Section 15
Summary and Conclusions

15.1 Introduction and Background

Calcasieu Estuary is a complex estuarine system consisting of numerous perennial wetland bayous and tributaries in a heavy industrial setting (Section 2). The term estuary is used to describe, "a semi-enclosed coastal body of water which has a free connection with the open sea and within which sea water is measurably diluted with freshwater derived from land drainage" (Pritchard 1967).

Calcasieu Estuary is a drowned river valley system. Pritchard's description of the drowned river valley system is "a wide coastal plain; only a portion of the area affected by tides [e.g.] is estuarine, based on salinity diluted by freshwater"(Pritchard 1967).

The nature of Calcasieu Estuary is best described by total energy contributed by the various regions of the estuary. Specific regions of the estuary have been grouped into 1 of 5 energy system classes, including bayous, marshes, shallow lakes, shipping channels, and river (Figure 3-3). A small area that does not fit these broad energy system classes has been categorized as "other". The energy of this "other" area will influence surface water variability and sediment nature and stability. Each system influences the nature and behavior of surface water and sediment differently.

Industrial development, including chemical manufacturing and distribution, and petroleum refining has been prevalent in the Lake Charles area since the early 1920s and has impacted the estuary through the release of hazardous chemicals (Curry et al. 1997). Additionally, facility discharges, urban and agricultural activities, dredging, stormwater runoff, and accidental releases have contributed to contaminated groundwater and surface water in and around the industrial areas. These same activities also have resulted in contaminated sediments within the various surface waters in the estuary. Further, fish and shellfish within the estuary have been impacted by industrial contaminants, prompting the State of Louisiana to issue health advisories for the Calcasieu Estuary (Louisiana Department of Environmental Quality [LDEQ] 1999 and Louisiana Department of Health and Hospitals [LDHH] 2000). In January 1999, EPA decided, in the interest of the public health, welfare, and the environment, to implement a government-lead RI/FS under CERCLA.

The purpose of the RI was to gather sufficient information to define the nature and extent of chemical contamination in sediment, surface water, and biota within the Calcasieu Estuary and to support ecological and human risk assessments. The RI was conducted in accordance with the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988). Two phases of the RI were completed during November 2000 and November 2001.

15.2 Summary

The RI for the Calcasieu Estuary has been demonstrated through the chemical and statistical analysis of sediments, water, and biota, as a result, the Calcasieu Estuary COPCs-fall into three categories:

- ***Background*** is ambient concentrations of chemicals or compounds present in the environment that are not the result of human activities (e.g., aluminum, magnesium).
- ***Anthropogenic*** are conditions generated or created by, or a result of, human and/or human activities. Usually used in the content of emissions or non-point source run-off that is produced as a result of human activity.
- ***Industrial*** are spills, releases, or point source releases (NPDES) that are the result of human activities and processes in the production of man made or man induced materials that are have been altered chemically, physically, or biologically.

Exhibit 15-1 presents constituents detected in the RI and the three categories the constituents fit within.

Exhibit 15-1 Example Background, Anthropogenic, and Industrial Constituents

Background	Anthropogenic	Industrial
Potassium, Silver, Beryllium, Iron, Aluminum, Magnesium, Manganese, Cobalt, Vanadium, Selenium, Arsenic, Sodium, (low level metals)	4,4-DDT, 4,4-DDD, 4,4-DDE, Endrin, Dieldrin, Ethylbenzene, Acetone, Delta-BHC, Aldrin, Benzaldehyde, Alpha Chlordane, Phenanthrene, PCBs, dioxin/furans, nickel, mercury	PAHs, dioxin/furans, copper, chromium, PCBs, nickel, Aroclor 1254, alpha-BHC, Benzaldehyde, mercury, zinc

The three categories and their associated constituents are the result of the evaluation of the RI data through statistical analysis and a variety of published literature. It should be noted that analytes listed as background and anthropogenic also occur as industrial contaminants when generated in or released from a process (or non-point source) to the environment. From these categories, the RI focuses on areas within the Calcasieu Estuary that have been affected by industrial constituents that are related to historical releases and spills, ongoing releases, and to a lesser extent industrial anthropogenic effects. The discussion will begin in the northern portion of the study area (Upper Calcasieu) and conclude with the southern most area (Lower Calcasieu).

Upper Calcasieu

The areas that define the Upper Calcasieu portion of the estuary represent a mixture of land-uses and energy systems. Upper Calcasieu is divided into five energy systems: river, marsh, shallow lake, ship channel, and bayou. Contraband Bayou represents the bayou energy system in Upper Calcasieu and is a moderately saline low flow bayou. It receives effluent from the Lake Charles POTW. The river energy system consists of low salinity marsh areas above Lake Charles. The shallow lake area includes Lake Charles, the West Slip of Clooney Island Loop, and the eastern portion of Coon Island Loop; they are characterized by confined and shallow low-flow systems with generally limited circulation. The ship channel energy system includes the main ship channel from I-210 to Lake Charles and the slightly smaller limbs of Clooney Island Loop and western Coon Island Loop.

The portions of the river above Lake Charles are considerably less saline and are protected somewhat from storm surge and tidal influence. Lake Charles and the natural river segment between Lake Charles and the saltwater barrier experience seasonal salinity shifts, and the installation of the saltwater barrier was in response to saltwater intrusion in the region.

Upper Calcasieu in Coon Island Loop and Clooney Island Loop, receives surface runoff and wastewater discharge from industrial facilities (Lyondell, Conoco, and PPG), see Figure 9-2. These sources appear to define most of the COPC occurrences. However, isolated and discontinuous detections also occur for which associated releases are not discernable (e.g., oil field operations, railroad or highway associated runoff). Contraband Bayou receives effluent from the Lake Charles municipal wastewater treatment facility. Additional non-point sources (rural, residential, and light industrial areas) are also present throughout this system. Primary introduction of contaminants to this system appears to occur in Clooney Island Loop and Coon Island Loop.

The most extensive set of contaminants, and generally the greatest concentrations, are found in the shallow lake system portion within the Coon Island Loop and the Clooney Island Loop West Slip area.

The West Slip, (see Figure 9-2) has the highest levels of industrial contaminants in Upper Calcasieu and appears to be related to discharge from Lyondell. Contaminants in this area include PAHs, dioxins, PCBs, and metals. Similar contaminants can also be found in the northeast corner of Clooney Island Loop adjacent to the Conoco dock and at the southwest corner of Clooney Island Loop. Contaminants within the Clooney Island Loop are associated with outfalls from Lyondell and Conoco. Bayou Verdine is also a documented source to Upper Calcasieu.

Coon Island Loop is located in the southwest corner of Upper Calcasieu. Within Coon Island Loop, there are areas that have been identified to have high localized PAH and PCB contamination. The PAHs are located along the turning basin and in the northeast portion of Coon Island Loop (the shallow lake portion adjacent to the turning basin) at the mouth of Bayou Verdine. A linear pattern of PAHs is noted, but upon examination a shift from the LPAHs to HPAHs is seen. The PAHs detected in eastern Coon Island Loop are HPAHs, and those prevalent in the lower 100 m of Bayou Verdine are LPAHs. The HPAHs may be attributed to Lyondell/Olin NPDES outfalls or surface run-off within this area. PCBs, copper and lead were detected at elevated concentrations across Coon Island into the western portion of the loop and ecologic risks are noted for this area in the BERA.

Upper Calcasieu most Contaminated Areas

- West Slip
- Bayou Verdine Confluence
- Coon Island Loop (East)
- Clooney Island (East)

The Calcasieu Estuary BERA (CDM 2002c) has identified this area as a high risk to benthic invertebrate and fish communities based on multiple lines of evidence. The multiple lines of evidence are based on sediment and porewater toxicity tests, along with laboratory data. Similar contaminant driven risk can also be found in the northeast corner of Clooney Island Loop adjacent to the Conoco dock and at the southwest corner of Clooney Island Loop.

Fish and shellfish samples used to calculate human health consumption risk for Upper Calcasieu were collected from 9 locations. The sample locations were in Lake Charles, Clooney Island Loop and Coon Island Loop and represent popular public fishing spots. The locations are not necessarily in areas with impacted sediment.

The Reasonable Maximum Exposure (RME) calculated excess cancer risk for shellfish (only) consumption in Upper Calcasieu was driven by dioxin/furans (risk of 2×10^{-4}), Aroclor 1254 (5×10^{-5}) and arsenic (5×10^{-5}). Total excess risk for residential fish and shellfish consumption was 4×10^{-4}, total excess risk for subsistence fish and shellfish consumption was 1×10^{-3}. The residential and subsistence RME derived Hazard Indices (HI) are elevated for Upper Calcasieu, driven by Aroclor 1254 in shellfish.

Bayou Verdine

As noted earlier, Bayou Verdine is a source of contaminants to Upper Calcasieu. Bayou Verdine is a single energy system that was divided into five geographic reaches to facilitate data presentation and discussion. The reaches are defined in Section 8.1.2 and Figure 8-1. Bayou Verdine can be characterized as a moderately saline, channelized, moderately low-flow system with significant industrial discharge in the lower three reaches (Reaches 1 through 3). The upper reaches (Reaches 4 and 5) are generally a less-saline, shallow, and narrow vegetated low-flow system.

Bayou Verdine most Contaminated Areas
- Below west ditch to I-10
- Middle reach 1 to the mouth of bayou

The greatest extent and concentration of contaminants for this energy system are seen in Reaches 1 and 2, generally from the Vista West Ditch to below I-10 and from middle Reach 1 to the mouth of Bayou Verdine. The primary contaminant group is PAHs (predominantly LPAHs), however, Reach 2 is also impacted by dioxin/furans and various VOCs, primarily EDC. The maximum concentration of EDC was 19,000,000 µg/Kg. Concentrations of HPAHs were elevated throughout Reach 2, while dioxin/furans were moderately low.

Contaminant occurrence indicates that several sources are present throughout Bayou Verdine. The upstream reaches are relatively un-impacted by industry. The Conoco Lube Tank Farm area appears to be the primary source of LPAHs and minor HPAHs in Reach 3.

Reach 2 is primarily impacted by release through the Vista West Ditch and Vinyl Chloride Monomer (VCM) wastewater treatment unit discharge, Fabaucher Ditch, releases via Conoco Outfalls 001 and 004, and release through KCSRR Ditch. Reach 2 appears to be the most heavily impacted segment of Bayou Verdine.

Reach 1 appears to be impacted by release through outfalls that discharged to the upper third of the reach from I-10 through the PPG Derivatives Area (Plant B). Potential sources include the former Conoco, Olin, and Lyondell outfalls that discharge into Bayou Verdine below I-10. Releases to the lower reaches (Reaches 1 and 2) appear to come from PPG outfall 004 and activities (barge operations, periodic spills and associated releases) at the PPG North Dock area.

A high mortality rate for benthic invertebrates were identified within these reaches in the Conoco BERA prepared by Entrix, Inc. (Entrix 2001). Shellfish samples used to calculate human health consumption risks for Bayou Verdine were collected by Conoco. Biota samples were collected from 31 locations located in Reaches 1 through 3 in Bayou Verdine. Public access is limited although not restricted in Bayou Verdine. CDM staff collected fish filets for dioxin/furan analysis, as Conoco did not analyze dioxin/furans. Alligator gar was used as the representative fish as it was the only fish observed in Bayou Verdine during the sampling period.

The Total Reasonable Maximum Exposure (RME) calculated excess cancer risk for fish and shellfish consumption in Bayou Verdine was driven by arsenic and bis(2ethylhexyl)phthalate in fish. Total subsistence excess cancer risk for consumption was 1×10^{-3}.

Bayou d'Inde

The single largest bayou and most industrially impacted area the estuary is Bayou d'Inde. Bayou d'Inde is split into two energy systems, marsh and bayou. The bayou was divided into four geographic reaches to facilitate data presentation and discussion. The reaches are defined in Section 7.1.2 and Figure 7-1. The most

extensive set of contaminants, and generally the greatest concentrations are found in Reach 1 of Bayou d'Inde and Lockport Marsh. Contaminants found throughout Bayou d'Inde include PAHs, SVOCs, PCBs, dioxin/furans, and metals. Contaminants are widespread throughout the bayou and marsh energy systems.

PCBs are extensive throughout Reaches 1, 2 and 3. Dioxin/furans are predominant in Reaches 1 and 2, Lockport Marsh, and the Reach 2 marshes. Concentrations are often comparable where bayou and marsh locations are present. Overall, the primary impacted areas are lower Reach, Reach 1 and Lockport Marsh.

PCBs tend to occur in two primary PCB congener groupings, those grouped with PCB-118 and those with PCB-15. The PCB-118 group appears to originate in lower Reach 3 and extend through to the middle Reach 2 marsh area. The PCB-15 impacted areas begin at PPG Canal and are prevalent up to the middle of Reach 2 marsh and extend downstream through Reach 1 to the ship channel. Lockport Marsh contains the highest detections of PCBs. No documented PCB releases were noted in the regulatory record, however it is important to note that industrial processes, which combine carbon and chlorine at elevated temperatures, may generate PCBs as a by-product.

Bayou d'Inde most Contaminated Areas

- Lockport Marsh
- Citgo to LA-108
- PPG canal to the ship channel

Elevated concentrations of mercury tend to be found from Maple Fork Bayou through Reach 1 to the ship channel. Minor concentrations extend into upper Reach 3. Mercury concentrations are highest in the marshes, Lockport Marsh in particular. A potential source includes the former PPG mercury cell-settling pond that was operated in the late 1960s. The pond was an unlined impoundment within the PPG Canal drainage area. Additionally, localized elevated mercury detections within Lockport Marsh may be due to manometer use in by the oil field industry, however elevated mercury was not noted in Coon Island Loop where oil and gas drilling has also occurred.

HPAHs are found in the highest concentration in Reach 1, Lockport Marsh, and reach 2 marshes (near Maple Fork Bayou and marshes to the east). PPG Canal, Maple Fork Bayou and lower Reach 3 appear to be the sources of these PAHs. Elevated concentrations are noted in the marshes upstream of PPG Canal and may indicate PPG Canal overflow to these marshes. No known sources exist on Maple Fork Bayou, although industrial pipelines and a highway and a railroad spur cross Maple Fork near the highest detections. Urban runoff (anthropogenic) from the nearby highways may be a source of contaminants.

Documented releases from these features are unknown.

LPAH distribution is not as widespread in Bayou d'Inde as HPAHs. The LPAHs tend to be found in Lockport Marsh. Concentrations are generally higher than HPAHs. Additional LPAHs are noted in Maple Fork Bayou, lower Reach 3 and near LA-108 in upper Reach 2. In general, LPAHs tend to increase with depth, indicating historic release. Potential LPAH sources include processes at Citgo.

BEHP is found throughout Bayou d'Inde, however highest concentrations are noted in Reaches 1 and 2. BEHP appears to accumulate in the Reach 2 marshes and Reach 1. However, in Reach 1 where significant levels of BEHP were detected, the bayou rather than the marsh contains the majority of the contaminant. The concentrations in the bayou are greater than the Lockport Marsh by an order of magnitude in Reach 1. The overall distribution of BEHP suggests that the compound is greatly influenced by the presence of suspended or colloidal phase material in the water column. The distribution of BEHP indicates the greatest degree of transport of any COPC in Bayou d'Inde and suggests that its concentration in sediment is an indicator of low surface water flow velocity (high settling rate) and high organic or detritus material, either particulate or suspended.

The Calcasieu Estuary BERA (CDM 2002c) has identified this area as a high risk to benthic invertebrate and fish communities based on multiple lines of evidence. Fish and shellfish samples used to calculate human health consumption risk for Bayou d'Inde were collected from 6 areas. The sample locations were located in Reach 1 and the mouth of Bayou d'Inde, and lower Maple Fork Bayou. The locations represent popular public fishing spots.

The Reasonable Maximum Exposure (RME) calculated excess cancer risk for shellfish (only) consumption in Bayou d'Inde was driven by dioxin/furans (risk of 8×10^{-4}), Aroclor 1254 (6×10^{-5}) and Bis(2 ethylhexyl)phthalate (4×10^{-5}). Total excess risk for residential fish and shellfish consumption was 1×10^{-3}, total excess risk for subsistence fish and shellfish consumption was 3×10^{-3}. The residential and subsistence RME derived Hazard Indices (HI) are elevated for Bayou d'Inde, driven primarily by Manganese and Aroclor 1254 in shellfish.

Lower Calcasieu

South of Bayou d'Inde is Lower Calcasieu, which is divided into four energy areas: bayou, shallow lake, other (Indian Marais Lagoon), and ship channel. The energy areas are defined in Section 10.1.2 and Figure 10-1.

Bayous Olsen and Guy represent the bayou energy area in Lower Calcasieu. Both bayous are saline, low-flow systems. Bayou Guy receives predominantly rural residential flow. Bayou Olsen receives industrial discharge from W. R. Grace Inc., and rural residential run-off. Both bayous are net sediment exporters and receiving bodies are Moss Lake for Bayou Olsen and the Old Calcasieu River channel below Prien Lake for Bayou Guy.

The shallow lake areas include Prien Lake and Moss Lake; they are semi-confined shallow low-flow systems with limited circulation. Moss Lake tends to have the larger opening to the ship channel. The ship channel system includes the main ship channel from I-210 south to the southern end of Moss Lake.

The areas that define Lower Calcasieu represent a mixture of land-uses and point and non-point contaminant sources. Additional input to the Lower Calcasieu area includes flow from Upper Calcasieu, Bayou Verdine, and Bayou d'Inde sources. The most significant introduction of contaminants to the system appears to occur near the Citgo facility. The accumulation of low-level sediments in the bend of the ship channel south of Indian Marais Lagoon may come from any of the various sources upstream. Presence of material in this area appears to be the result of velocity drops and sediment particle settling.

Lower Calcasieu most Contaminated Area
- Indian Marais Lagoon

The most impacted area within Lower Calcasieu is the Indian Marais Lagoon. The most extensive set of contaminants and highest concentrations are located in the lagoon. Former discharges have impacted lagoon sediments. Primary COPCs include PAHs and various metals, primarily lead, copper, chromium, and zinc.

The shallow lake areas, specifically Prien Lake, tend to have broad distribution of moderate to low-level concentrations of dioxin/furans, PAHs, and some metals. Copper, lead, mercury, nickel, and zinc were present in elevated concentrations in Prien Lake in the surface water. Copper concentrations exceed the ambient water quality criteria set for acute and chronic marine exposure and chronic freshwater exposure limits. Mercury concentrations exceed the chronic ambient water quality criteria for freshwater systems.

Data from the ship channel portion of Lower Calcasieu indicated limited detections of dioxin/furans, PAHs, BEHP, and mercury. The distribution of COPCs is primarily associated with the Citgo facility and the Indian Marais Lagoon. Distribution appears to represent some degree of sediment transport downstream of the potential sources, e.g., the Citgo Outfalls 004 and 006 or the Indian Marais Lagoon, to a shallow shelf on the eastern side of the ship channel where velocities appear to decrease and settling occurs.

The Calcasieu Estuary BERA (CDM 2002c) has identified this area as a high risk to benthic invertebrate and fish communities based on multiple lines of evidence. Fish and shellfish samples used to calculate human health consumption risk for Lower Calcasieu were collected from 5 areas. The sample locations were located in Prien Lake, Indian Marais and Moss Lake. The locations represent accessible and popular public fishing spots.

The Reasonable Maximum Exposure (RME) calculated excess cancer risk for shellfish (only) consumption in Lower Calcasieu was driven by benzo (a) pyrene (risk of 2×10^{-4}), dioxin/furans (9×10^{-5}) Aroclor 1254 (2×10^{-5}) and arsenic (5×10^{-5}). Total excess risk for residential fish and shellfish consumption was 5×10^{-4}, total excess risk for subsistence fish and shellfish consumption was 1×10^{-3}. The residential and subsistence RME derived Hazard Index (HI) are elevated for Lower Calcasieu, driven primarily by copper and zinc.

15.3 Discussion

Localized hot spots occur throughout the study area and are the result of historical spills, releases, and/or current activities attributed, primarily to industries surrounding the Calcasieu Estuary. The RI has attempted to narrow the original study area, which started at the saltwater barrier and extended south to Moss Lake to more focused Areas of Interest (AOI). The AOI are based on the frequency of detects and the elevated concentration of COPCs and the result of the PCA as discussed in Sections 7 through 10.

Exhibit 15-2 summarizes the most significant AOI by geographic location in the estuary followed by COPC concentration compared to estuary-wide data population 95 percent Upper Confidence Limit (UCL) concentration, a general sediment stability ranking, potential contaminant sources to the study area, a ranking of ecological risk (from the BERA) posed by sediment to the benthic invertebrate community and a ranking of human health risk (RME) to potential subsistence and residential consumption of shellfish from each area (shellfish samples were collected for Bayou Verdine, Bayou d'Inde, Upper and Lower Calcasieu). Use of the 95 percent UCL is a standard statistical approach to identify the maximum values in a population. The data from all of the AOC and individual energy areas were combined to generate the estuary-wide population statistics provided in Appendix J. The statistical output is provided for all compounds, summation data is provided for total HPAHs, total LPAHs, and 2,3,7,8-TCDD TEQ.

This summary organic data is shown graphically on Figure 15-1. Inorganic data is shown on Figure 15-2. Each figure shows the data points where the 95 percent UCL was exceeded for the select group of compounds. The figures illustrate the primary areas impacted by the highest concentrations. They show correlation to physical conditions that influence contaminant occurrence and transport with the estuary as a whole. The COPC list is based on those compounds that are most prevalent, most concentrated and/or are a concern from a human health or ecological risk perspective.

Figures 15-1 and 15-2 and Exhibit 15-2 are intended to provide a summary of the most prevalent and/or significant contaminants. The figures illustrate distribution and a number of the physical conditions that influence chemical fate and transport. The presentation is not based on clean-up standards (site-specific standards have not been established in this report) but on standard statistical approaches to enable stakeholders and risk managers to evaluate the status of the estuary.

The following paragraphs discuss Exhibit 15-2 and provide the stakeholders and risk managers an overall understanding of the impacted areas and the risks associated.

Clooney Island West Slip

The Clooney Island West Slip area sediments are impacted by PAHs (high [HPAHs] and low [LPAHs] molecular weight), BEHP, mercury, zinc, and Aroclor-1254. Each of these compounds exceeds the estuary-wide population 95 percent UCL. The highest

concentrations are located in the West Slip area from UCR2028, and UCR2026 at the Conoco Dock. This AOI has also been identified as a high risk to benthic invertebrate and fish (CDM 2002c). Overall, sediment stability tends to be moderate, however, there is potential for the sediments to mobilize, particularly under heavy storm conditions. The sources of contaminants within this AOI are potentially attributed to Lyondell/Olin and Conoco storage, transfer, and transport activities. Elevated concentrations appear to be associated with current and historical outfalls releases as well as various non-point source releases associated with these operations.

Clooney Island Loop East
Sources of contaminants within this area potentially include Lyondell/Olin and Conoco, however the highest concentrations do not exceed the 95 percent UCL. Low-level contaminants include BEHP, dioxin/furans, copper, and Aroclor-1254. This distribution appears to be due to the physical transport and settling of adsorbed particulate matter. Overall, sediment stability tends to be moderate. It appears that re-suspension of fine grained material facilitates physical transport occurs throughout the Clooney Island Loop. Elevated concentrations appear to be associated with release from current and historical outfalls as well as various non-point source releases associated with these operations.

Coon Island Loop East
The primary contaminants in the eastern Coon Island Loop shallow lake include chromium, lead, and copper. It should be noted that significant HPAH concentrations are detected at the mouth of Bayou Verdine adjacent to this area. However, distribution gradients indicate salting-out of these PAHs as the enter Coon Island Loop. Lateral extent of PAHs is limited as distance increases from the mouth of Bayou Verdine. The extent of elevated metals within this area is greater than their PAHs. The highest lead and chromium concentrations are detected mid-way through the loop to station UCR 1-23-SD.

Overall, sediment stability tends to be moderate, however, there is potential for the sediments to mobilize, particularly under heavy storm conditions. The data suggests that moderate fine or suspended particle inorganic transport occurs. The BERA (CDM 2002c) indicates this is a high-risk area for benthic invertebrates and fish. The source of these contaminants is not fully understood, but is most likely Bayou Verdine. Limited surface run-off from adjacent industrial properties is possible, however, the distribution of contaminants indicates that deposition is from the mouth of Bayou Verdine not Coon Island.

Coon Island Loop (PPG North Dock Area and western portion of the Loop)
Limited various PAHs, BEHP, metals,, and PCBs were noted in the upper Coon Island Loop area near the confluence of Bayou Verdine and the Coon Island Loop turning basin. Lateral distribution extends approximately 1200 m upstream along the western Coon Island Loop from the mouth of Bayou Verdine. A metal that exceeds the 95 percent UCL is lead, which is detected mid-way through the loop to station UCR 1-13-SD.

Overall, sediment stability appears to have potential to mobilize. These contaminants suite appears to be from release to the mouth of Bayou Verdine and the lateral extent of PAHs, metals, PCBs, and dioxin/furans indicates that impacted sediments have been covered approximately 1,000 to 1,200 m along the ship channel from the PPG North Dock Area.

Discharges from outfalls 002 and 003 enter Coon Island Loop in this region, however, release histories and the contaminant levels indicate that material from the north dock area has also impacted sediments away from the North Dock Area. Potential for the sediments to be drawn further downstream exists, particularly under heavy storm conditions.

The BERA (CDM 2002c) indicates this is a high-risk area for benthic invertebrates and fish. Potential sources are the distribution, storage, and transportation of products and waste locally by PPG. Releases through the PPG Outfalls 002 through 004 are documented and appear to have contributed to current sediment quality. Additionally, oil field activities on Coon Island may be a potential source of PAHs and lead. The BERA (CDM 2002c) indicates this is a high-risk area for benthic invertebrates and fish.

Bayou Verdine Reach 1

The primary contaminants in the lower portion of Bayou Verdine include HPAHs, BEHP, PCBs, dioxin/furans, and metals. Contaminant extent is concentrated around I-10 and PPG Outfall 004 located upstream of the North Dock Area.

Reach 1 has received discharge from multiple industrial outfalls. It may be impacted by release associated with the KCSRR drainage ditch and/or runoff from I-10. Release from these process areas mix with the saline waters of Bayou Verdine contaminants noted in overlapping areas. PAH distribution appears to be due primarily to "salting-out". The PAH concentrations tend to indicate that localized areas with higher concentrations are present along Reach 1. The NPDES compliance data does not indicate significant release to these areas; therefore, other sources are suspect to have impacted this area.

Sediment stability in Reach 1 of Bayou Verdine is susceptible to tidal surge or storm scouring. Localized impact from surface drainage ditches is noted in the reaches upstream in Bayou Verdine and similar effects are likely to occur in Reach 1. While multiple sources exist, the broad distribution along the length of Reach 1 is indicative of contaminant transport and sediment movement. Based on this assumption, the sediment stability for this portion of Bayou Verdine is considered low. In addition, ecological risk evaluations conducted for Conoco (Entrix 2001) indicate that this area is a high-risk area for benthic invertebrates and fish.

Possible industrial sources of contaminants to Bayou Verdine Reach 1 include Condea Vista, Conoco, Tetra Technologies, Lyondell, and PPG. Additional potential sources likely include KCSRR railroad activities and run-off from I-10. Reach 1 sediments

contamination may be related to spills, release by impacted soils or groundwater or outfall discharge.

Bayou Verdine Reach 2
The contaminants that exceed the 95 percent UCL in Reach 2 of Bayou Verdine include LPAHs, EDC, and zinc. PCBs and PAHs were detected in previous studies and in the RI throughout Reach 2; however, the concentrations do not exceed the 95 percent UCL. The data indicates that most contaminant concentrations are higher in shallow surface sediments indicative of recent deposition. Reach 1 has received discharge from multiple industrial (i.e., CONDEA Vista and Conoco) outfalls. Surface run-off flow from industrial ditches and the distribution of contaminants indicate that the in-flow alters distribution locally. Release may also be impacted in lower Reach 2 by release associated with the KCSRR drainage ditch and/or runoff from I-10.

Tidal surge or high freshwater inflows tend to facilitate sediment transport in Reach 1. Based on this transport mechanism and shallow sediment concentrations, the sediment stability within this area is moderate. In addition, ecological risk evaluations conducted for Conoco (Entrix 2001) indicate that this area is a high-risk area for benthic invertebrates and fish.

Bayou Verdine Reach 3
The primary contaminants that exceed the 95 percent UCL in Reach 3 of Bayou Verdine are PAHs, PCBs, zinc, and VOCs (EDC). LPAHs in Reach 3 tend to be more concentrated than other areas throughout the estuary. Vertically, the concentrations of PAHs consisting of LPAHs and HPAHs tend to be highest in the subsurface in Reach 3. Sediment transport is evidenced by the broad distribution of PAHs from New Trousdale Road downstream in Reach 3. Primary contaminant sources to Reach 3 appear to be the Conoco Lube Tank Farm and the CONDEA Vista via the Vista West Ditch. While multiple sources exist, the broad distribution along the length of the bayou is indicative of moderate contaminant transport and sediment movement. Potential sources include CONDEA Vista and Conoco.

Bayou d'Inde - Lockport Marsh
The primary contaminants that exceed the 95 percent UCL in Lockport Marsh include dioxin/furans, PCBs, BEHP, HPAHs, LPAHs, copper, mercury, lead, and zinc. The potential responsible industries discharging these contaminants include PPG and the oil industry. The BERA (CDM 2002c) identifies areas throughout Lockport Marsh as high-risk to benthic invertebrates and fish. The distribution of contaminants throughout Lockport Marsh indicates a similar pattern. The areas with significant contamination are generally within the upper, bermed portion of Lockport Marsh. Sediment stability is poor in the lower portion of the area, outside of the levees. Circulation through the area can be substantial and contaminant distribution indicates that impacted sediments have been transported out of the area.

The potential source of contaminants within this AOI is PPG. Overall, Lockport Marsh is not considered a significant sink for contaminated sediments exported by

upper reaches. The upper portions of Lockport Marsh appear to receive contaminant input from PPG Canal and sediment stability in these areas is moderate. Protection by the levees however, would be compromised by high storm surges or flooding. Release to Lockport Marsh appears to be primarily from waste storage or discharge activities and/or impacted groundwater in-flow.

Bayou d'Inde Reach 1
Reach 1 was the Bayou d'Inde area with the greatest number of detections and the highest COPC concentrations. Reach 1 contaminants that exceed the 95 percent UCL include dioxin/furans, PCBs, BEHP, mercury, lead, and zinc. The HPAHs, LPAHs, HCB, and HCBD concentrations are also elevated, however, they are not shown on Figure 15-1. The contaminant concentrations and distribution in this reach warrant further evaluation. The BERA (CDM 2002c) identified areas throughout Reach 1 as high-risk to benthic invertebrate and fish.

The major potential source of contaminants within Reach 1 is PPG. Reach 1 also appears to receive minor amounts of impacted sediment (primarily BEHP and possibly Aroclor-1254) from upper reaches. Reach 1 may, under specific flow conditions, act as a sink for contaminated sediments exported by upper reaches. The primary contaminant source to Reach 1 is the PPG Canal. Sediment stability in Reach 1 is generally considered low and storm surges or wind forcing would likely mobilize sediments.

Bayou d'Inde Reach 2 Bayou and Marshes
The Reach 2 COPCs that exceed the 95 percent UCL include metals, PCBs, and dioxin/furans. The contaminant concentrations of metals are highest for copper, chromium, mercury, lead, and zinc. Reach 2 marshes tend to exhibit the highest concentrations for metals, dioxin/furans, and most HPAHs. Lead and zinc do not exceed the 95 percent UCL for the marshes; however, they are present in Reach 2 of the bayou at elevated concentrations.

Similarly, the HPAH compound 1,2-BPA is absent from Reach 2 marshes even though 1,2-BPA is present in the bayou, possibly indicating rapid chemical precipitation when it was released. The BERA (CDM 2002c) identified both bayou and marsh areas throughout Reach 2 as high-risk to benthic invertebrate and fish.

Potential sources of contaminants within Reach 2 include Citgo, Westlake Polymers, Equistar, and PPG. Reach 2 appears to receive impacted sediment from Reach 3 industrial releases. Reach 2 bayou is a net sediment exporter and its marshes act as sinks for contaminated sediments exported by Reaches 2 and 3. Evidence of flow both up and down stream is noted for Reach 2, specifically from contaminant gradient and compound presence. Sediment stability in Reach 2 is low to moderate as supported by contaminant distribution. Sediments may be mobilized by storm surges or wind forcing throughout lower Reach 2.

Bayou d'Inde Reach 3
Reach 3 contained a limited number of COPCs that exceed the 95 percent UCL, specifically PCBs, copper, zinc, and lead. However, concentrations of PAHs, BEHP, mercury, and dioxin/furans in Reach 3 tend to be the second highest of all detections observed in Bayou d'Inde. Two areas of possible contaminant sources are observed; the area between the uppermost Cit-Con Outfall and the Firestone outfall, and the area between OxyChem outfall 001 and Westlake outfall 002B near the LA-108 Bridge. The BERA (CDM 2002c) identified both bayou and marsh areas throughout Reach 2 as high-risk to benthic invertebrates and fish.

Reach 3 is a net sediment exporter. Reach 2 marshes appear to receive contaminated sediments exported by Reach 3. Sediment stability in Reach 2 is low to moderate as supported by contaminant distribution, and is likely mobilized by barge traffic near the docks at LA-108. Further, it appears likely that the shallow depth of Reach 3 makes the area susceptible to turbulence driven mixing due to strong winds or tidal forces.

Maple Fork Bayou
Contaminants that exceed the 95 percent UCL in Maple Fork Bayou include Aroclor-1254, chromium, and zinc. Mercury and dioxin/furans are also present at elevated levels. The BERA (CDM 2002c) identified both bayou and marsh areas throughout Reach 2 as high-risk to benthic invertebrates and fish.

No major contaminant sources are known to exist for Maple Fork Bayou. Anthropogenic releases from the railroad and industrial pipelines that cross Maple Fork Bayou appear to be a possible contaminant source. Contaminant concentrations indicate local release within the bayou.

Maple Fork Bayou appears to be a net sediment exporter. Sediment stability in Maple Fork Bayou is moderate given the limited temporal data available to evaluate the contaminant entry into Maple Fork Bayou. Storm surge or wind forcing may mobilize sediments.

Indian Marais Lagoon
The primary contaminants in Indian Marais Lagoon that exceed the 95 percent UCL include PAHs (HPAH and LPAH), PCBs, lead and zinc. Vertical core data indicate that sediment scouring has occurred in Indian Marais Lagoon.

The leading potential source of contaminants appears to be the former waste handling activities in the Indian Marais Lagoon with some addition from outfalls within the area (e.g., Citgo) or upstream industrial releases to Upper Calcasieu, Bayou Verdine or Bayou d'Inde. The BERA (CDM 2002c) has indicated that Indian Marais is a high risk for benthic invertebrate and fish. Overall, sediment stability appears to be low. Current conditions have led to sediment accumulation, however, historically the site has been susceptible to storm scouring. It appears that material moves out of the lagoon into the ship channel during periods of high flow.

15.4 Conclusions

Calcasieu estuary represents a mixture of land-uses and energy systems. It is a complex system consisting of numerous perennial wetland bayous and tributaries in a heavy industrial setting. Development along the banks of the estuary has culminated in point and non-point discharge to the system that has resulted in impacted sediments than pose a risk to ecological biota.

The estuary can be characterized in many ways, and for the purpose of evaluating sediment stability; an energy-based approach was been chosen for the RI. By grouping areas into energy systems trends in contaminant behavior became apparent. The overall findings of the investigation indicate that the multiple lines of evidence approach yield a comprehensive evaluation of sediment quality within Calcasieu Estuary.

The figures in this section illustrate the primary areas impacted by the highest concentrations. They show correlation to physical conditions that influence contaminant occurrence and transport with the estuary as a whole. The summary is based on those compounds that are most prevalent; most concentrated and/or are a concern from a human health or ecological risk perspective.

Exhibit 15-2 Areas of Interest and Chemicals of Concern for the Calcasieu Estuary - Conclusions

Areas of Interest	PAHs	SVOCs[1]	VOCs	Metals[2]	PCBs	2,3,7,8-TCDD TEQ	Sediment Stability	Potential Sources	Human Health Risk Subsistence/Residential	BERA RISK
Upper Calcasieu										
▪ Clooney Island West Slip	A	A	B	A (Hg, Zn)	A	B	2	Lyondell/Olin, Conoco	High/Indeterminate	High
▪ Clooney Island Loop (East)	C	B	B	B	B	B	2	Conoco, Lyondell		High
▪ Coon Island Loop (East, shallow lake)	B	B	B	A (Cr, Pb); C (Cu)	B	B	2	PPG, Conoco, CONDEA Vista, Oil field Activities		High
▪ Coon Island Loop (PPG North Dock Area and west loop)	A	A	B	A (Pb); C (Cu)	A	C	1	PPG, Conoco, CONDEA Vista, Oil field Activities		High
Bayou Verdine										
▪ Reach 1	A	A	B	A (Zn)	B	B	1	Conoco, CONDEA Vista	High/Indeterminate	High[3]
▪ Reach 2	C	B	A	A (Zn)	B	B	2	Conoco, CONDEA Vista		High[3]
▪ Reach 3	A	B	A	A (Zn)	B	B	1	Conoco, CONDEA Vista		High[3]
Bayou d'Inde										
▪ Lockport Marsh	A	A	B	A (Cu, Hg, Pb, Zn)	A	A	1	PPG, Oil Field Activities	High/High	High
▪ Reach 1	C	A	B	A (Hg, Pb, Zn)	A	A	1	PPG		High
▪ Reach 2	B	B	B	A (Cu, Cr, Hg, Pb, Zn)	A	A	2	Citgo, Equistar, Westlake Polymers		High
▪ Reach 3	C	C	B	A (Cu, Zn)	A	C	2	Citgo, Equistar, Westlake Polymers		High
▪ Maple Fork Bayou	C	B	B	A (Cr, Zn)	A	C	2	Unknown (incl. Railroad activities, interstate runoff, industrial pipelines)		High
▪ Reach 2 Marshes	C	A	B	A (Cr, Cu, Hg)	A	A	3	Citgo, Equistar, Westlake Polymers, PPG		High
Lower Calcasieu										
▪ Indian Marais Lagoon	A	B	B	A (Pb, Zn)	A	B	1	Citgo	High/Indeterminate	High

Concentration Level Classes and Footnotes

A = Area Mean Exceeds the Estuary-wide 95 percent UCL

B = Area Mean does not exceed the Estuary-wide 95 percent UCL

C = Area Mean does not exceed the Estuary-wide 95 percent UCL but area remains AOI due to distribution or compound nature.

[1] - BEHP

[2] - Cr, Cu, Hg, Pb, Zn

[3] - Ecologic Risk for Bayou Verdine performed by Entrix, Inc., 2001 for Conoco

Stability

1 – High potential to re-mobilize

2 – Moderate potential to re-mobilize

3 – Low potential to re-mobilize

BERA (CDM 2002a)

Low Risk = Low

Indeterminate Risk = Ind.

High Risk = High

HHRA (CDM 2002b)

Low risk = excess risk > $1X\ 10^{-6}$

Indeterminate risk = $1\ X\ 10^{-4}$ to $1\ X\ 10^{-6}$

High risk = $<1\ X\ 10^{-4}$

Exhibit 15-2
Areas of Interest and Chemicals of Concern for the Calcasieu Estuary - Conclusions