEPONENT WAS FIRST DULY SWORN BY ME, AND THAT THE DEPONENT AND PARTIES WAIVED THE SIGNING OF THE DEPOSITION BY THE DEPONENT.

I FURTHER CERTIFY THAT I AM NOT FINANCIALLY INTERESTED IN THE OUTCOME OF THIS ACTION, A RELATIVE, EMPLOYEE, ATTORNEY OR COUNSEL OF ANY OF THE PARTIES, NOR A RELATIVE OR EMPLOYEE OF SUCH ATTORNEY OR COUNSEL.

THIS THE 28TH DAY OF JULY, 2008.

NOTARY PUBLIC NUMBER 200616600172.

/s/ Bobbie G. Newman

BOBBIE G. NEWMAN
COURT REPORTER AND NOTARY PUBLIC
CAROLINA COURT REPORTERS, INC.
105 OAKMONT PROFESSIONAL PLAZA
GREENVILLE, NC 27858

APPENDIX B: STATE CONCURRENCE LETTER

NCDENR

North Carolina Department of Environment and Natural Resources

Dexter R. Matthews, Director

Division of Waste Management

Michael F. Easley, Governor
William G. Ross Jr., Secretary

25 September 2008

Mr. Randy Bryant
Superfund Branch, Waste Management Division
US EPA Region IV
61 Forsyth Street. SW
Atlanta, Georgia 30303

SUBJECT: Concurrence with Record of Decision
Domtar (formerly Weyerhaeuser) Site, Operable Unit #2 (Lower Roanoke River)
Plymouth, Martin County

Dear Mr. Bryant:

The State of North Carolina by and through its Department of Environment and Natural Resources, Division of Waste Management (herein after referred to as "the state"), reviewed the Record of Decision (ROD) received by the Division on 25 September 2008 for the Domtar (formerly Weyerhaeuser) Site Operable Unit #2 (Lower Roanoke River) and concurs with the selected remedy, subject to the following conditions:

1. State concurrence on the ROD for this site is based solely on the information contained in the ROD received by the State on 25 September 2008. Should the State receive new or additional information which significantly affects the conclusions or amended remedy contained in the ROD, it may modify or withdraw this concurrence with written notice to EPA Region IV.

2. State concurrence on this ROD in no way binds the State to concur in future decisions or commits the State to participate, financially or otherwise, in the clean up of the site. The State reserves the right to review, overview comment, and make independent assessment of all future work relating to this site.

3. If, after remediation is complete, the total residual risk level exceeds 10^{-6}, the State may require deed recordation/restriction to document the presence of residual contamination and possibly limit future use of the property as specified in NCGS 130A-310.8

The State of North Carolina appreciates the opportunity to comment on the ROD and looks forward to working with EPA on the remedy for the subject site. If you have any questions or comments, please call Mr. Nile Testerman at 919 508-8482.

Sincerely,

Dexter R. Matthews, Director
Division of Waste Management

cc: Jack Butler, Chief NC Superfund Section
David Lown, NC Superfund
Nile Testerman, NC Superfund

APPENDIX C: RESPONSIVENESS SUMMARY

A public meeting was held on July 17, 2008. At this meeting, representatives from the USEPA answered questions about the Site and the remedial alternatives under consideration. EPA did not receive any written or verbal comments other than the verbal comments provided at the public meeting. As a result, it was not necessary to prepare a Responsiveness Summary.

APPENDIX D: Data from March 2008 NPDES monitoring report

Data from March 2008 NPDES monitoring report

Variation in average catfish 2, 3, 7, 8-TCDD/F TEQ values (ppt) by location and year. Available data are separated into channel catfish (CC), white catfish (WC), and all catfish (All) to illustrate how species collected affects observed change over time. TEQ values are also affected by fish size and lipid content of fish collected each year and at different locations.

	Roanoke River @ Williamston			Roanoke River @ Discharge			Welch Creek			Roanoke River @ Marker 15			
	CC	WC	All	CC	WC	All	CC	WC	All	CC	WC	BC	All
1989-90	14.4	ND	9.6	--	26.2	26.2	67.3	6.0	36.6	33.3	13.8	--	21.6
1991	2.2	--	2.2	--	--	--	--	4.5	4.5	32.0	5.2	--	18.6
1992	1.5	ND	0.8	--	--	--	--	5.6	5.6	3.4	1.7	--	2.6
1993	0.8	0.0	0.4	--	--	--	19.1	3.2	11.1	5.2	1.4	--	3.3
1994	0.9	1.0	0.9	--	--	--	--	10.4	7.8*	8.2	2.5	--	6.3
1995	0.6	0.4	0.5	--	--	--	6.9	4.6	6.2	6.7	2.8	--	4.1
1996	0.9	1.4	1.2	--	--	--	15.4	6.3	9.3	8.2	2.0	--	4.0
1997	1.0	0.7	0.9	2.4	--	2.4	0.9	4.9	2.9	3.5	2.2	--	3.1
1998	0.6	1.4	0.9	--	--	--	--	8.0	8.6	7.6	1.2	--	3.3
1999	0.6	0.7	0.6	--	--	--	--	2.6	2.6	5.0	1.2	--	2.5
2000	0.5	0.7	0.6	--	--	--	4.2	5.1	4.5	1.6	2.1	--	1.7
2001	1.2	0.8	1.0	--	--	--	6.5	2.7	4.0	3.7	1.0	--	2.8
2002	0.6	0.2	0.4	1.5	--	1.5	--	9.4	9.4	6.6	2.6	--	5.3
2003	0.6	0.3	0.5	1.7	1.9	1.8	1.6	4.7	3.7	2.1	1.2	--	1.8
2004	0.8	0.5	0.7	3.1	0.8	1.6	--	2.1	2.1	4.6	1.5	--	2.5
2005	0.5	0.5	0.5	3.4	0.7	2.5	--	1.2	1.2	2.9	0.7	--	1.4
2006	0.7	--	0.7	1.0	1.2	1.1	3.1	1.6	2.1	2.2	0.7	--	1.7
2007	0.1	0.1	0.1	1.0	0.2	0.4	--	0.2	0.2	--	0.4	0.3	0.3

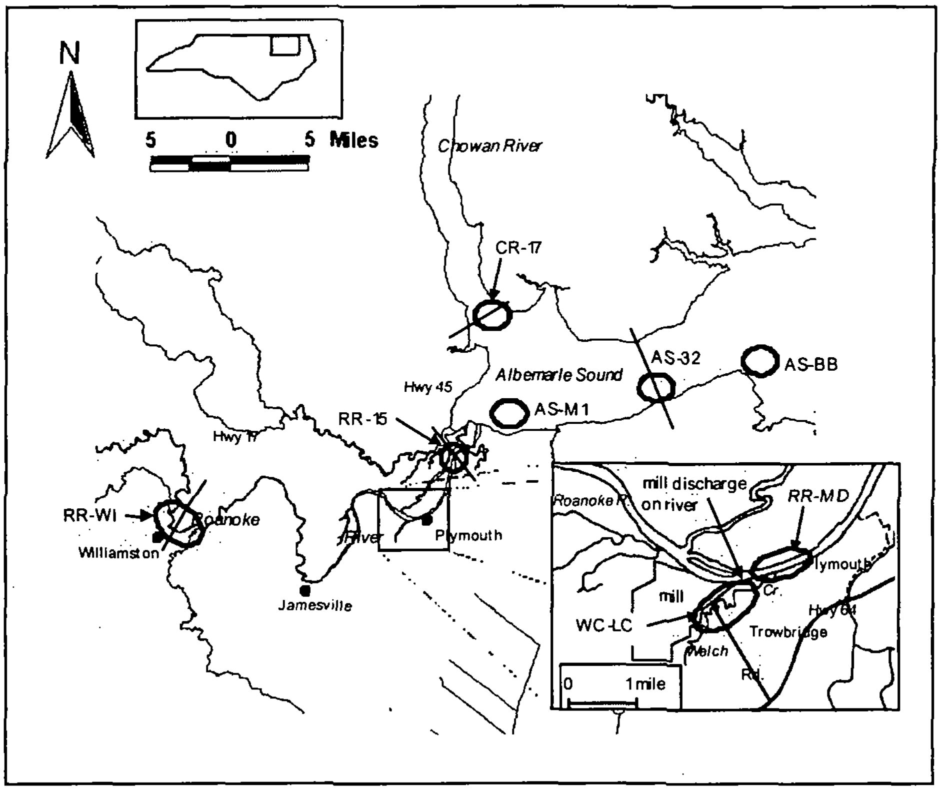
Note: (*) includes species other than CC, WC, and Blue Catfish (BC).

Data from March 2008 NPDES monitoring report (cont.)

Variation in average catfish 2, 3, 7, 8-TCDD/F TEQ values (ppt) by location and year. Available data are separated into channel catfish (CC), white catfish (WC), and all catfish (All) to illustrate how species collected affects observed change over time. TEQ values are also affected by fish size and lipid content of fish collected each year and at different locations.

	Chowan River @ Highway 17			Albemarle Sound @ Marker 1			Albemarle Sound @ Hwy 32			Albemarle Sound @ Bull Bay		
	CC	WC	All	CC	WC	All	CC	WC	All	CC	WC	All
1989-90	4.9	0.3	2.6	14.6	--	14.6	2.6	8.5	7.0	--	7.7	7.7
1991	20.3	--	20.3	47.4	--	47.4	14.8	--	14.8	14.5	5.2	9.8
1992	15.3	1.4	8.4	13.6	4.3	9.0	20.6	6.6	13.6	--	2.1	2.1
1993	11.1	1.6	6.4	2.8	1.6	2.2	19.6	1.8	10.6	--	0.8	0.8
1994	3.4	1.6	2.8	6.1	1.6	4.6	13.5	4.0	7.2	--	2.2	2.2
1995	7.8	4.2	6.6	11.0	3.0	5.7	16.7	5.3	9.1	9.6	2.2	7.2
1996	6.0	2.3	4.8	13.0	4.1	7.1	14.5	3.6	10.9	10.0	1.8	4.5
1997	5.5	1.0	4.0	10.1	3.6	5.7	16.8	3.8	8.1	--	1.9	1.9
1998	8.6	3.2	6.8	5.4	3.4	4.1	--	1.2	1.2	--	1.9	1.9
1999	7.4	1.9	5.6	5.6	2.6	3.6	--	1.1	1.1	--	1.8	1.8
2000	2.3	1.5	2.0	4.5	2.6	3.2	--	1.2	1.2	4.2	0.9	2.0
2001	2.7	1.2	2.2	5.7	1.4	2.8	--	2.0	2.0	--	1.2	1.2
2002	--	1.5	1.5	--	1.8	1.8	--	1.7	1.7	--	1.3	1.3
2003	6.6	1.1	3.0	5.9	2.8	3.8	--	1.8	1.8	--	0.8	0.8
2004	5.6	0.8	2.4	5.3	1.6	3.1	--	2.0	2.0	--	1.1	1.1
2005	2.2	1.0	1.4	4.3	1.5	2.4	--	0.6	0.6	--	0.6	0.6
2006	0.9	0.7	0.8	4.5	2.5	3.8	--	1.2	1.2	--	0.7	0.7
2007	0.7	0.0	0.3	2.2	0.2	0.9	--	0.2	0.2	--	0.0	0.0

Note: (*) includes species other than CC, WC, and Blue Catfish (BC).



Legend: (RR-WI) Roanoke R. near Williamston (CR-17) Chowan R. at Highway 17
(RR-MD) Roanoke R. below Discharge (AS-M1) Albemarle Sound at Marker 1
(RR-15) Roanoke R. at Marker 15 (AS-32) Albemarle Sound at Highway 32
(WC-LC) Lower Welch Creek (AS-BB) Albemarle Sound in Bull Bay

Station locations for 2007 fish collections for Plymouth Mill (NPDES No. NC0000680).