Exxon Valdez Oil Spill
State/Federal Natural Resource Damage Assessment Annual Report

Assessment of the *Exxon Valdez* Oil Spill on the Sitka Black-Tailed Deer in Prince William Sound and the Kodiak Archipelago

Terrestrial Mammal Study Number 1
Annual Report

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Study History: Terrestrial Mammal Study Number 1 was initiated as part of a detailed study plan in 1989 and the project effort continued through 1990.

Abstract: Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) are the most abundant large mammal in Prince William Sound and the Kodiak Archipelago. Many of the beaches that constitute deer winter habitat, where deer feed extensively on kelp and other marine flora, were oiled by the *Exxon Valdez* oil spill. Hydrocarbon concentrations were measured by analyzing tissues from 32 deer for aliphatic and aromatic hydrocarbons. One deer had elevated concentrations of aliphatic hydrocarbons but normal concentrations of aromatics in liver samples; muscle samples contained no hydrocarbons that indicate exposure. Two other deer had elevated concentrations of both compound types in muscle samples; accidental contamination is presumed. No significant observations of oil ingestion were noted during gross field necropsies. Tissues from 30 deer were submitted for histological analysis. No oil related lesions or pathologies were noted during gross field necropsy nor during later microscopic examination. A pilot deer mortality study located 38 dead deer; based on bone marrow characteristics, starvation appeared to be the primary cause of death. During a second mortality survey conducted in spring 1990, seven deer carcasses were located on the nineteen beaches searched. Starvation seemed to be a major source of winter mortality. Obvious oil related mortality was not observed.

Key Words: Damage assessment, histological analysis, Kodiak Archipelago, mortality surveys, *Odocoileus hemionus sitkensis*, Prince William Sound, Sitka black-tailed deer.

Project Data: there is no available data beyond that summarized in the report.

Citation:

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EXECUTIVE SUMMARY

Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) are the most abundant large mammal in Prince William Sound and the Kodiak Archipelago. They live at or above timberline during the summer, but by late winter they are forced down to beaches that are free from snow. It is on these beaches that deer feed extensively on kelp and other marine flora. Many of the beaches that constitute deer winter habitat were oiled during the *Exxon Valdez* oil spill.

Hydrocarbon concentrations in deer tissues were measured by analyzing tissues from 32 deer for aliphatic and aromatic hydrocarbons. One deer had elevated concentrations of aliphatic hydrocarbons but normal concentrations of aromatics in liver samples. Muscle samples from that deer contained no hydrocarbons that are indicative exposure. Two other deer had elevated concentrations of both compound types in their muscle samples, however, accidental contamination of these samples is presumed. No significant observations of oil ingestion were noted during gross field necropsies. Tissues from 30 deer were submitted for histological analysis. No oil related lesions or pathologies were noted during gross field necropsy nor during later microscopic examination.

Deer mortality was assessed during two searches of winter habitat. A pilot study located 38 dead deer, none of which were determined to have died as a result of oiling. Based on bone marrow characteristics, starvation appeared to be the primary cause of death. Oiling or human disturbance could have led to increased starvation, however, no documentation for this exists.

Aerial surveys were conducted during the winter of 1989-1990 and deer were observed using oiled and unoiled beaches similarly. Because deer were continuing to use oiled beaches, a second mortality survey was conducted during the spring of 1990. Seven deer carcasses were located on the nineteen beaches (15.8 kilometers) that were searched. Again starvation seemed to be a major source of winter mortality. Three deer died from causes other than starvation. Obvious oil related mortality was not observed.

OBJECTIVES

The objectives of this study were as follows:

1. Test the hypothesis that deer on heavily oiled islands have tissues and rumen contents that have been contaminated by oil.

2. Test the hypothesis that deer found dead have rumen contents in their lungs.

3. Estimate the number of dead deer per unit area on both a heavily oiled and a non-oiled island in Prince William Sound, if substantial numbers of deer concentrate on oiled beaches in the late winter of 1989-90, and there is evidence to suggest that some of these deer are dying from oil contamination.

4. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat if injury is identified.

INTRODUCTION

Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) are not native to Prince William Sound nor the Kodiak Archipelago. Between 1916 and 1923, 24 deer were captured near Sitka and transported to Hawkins and Hinchinbrook Islands in Prince William Sound. Deer were introduced to the Kodiak area between 1924 and 1934 when 25 deer were released on Long and Kodiak Islands. Today, deer are the most abundant large mammal in these areas, however, the populations have declined from the highs in 1986-1987 due to wet springs and deep winter snows.

Hawkins, Hinchinbrook, and Montague Islands support the greatest densities of deer in Prince William Sound. The beaches of Hawkins and Hinchinbrook Islands were not affected by the oil spill and only the northern beaches of Montague Island were lightly oiled. Latouche, Green, Knight, and the Naked Island Group, some of which have beaches that were heavily impacted by oil, also support high densities of deer.

Deers are abundant on most islands of the Kodiak group. Shuyak Island to the north, and Uyak Bay on southwest Kodiak Island were the most heavily oiled. Most of the Kodiak Archipelago experienced light or no oiling.

During the summer, deer prefer habitat that is at or above timberline. Deer move into the high timber during fall and are found just below the snow line during the winter months. They continue to feed on evergreen forbs until snow forces them to feed on woody plants such as *Vaccinium spp.* (blueberry). When these plants become scarce, deer concentrate on beaches and feed extensively on intertidal flora such as kelp (Reynolds 1979). Oil covered large amounts of coastal flora in the weeks following the oil spill.

The oil spill may have affected deer reproduction and mortality in a number of different ways. Ingestion of oil can affect the fermentation process in the rumen and potentially cause death from aspiration of rumen fluids into the lungs (Rowe et al. 1972). Exposure to crude oil, or its vapors, can have physiological effects, leading to illness, decreased reproduction, and ultimately death. Additionally, disturbance caused by beach cleanup workers may have displaced deer from the coastal fringe to higher elevations. If animals were forced from beach feeding areas prematurely, limited energy reserves may have been depleted making animals more susceptible to disease and mortality.

STUDY METHODS

Tissue Collection and Analysis

A sample of 32 deer was collected from Prince William Sound and the Kodiak Archipelago by shooting with high power rifles. Collection sites were chosen for their proximity to oiled beaches. Deer were necropsied as soon as possible after death and tissues for hydrocarbon and histopathology analysis were collected according to prescribed protocol. The presence or absence of rumen fluid in the lungs was determined during the necropsy. Histopathology samples were sent to a veterinary pathologist (Dr. Terry Spraker, Colorado State University) for analysis.

Summary of Hydrocarbon Analytical Methods

Muscle and liver samples were analyzed for petroleum hydrocarbons by Texas A&M University, Geochemical and Environmental Research Group, College Station Texas. The samples were freeze dried and extracted in a Soxhlet extraction apparatus. The freeze dried samples were homogenized and a ten gram sample was weighed into the extraction thimble. Surrogate standards and methylene chloride were added and the samples extracted for 12 hours. The extracts were treated with copper to remove sulfur and were purified by silica/alumina column chromatography (MacLeod et al. 1985, Brooks et al. 1989) to isolate the aliphatic and aromatic/pesticide/PCB fractions.

The tissue samples were extracted by the NOAA Status and Trends Method (MacLeod et al. 1985) with minor revisions (Brooks et al. 1989, Wade et al. 1988). The tissue samples were homogenized with a Teckmar Tissuemizer. A one to ten gram sample (wet weight) was extracted with the Teckmar Tissuemizer by adding surrogate standards, Na^2SO^4 and methylene chloride in a centrifuge tube. The tissue extracts were purified by silica/alumina column chromatography to isolate the aliphatic and PAH/pesticide/PCB fractions. The PAH/pesticide/PCB fraction was further purified by HPLC to remove the interfering lipids.

The quantitative analyses were performed by capillary gas chromatography (CGC) with a flame ionization detector for aliphatic hydrocarbons, CGC with electron capture detector for pesticides and PCBs, and a mass spectrometer detector in the SIM mode for aromatic hydrocarbons (Wade et al. 1988).

Mortality Surveys

To determine if there was evidence to suggest that deer were dying from oil contamination, and to determine if a systematic mortality survey should be conducted, a pilot study was conducted from May 25 to June 15, 1989. Three highly experienced deer biologists spent over 235 man-hours surveying nine islands in Prince William Sound and Shuyak Island near Kodiak for deer carcasses They searched from the beaches to an elevation of approximately 600 feet.

To assess the distribution and numbers of deer on oiled and unoiled beaches during the winter of 1989-1990, four aerial surveys of the western islands in Prince William Sound were conducted

between November and February. From small aircraft, biologists recorded observations of deer numbers and behavior, tracks, trails and snow conditions on the beaches.

A second mortality survey was conducted on the beaches of northeast Knight Island, Ingot Island, and Eleanor Island in April 1990. Twenty-three man-hours were spent searching a total of 19 beaches (15.8 linear kilometers) and low elevation deer habitat for evidence of effects of oiled beaches.

During both surveys, carcasses were examined, and age, sex, condition, location, and estimated time and cause of death of each carcass located were recorded. The nutritional condition of the animal prior to death was estimated by examining the marrow within femurs and humeri (long-bones) if available. If the bone contained no marrow, or if the marrow was red, an assumption that fat reserves in the animal had been metabolized prior to death was made. If the marrow was white to yellow and gelatinous, the presence of fat and a cause of death other than malnutrition were assumed (Neiland 1970, Riney 1955). Deer density was inferred subjectively from pellet groups, browse use, tracks, and trails. Beaches were subjectively classified according to oil characteristics.

STUDY RESULTS

Tissue Collection and Analysis

Thirty-two live deer were collected from Prince William Sound and the Kodiak Archipelago. No oil was observed on any of the deer collected from Prince William Sound. Two of the deer collected from Shuyak Island had oil on their feet and legs and were killed near or on an oiled beach. No internal abnormalities that could be linked to oil ingestion or contact were noted during field necropsies.

A total of over 250 tissue samples for hydrocarbon analysis was collected from 46 deer. Thirty two of these deer were shot and the remainder were dead when located.

Muscle and/or liver tissue from 24 of the 32 deer were analyzed for aliphatic and aromatic hydrocarbons. One deer (Deer No. RH-D-10; Lab No. W18064) collected from an oiled beach in Prince William Sound had elevated concentrations of even-numbered long chain alkanes in the muscle but not in the liver. Phytane/pristane ratios and aromatic hydrocarbon concentrations in both tissues from this deer, however, were not indicative of exposure.

Tissues from both the deer collected on oiled beaches on Shuyak Island (Deer Nos. TRS-SBTD-4 and TRS-SBTD-5; Lab Nos. 20476 and 20477) had elevated concentrations of even-numbered long chain alkanes, high phytane/pristane ratios, c1 -c4 naphthalenes of 838 and 3407 ng/g (or parts per billion), dibenzothiophene concentrations of 64 and 226 nb/b, and c1-c3 dibenzothiophenes of 800 and 3579 ng/g in muscle samples. These deer were observed feeding on the oiled beaches and oil covered their legs when they were shot. According to the collector some potential for contamination of these muscle samples exists. Since samples from the liver

(the primary organ for detoxification) of these two deer did not contain any evidence of elevated hydrocarbon concentrations, (Lab Nos. 20479 and 20483) accidental contamination is presumed.

Tissues from 30 deer were sent for histopathological investigation. Tissues from 23 of those deer were also sent for hydrocarbon analysis. Those tissues were microscopically examined for lesions and any other oil related pathology, however none were found.

Mortality Surveys

During the pilot study of nine islands in Prince William Sound and Shuyak Island, 38 dead deer were examined. None had tissues that were suitable for either hydrocarbon or histological analysis. No oil was observed on any of the deer found dead.

Few live deer were observed on either oiled or unoiled beaches during any mortality survey. This may have reflected the natural tendency to move to higher elevations and away from beaches, or it may have been a result of displacement due to human disturbance. Sign of human activity was heavy on all of the beach fringe wintering areas searched. Displacement could have lead to an earlier than normal depletion of stored energy reserves and could have caused some increase in winter mortality.

Deer densities in the area were high prior to the oil spill. Twenty-nine of the 38 deer examined during the pilot study were believed to have died as a result of malnutrition during the somewhat severe winter of 1988-1989. Eight deer were assumed to have died from unidentifiable causes other than starvation or oiling and the type of death of one deer was unknown. Deer that may have been killed by a combination of starvation and oiling, probably would have been classified as starvation mortality by examination for the remaining bone marrow. The typical winter mortality carcass consisted of hair, bones, and some skin. No soft tissues were found and little or no odor could be detected. The composition of starvation mortalities was 17 fawns, seven adult males and five adult females.

Some fresh deer sign was found in all forested areas and many of the beaches walked. For the most part, biologists observed that the *Vaccinium spp.* in the area was heavily browsed. Deer mortalities that could be directly attributed to the oil spill were not detected.

A total of eight hours, distributed over four surveys, was spent in the air documenting the use of oiled and unoiled beaches by deer. The first flight was flown at the end of November 1989 and few deer were observed using the beaches. Snow had not yet covered all other available habitat. Two other flights were flown in late January 1990, and 38 and 74 deer respectively were observed. During a third flight, in February, observers located 104 deer in the beaches. During none of the surveys were any differences in deer behavior, distribution, or numbers detected between oiled and unoiled beaches. Snow depth was observed to be the greatest influence on the deer use of beaches.

Because deer were continuing to use beaches that had been oiled, a follow-up investigation of deer mortality on the beaches of northeast Knight Island, Ingot Island, and Eleanor Island was

conducted in April 1990. During this survey, ten of 19 beaches were subjectively classified as heavily oiled, five beaches as moderately oiled, and four beaches as lightly or not oiled. Each of these classifications is in general agreement with the Alaska Department of Environmental Conservation beach-segment oiling classifications developed from surveys conducted throughout 1989.

A total of seven carcasses were located on three beaches. No deer carcasses were located on the other 16 beaches. All of the carcasses found consisted of only a few bones, skin, and hair. The possibility of oil contributing to the death of these deer could not be confirmed or denied. Of the seven deer, two male fawns and female fawn were located on a large, heavily oiled beach on the eastern shore of Knight Island between Louis Bay and Bay of Isles. Bone marrow was lacking in all three of these deer, suggesting the deer had died of malnutrition.

Four other deer were located on the northeast shore of Knight Island between Louis Bay and Mew Cove. This group was composed of two adult deer of unknown sex, one which had been dead too long for an accurate marrow determination, and one that contained marrow that indicated malnutrition was not the cause of death. One adult male and one female fawn were also found, both of which had healthy active marrow, indicative of some other cause of death than malnutrition.

Generally, deer continued to use oiled and unoiled beaches similarly. Subjective evaluation of density of deer tracks, pellet group density, and browse use, indicated a similar pattern on both types of beaches. It is possible, although unlikely, that some of the seven deer carcasses located during this second survey had drifted into the beaches on which they were found and had not died there. This is based on the exposure of the beaches, and the location of the carcasses when found (in the drift line). No conclusion regarding the effects of oil on deer survival on these beaches could be made.

DISCUSSION

Thirty-two deer were collected for hydrocarbon and histological analysis. Gross field necropsies of collected deer showed no indication of internal effects of oil contamination. Analytical results indicate that up to 13 percent of the deer sampled (three of 24) may have contained some sort of elevated hydrocarbon concentrations. Exposure in one of these deer is uncertain because only one type of hydrocarbon indicator was found in elevated concentrations. The other two deer had high concentrations of aromatics and aliphatics in the muscle, however, no hydrocarbons indicative of exposure in the liver. The collector feels that some possibility of accidental contamination exists.

Histological reports indicate no oil related pathologies found, however, physiological damage to deer cannot be completely ruled out. If deer were only mildly affected by oil ingestion or if they were displaced from critical winter habitats by cleanup activities, they may have been less able to survive the winter. These effects would have been masked by normal late winter malnutrition and starvation.

Mortality surveys conducted in May and June 1989, and April 1990 indicated that the primary cause of deer mortality was starvation. Mortality complicated by oiling was not detected. It is possible that some mortality may have been caused by subjecting deer to increased physiological stress due to contact with oil, or by earlier than normal displacement from their winter habitat due to cleanup related disturbance. This study would not have documented these effects as oil damage but instead would have attributed this type of mortality as malnutrition/winter starvation. This type of indirect mortality was probably the greatest source of damage to deer populations as a result of the oil spill. With the information and methods available, the number of deer affected in this way cannot be estimated.

Two non-oil related pathologies were noted during field necropsies and histological investigations. Lungworm (*Dictyocaulus spp.*) was noted in 28 of 30 deer examined. Lungworm is a parasitic roundworm (Nematoda) that occurs in five stages. Its general life cycle includes ingestion of larva by ruminants while feeding on vegetation, molt in the intestine of the ruminant, transport via the lymph and bloodstream to the lungs where the larvae overwinter, and migration of the fifth stage lungworm to the trachea where it is swallowed and ultimately passed out in the feces (Dau 1981).

The most significant effect of lungworm infection is its frequent association with pneumonia. Pneumonia is thought to be a result of the secondary infection of lung tissues that have been affected by the worms (Anderson 1971). Lungworm and the associated pneumonia have been suggested as the primary natural regulating force of bighorn sheep populations in the Rocky Mountains (Buechner 1960, Forrester and Senger 1964).

Cryptorchidism (failure of the testes to descend) was also noted in one of six males that were examined. Bilateral cryptorchidism would lead to sterility because of the temperature of the abdominal environment in which the testes are retained. Unilateral cryptorchids are usually fertile, however, sperm count would be reduced from normal (Jubb and Kennedy 1970). If some deer are unable to reproduce it may be of importance to the current reproductive potential of the population as a whole. Cryptorchidism is more likely attributable to the small gene pool derived from the original transplant of only 24 deer. Some deer may possess the gene for cryptorchidism but not exhibit the trait. Subsequent transplants from this population should be sufficiently large to ensure that cryptorchidism is not a predominant trait in the transplanted gene pool.

CONCLUSIONS

Laboratory analysis of samples of deer muscles and livers found no conclusive evidence of hydrocarbon exposure in deer Three samples contained hydrocarbons indicative of exposure, however, possible contamination and difficulty in interpretation of hydrocarbon data do not allow for an interpretation of exposure to oil from the *Exxon Valdez* oil spill.

Field necropsies and histological examination of deer tissues detected no abnormalities associated with oil.

Mortality from oil exposure was not documented. The primary cause of death of deer found dead on the beaches was winter starvation. Oil exposure and premature displacement of deer from late winter habitat by cleanup activities probably were the greatest contributors to any increased mortality due to the oil spill. This study did not assess displacement mortality. Future damage assessment projects should address this form of mortality. A rapid response by investigators in the field may be the best opportunity to document displacement.

Further data collection and analysis on this project would not be expected to provide additional documentation of injury.

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Appendix A:

GERG Analytical Methohds
&
Tissue Sample Hydrocarbon Data

Summary of GERG Analytical Methods

The sediment samples were freeze-dried and extracted in a Soxhlet extraction apparatus. A flow diagram of the procedure is attached. Briefly, the freeze-dried sediment samples were homogenized and a 10-gram sample was weighed into the extraction thimble. Surrogate standards and methylene chloride were added and the samples extracted for 12 hrs. The extracts were treated with copper to remove sulfur and were purified by silica/alumina column chromatography (MacLeod *et al.*, 1985; Brooks *et al.*, 1989) to isolate the aliphatic and aromatic/pesticide/PCB fractions.

The tissue samples were extracted by the NOAA Status and Trends Method (MacLeod *et al.*, 1985) with minor revisions (Brooks *et al.*, 1989; Wade *et al.*, 1988). A flow diagram of the procedure is attached. Briefly, the tissue samples were homogenized with a Teckmar Tissumizer. A 1 to 10-gram sample (wet weight) was extracted with the Teckmar Tissumizer by adding surrogate standards, Na_2SO_4, and methylene chloride in a centrifuge tube. The tissue extracts were purified by silica/alumina column chromatography to isolate the aliphatic and PAH/pesticide/PCB fractions. The PAH/pesticide/PCB fraction was further purified by HPLC in order to remove interfering lipids.

The quantitative analyses were performed by capillary gas chromatography (CGC) with a flame ionization detector for aliphatic hydrocarbons, CGC with electron capture detector for pesticides and PCB's, and a mass spectrometer detector in the SIM mode for aromatic hydrocarbons (Wade *et al..*, 1988).

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NATIONAL RESOURCE DAMAGE ASSESSMENT - GENERAL INFORMATION - CATALOG # 6113

INVEST#:					
ID:	20474	20475	20476	20477	20479
LABSAMNO:	N2287	N2289	N2291	N2293	N2295
METHOD:	GCFID	GCFID	GCFID	GCFID	GCFID
LABSAMNO:	N2288	N2290	N2292	N2294	N2296
METHOD:	GCMS	GCMS	GCMS	GCMS	GCMS
QCBATCH:	NP003	NP003	NP003	NP003	NP003
LAB:	GERG	GERG	GERG	GERG	GERG
MATRIX:	TISSUE	TISSUE	TISSUE	TISSUE	TISSUE
SUBMAT:	LIVER	LIVER			LIVER
SAMPLWT:					
WETWT:	2.21	2.09	5.37	5.32	2.48
DRYWT:	0.70	0.69	0.68	0.72	0.75
VOL:					
ACEND10:	103.0	72.6	66.0	88.0	71.4
BENAD12:					
CHRYD12:	83.9	77.0	113.5	105.5	87.8
FLUOD10:					
NAPHD8:	76.4	65.7	47.0	71.4	66.3
PERYD12:	66.3	81.4	121.8	142.7	107.8
PHEND10:	92.8	81.2	70.0	93.4	88.1
C12ALKD:	82.2	80.3	101.1	89.6	70.6
C20ALKD:	92.6	87.9	119.4	79.2	87.2
C24ALKD:	93.8	87.4	116.6	137.6	87.8
C30ALKD:	94.1	85.8	110.4	91.1	85.6
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LABNAME: GERG/TAMU DATE: 27-Apr-90 LAB APPROVAL: Terry L. Wade

NATIONAL RESOURCE DAMAGE ASSESSMENT - GENERAL INFORMATION - CATALOG # 6113

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LABSAMNO:	N2298	N2300	N2302	N2304	N2306
METHOD:	GCMS	GCMS	GCMS	GCMS	GCMS
QCBATCH:	MP003	MP003	MP003	MP003	MP003
LAB:	GERG	GERG	GERG	GERG	GERG
MATRIX:	TISSUE	TISSUE	TISSUE	TISSUE	TISSUE
SUBMAT:	LIVER	LIVER	LIVER		LIVER
SAMPLWT:					
WETWT:	2.50	2.51	2.55	5.23	2.24
DRYWT:	0.63	0.74	0.57	0.63	0.62
VOL:					
ACEND10:	74.2	79.7	56.2	81.1	66.9
BENAD12:					
CHRYD12:	79.5	74.8	70.9	79.5	79.1
FLUOD10:					
NAPHD8:	67.4	60.7	52.3	56.6	57.6
PERYD12:	90.0	83.6	86.5	88.5	74.5
PHEND10:	92.3	79.8	68.0	78.2	80.2
C12ALKD:	74.1	73.3	74.7	78.3	83.0
C20ALKD:	86.0	87.1	85.2	88.1	88.5
C24ALKD:	83.6	88.5	85.0	86.2	88.8
C30ALKD:	82.9	85.8	85.6	88.1	85.6
INTFLAG:					
PON:	85800-0-6017	85800-0-6017	85800-0-6017	85800-0-6017	85800-0-6017
CATNO:	6113	6113	6113	6113	6113

LABNAME: GERG/TAMU DATE: 27-Apr-90 LAB APPROVAL: Terry L. Wade

NATIONAL RESOURCE DAMAGE ASSESSMENT - GENERAL INFORMATION - CATALOG # 6113

INVEST#:	PROC BLANK	SPIKED MATRIX	SPIKED MATRIX
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METHOD:	GCFID	GCFID	GCFID
LABSAMNO:	U0146	U0148	U0150
METHOD:	GCMS	GCMS	GCMS
QCBATCH:	MP003	MP003	MP003
LAB:	GERG	GERG	GERG
MATRIX:		TISSUE	TISSUE
SUBMAT:			
SAMPLWT:			
WETWT:		2.12	2.30
DRYWT:		0.47	0.51
VOL:			
ACEND10:	74.7	75.2	70.7
BENAD12:			
CHRYD12:	59.6	93.8	85.3
FLUOD10:			
NAPHD8:	66.4	65.9	59.1
PERYD12:	67.6	107.6	104.5
PHEND10:	81.0	87.5	84.5
C12ALKD:	80.0	82.7	79.9
C20ALKD:	89.0	93.7	93.7
C24ALKD:	92.2	89.0	95.3
C30ALKD:	85.0	93.6	98.0
INTFLAG:			
PON:	85800-0-6017	85800-0-6017	85800-0-6017
CATNO:	6113	6113	6113

LABNAME: GERG/TAMU DATE: 27-Apr-90 LAB APPROVAL: Terry L. Wade

NATIONAL RESOURCE DAMAGE ASSESSMENT - ALIPHATIC HYDROCARBON DATA - CATALOG # 6113

INVEST#:					
ID:	20474	20475	20476	20477	20479
LABSAMNO:	N2287	N2289	N2291	N2293	N2295
Alkanes and Isoprenoids	Conc DB QUAL	Conc DB QUAL	Conc DB QUAL	Conc DB QUAL	Conc DB QUAL
UNIT:	ng/g	ng/g	ng/g	ng/g	ng/g
C10	73.59	0.00	4087.71	9843.98	90.72
C11	0.00	0.00	143.84	45.32	0.00
C12	0.00	0.00	172.76	179.49	18.51
C13	15.37	13.20	736.57	850.93	25.33
C14	32.17	21.60	1766.02	1129.80	33.22
C15	0.00	0.00	4741.77	5504.77	15.17
C16	114.49	0.00	5006.89	1425.88	84.35
C17	60.00	0.00	5639.30	2334.15	58.01
PRISTANE	0.00	0.00	4130.84	1390.34	57.38
C18	28.29	0.00	5463.30	2150.46	25.18
PHYTANE	24.52	0.00	3455.01	1275.05	72.91
C19	20.39	0.00	5351.69	2012.84	21.30
C20	0.00	0.00	5419.11	1867.21	31.19
C21	109.15	34.68	5382.43	2016.56	33.07
C22	15.32	0.00	4954.41	1810.67	155.85
C23	202.56	95.25	5928.87	1291.54	64.45
C24	29.54	18.38	4633.02	954.97	27.46
C25	301.55	215.21	6968.49	1261.29	51.05
C26	28.09	0.00	3163.65	766.13	26.94
C27	713.78	499.53	16416.18	1056.42	32.23
C28	54.38	25.24	5725.20	550.49	22.43
C29	1363.78	566.05	57598.23	1448.81	170.02
C30	108.53	0.00	5394.49	583.33	15.76
C31	2295.00	727.41	81313.94	3497.55	834.20
C32	71.46	28.01	3128.57	519.50	50.75
C33	1653.73	444.86	29020.75	3164.70	888.80
C34	0.00	0.00	1253.22	446.77	0.00
TOT ALKANES	7315.7	2689.4	276996.3	49378.9	2906.3
UNIT:	ug/g	ug/g	ug/g	ug/g	ug/g
UCM	13.0	8.6	754.6	336.8	0.0
Surrogate Recoveries					
C12ALKD:	82.2	80.3	101.1	89.6	70.6
C20ALKD:	92.6	87.9	119.4	79.2	87.2
C24ALKD:	93.8	87.4	116.6	137.6	87.8
C30ALKD:	94.1	85.8	110.4	91.1	85.6

LABNAME: GERG/TAMU DATE: 27-Apr-90 LAB APPROVAL: Terry L. Wade

NATIONAL RESOURCE DAMAGE ASSESSMENT - ALIPHATIC HYDROCARBON DATA - CATALOG # 6113

INVEST#:					
ID:	20478	20480	20481	20482	20483
LABSAMNO:	N2297	N2299	N2301	N2303	N2305
Alkanes and Isoprenoids	Conc DB QUAL	Conc DB QUAL	Conc DB QUAL	Conc DB QUAL	Conc DB QUAL
UNIT:	ng/g	ng/g	ng/g	ng/g	ng/g
C10	42.23	75.88	73.40	8779.22	44.77
C11	0.00	0.00	37.99	21.21	0.00
C12	0.00	0.00	17.20	10.12	0.00
C13	0.00	0.00	11.76	13.00	0.00
C14	0.00	24.13	27.95	32.70	0.00
C15	15.18	0.00	62.07	6644.58	10.71
C16	53.65	61.70	57.49	67.45	30.97
C17	33.15	34.84	84.82	101.71	29.51
PRISTANE	0.00	0.00	0.00	0.00	30.74
C18	0.00	27.20	19.73	442.90	13.33
PHYTANE	0.00	0.00	0.00	82.63	42.47
C19	0.00	0.00	0.00	115.46	10.49
C20	0.00	0.00	0.00	26.02	15.31
C21	0.00	29.08	0.00	201.82	17.04
C22	0.00	0.00	0.00	52.03	16.05
C23	0.00	65.95	0.00	370.05	19.11
C24	0.00	0.00	0.00	44.60	14.01
C25	0.00	51.38	34.08	393.92	25.22
C26	0.00	0.00	0.00	94.97	13.50
C27	58.16	75.41	38.60	1091.39	56.05
C28	0.00	0.00	15.84	4.98	0.00
C29	108.74	191.72	77.34	2843.77	233.89
C30	0.00	58.92	34.85	421.96	53.08
C31	195.68	319.54	149.27	2201.72	581.92
C32	0.00	0.00	0.00	127.45	26.92
C33	189.85	197.73	107.63	359.04	292.82
C34	0.00	0.00	28.70	0.00	0.00
TOT ALKANES	696.7	1213.5	878.7	24544.7	1577.9
UNIT:	ug/g	ug/g	ug/g	ug/g	ug/g
UCM	0.0	0.0	0.0	108.2	0.0
Surrogate Recoveries					
C12ALKD:	74.1	73.3	74.7	78.3	83.0
C20ALKD:	86.0	87.1	85.2	88.1	88.5
C24ALKD:	83.6	88.5	85.0	86.2	88.8
C30ALKD:	82.9	85.8	85.6	88.1	85.6

LABNAME: GERG/TAMU DATE: 27-Apr-90 LAB APPROVAL: Terry L. Wade

NATIONAL RESOURCE DAMAGE ASSESSMENT - ALIPHATIC HYDROCARBON DATA - CATALOG # 6113

INVEST#:	PROC BLANK	SPIKED MATRIX	SPIKED MATRIX
ID:		20481	20481
LABSAMNO:	U0145	U0147	U0149
Alkanes and Isoprenoids	Conc DB QUAL	% Recov DB QUAL	% Recov DB QUAL
UNIT:	ng/g	%	%
C10	0.00	NA	NA
C11	0.00	NA	NA
C12	0.00	101.41	94.66
C13	0.00	NA	NA
C14	0.00	NA	NA
C15	0.00	102.34	100.32
C16	0.00	NA	NA
C17	16.03	97.06	94.43
PRISTANE	0.00	97.66	95.56
C18	0.00	95.45	93.95
PHYTANE	0.00	NA	NA
C19	0.00	NA	NA
C20	0.00		
C21	0.00	99.68	98.80
C22	0.00	NA	NA
C23	0.00	NA	NA
C24	73.66	110.00	101.51
C25	0.00	NA	NA
C26	0.00	NA	NA
C27	0.00	NA	NA
C28	0.00	107.17	98.81
C29	0.00	NA	NA
C30	0.00	99.84	94.43
C31	0.00	NA	NA
C32	0.00	118.05	111.86
C33	0.00	NA	NA
C34	0.00	103.14	98.75
TOT ALKANES	89.7	NA	NA
UNIT:	ug/g	ug/g	ug/g
UCM	0.0	NA	NA
Surrogate Recoveries			
C12ALKD:	80.0	82.7	79.9
C20ALKD:	89.0	93.7	93.7
C24ALKD:	92.2	89.0	95.3
C30ALKD:	85.0	93.6	98.0

LABNAME: GERG/TAMU DATE: 27-Apr-90 LAB APPROVAL: Terry L. Wade

NATIONAL RESOURCE DAMAGE ASSESSMENT - AROMATIC HYDROCARBON DATA - CATALOG # 6113

INVEST#:					
ID:	20474	20475	[illegible]	[illegible]	20479
LABSAMNO:	N2288	N2290	N2292	N2294	N2296
UNIT:	ng/g	ng/g	ng/g	ng/g	ng/g
PNA Analyte	Conc DB QUAL	Conc DB QUAL	Conc DB QUAL	Conc DB QUAL	Conc DB QUAL
NAPHTHALENE	4.78	4.73	3.73	2.29	6.74
C1-NAPHTHALENES	0.00	0.00	68.70	26.70	0.00
C2-NAPHTHALENES	0.00	0.00	593.20	181.20	0.00
C3-NAPHTHALENES	0.00	0.00	1469.90	362.20	0.00
C4-NAPHTHALENES	0.00	0.00	1272.30	265.90	0.00
BIPHENYL	0.12	0.75	20.92	8.24	1.94
ACENAPHTHYLENE	4.68	4.73	0.69	1.45	3.77
ACENAPHTHENE	0.48	1.06	7.38	2.10	1.16
FLUORENE	4.20	3.81	55.96	15.81	4.32
C1-FLUORENES	0.00	0.00	273.50	85.10	0.00
C2-FLUORENES	0.00	0.00	0.00	192.90	0.00
C3-FLUORENES	0.00	0.00	761.00	182.20	0.00
PHENANTHRENE	2.67	2.61	348.03	86.77	2.72
ANTHRACENE	0.00	0.00	31.63	2.05	0.00
C1-PHEN_ANTHR	0.00	0.00	112.70	266.50	0.00
C2-PHEN_ANTHR	0.00	0.00	1569.90	374.80	0.00
C3-PHEN_ANTHR	0.00	0.00	1232.20	278.70	0.00
C4-PHEN_ANTHR	0.00	0.00	721.20	160.30	0.00
DIBENZOTHIO	0.68	0.65	225.90	64.24	1.38
C1-DIBEN	0.00	0.00	757.30	178.20	0.00
C2-DIBEN	0.00	0.00	1428.70	317.80	0.00
C3-DIBEN	0.00	0.00	1393.10	304.20	0.00
FLUORANTHENE	3.44	3.50	54.89	7.67	3.00
PYRENE	1.32	1.74	31.44	5.67	1.54
C1-FLUORAN_PYR	0.00	0.00	213.50	57.50	0.00
BENaANTHRACENE	0.00	5.62	17.91	5.00	4.69
CHRYSENE	3.78	3.91	87.37	29.75	3.81
C1-CHRYSENES	0.00	0.00	167.90	78.80	0.00
C2-CHRYSENES	0.00	0.00	227.50	112.90	0.00
C3-CHRYSENES	0.00	0.00	121.10	67.90	0.00
C4-CHRYSENES	0.00	0.00	89.70	45.60	0.00
BENbFLUORAN	0.00	0.00	8.56	0.79	0.00
BENkFLUORAN	0.00	0.00	9.09	0.84	0.00
BENePYRENE	0.00	0.00	24.87	5.20	0.00
BENaPYRENE	0.00	0.00	7.10	0.83	0.00
PERYLENE	1.32	1.17	2.45	1.05	0.92
I123cdPYRENE	5.32	5.35	3.34	2.22	4.60
DBahANTHRA	0.59	0.42	6.96	1.43	1.53
BghiPERYLENE	0.00	0.00	9.05	3.57	0.00

LABNAME: GERG/TAMU DATE: 27-Apr-90 LAB APPROVAL: Terry L. Wade

NATIONAL RESOURCE DAMAGE ASSESSMENT - AROMATIC HYDROCARBON DATA (CONT)- CATALOG # 6113

INVEST#:					
ID:	20474	20475	20476	20477	20479
LABSAMNO:	N2288	N2290	N2292	N2294	N2296
UNIT:	ng/g	ng/g	ng/g	ng/g	ng/g
Analyte (Cont)	Conc DB QUAL	Conc DB QUAL	Conc DB QUAL	Conc DB QUAL	Conc DB QUAL
2-METHYLNAPH	6.30	12.08	85.94	35.32	9.58
1-METHYLNAPH	6.55	7.43	57.74	24.75	6.58
2,6-DIMETHNAPH	1.34	2.98	163.53	61.15	2.17
2,3,5-TRIMETHNAPH	4.83	5.13	298.29	86.53	7.71
1-METHYLPHEN	1.83	0.62	239.01	81.53	1.56
Surrogate Recoveries					
NAPHD8:	76.4	65.7	47.0	71.4	66.3
ACEND10:	103.0	72.6	66.0	88.0	71.4
PHEND10:	92.8	81.2	70.0	93.4	88.1
CHRYD12:	83.9	77.0	113.5	105.5	87.8
PERYD12:	66.3	81.4	121.8	142.7	107.8

LABNAME: GERG/TAMU DATE: 27-Apr-90 LAB APPROVAL: Terry L. Wade

NATIONAL RESOURCE DAMAGE ASSESSMENT - AROMATIC HYDROCARBON DATA - CATALOG # 6113

INVEST#:										
ID:	20478		20480		20481		20482		20483	
LABSAMNO:	N2298		N2300		N2302		N2304		N2306	
UNIT:	ng/g		ng/g		ng/g		ng/g		ng/g	
PNA Analyte	Conc	DB QUAL	Conc	DB QUAL	Conc	DB QUAL	Conc	DB QUAL	Conc	DB QUAL
NAPHTHALENE	3.44		6.01		5.92		2.49		4.21	
C1-NAPHTHALENES	0.00		0.00		0.00		0.00		0.00	
C2-NAPHTHALENES	0.00		0.00		0.00		0.00		0.00	
C3-NAPHTHALENES	0.00		0.00		0.00		0.00		0.00	
C4-NAPHTHALENES	0.00		0.00		0.00		0.00		0.00	
BIPHENYL	0.00		0.31		0.00		0.17		0.45	
ACENAPHTHYLENE	4.09		3.71		3.88		2.38		4.88	
ACENAPHTHENE	1.26		0.00		1.26		0.40		0.97	
FLUORENE	3.04		2.94		3.61		1.66		3.51	
C1-FLUORENES	0.00		0.00		0.00		0.00		0.00	
C2-FLUORENES	0.00		0.00		0.00		0.00		0.00	
C3-FLUORENES	0.00		0.00		0.00		0.00		0.00	
PHENANTHRENE	2.68		3.17		3.01		1.67		2.09	
ANTHRACENE	0.00		0.00		0.00		0.00		0.00	
C1-PHEN_ANTHR	0.00		0.00		0.00		0.00		0.00	
C2-PHEN_ANTHR	0.00		0.00		0.00		0.00		0.00	
C3-PHEN_ANTHR	0.00		0.00		0.00		0.00		0.00	
C4-PHEN_ANTHR	0.00		0.00		0.00		0.00		0.00	
DIBENZOTHIO	1.07		0.40		0.68		0.81		2.18	
C1-DIBEN	0.00		0.00		0.00		0.00		0.00	
C2-DIBEN	0.00		0.00		0.00		0.00		0.00	
C3-DIBEN	0.00		0.00		0.00		0.00		0.00	
FLUORANTHENE	2.94		2.74		2.82		0.68		3.27	
PYRENE	1.47		1.55		1.40		1.03		1.62	
C1-FLUORAN_PYR	0.00		0.00		0.00		0.00		0.00	
BENaANTHRACENE	4.90		4.62		4.48		2.26		5.39	
CHRYSENE	3.57		3.52		3.18		1.96		3.92	
C1-CHRYSENES	0.00		0.00		0.00		0.00		0.00	
C2-CHRYSENES	0.00		0.00		0.00		0.00		0.00	
C3-CHRYSENES	0.00		0.00		0.00		0.00		0.00	
C4-CHRYSENES	0.00		0.00		0.00		0.00		0.00	
BENbFLUORAN	0.00		0.00		0.00		0.00		0.00	
BENkFLUORAN	0.00		0.00		0.00		0.00		0.00	
BENePYRENE	0.00		0.00		0.00		0.00		0.00	
BENaPYRENE	0.00		0.00		0.00		0.00		0.00	
PERYLENE	0.00		0.88		0.82		0.00		0.00	
I123cdPYRENE	0.00		4.51		4.67		0.00		0.00	
DBahANTHRA	0.00		0.00		0.00		0.36		0.00	
BghiPERYLENE	0.00		4.12		4.04		0.00		4.52	

LABNAME: GERG/TAMU DATE: 27-Apr-90 LAB APPROVAL: Terry L. Wade

NATIONAL RESOURCE DAMAGE ASSESSMENT - AROMATIC HYDROCARBON DATA (CONT)- CATALOG # 6113

INVEST#:					
ID:	20478	20480	20481	20482	20483
LABSAMNO:	N2298	N2300	N2302	N2304	N2306
UNIT:	ng/g	ng/g	ng/g	ng/g	ng/g
Analyte (Cont)	Conc DB QUAL	Conc DB QUAL	Conc DB QUAL	Conc DB QUAL	Conc DB QUAL
2-METHYLNAPH	8.46	9.88	7.83	4.38	8.62
1-METHYLNAPH	5.52	5.29	5.52	3.57	6.15
2,6-DIMETHNAPH	1.69	2.70	2.37	1.65	2.39
2,3,5-TRIMETHNAPH	3.73	4.18	7.01	2.93	4.58
1-METHYLPHEN	2.87	1.19	1.94	0.71	1.54
Surrogate Recoveries					
NAPHD8:	67.4	60.7	52.3	56.6	57.6
ACEND10:	74.2	79.7	56.2	81.1	66.9
PHEND10:	92.3	79.8	68.0	78.2	80.2
CHRYD12:	79.5	74.8	70.9	79.5	79.1
PERYD12:	90.0	83.6	86.5	88.5	74.5

LABNAME: GERG/TAMU DATE: 27-Apr-90 LAB APPROVAL: Terry L. Wade

NATIONAL RESOURCE DAMAGE ASSESSMENT - AROMATIC HYDROCARBON DATA - CATALOG # 6113

INVEST#:	PROC BLANK		SPIKED MATRIX		SPIKED MATRIX	
ID:			20481		20481	
LABSAMNO:	U0146		U0148		U0150	
UNIT:	ng/g		%		%	
PNA Analyte	Conc	DB QUAL	% Recov	DB QUAL	% Recov	DB QUAL
NAPHTHALENE	4.06		89.7		87.7	
C1-NAPHTHALENES	10.15			NA		NA
C2-NAPHTHALENES	0.00			NA		NA
C3-NAPHTHALENES	0.00			NA		NA
C4-NAPHTHALENES	0.00			NA		NA
BIPHENYL	0.02		98.5		94.4	
ACENAPHTHYLENE	4.49		93.0		88.0	
ACENAPHTHENE	0.00		97.2		92.3	
FLUORENE	4.10		93.9		92.9	
C1-FLUORENES	0.00			NA		NA
C2-FLUORENES	0.00			NA		NA
C3-FLUORENES	0.00			NA		NA
PHENANTHRENE	1.89		97.1		92.0	
ANTHRACENE	0.00		94.1		88.2	
C1-PHEN_ANTHR	0.00			NA		NA
C2-PHEN_ANTHR	0.00			NA		NA
C3-PHEN_ANTHR	0.00			NA		NA
C4-PHEN_ANTHR	0.00			NA		NA
DIBENZOTHIO	1.06		105.4		99.9	
C1-DIBEN	0.00			NA		NA
C2-DIBEN	0.00			NA		NA
C3-DIBEN	0.00			NA		NA
FLUORANTHENE	3.49		109.0		101.1	
PYRENE	1.32		98.8		91.5	
C1-FLUORAN_PYR	0.00			NA		NA
BENaANTHRACENE	1.10		84.6		87.2	
CHRYSENE	4.64		102.8		101.0	
C1-CHRYSENES	0.00			NA		NA
C2-CHRYSENES	0.00			NA		NA
C3-CHRYSENES	0.00			NA		NA
C4-CHRYSENES	0.00			NA		NA
BENbFLUORAN	0.00		84.3		81.5	
BENkFLUORAN	0.00		89.5		86.6	
BENePYRENE	0.00		109.0		99.3	
BENaPYRENE	0.00		74.3		70.2	
PERYLENE	1.36		84.7		88.4	
I123cdPYRENE	0.00		68.2		70.7	
DBahANTHRA	1.39		93.5		100.9	
BghiPERYLENE	5.17		63.5		61.8	

LABNAME: GERG/TAMU DATE: 27-Apr-90 LAB APPROVAL: Terry L. Wade

NATIONAL RESOURCE DAMAGE ASSESSMENT - AROMATIC HYDROCARBON DATA (CONT)- CATALOG # 6113

INVEST#:	PROC BLANK	SPIKED MATRIX	SPIKED MATRIX
ID:	0	20481	20481
LABSAMNO:	U0146	U0148	U0150
UNIT:	ng/g	%	%
Analyte (Cont)	Conc DB QUAL	% Recov DB QUAL	% Recov DB QUAL
2-METHYLNAPH	7.07	139.8	143.2
1-METHYLNAPH	3.08	108.4	106.5
2,6-DIMETHNAPH	1.50	85.4	82.6
2,3,5-TRIMETHNAPH	4.67	91.3	89.6
1-METHYLPHEN	0.87	100.4	91.5
Surrogate Recoveries			
NAPHD8:	66.4	65.9	59.1
ACEND10:	74.7	75.2	70.7
PHEND10:	81.0	87.5	84.5
CHRYD12:	59.6	93.8	85.3
PERYD12:	67.6	107.6	104.5

LABNAME: GERG/TAMU DATE: 07-May-90 LAB APPROVAL: Terry L. Wade