137611

found in wells sunk near the fly ash pile and between the solid waste drainage area and Twine Hollow Road to the south.

It should be noted, however, that the maximum detected concentration of arsenic was only 5 ug/L which is 10 times lower than the MCL for arsenic (50 ug/L). In addition, recent evidence suggest that the slope factor for arsenic is based on a non-lethal cancerous effect (i.e., skin rash). Also, exposure to arsenic may have a threshold (similar to a noncarcinogenic effect), for which the maximum concentration does not exceed.

The potential noncarcinogenic hazards to hypothetical residents due to use of groundwater are presented in Table 6-40. Since none of the identified chemicals of potential concern were volatile organics, only ingestion was evaluated. The hazard index associated with ingestion of groundwater at the DCL site exceeded unity by a factor of 5, mainly due to antimony and manganese, the only contaminants with hazard quotients that exceeded one. Therefore, noncarcinogenic effects from ingestion of groundwater from the DCL site may occur. Antimony was detected in four monitoring wells: RIW-1, RIW-7, RIW-10, and RIW-12. Manganese was detected in all monitoring wells, with the highest levels found at RIW-2 and RIW-10. It should be noted, however, that the RfD for antimony was derived using an uncertainty factor of 1,000.

Table 6-40

Potential Noncarcinogenic Risks Associated with Use of Groundwater at the Dixie Caverns Landfill Site by Hypothetical Residents for the RME Case (a)

Chemical	Total RME Chronic Daily Intake (mg/kg/day)	RfD (mg/kg/day)	RfD Uncertainty Factor	Hazard Quotient
Organics:				
Naphthalene	1.9E-04	4.0E-03	10000	4.8E-02
Inorganics:				
Antimony	1.3E-03	4.0E-04	1000	3.2E+00
Arsenic	3.5E-04	1.0E-03	1	3.5E-01
Barium	3.9E-02	7.0E-02	3	5.6E-01
Chromium	6.7E-04	5.0E-03	500	1.3E-01
Manganese	1.1E-01	1.0E-01	1	1.1E+00
Silver	1.3E-04	3.0E-03	2	4.3E-02
		Total Hazard Index:		5E+00

(a) Exposure routes include ingestion and dermal absorption while bathing. Naphthalene and inorganics are not volatile; therefore, exposure via inhalation while showering would not occur.

6.1.6 Uncertainties Associated with the Human Health Risk Assessment

This section outlines the uncertainties associated with the results of the Dixie Caverns Landfill site baseline risk assessment. The primary areas of uncertainty include: 1) environmental sampling and analysis; 2) estimation of exposure; and 3) toxicity assessment. An overview of the primary areas of uncertainty in the quantitative risk assessment is presented in Table 6-41 and is discussed below.

6.1.6.1 Environmental Sampling and Analysis

As discussed in Section 6.1.2, monitoring data collected from groundwater, surface and subsurface soil, surface water, and sediments were used to characterize the extent of contamination in these media. These data were considered to be representative of site contamination, yet the degree to which the RI data characterize site contamination is unknown. For example, the potential impact of seasonal variability on site contamination may not be fully evaluated. The extent of sampling of groundwater, soil, surface water, and sediment, however, was considered to be extensive relative to other typical landfill Remedial Investigations. Given the uncertainty associated with the monitoring data, the 95th UCL on the arithmetic mean was used when estimating exposure for the various exposure pathways evaluated in this assessment in order that potential exposure would not be underestimated.

Another area of uncertainty concerns the treatment of non-detected concentrations in the quantitative assessment of risk. One-half of the Sample Quantitation Limit (SQL) was used as the detection limit for samples qualified with a "U," "UJ," or "UL" qualifier. The actual concentration of the contaminant may be zero to just below the SQL. In all probability, the actual concentration may be below one-half the SQL given that the instrument detection limit (IDL) is often much lower than one-half the SQL. The methods used to evaluate non-detects in this assessment, however, probably do not contribute significantly to the overall uncertainty of the results (probably less than a factor of 2).

Table 6-41

Uncertainties Associated with the Dixie Caverns Landfill Site
Baseline Risk Assessment

Source of Uncertainty	Effect on Estimated Risk (a): Potential for Over-Estimation of Risk	Potential for Under-Estimation of Risk	Potential for Over or Under-Estimation of Risk
Environmental Sampling and Analysis			
Available sampling data used to characterize the extent of contamination at the site			Low
Chemicals of Potential Concern were assumed to be site related.	Moderate		
Systematic and/or random errors in analysis and reporting			Low
TICs were not quantitatively evaluated		Low	
Estimation of Exposure			
Exposure paramaters were assumed to be characteristic of the potentially exposed population	Moderate		
The amount of media intake is assumed to be constant and representative of the exposed population	Moderate		
Toxicity Assessment			
An additive model is used to evaluate risk from a chemical mixture			Moderate
Toxicity criteria not available for certain chemicals of potential concern		Low	
Conservative methods used to derive toxicity criteria (particularly slope factors [see text])	Moderate to high		

(a) As a general guideline, assumptions marked as "low" may affect estimates of exposure by less than one order of magnitude; assumptions marked "moderate" may affect estimates of exposure by between one and two orders of magnitude; and assumptions marked "high" may affect estimates of exposure by more than two orders of magnitude.

For many of the inorganic compounds detected in groundwater, it is uncertain whether these chemicals are within natural background. Particularly, the site relatedness of arsenic, antimony, and manganese which resulted in significant risk estimates is questionable. No site-specific or regional background data were available for comparing inorganic concentrations found in monitoring wells.

Another potential source of uncertainty involves the analytical methods used to quantify the levels of contaminants in samples collected at the DCL site. There is a certain degree of variability associated with the ability of laboratory instruments to quantify low levels of a compound in a sample. This variability tends to be normally distributed. The potential contribution of this source of uncertainty, however, is considered to be low given QA/QC requirements for samples and analysis.

Several TICs were identified in groundwater, soil, surface water, and sediment. Given the uncertainty associated with their identification and concentration, as well as the lack of toxicity criteria, these compounds were not quantitatively evaluated in this report. Thus, the risks associated with contact with various media may be underestimated. However, the source of certain unknown hydrocarbons found in surface water and sediment may not be site related but rather from other anthropogenic activities.

6.1.6.2 Estimation of Exposure

As discussed in Sections 6.1.3 and 6.1.5, conservative assumptions were used to estimate exposure for the various exposure pathways quantitatively evaluated in this report. Under current land-use conditions, it was assumed that children would play in streams and groundwater seeps 125 days per year for 10 years. During these play activities, children would incidentally ingest 140 mg of sediment each day. Similar assumptions were used to estimate exposure from direct contact with surface soil at the DCL site. In addition, children were assumed to contact surface water and sediments over one-third of the surface area of their hands, arms, and legs. These are conservative assumptions used to evaluate a reasonable maximum exposure case. The likelihood of children in the area actually engaging in such behavior is unknown.

For future land-use exposure pathways, it was assumed that an individual could ingest surface soil at a rate of 120 mg/day (weighted average of children: 200 mg/day, adult: 100 mg/day). Possible dermal contact could affect a skin surface area of 2600 cm^2 (weighted average of children: 1000 cm^2; adult: 3000 cm^2). Direct contact was assumed to occur over a 30 year period (6 years as a child; 24 years as an adult). For use of groundwater, it is assumed that an individual would ingest 2 liters per day of groundwater from the more contaminated areas at the site over a 30 year period and bathe each day for 30 years. It is highly unlikely that the DCL site would be used for residential purposes. These pathways, however, were evaluated primarily to justify restrictions on the future use of the site for residential purposes and provide the basis for making risk management decisions for the site.

6.1.6.3 Toxicity Assessment

USEPA (1989a, 1986a,b) recommends summing chemical-specific risks in order to quantify the combined risk associated with exposure to a chemical mixture. Limited data are available for actually quantifying the potential synergistic and/or antagonistic relationships between compounds in a chemical mixture. Thus, compounds are assumed to act independently in the body to cause an effect. If this assumption is incorrect regarding chemical interaction, then over- or underestimation of potential risk of the chemical mixture may occur.

Several contaminants, presented in Section 6.1.2, did not have available toxicity criteria. Because of the exclusion of these compounds, the potential risks associated with the site may be underestimated.

There is a high degree of uncertainty associated with the derivation of available toxicity criteria. The primary sources of uncertainty associated with the derivation of toxicity criteria, as summarized by the USEPA (1989a), include:

- using dose-response information from effects observed at high doses to predict the adverse health effects that may occur following exposure to the low levels expected from human contact with the agent in the environment;
- using dose-response information from short-term exposure studies to predict the effects of long-term exposures, and vice-versa;
- using dose-response information from animal studies to predict effects in humans; and
- using dose-response information from homogeneous animal populations or healthy human populations to predict the effects likely to be observed in the general population consisting of individuals with a wide range of sensitivities.

USEPA (1989a,b,c, 1986a,b) uses a conservative approach to derive toxicity criteria given the uncertainties in the toxicity studies and dose-response information. For example, the slope factor is the 95th UCL on the linear slope that describes the cancer potency of the contaminant. Using the 95th UCL on the linear slope is a conservative approach adopted by the USEPA in order that the true risks will not be underestimated. A thorough assessment of the high degree of uncertainty associated with the derivation of slope factors was presented in a USEPA (1985c) document entitled "Techniques for the Assessment of the Carcinogenic Risk to the U.S. Population Due to Exposure from Selected Volatile Organic Compounds from Drinking Water Via the Ingestion, Inhalation, and Dermal Routes." Based on the conservative approaches used to derive slope factors outlined in this report (USEPA 1985c), it may be concluded that the "true carcinogenic risk" may be orders of magnitude less than the carcinogenic risks presented in this report.

Thus, risks presented in the DCL site baseline risk assessment should not be construed as absolute estimates of risk given the degree of uncertainty associated with the risk assessment process as described above. Rather, the DCL site baseline risk assessment characterizes the potential for an adverse effect to occur if an individual is exposed to contaminants at the site as outlined in Section 6.1.3. When reviewing the results of this assessment, the conservative assumptions used should be considered. The conservative methods are recommended in USEPA guidance (1989a) in order to ensure that risks are not underestimated.

6.1.7 Summary and Conclusions of the Human Health Risk Assessment

This section summarizes the findings of the human health risk assessment for the DCL site. This report determines whether contaminants at the DCL site pose a current or future risk to human health under the no-action alternative (i.e., in the absence of remediation of the site). Contaminants under review selected for evaluation in the baseline risk assessment are discussed in Section 6.1.7.1. Exposure pathways of concern selected for quantitative evaluation in the baseline risk assessment are summarized in Section 6.1.7.2. Potential carcinogenic risks and noncarcinogenic hazards estimated for the pathways quantitatively evaluated in this report are summarized below in Section 6.1.7.3.

6.1.7.1 Chemicals of Potential Concern

Over 20 compounds were selected as chemicals of potential concern at the DCL site, including carcinogenic and noncarcinogenic PAHs, phthalate esters, and several heavy metal compounds such as cadmium, lead, and zinc. Chemicals of potential concern selected for impacted media at the DCL site are discussed below.

Groundwater. From the groundwater monitoring results, arsenic and manganese appeared to be the primary contaminants of concern; however, the concentrations of these inorganics did not appear to be elevated above naturally occurring background levels. Inorganics that may have been released from the fly ash pile, such as cadmium, lead, and zinc did not appear to have significantly impacted groundwater at the site. Residential wells in the area also did not appear impacted by the site based on a comparison of water chemistry.

Soil. Lead released from the site did not appear to significantly impact soil, beyond the influence of storm water runoff from the fly ash pile, at the DCL site. Both carcinogenic and noncarcinogenic PAHs were found in surface soil and subsurface soil.

Surface Water/Sediment. In surface water, barium, cadmium, manganese, and zinc were the primary chemicals of potential concern. Surface water and sediments in the southern drainage area do not appear to be impacted by the site. However, the northern drainage area appears to be significantly impacted from soils eroded from the fly ash pile. Highly elevated levels of cadmium, lead, and zinc were found in sediment samples collected near the fly ash pile. In addition, elevated levels of cadmium were found in surface water. Slightly elevated levels of cadmium, lead, and zinc also were found as far downstream as the Stream F sample location.

6.1.7.2 Exposure Assessment

The following current land-use exposure pathways were quantitatively evaluated in this report:

- ingestion and dermal absorption of chemicals of potential concern in groundwater from private wells by off-site residents;
- direct contact with surface soil by trespassers (i.e., children) playing at the DCL; and
- direct contact with surface water and sediments by children playing in various streams and groundwater seeps in the vicinity of the DCL site.

The following future land-use exposure pathways will be quantitatively evaluated in this report:

- direct contact with surface soil by hypothetical future residents; and
- ingestion and dermal absorption of chemicals of potential concern in groundwater at the DCL site by hypothetical future residents.

Exposure point concentrations were estimated for each contaminant and exposure pathway. Exposure point concentrations and exposure parameter values were combined using a chemical intake equation to estimate exposure (i.e., chronic daily intake [CDI]) for the reasonable maximum exposure (RME) case for each contaminant and pathway.

6.1.7.3 Results of the Human Health Risk Characterization

Toxicity criteria identified in Section 6.1.4 and CDIs estimated in Section 6.1.3 were combined to quantify potential carcinogenic risk and noncarcinogenic hazard associated with the exposure pathways quantitatively evaluated in the DCL baseline risk assessment.

Potential carcinogenic risk was quantified by multiplying the CDI by the slope factor when the cancer risk was below 10^{-2}. Chemical-specific cancer risks were summed in order to quantify the total cancer risk associated with exposure to a chemical mixture. Potential carcinogenic risks are expressed as an increased probability of developing cancer over a lifetime (i.e., excess individual lifetime cancer risk) (USEPA 1989a). For example, a 10^{-6} increased cancer risk can be interpreted as an increased risk of 1 in 1,000,000 for developing cancer over a lifetime if an individual is exposed as defined by the pathways presented in this report. A 10^{-6} increased cancer risk is the point of departure established in the NCP (USEPA 1990). In addition, the NCP (USEPA 1990) states that "for known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6}." Carcinogenic risks in excess of the acceptable risk range are likely to trigger a remedial response. Carcinogenic risks within the acceptable risk range, yet in excess of the point of departure (i.e., 10^{-6}), also may trigger a remedial response.

Noncarcinogenic effects associated with exposure to a contaminant was quantified by dividing its CDI with its reference dose (RfD). This ratio is called the hazard quotient. If the hazard quotient exceeds unity (i.e., 1), then an adverse health effect may occur. If the estimated hazard quotient is less than unity, then adverse noncarcinogenic effects are unlikely to occur. The potential risk from a chemical mixture was evaluated by calculating the hazard index which is the sum of the chemical-specific hazard quotients.

As discussed in Section 6.1.3.3, Section 6.1.5, and Section 6.1.6, conservative assumptions were used to estimate CDIs and risk in order that potential risk will not be underestimated. The conservative assumptions are used because of the uncertainty associated with the risk assessment process. The assumptions discussed in this report should be considered when reviewing the risks presented in this section. In particular, the risk estimates presented for future use of groundwater should be interpreted as an evaluation of groundwater quality at the site for developing remediation strategies. Groundwater at DCL is currently not used as a drinking water resource.

A summary of the potential carcinogenic risks and noncarcinogenic hazards estimated for the exposure pathways quantitatively evaluated in the DCL baseline risk assessment are presented in Table 6-42 and discussed below.

Current Land-Use: Use of Groundwater from Residential Wells Downgradient of the Site. No potential carcinogenic chemicals were detected in the 9 residential wells detected southeast of the DCL site. In addition, the hazard indices for all of the private residential wells were below unity (1). The highest hazard index of 0.3 was estimated for use of groundwater from PW-8. Therefore, noncarcinogenic effects associated with ingestion and dermal absorption of contaminants from these residential wells are unlikely to occur.

Several potential carcinogenic organic chemicals, as well as arsenic (which is a known human carcinogen), were detected in four residential wells (i.e., PW-9,

Table 6 42
Conclusions for the Dixie Caverns Landfill
Baseline Risk Assessment

Exposure Pathway	Potential Carcinogenic Risk	Potential Noncarcinogenic Risk (Hazard Index)(HI)	Comments
<u>Current Land-Use Conditions</u>			
Use of Groundwater from Downgradient Residential Wells (a).			
PW-1	- -	<1(2E-1)	No carcinogens were detected in residential wells downgradient of the site. Hazard indices were well below unity (1); therefore, noncarcinogenic risks unlikely to occur. However, residenial wells PW-9 and PW-14, which are not hydrogeologically connected to the site, had carcinogenic risks of 2E-4 which exceeds the NCP acceptable risk range. In addition, residential wells, which are also isolated from the site, had cancer risks equal to the NCP point of departure (i.e., 10^{-6}). Elevated levels of lead also were found in PW-10.
PW-2	- -	<1(2E-1)	
PW-3	- -	<1(5E-2)	
PW-4	- -	<1(1E-1)	
PW-5	- -	<1(1E-1)	
PW-6	- -	<1(2E-1)	
PW-7	- -	<1(8E-2)	
PW-8	- -	<1(3E-1)	
PW-16	- -	<1(2E-1)	
Children Playing in Surface Soil at the site	2E-5	<1(1E-1)	Potential carcinogenic risk within the NCP acceptable risk range ($<10^{-4}$). Risks due to carcinogenic PAHs, beryllium, and arsenic. Hazard index below unity (1); therefore, noncarcinogenic risks unlikely to occur.
Children Playing in Streams and Groundwater Seeps (b)			
Northern Drainage Area	8E-6	8	Potential carcinogenic risk within acceptable risk range for northern drainage area (i.e., $<10^{-4}$). Risks are due to bis(2-ethylhexyl)phthalate and carcinogenic PAHs. Carcinogenic risk below NCP point of departure for southern drainage area and stream F. Hazard index exceeds unity (1) in northern drainage area due to cadmium, silver, and zinc. Levels of lead in stream B and stream E sediments also were highly elevated and may be of concern to children ingesting sediments. Hazard indices for southern drainage area and stream F below unity; therefore, noncarcinogenic effects unlikely to occur.
Southern Drainage Area	6E-7	<1(6E-1)	
Stream F	7E-7	<1(3E-2)	

Table 6-42 (cont.)
Conclusions for the Dixie Caverns Landfill
Baseline Risk Assessment

Exposure Pathway	Potential Carcinogenic Risk	Potential Noncarcinogenic Risk (Hazard Index)(HI)	Comments
Future Land-Use Conditions			
Direct Contact with Surface Soil by Hypothetical Residents	8E-5	<1(1E-1)	Potential carcinogenic risk slightly below the upper-bound of the NCP acceptable risk range (i.e., $<10^{-4}$). Risk due to carcinogenic PAHs, beryllium, and arsenic. Hazard index below unity (1); therefore, noncarcinogenic risks unlikely to occur.
Use of Groundwater at the Dixie Caverns Landfill (a)	3E-4	5	Potential carcinogenic risk exceeds the NCP acceptable risk range (10^{-4}) due to arsenic. However, arsenic levels were 10 times lower than MCL of 50 ug/L. Hazard index exceeds unity (1) by a factor of 5; therefore, noncarcinogenic risks may occur. Noncarcinogenic risks primarily due to antimony and manganese. It is unclear, however, whether these chemicals are associated with the site or natural background.

(a) Risk estimates include exposure from ingestion and dermal absorption while showering.
(b) Risk estimates include exposure from dermal absorption of chemicals in surface water and sediments, and incidental ingestion of sediments.

PW-10, PW-12, and PW-14) located south/southwest of the DCL. These chemicals are not site-related, since these wells are hydrogeologically isolated from the site. In addition, the organic carcinogenic chemicals detected in these wells (which consisted of low levels of pesticides and bis(2-chloroethyl)ether) were not detected at the site. Specifically, the potential carcinogenic risks associated with use of groundwater (i.e., ingestion and bathing) from PW-9 and PW-14 were estimated to be approximately $2x10^{-4}$, which slightly exceeds the upper-bound of the NCP acceptable risk range (i.e., 10^{-4}). However, the carcinogenic chemical found in PW-9, bis(2-chloroethyl)ether, was not detected during the second round of sampling from this well. In addition, the arsenic found in PW-14 was detected at a concentration 10 times below the current MCL of 50 ug/L. The low detected concentrations of pesticides found in PW-10 and PW-12 resulted in carcinogenic risks of $1x10^{-6}$, which equals the NCP point-of-departure. In addition, the level of lead in PW-10 (Round 1: 26 ug/L, Round 2: 16 ug/L) exceeds the Action Level of 15 ug/L; therefore, the levels of lead in PW-10 may be of concern, particularly to children.

Current Land-Use: Direct Contact with Surface Soil by Children Playing at the DCL. The total excess cancer risk associated with incidental ingestion and dermal absorption (i.e., $2x10^{-5}$) exceeded the NCP point of departure (i.e., 10^{-6}), but was below the upper-bound of the NCP acceptable risk range (i.e., 10^{-4}) (USEPA 1990). Potential carcinogens detected in surface soil include carcinogenic PAHs, beryllium, and arsenic. The only detected concentration of benzo(a)pyrene (equivalents) was found in sample SWD-2 which was collected in the solid waste disposal area. Similar levels of arsenic and beryllium were found in both the solid waste disposal area and in the vicinity of the fly ash pile. All of the contaminant-specific hazard quotients, as well as the hazard index, were below unity. Therefore, noncarcinogenic effects associated with direct contact with surface soil while playing at the DCL are unlikely to occur.

Current Land-Use: Children Playing in Streams in the Northern Disposal Area. The potential carcinogenic risk associated with dermal absorption of contaminants in surface water and sediments, and incidental ingestion of sediments in the northern disposal area was $8x10^{-6}$. Thus, the estimated carcinogenic risk exceeds the NCP point of departure of 10^{-6}, yet is below the upper-bound of the NCP acceptable risk range (i.e., < 10^{-4}) (USEPA 1990). The primary carcinogens of concern in the northern disposal area include: bis(2-ethylhexyl)phthalate in surface water and carcinogenic PAHs in sediments. These chemicals were detected near the fly ash pile. It should be noted, however, that background risks associated with exposure to arsenic and beryllium in surface water and sediments are much higher than those estimated for the two organic compounds, which may or may not be associated with the site.

With respect to noncarcinogenic hazards, the hazard index exceeded unity (1) by a factor of 8. Chemicals that significantly contributed to this hazard index include: cadmium in surface water, and cadmium, silver, and zinc in sediments. Thus, noncarcinogenic effects associated with direct contact with surface water and sediments directly downstream of the fly ash pile may occur. In surface water, the highest detected concentrations of cadmium were found at Stations SB-5 and SB-6 which are located near the fly ash pile. The highest detected concentrations of cadmium, silver, and zinc in sediments also were found near the fly ash pile. The fly ash pile itself consisted of approximately 0.1% cadmium and 20% zinc. The origin of these chemicals in sediments is most likely due to surface water runoff from the fly ash pile.

The potential noncarcinogenic hazard associated with exposure to lead in sediments was evaluated using a pharmacokinetic approach. There is a 96% chance that a six year old child regularly playing in sediments near the fly ash pile (sample location SB-7) would have elevated blood-lead levels (i.e., > 10 ug/dL). The maximum detected concentration of lead (30,800 ug/kg) also exceeds the interim soil cleanup level for lead at Superfund sites by a factor of 60, which is considered sufficiently protective for direct contact in residential settings (i.e., 500 mg/kg) (USEPA 1989d). Evaluation of lead concentrations further

downstream indicates that elevated lead levels in sediments may be present from the fly ash pile to stream locations in the vicinity the confluence between Streams E and G.

Current Land-Use: Children Playing in Streams and Seeps in the Southern Drainage Area. The total potential carcinogenic risks associated with direct contact with surface water in the southern drainage area was below the NCP point of departure (i.e., 10^{-6}) (USEPA 1990). No potential carcinogenic compounds were selected as chemicals of potential concern in sediment in the southern drainage area.

With respect to noncarcinogenic hazards, individual contaminant-specific hazard quotients and the hazard index for all chemicals of potential concern in surface water for the southern drainage area were below unity; thus, noncarcinogenic effects are unlikely to occur. Di-n-octylphthalate was the only chemical of potential concern selected for sediment; however, toxicity criteria were not available for this chemical. Background levels of several inorganics detected in this stream may present a greater hazard than those estimated for the chemicals of potential concern which may or may not be related to the site. Therefore, it does not appear that the site has significantly impacted this stream from a human health stand point.

Current Land-Use: Children Playing in Stream F. All chemicals detected in surface water at Stream F were found to be within natural background and; therefore, were not selected as chemicals of potential concern. The total potential carcinogenic risks associated with direct contact with sediment in Stream F was below the NCP point of departure (i.e., 10^{-6}) (USEPA 1990). With respect to noncarcinogenic hazards, individual contaminant-specific hazard quotients and the hazard index for all chemicals of potential concern in sediment at Stream F were below unity; therefore, noncarcinogenic effects are unlikely to occur. Although, no significant health risks were found, certain metals associated with the fly ash pile were found above background levels in Stream F sediments.

Multimedia Assessment of Risk under Current Land-Use Conditions. For the multimedia exposure assessment, it was conservatively assumed that an individual is exposed via all exposure routes evaluated, as well as the highest risk estimated for any given location according to the RME case (i.e., highest risk estimated for direct contact with surface water and sediment, and use of untreated groundwater from PW-8). The total carcinogenic risk was 3×10^{-5} and the hazard index was 9. The highest carcinogenic risks were associated with direct contact with surface soil, while the highest noncarcinogenic hazards were estimated for direct contact with sediments and surface water in the northern drainage area. The most significant risk estimates associated with direct contact with streams in the northern drainage area are probably associated with surface water runoff from the fly ash pile.

Future Land-Use Conditions: Direct Contact with Surface Soils by Hypothetical Residents at the DCL Site. Potential carcinogenic risks to hypothetical residents at the DCL site from incidental ingestion of surface soils was 5×10^{-5}. This risk exceeded the NCP point of departure (i.e., 10^{-6}) but did not exceed the upper-bound of the NCP acceptable risk range (i.e., 10^{-4}) (USEPA 1990). The potential carcinogenic risk from dermal absorption of surface soils was 4×10^{-5} which was also between the NCP point of departure and the upper-bound of the NCP acceptable risk range.

The hazard index associated with incidental ingestion of surface soils at the DCL site by hypothetical residents was 0.1 and therefore, is below unity (1). The selected chemicals of potential concern were all inorganics; therefore, no hazard quotient for dermal absorption was calculated.

Future Land-Use Conditions: Use of Groundwater by Hypothetical Residents at the DCL Site. The potential carcinogenic risk from using groundwater for ingestion and bathing was $3x10^{-4}$. This risk exceeded the NCP point of departure (i.e., 10^{-6}) and the upper-bound of the NCP acceptable risk range (i.e., 10^{-4}) (USEPA 1990). Arsenic was found in wells sunk near the fly ash pile and between the solid waste disposal area and Twine Hollow Road to the south. It should be noted, however, that the maximum detected concentration of arsenic was only 5 ug/L which is 10 times lower than the MCL for arsenic (50 ug/L). In addition, recent evidence suggest that the slope factor for arsenic is based on a non-lethal cancerous effect (i.e., skin rash). Also, exposure to arsenic may have a threshold (similar to a noncarcinogenic effect), for which the maximum concentration does not exceed.

The hazard index associated with ingestion of groundwater at the DCL site exceeded unity by a factor of 5, mainly due to antimony and manganese, the only contaminants with hazard quotients that exceeded one. Antimony was detected at four monitoring well locations: RIW-1, RIW-7, RIW-10, and RIW-12. Manganese was detected at all sample locations, with the highest levels found in RIW-2 and RIW-10. Therefore, noncarcinogenic effects from ingestion of groundwater from the DCL site may occur. It should be noted, however, that the RfD for antimony was derived using an uncertainty factor of 1,000.

Section 6.2

ECOLOGICAL INVESTIGATION

6.2.1 General Description of Study Area

The following is a general description of the Dixie Caverns Landfill (DCL) site study area.

6.2.1.1 Terrestrial Ecology

The terrestrial vegetation on and in the vicinity of the site was subdivided into three groups: forest vegetation, streamside vegetation, and emergent growth on the site. The forest vegetation on relatively undisturbed portions of the site are of a Chestnut Oak-Pitch Pine forest cover type (see Eyre, 1980). The forested vegetation in close proximity to the site appears to be in an earlier successional stage than the forested vegetation found on the site periphery. This may be related to historic lumbering activities or other physical human disturbances.

The undisturbed streamside vegetation has a slightly different species composition then areas more distant from the streams. Specifically, the streamside vegetation has more tulip-trees, white oaks, and northern red oaks. The forest streamside vegetation near the forest edge has a denser understory, because the decreased canopy cover allows shade intolerant species to grow in the lower vegetative layers. Much of the lower elevation streamside vegetation lacks shrubs and trees altogether, resulting in a different vegetative structure. There is obvious maintenance and/or other human disturbances in some areas.

The vegetation types found on the site proper consist of seven subtypes. The approximate percentages of each type follows. The approximate percentages of each type follows. Approximately 22 acres (34% of the site) is barren due to recent site activities. Approximately 19 acres (30% of the site) consists of the previously mentioned forest type. Approximately 3 acres (5% of the site) is a field type dominated by grasses (Poaceae). Approximately 3 acres (5% of the site) is an emergent field type dominated by broomsedge (Andropogon spp.). Approximately 5 acres (8% of the site) is an emergent field type dominated by various composites and, to a lesser degree, grasses. Approximately 5 acres

(8% of the site) is dominated by broomsedge and mix of bryophytes. Approximately 6 acres (10% of the site is dominated by broomsedge and composites on the herb layer, pitch pine and Virginia pine saplings, and table mountain pine as mature trees. The emergent areas represent various stages of successional growth influenced by soil type and variations in the times and degrees of past disturbances.

An indepth assessment of wetlands was not performed at the site due to the general nature of the site. The site is found on a steep hillside which, historically, was forested. Based on field observations of the current site conditions, four small (less than 1 acre) areas may be characterized as wetlands (based on the presence of hydric vegetation). Each of these small areas are obviously man-made (due to features like roadways which cut across the 30% land slope). In the absence of such features these "wetland" areas would not naturally occur.

6.2.1.2. Aquatic Ecology

The non-impacted stream habitat in the site vicinity appears to be representative of the first-order mountain streams found in the area. Lower reaches of the tributaries have characteristics of second-order streams and often have limited canopy cover which may influence the aquatic community.

Non-impacted sections of stream have a healthy diverse community structure dominated by Ephemeropteran, Plecopteran, and Trichopteran (EPT) populations which are primarily collectors. The shredder abundance was low, due to the limited Coarse Particulate Organic Material (CPOM) present. Impacted areas have lower EPT diversity and abundance and a decrease in the quality of the aquatic community structure. Sections having severe impairment have relatively low EPT diversity and abundance, poor community structure, and low numbers of all organisms.

6.2.2 Identification of Potential Receptors

One of the objectives of risk analysis is to identify the receptors that may potentially be affected by site-related conditions. Potential receptors include vegetation and/or wildlife that may come in contact with the site. The following discussion describes the potential receptors within the ecological study area.

6.2.2.1 Threatened and Endangered Species

A list of animal species of concern in Virginia was provided by the Virginia Department of Game and Inland Fisheries (VDGIF; Table 6-43). Table 6-43 lists the animals of special concern that are known to occur in the USGS topographic quads of Glenvar, Salem and Elliston. Of these species, only the orangefin madtom and the Roanoke logperch are known to occur in vicinity of the site, although it was noted that the loggerhead shrike was likely to occur in the area (Kitchel, 1991). The two fish species are of particular concern. The Roanoke logperch is federally listed as endangered, and the orangefin madtom is a federal candidate species. Both have been collected from the Roanoke River according to data provided by the VDGIF (Kitchel, 1991). Both species have not been documented in any Roanoke River tributaries, including those near the DCL site. The Indiana bat may occur within the area of the DCL site, however, these bats strongly prefer caves with standing water. There are no known caves on the site so it is not likely that the Indiana bat would roost on-site. There is little known about the bat's activities outside the cave and it is extremely difficult to determine if it visits the site at night. The New England Cottontail (Sylvilagus transitionalis), noted in Tetra Tech (1990), is no longer listed as a species of concern for the state.

The only plants of special concern that may be in the area are the purple coneflower (Echinacea laevigata) and piratebush (Buckleya distichopophylla; Tetra Tech, 1990), but there are no plants of special concern known to be in the study area.

TABLE 6-43

ANIMALS OF SPECIAL CONCERN IN VIRGINIA[1,2]

Common Name	Scientific Name	Status
Mammals		
Bat, Indiana	Myotis sodalis	Fed. End.
Bat, Virginia Big-eared	Plecotus townsendii virginianus	Fed. End.
Bat, Eastern Big-eared	Plecotus rafinesquii macrotis	State End.
Bat, Gray	Myotis grisescens	Fed. End.
Cougar, Eastern	Felis concolor concolor	Fed. End.
Fisher	Martes pennanti penanti	State End.
Shrew, Dismal Swamp Southeastern	Sorex longirostriss fisheri	Fed. Thr.
Shrew, Water	Sorex palustris punctulatus	State End.
Squirrel, Delmarva Peninsulá Fox	Sciurus niger cinereus	Fed. End.
Squirrel, Northern Flying	Glaucomys sabrinus	Fed. End.
Birds		
Eagle, Bald	Haliaeetus leucocephalus	Fed. End.
Falcon, Peregrine	Falco peregrinus	Fed. End.
Plover, Wilson's	Charadrius Wilsonia	State End.
Plover, Piping	Charadrius melodus	Fed. Thr.
Shrike, Loggerhead	Lanius Ludovicianus	State End.
Tern, Roseate	Sterna dougallii	Fed. End.
Warbler, Bachman's	Vermivora bachmanii	Fed. End.
Warbler, Kirtland's	Dendroica kirtlandii	Fed. End.
Woodpecker, Red-Cockaded	Picoides borealis borealis	Fed. End.
Wren, Appalachian Bewick's	Thryomanes bewickii altus	State End.
Reptiles		
Turtle, Bog	Clemmys muhlenbergii	State End.
Turtle, Eastern Chicken	Deirochelys reticularia reticularia	State End.
Amphibians		
Salamander, Shenandoah	Plethodon nettingi shenandoah	Fed. End.
Salamander, Eastern Tiger	Ambystoma tigrinum tigrinum	State End.
Fish		
Chub, Slender	Hybopsis cahni	Fed. Thr.
Chub, Spotfin	Hybopsis monacha	Fed. Thr.
Darter, Carolina	Etheostoma collis lepidinion	State End.
Darter, Tippecanoe	Etheostoma tippecanoe	State End.
Darter, Blueside	Etheostoma jessiae	State End.
Darter, Sharphead	Etheostoma acuticeps	State End.
Logperch, Roanoke	Percina rex	Fed. End.
Madtom, Yellowfin	Noturus flavipinnis	Fed. Thr.
Sturgeon, Shortnose	Acipenser brevirostrum	Fed. End.
Sunfish, Blackbanded	Enneacanthus chaetodon	State End.

[1]Information obtained from the Virginia Department of Game and Inland Fisheries.

[2]Excluding marine species.

TABLE 6-43 cont'd

ANIMALS OF SPECIAL CONCERN IN VIRGINIA

Common Name	Scientific Name	Status
Invertebrates		
Mussel, Appalachian Monkeyface	Quadrula sparsa	Fed. End.
Mussel, Cumberland Bean	Villosa trabalis	Fed. End.
Mussel, Cumberland Combshell	Epioblasma brevidens	State End.
Mussel, Cumberland Monkeyface	Quadrula intermedia	Fed. End.
Mussel, James Spiny	Pleurobema collina	Fed. End.
Mussel, Birdwing Pearly	Lemiox rimosus	Fed. End.
Mussel, Crackling Pearly	Hemistena lata	Fed. End.
Mussel, Dromedary Pearly	Dromus dromus	Fed. End.
Mussel, Dwarf Wedge	Alasmidonta heterodon	Fed. End.
Mussel, Fanshell	Cyprogenia stegaria	Fed. End.
Mussel, Fine-rayed Pigtoe	Fusconaia cuneolus	Fed. End.
Mussel, Green Blossom	Epioblasma torulosa gubernaculum	Fed. End.
Mussel, Little-wing Pearly	Pegias fabula	Fed. End.
Mussel, Oyster	Epioblasma capsaeformis	State End.
Mussel, Pink Mucket	Lampsilis orbiculata orbiculata	Fed. End.
Mussel, Rough Pigtoe	Pleurobema plenum	Fed. End.
Mussel, Shiny Pigtoe	Fusconaia edgariana	Fed. End.
Mussel, Snuffbox	Epioblasma triquetra	State End.
Mussel, Tan Riffle Shell	Epioblasma florentina walkeri	Fed. End.
Snail, Virginia Fringed Mountain	Polygyriscus virginianus	Fed. End.
Isopod, Madison Cave	Antrolana lira	Fed. Thr.

TABLE 6-43 cont'd

ANIMALS OF SPECIAL CONCERN IN ROANOKE COUNTY[3]

Common Name	Scientific Name	Status
Vole, Rock	Microtus chrotorrhinus	Fed. Candidate
Woodrat, Eastern	Neotoma floridа	Fed. Candidate
Loggerhead Shrike	Lanius ludovicianus	State Endangered
Roanoke Logperch	Percina rex	Fed. Endangered
Orangefin Madtom	Noturus gilberti	Fed. Candidate

[3]Information obtained from the Virginia Department of Game and Inland Fisheries. Coverage within Roanoke county is restricted to the U.S.G.S. topographic quads of Glenvar, Salem and Elliston.

6.2.2.2 Potential Terrestrial Receptors

A list of potential terrestrial receptors is given in Table 6-44. The site occurs along a major raptor migratory route, which expands the potential receptors list for birds to include any species whose migratory route may pass through the study area. On the landfill itself, potential receptors would include any species that are typically found in either the successional or the forest communities on the site, described earlier in section 4.4. Bird species observed on or near the site include: turkey vulture, red-tailed hawk, mourning dove, common flicker, pileated woodpecker, downy woodpecker, hairy woodpecker, eastern phoebe, American crow, Carolina chickadee, tufted titmouse, Carolina wren, northern mockingbird, eastern bluebird, brown thrasher, European starling, common grackle, northern cardinal, rufous-sided towhee, slate-colored junco, nuthatch, and the song sparrow. Also detected was a warbler that was thought to be a chestnut-sided warbler. These birds are typical of those found in the habitats described during the season of the site visit. Deer, small mammal sign, and domestic dogs were also observed on the landfill.

6.2.2.3 Aquatic Receptors

The aquatic organisms listed in Tables 6-44 are considered potential aquatic receptors. Table 6-43 is a listing of vertebrates species from information supplied by VDGIF. Two species of dusky salamander were observed during the ecological investigation and unidentified tadpoles were observed in one of the on-site ponds. Table 4-6 is a compilation of all aquatic organisms found at all of the ecological sampling stations.

6.2.3 Characterization of Contaminants

The characterization of contaminants summarizes the compounds were detected in concentrations that are elevated above background levels and thus pose a potential ecological concern. The compounds identified in this section serve as the basis for the remainder of the ecological risk assessment.

TABLE 6-44

POTENTIAL RECEPTORS IN THE DIXIE CAVERNS STUDY AREA

Common Name	Scientific Name
MAMMALS[1]	
MARSUPIALS	
OPOSSUM, VIRGINIA	Didelphis marsupialis virginiana
SHREWS	
SHREW, MASKED	Sorex cinereus cinereus
SHREW, WATER	Sorex palustris albibarbis
SHREW, SMOKY	Sorex fumeus fumeus
SHREW, SOUTHEASTERN	Sorex longirostris
SHREW, LONG-TAIL	Sorex dispar
SHREW, SHORT-TAIL	Blarina brevicauda kirtlandi
SHREW, LEAST	Cryptotis parva
MOLES	
MOLE, EASTERN	Parascalops breweri
MOLE, HAIRY-TAILED	Scalopus aquaticus aquaticus
MOLE, STAR-NOSED	Condylura cristata cristata
BATS	
MYOTIS, KEENS	Myotis keeni
BAT, LITTLE BROWN	Myotis lucifugus lucifugus
BAT, SILVER-HAIRED	Lasionycteris noctivagans
BAT, PYGMY	Pipistrellus subflavus subflavus
BAT, BIG BROWN	Eptesicus fuscus fuscus
BAT, SEMINOLE	Lasiurus seminolus
BAT, RED	Lasiurus borealis borealis
BAT, HOARY	Lasiurus cinereus cinereus
BAT, EVENING	Nycticeius humeralis
RABBITS	
COTTONTAIL, EASTERN	Sylvilagus floridanus mallurus
COTTONTAIL, NEW ENGLAND	Sylvilagus transitionalis
HARE, SNOWSHOE	Lepus americanus virginianus
RODENTS	
CHIPMUNK	Tamias striatus fisheri
WOODCHUCK	Marmota monax monax
SQUIRREL, GRAY	Sciurus carolinensis pennsylvanicus
SQUIRREL, RED	Tamiasciurus hudsonicus loquax
SQUIRREL, SOUTHERN FLYING	Glaucomys volans volans
MOUSE, EASTERN HARVEST	Reithrodontomys humulis
MOUSE, DEER	Peromyscus maniculatus
MOUSE, WHITE-FOOTED	Peromyscus leucopus noveboracensis
MOUSE, GOLDEN	Peromyscus nuttalli
VOLE, RED-BACKED	Clethrionomys gapperi gapperi
VOLE, MEADOW	Microtus pennsylvanicus pennsylvanicus
VOLE, YELLOW-NOSED	Microtus chrotorrhinus
VOLE, PINE	Pitymys pinetorum scalopsoides
MUSKRAT	Ondatra zibethicus macrodon
LEMMING, SOUTHERN BOG	Synaptomys cooperi cooperi

TABLE 6-44 cont'd

POTENTIAL RECEPTORS IN THE DIXIE CAVERNS STUDY AREA

Common Name	Scientific Name
MAMMALS cont'd	
RODENTS cont'd	
RAT, NORWAY	Rattus norvegicus norvegicus
MOUSE, MEADOW JUMPING	Zapus hudsonius americanus
MOUSE, WOODLAND JUMPING	Napaeozapus insignis insignis
BEAVER	Castor canadensis canadensis
CARNIVORES	
FOX, RED	Vulpes vulpes fulva
FOX, GRAY	Urocyon cinereoargenteus
BEAR, BLACK	Ursus americanus americanus
RACCOON	Procyon lotor lotor
WEASEL, LEAST	Mustela rixosa
WEASEL, LONG-TAILED	Mustela frenata noveboracensis
MINK	Mustela vison mink
SKUNK, STRIPED	Mephitis mephitis nigra
SKUNK, SPOTTED	Spilogale putorius
OTTER, RIVER	Lutra canadensis canadensis
BOBCAT	Lynx rufus rufus
DEER	
DEER, WHITE-TAILED	Odocoileus virginianus
BIRDS[2]	
GREBES	
GREBE, PIED-BILLED	Podilymbus podiceps
CORMORANTS	
CORMORANT, DOUBLE-CRESTED	Phalacrocorax auritus
HERONS, BITTERNS	
HERON, GREAT-BLUE	Ardea herodias
HERON, GREEN-BACKED	Butorides striatus
HERON, LITTLE-BLUE	Egretta caerulea
EGRET, COMMON	Egretta albus
EGRET, CATTLE	Bubulcus ibis
EGRET, GREAT	Casmerodias albus
EGRET, SNOWY	Egretta thula
BITTERN, AMERICAN	Botaurus lentiginosus
IBIS, WHITE-FACED	Plegadis chihi

TABLE 6-44 cont'd

POTENTIAL RECEPTORS IN THE DIXIE CAVERNS STUDY AREA

Common Name	Scientific Name
BIRDS	
WATERFOWL	
SWAN, MUTE	Cygnus olar
GOOSE, CANADA	Branta canadensis
GOOSE, SNOW	Chen hyperborea
DUCK, MALLARD	Anas platyrhynchos
DUCK, AMERICAN BLACK	Anas rubripes
GADWALL	Anas strepera
PINTAIL	Anas acuta
TEAL, GREEN-WINGED	Anas crecca
TEAL, BLUE-WINGED	Anas discors
WIDGEON, AMERICAN	Anas americanus
SHOVELOR, NORTHERN	Anas clypeata
DUCK, WOOD	Aix sponsa
REDHEAD	Aythya americana
DUCK, RING-NECKED	Aythya collaris
CANVASBACK	Aythya valisineria
SCAUP, GREATER	Aythya marila
SCAUP, LESSER	Aythya affinis
GOLDENEYE, COMMON	Bucephala clangula
BUFFLEHEAD	Bucephala albeola
SCOTER, WHITE-WINGED	Melanitta fusca
DUCK, RUDDY	Oxyura jamaicensis
MERGANSER, HOODED	Lophodytes cucullatus
MERGANSER, COMMON	Mergus merganser
MERGANSER, RED-BREASTED	Mergus serrator
VULTURES	
VULTURE, TURKEY	Cathartes aura
VULTURE, BLACK	Coragyps atratus
HAWKS, FALCONS, EAGLES	
GOSHAWK, NORTHERN	Accipiter gentilis
HAWK, SHARP-SHINNED	Accipiter striatus
HAWK, COOPER'S	Accipiter cooperii
HAWK, RED-TAILED	Buteo jamaicensis
HAWK, RED-SHOULDERED	Buteo lineatus
HAWK, BROAD-WINGED	Buteo platypterus

TABLE 6-44 cont'd

POTENTIAL RECEPTORS IN THE DIXIE CAVERNS STUDY AREA

Common Name	Scientific Name
BIRDS cont'd	
HAWKS, FALCONS, EAGLES cont'd	
EAGLE, GOLDEN	Aquila chrysaetos
EAGLE, BALD	Haliaeetus leucocephalus
HARRIER, NORTHERN	Circus cyanus
OSPREY	Pandion haliaetus
FALCON, PEREGRIN	Falco peregrinus
MERLIN	Falco columbarius
KESTRAL, AMERICAN	Falco sparverius
GROUSE	
GROUSE, RUFFED	Bonasa umbellus
QUAIL	
BOBWHITE, NORTHERN	Colinus virginianus
PHEASANT, RING-NECKED	Phasianus colchicus
TURKEYS	
TURKEY, WILD	Meleagris gallopavo
RAILS	
RAIL, KING	Rallus elegans
RAIL, VIRGINIA	Rallus limicola
SORA	Porzana carolina
RAIL, YELLOW	Coturnicops noveboracensis
MOREHEN, COMMON	Gallinula chloropus
COOT, AMERICAN	Fulica americana
PLOVERS	
PLOVER, SEMIPALMATED	Charadrius semipalmatus
KILLDEER	Charadrius vociferus
PLOVER, LESSER-GOLDEN	Pluvialis dominica
PLOVER, BLACK-BELLIED	Pluvialis sauatarola
SANDPIPERS	
WOODCOCK, AMERICAN	Scolopax minor
SNIPE, COMMON	Gallinago gallinago
SANDPIPER, UPLAND	Bartramia longicauda
SANDPIPER, SPOTTED	Actitis macularia
PHALAROPE, RED-NECKED	Phalaropus lobatus
SANDPIPER, SOLITARY	Tringa solitaria
YELLOWLEGS, GREATER	Tringa melanoleuca
YELLOWLEGS, LESSER	Tringa flavipes
SANDPIPER, SEMIPALMATED	Calidris pusilla
SANDPIPER, PECTORAL	Calidris melanotos
DUNLIN	Calidris alpina
DOWITCHER, SHORT-BILLED	Limnodromus griseus

TABLE 6-44 cont'd

POTENTIAL RECEPTORS IN THE DIXIE CAVERNS STUDY AREA

Common Name	Scientific Name
BIRDS cont'd	
GULLS	
GULL, HERRING	Larus argentatus
GULL, RING-BILLED	Larus delawarensis
GULL, BONAPARTE'S	Larus philadelphia
TERNS	
TERN, COMMON	Sterna hirundo
TERN, BLACK	Chlidonias niger
PIGEONS, DOVES	
DOVE, ROCK	Columba livia
DOVE, MOURNING	Zenaida macroura
CUCKOOS	
CUCKOO, YELLOW-BILLED	Coccyzus americanus
CUCKOO, BLACK-BILLED	Coccyzus erythropthalmus
OWLS	
OWL, GREAT HORNED	Bubo virginianus
OWL, BARRED	Strix varia
OWL, EASTERN SCREECH-	Otus asio
OWL, LONG-EARED	Asio otus
OWL, SHORT-EARED	Asio flammeus
OWL, NORTHERN SAW-WHET	Aegolius acadicus
NIGHTHAWKS	
CHUCK-WILL'S-WIDOW	Caprimulgus carolinensis
WHIP-POOR-WILL	Caprimulgus vociferus
COMMON NIGHTHAWK	Chordeiles minor
SWIFTS	
SWIFT, CHIMNEY	Chaetura pelagica
HUMMINGBIRDS	
HUMMINGBIRD, RUBY-THROATED	Archilochus colubris
KINGFISHERS	
KINGFISHER, BELTED	Ceryle alcyon
WOODPECKERS	
FLICKER, NORTHERN	Colaptes auratus
WOODPECKER, PILEATED	Dryocopus pileatus
WOODPECKER, RED-BELLIED	Melanerpes carolinus
WOODPECKER, RED-HEADED	Melanerpes erythrocephalus
SAPSUCKER, YELLOW-BELLIED	Sphyrapicus varius
WOODPECKER, HAIRY	Picoides villosus
WOODPECKER, DOWNY	Picoides scalaris

TABLE 6-44 cont'd

POTENTIAL RECEPTORS IN THE DIXIE CAVERNS STUDY AREA

Common Name	Scientific Name
BIRDS cont'd	
FLYCATCHERS	
KINGBIRD, EASTERN	Tyrannus tyrannus
FLYCATCHER, GREAT-CRESTED	Myiarchus crinitus
PHOEBE, EASTERN	Sayornis phoebe
FLYCATCHER, YELLOW-BELLIED	Empidonax flaviventris
FLYCATCHER, ACADIAN	Empidonax virescens
FLYCATCHER, WILLOW	Empidonax traillii
FLYCATCHER, ALDER	Empidonax alnorum
FLYCATCHER, LEAST	Empidonax minimus
PEEWEE, EASTERN WOOD	Contopus virens
FLYCATCHER, OLIVE-SIDED	Contopus borealis
SWALLOWS	
LARK, HORNED	Eremophila alpestris
SWALLOW, BARN	Hirundo rustica
SWALLOW, CLIFF	Hirundo pyrrhonota
SWALLOW, TREE	Tachycineta bicolor
SWALLOW, BANK	Riparia riparia
SWALLOW, ROUGH-WINGED	Stelgidopteryx ruficollis
MARTIN, PURPLE	Progne subis
JAYS, CROWS	
JAY, BLUE	Cyanocitta cristata
CROW, AMERICAN	Corvus brachyrhynchos
CROW, FISH	Corvus ossifragus
TITMICE, CHICKADEES	
CHICKADEE, BLACK-CAPPED	Parus atricapillus
CHICKADEE, CAROLINA	Parus carolinensis
TITMOUSE, TUFTED	Parus bicolor
NUTHATCHES	
NUTHATCH, WHITE-BREASTED	Sitta carolinensis
NUTHATCH, RED-BREASTED	Sitta canadensis
CREEPERS	
CREEPER, BROWN	Certhia americana
WRENS	
WREN, HOUSE	Troglodytes aedon
WREN, WINTER	Troglodytes troglodytes
WREN, BEWICK'S	Troglodytes bewickii
WREN, CAROLINA	Thryothorus ludivicianus
WREN, MARSH	Cistothorus palustris

TABLE 6-44 cont'd

POTENTIAL RECEPTORS IN THE DIXIE CAVERNS STUDY AREA

Common Name	Scientific Name
BIRDS cont'd	
THRUSHES	
MOCKINGBIRD, NORTHERN	Mimus polyglottos
CATBIRD, GREY	Dumetella carolinensis
THRASHER, BROWN	Toxostoma rufum
ROBIN, AMERICAN	Turdus migratorius
THRUSH, WOOD	Hylocichla mustelina
THRUSH, HERMIT	Catharus guttatus
THRUSH, SWAINSON'S	Catharus ustulatus
THRUSH, GRAY-CHEEKED	Catharus minimus
VEERY	Catharus fuscescens
BLUEBIRD, EASTERN	Sialis sialis
KINGLETS	
GNATCATCHER, BLUE-GRAY	Polioptila caerulea
KINGLET, GOLDEN-CROWNED	Regulus satrapa
KINGLET, RUBY-CROWNED	Regulus calendula
PIPITS	
PIPIT, WATER	Anthus spinoletta
WAXWINGS	
WAXWING, CEDAR	Bombycilla cedrorum
SHRIKES	
SHRIKE, LOGGERHEAD	Lanius ludivicianus
STARLINGS	
STARLING, EUROPEAN	Sturnus vulgaris
VIREOS	
VIREO, WHITE-EYED	Vireo griseus
VIREO, YELLOW-THROATED	Vireo flavifrons
VIREO, SOLITARY	Vireo solitarius
VIREO, RED-EYED	Vireo olivaceus
VIREO, PHILADELPHIA	Vireo philadelphicus
VIREO, WARBLING	Vireo gilvus
WOOD WARBLERS	
WARBLER, BLACK-AND-WHITE	Mniotilta varia
WARBLER, PROTHONOTARY	Protonotaria citrea
WARBLER, SWAINSON'S	Limnothlypis swainsonii
WARBLER, WORM-EATING	Helmitheros vermivorus
WARBLER, GOLDEN-WINGED	Vermivora chrysoptera
WARBLER, BLUE-WINGED	Vermivora pinus
WARBLER, TENNESSEE	Vermivora peregrina
WARBLER, ORANGE-CROWNED	Vermivora celata
WARBLER, NASHVILLE	Vermivora ruficapilla
PARULA, NORTHERN	Parula americana

TABLE 6-44 cont'd

POTENTIAL RECEPTORS IN THE DIXIE CAVERNS STUDY AREA

Common Name	Scientific Name
BIRDS cont'd	
WARBLERS	
WARBLER, YELLOW	Dendroica petechia
WARBLER, MAGNOLIA	Dendroica magnolia
WARBLER, CAPE MAY	Dendroica tigrina
WARBLER, BLACK-THROATED BLUE	Dendroica caerulescens
WARBLER, YELLOW-RUMPED	Dendroica coronata
WARBLER, BLACK-THROATED GREEN	Dendroica virens
WARBLER, CERULEAN	Dendroica cerulea
WARBLER, BLACKBURNIAN	Dendroica fusca
WARBLER, YELLOW-THROATED	Dendroica dominica
WARBLER, CHESTNUT-SIDED	Dendroica pensylvanica
WARBLER, BAY-BREASTED	Dendroica castanea
WARBLER, BLACKPOLL	Dendroica striata
WARBLER, PINE	Dendroica pinus
WARBLER, KIRKLAND'S	Dendroica kirklandii
WARBLER, PRAIRIE	Dendroica discolor
OVENBIRD	Seiurus aurocapillus
WATERTHRUSH, NORTHERN	Seiurus noveboracensis
WATERTHRUSH, LOUISIANA	Seiurus motacilla
WARBLER, KENTUCKY	Oporornis formosus
WARBLER, CONNETECUT	Oporornis agilis
WARBLER, MOURNING	Oporornis philadelphia
YELLOWTHROAT, COMMON	Geothlypis trichas
CHAT, YELLOW-BREASTED	Icteria virens
WARBLER, HOODED	Wilsonia citrina
WARBLER, WILSON'S	Wilsonia pusilla
WARBLER, CANADA	Wilsonia canadensis
REDSTART, AMERICAN	Setophaga ruticilla
WEAVER FINCHES	
SPARROW, HOUSE	Passer domesticus
SPARROW, EUROPEAN-TREE	Passer montanus
BLACKBIRDS	
BOBOLINK	Dolichonyx oryzivorus
MEADOWLARK, EASTERN	Sturnella magna
BLACKBIRD, RED-WINGED	Agelaius phoeniceus
ORIOLE, ORCHARD	Icterus spurius
ORIOLE, NORTHERN	Icterus galbula
BLACKBIRD, RUSTY	Euphagus carolinus
GRACKLE, COMMON	Quiscalus quiscula
COWBIRD, BROWN-HEADED	Molothrus ater

TABLE 6-44 cont'd

POTENTIAL TERRESTRIAL RECEPTORS IN THE DIXIE CAVERNS STUDY AREA

Common Name	Scientific Name
BIRDS cont'd	
TANAGERS	
TANAGER, SCARLET	Piranga olivacea
TANAGER, SUMMER	Piranga rubra
FINCHES, SPARROWS	
CARDINAL, NORTHERN	Cardinalis cardinalis
GROSBEAK, ROSE-BREASTED	Pheucticus sinuatus
GROSBEAK, BLUE	Pheucticus melanocephalus
BUNTING, INDIGO	Passerina cyanea
DICKCISSEL	Spiza americana
GROSBEAK, EVENING	Coccothraustes vespertinus
FINCH, PURPLE	Carpodacus purpureus
FINCH, HOUSE	Carpodacus mexicanus
SISKIN, PINE	Carduelis pinus
GOLDFINCH, AMERICAN	Carduelis tristis
TOWHEE, RUFOUS-SIDED	Pipilo erythrophthalmus
SPARROW, SAVANNAH	Passerculus sandwichensis
SPARROW, GRASSHOPPER	Ammodramus savannarum
SPARROW, HENSLOW'S	Ammodramus henslowii
SPARROW, SHARP-TAILED	Ammodramus caudacutus
SPARROW, VESPER	Pooecetes gramineus
SPARROW, BACHMAN'S	Aimophila carpalis
JUNCO, DARK-EYED	Junco hyemalis
SPARROW, AMERICAN TREE	Spizella arborea
SPARROW, CHIPPING	Spizella passerina
SPARROW, FIELD	Spizella pusilla
SPARROW, WHITE-CROWNED	Zonotrichia leucophrys
SPARROW, WHITE-THROATED	Zonotrichia albicollis
SPARROW, FOX	Passerella iliaca
SPARROW, LINCOLN'S	Melospiza lincolnii
SPARROW, SWAMP	Melospiza georgiana
SPARROW, SONG	Melospiza melodia

TABLE 6-44 cont'd

POTENTIAL RECEPTORS IN THE DIXIE CAVERNS STUDY AREA

Common Name	Scientific Name
REPTILES[3]	
TURTLES	
TURTLE, WOOD	Clemmys insculpta
TURTLE, EASTERN BOX	Terrapene carolina
SNAKES	
SNAKE, BROWN	Storeria dekayi
SNAKE, NORTHERN RED-BELLIED	Storeria occipitomaculata
SNAKE, COMMON GARTER	Thamnophis sirtalis
SNAKE, EASTERN RIBBON	Thamnophis sauritus
SNAKE, RING-NECK	Diadophis punctatus
SNAKE, BLACK RAT	Elaphe obsoleta
SNAKE, EASTERN MILK	Lampropeltis triangulum
RATTLESNAKE, TIMBER	Crotalus horridus

TABLE 6-44 cont'd

POTENTIAL RECEPTORS IN THE DIXIE CAVERNS STUDY AREA

Common Name	Scientific Name
FISH[4,5]	
EELS - ANGUILLIDAE	
EEL, AMERICAN	Anguilla rostrata
SAMON AND TROUT - SALMONIDAE	
TROUT, RAINBOW	Salmo gairdneri
TROUT, BROWN	Salmo trutta
PIKES - ESOCIDAE	
PICKEREL, CHAIN	Esox niger
MINNOWS - CYPRINIDAE	
DACE, ROSYSIDE	Campostoma pauciradii
DACE, MOUNTAIN REDBELLY	Phoxinus oreas
CHUB, BULL	Nocomis raneyi
CHUB, BLUEHEAD	Nocomis leptocephalus
STONEROLLER, CENTRAL	Campostoma anomalum
MINNOW, CUTLIPS	Exoglossum maxillingua
DACE, BLACKNOSE	Rhinichthys atratulus
MINNOW, EASTERN SILVERY	Hybognathus regius
SHINER, WHITE	Notropis albeolus
SHINER, CRESCENT	Notropis cerasinus
SHINER, ROSEFIN	Notropis ardens
SHINER, SATINFIN	Notropis analostanus
MINNOW, BLUNTNOSE	Pimphales notatus
SHINER, SWALLOWTAIL	Notropis procne
SHINER, MIMIC	Fundulus diaphanus
SHINER, SPOTTAIL	Noturus insignis
SUCKERS - CATOSTOMIDAE	
SUCKER, WHITE	Catostomus commersoni
HOG SUCKER, ROANOKE	Hypentelium roanokense
HOG SUCKER, NORTHERN	Hypentelium nigricans
REDHORSE, GOLDEN	Moxostoma erythrurum
REDHORSE, SILVER	Moxostoma anisurum
REDHORSE, SUCKERMOUTH	Moxostoma pappillosum
JUMPROCK, BLACK	Moxostoma cervinum
JUMPROCK, BIGEYE	Moxostoma ariommum
SUCKER, TORRENT	Moxostoma rhothoecum
CATFISHES - ICTALURIDAE	
MADTOM, MARGINED	Noturus insignis
MADTOM, ORANGEFIN	Noturus gilberti
SCULPINS - COTTIDAE	
SCULPIN, MOTTLED	Cottus bairdi

TABLE 6-44 cont'd

POTENTIAL RECEPTORS IN THE DIXIE CAVERNS STUDY AREA

Common Name	Scientific Name
FISH cont'd	
SUNFISHES AND BASSES - CENTRARCHIDAE	
BASS, ROANOKE	Ambloplites cavifrons
BASS, ROCK	Ambloplites rupestris
BASS, SMALLMOUTH	Micropterus dolomieui
BLUEGILL	Lepomis cyanellus
PUMKINSEED	Lepomis gibbosus
SUNFISH, REDBREAST	Lepomis auritus
DARTERS, PERCHES - PERCIDAE	
DARTER, SHIELD	Percina peltata
DARTER, ROANOKE	Percina roanoka
LOGPERCH, ROANOKE	Percina rex
DARTER, JOHNNY	Etheostoma nigrum
DARTER, RIVERWEED	Etheostoma podostemone
DARTER, FANTAIL	Etheostoma flabellare
AMPHIBIANS	
MOLE SALAMANDERS	
SALAMANDER, MARBLED	Ambystoma opacum
SALAMANDER, JEFFERSON	Ambystoma jeffersonianum
SALAMANDER, SPOTTED	Ambystoma maculatum
NEWTS	
NEWT, EASTERN	Notophthalmus viridescens
LUNGLESS SALAMANDERS	
SALAMANDER, NORTHERN DUSKY	Desmognathus fuscus
SALAMANDER, MOUNTAIN DUSKY	Desmognathus ochrophaeus
WOODLAND SALAMANDERS	
SALAMANDER, RED-BACKED	Plethodon cinereus
SALAMANDER, SLIMY	Plethodon glutinosus
SPRING AND RED SALAMANDERS	
SALAMANDER, NORTHERN SPRING	Gyrinophilus porphyriticus
SALAMANDER, NORTHERN RED	Pseudotriton ruber
BROOK SALAMANDERS	
SALAMANDER, NORTHERN TWO-LINED	Eurycea bislineata
SALAMANDER, LONGTAIL	Eurycea longicauda
FROGS	
BULLFROG	Rana catesbeiana
PEEPER, NORTHERN SPRING	Hyla crucifer
REPTILES	
TURTLES	
TURTLE, COMMON SNAPPING	Chelydra serpentina
STINKPOT	Sternotherus odoratus
TURTLE, SPOTTED	Clemmys guttata
TURTLE, BOG	Clemmys muhlenbergi
TURTLE, MIDLAND PAINTED	Chrysemys picta
SNAKES	
SNAKE, NORTHERN WATER	Nerodia sipedon

1. Scientific names and taxonomic order for mammals follow Doutt, J.K., C.A. Heppenstall, and J.E. Guilday. 1977. Mammals of Pennsylvania. Pennsylvania Game Commission, Harrisburg, PA. 288 pp.

2. Scientific names and taxonomic order for birds follow Peterson, R.T. 1980. A Field Guild to the Eastern Birds. Houghton Mifflin Company, Boston. 384 pp.

3. Scientific names and taxonomic order to reptiles and amphibians based on Conant, R. 1975. A Field guide to Reptiles and Amphibians. Houghton Mifflin Company, Boston. 429 pp.

4. Taxonomic order based on Werner, R.G. 1980. Freshwater Fishes of New York State. Syracuse University Press, Syracuse, NY. 186 pp.

5. Species list for fishes compiled from collection data from U.S.G.S. topographic quads of Glenvar, Salem and Elliston supplied by the Virginia Department of Game and Insland Fisheries.

6.2.3.1 Characterization of Terrestrial Contaminants

Surface Soil Samples

Inorganics - Upon comparing on-site concentrations of inorganic compounds in surface soils with background concentrations; cadmium, lead, manganese, and zinc appear to be the only heavy metals which are elevated above background levels.

Cadmium levels in surface soils were below detection limits at all locations except FAP-3, FAP-4 and FAP-5, where concentrations ranged from 1.4 to 19.9 mg/kg. Lead concentrations in surface soils were elevated above background concentrations at SWD-5, FAP-1, FAP-3, FAP-4, and FAP-5, where the concentrations ranged from 46.8 to 395 mg/kg. Manganese concentrations in surface soils were elevated above background concentrations at SWD-1, SWD-2, SWD-3, SWD-4, FAP-3, FAP-4, and FAP-5, where concentrations ranged from 521 to 1,080 mg/kg. Zinc concentrations in surface soils were elevated above background concentrations at FAP-3 and FAP-5, where concentrations ranged from 1,230 to 3,520 mg/kg.

Organics - There were no volatile organic compounds detected in the surface soils at elevated levels except low levels of acetone. Acetone was detected in five, widely distributed locations on the site (B-1, B-2, B-3, SWD-1, and SWD-3) with concentrations ranging from 7 to 130 ug/L. The average detected concentration at these stations was 69.6 ug/kg.

The majority of the semi-volatiles detected in the surface soils on the site were localized around SWD-2, with a total semi-volatile concentration of 10,635 ug/kg. Seventeen different compounds were detected at this location. Bis(2-ethylhexyl)phthalate was detected at all "B" and "SWD" locations ranging from 42 to 150 ug/kg, with the highest concentration being found at SWD-2. In addition, di-n-butylphthalate was detected at B-3 and SWD-3 (140 ug/kg and 75 ug/kg, respectively), and bis-chloroethoxy methane was detected at B-3 and SWD-1 (88 ug/kg and 82 ug/kg, respectively).

No pesticides were detected in the surface soils on the site.

Additional Samples

A limited number of samples were taken from various seeps, leachate ponds, an old stream channel, and storm water run-off channels. These locations may provide additional sites of exposure for terrestrial organisms. It is not believed that the these locations presently support any aquatic life.

The two seep samples, SP-1 and SP-2, did not contain any organic compounds at elevated levels. Total barium concentration ranged from 411 to 518 ug/L.

Both leachate samples, SL-1 and SL-2, contained iron and manganese at elevated levels. Total barium concentrations ranged from 519 to 668 ug/L. Total iron concentrations in the leachate pond samples were 23,000 ug/L (SL-1) and 27,200 ug/L (SL-2). Dissolved iron concentrations were 13,400 ug/L (SL-1) and 25,400 ug/L (SL-2). The total manganese concentrations were 811 ug/L (Sl-1) and 636 ug/L (Sl-2). Dissolved manganese concentrations were 761 ug/L (SL-1) and 617 ug/L (SL-2). The hardness at the leachate pond exceeded 276 mg/L $CaCO_3$. There were no organic contaminants at elevated levels detected in the leachate ponds.

Two sediment samples were taken out of the "old stream channel" located near the site entrance. Elevated metals detected at OS-1 consisted of chromium (509 mg/kg) and manganese (6,140 mg/kg). Three semi-volatile compounds were detected at a total concentration of 202 ug/kg. No organic compound were detected at elevated levels at OS-2. Elevated metal concentrations detected at OS-2 consisted of barium (127 mg/kg) and manganese (2,710 mg/kg).

Both surface water samples and sediment samples were taken at the storm water run-off sampling locations. Elevated total metal concentrations in the surface water at SR-1 consisted of aluminum (4,450 ug/L), lead (3.4 ug/L), and copper (16.3 ug/L). Elevated total metal concentrations in the surface water at SR-2 consisted of aluminum (1,270 ug/L) and iron (1,300 ug/L). There were no metals detected in the sediments that exceeded background levels. The semi-volatile organic compound bis(2-ethylhexyl)phthalate was detected at both sample location at concentrations of 140 ug/kg (SR-1) and 57 ug/L (SR-2).

6.2.3.2 Characterization of Aquatic Contaminants

Two rounds of surface water samples were collected, one during a season of low flow (November) and one during a season of higher flow (March). To assume the worst case scenario, the greatest concentration of a contaminant from either sampling event will be used for the exposure concentration at a particular location during the exposure assessment.

Water Quality - Generally water quality parameters (i.e., dissolved oxygen, total dissolved solids, total suspended solids, alkalinity, pH, etc.) in the study area appear to be generally within acceptable ranges. The total dissolved solids (TDS), however, appears slightly elevated in Stream A at SA-4 (143 mg/L) and SA-5 (138 mg/L) and in Stream B at SB-5, SB-6, and SB-7 (208, 206,and 202 mg/L, respectively), as do the leachate samples SL-1 and SL-2 (176 and 138 mg/L, respectively). The leachate samples also had elevated alkalinity concentrations up to 644 mg/L. It should be noted that these elevated parameters were only present during the first round of sampling (low-water conditions).

Inorganics - In most cases inorganic contaminant concentrations in the surface water were higher during the sampling in November. This appears to be a result of the seasonally low flow of water. Aluminum, barium, cadmium, copper, iron, lead, manganese, nickel, silver, and zinc were detected above Virginia Water Quality Criteria (VAWQC) for the protection of aquatic life or were at elevated levels, where no criteria exists. Copper and zinc can not be accurately evaluated because similar concentrations were found in the laboratory blanks.
Mercury and silver were not detected in the surface water at any of the sampling locations, however, the detection limits (0.2 and 5.0, respectively) are above VAWQC and EPA WQC. Mercury was not detected in any sediment sample. Silver was detected in the sediments at SB-1, SB-4, SB-5, SB-6, SB-7, SE-1,

and SE-2 ranging from 1.7 to 92.6 mg/kg, with the average concentration being 39.3 mg/kg.

Total aluminum concentrations in stream surface water did not exceed 618 ug/L, with the exception being SB-2 where aluminum was detected at 1,880 ug/L. Dissolved aluminum did not exceed 73.9 ug/L at any of the stream sample stations during either of the sampling events. Aluminum in stream sediments ranged from 2,280 mg/kg (SA-1) to 11,100 mg/kg (SB-4), with an average being 6,890 mg/kg. The reference station had an aluminum concentration of 6,850 mg/kg. Aluminum in the sediments thus appears to be at naturally occurring concentrations.

The barium concentrations detected during the low water sampling event (first round) tended to be approximately double of that detected during the high water sampling event. However, during the first round, the majority of the reported values were qualified as: "Analyte present. Reported value may not be accurate or precise." During the second round, many of the values present were reported as: "Not detected substantially above the level reported in laboratory or field blanks." Despite the samples being qualified as stated above, the trends of both sampling events appear to be similar between sampling locations. Elevated levels were reported in both Streams A and B averaging between two to three times greater than the reference concentration of 22.0 ug/l. Barium levels tended to increase the further downstream (in both Streams A and B) the samples were taken. Highest concentrations were detected at SB-7 (87.4 ug/L), SB-6 (87.3), and SA-4 (80.0 ug/L). The majority of the detected barium was in its dissolved fraction.

The total cadmium concentration in stream surface water from stations SB-5, SB-6, SB-7, and SE-1, was reported as ranging from 5.8 ug/L (SE-1) to 19.2 ug/L (SB-5). Dissolved cadmium did not exceed 41.3 ug/L at any of the stream sample stations during either of the sampling events. It is unknown why the maximum dissolved cadmium concentration is higher than the maximum total cadmium concentration. Detected cadmium in stream sediments ranged from 3.1 mg/kg (SC-1) to 605 mg/kg (SB-7), with an average detected concentration of 233 mg/kg. Cadmium was not detected at the reference station.

Total iron concentrations in stream surface water was not detected above 1,000 ug/L except at SB-2, SB-4, SB-6, and SB-7, ranging from 1,080 ug/L (SB-7) to 2,520 ug/L (SB-2). Dissolved iron at SB-4 was more than twice that of any other station (600 ug/L). Detected iron in stream sediments ranged from 8,770 mg/kg (SA-1) to 184,000 mg/kg (SE-2), with an average being 50,200 mg/kg. The reference station had an iron concentration of 22,900 mg/kg. The highest iron concentrations were found in Streams B and E.

Many of the lead detections in the second round of sampling were quantified as being similar to that found in the laboratory blanks, thus these data could not be used in this assessment. Therefore, the majority of the lead data were obtained in the first round of sampling (November). Total lead concentrations in stream surface water samples was detected at SA-1, SA-2, SB-1, Sb-2, SB-3, SB-4, Sb-5, SB-6, SB-7, SD-1, and SE-1 at concentrations ranging from 1.1 ug/L (SD-1) to 55.7 ug/L (SB-7), with an average concentration of 14.5 ug/L. Dissolved lead concentrations in stream surface water ranged from 1.1 to 45.1 ug/L, with an average concentration of 11.5 ug/L. Greatest lead concentrations in the stream surface waters were found between sample stations SB-5 and SB-7. Detected lead in stream sediments ranged from 4.6 mg/kg (SA-1) to 30,800 mg/kg (SB-7), with an average being 5,410 mg/kg. The reference station had a lead concentration of 27.7 mg/kg. Lead concentrations in Streams A and D, and Stream B, upstream of SB-4 appear to be at background levels.

Total manganese concentrations in stream surface water was below 100 ug/L except at SB-2, SB-4, SB-5, SB-6, SB-7, and SE-1; where it ranged from 304 ug/L (SB-2) to 2,730 ug/L (SB-6). Detected dissolved manganese ranged from 4.6 to 2,620 ug/L, with an average being 754 ug/L. Excluding SB-4, SB-5, SB-6, SB-7, and SE-1, the highest dissolved concentration was 22.2 (SB-3). Detected manganese in stream sediments ranged from 184 mg/kg (SD-1) to 21,000 mg/kg (SB-7), with the average being 4,280 mg/kg. The reference station had a manganese concentration of 536 mg/kg. The highest manganese concentrations were found in Streams B and E, however, slightly elevated levels were also found in Stream A.

During the first sampling round of the stream surface water, nickel was detected only at locations (SB-6) at a concentration of 6.4 ug/L total metals and 6.9 ug/L dissolved metals, and at SA-4 at a concentration of 64.1 ug/L dissolved metals. It is uncertain as to why the dissolved metal concentration exceeded the total metal concentration. However, these concentrations were well within acceptable limits. During the second round of surface water sampling, nickel was detected at all the sampling locations in both the total metal and dissolved metal samples. The greatest concentration was detected at SB-6 (110 ug/L). SB-6 was over twice the concentration of the next highest detect concentration (SA-1; 52.4 ug/L, total metals). Levels reported at stations SA-1, SB-1, SB-2, SB-3, SB-6, SC-1, SD-1, and SE-1 were above water quality criteria. All samples, with the exception of SB-6 total metals, were qualified to be not detected substantially above the level reported in the laboratory and field blank. Because of the disagreement between sampling rounds and the round two sample results having potential field blank contamination, the actual nickel concentrations are uncertain and are not able to be evaluated. The reported reference (SG-1) concentration of nickel in the sediments was 22.4 mg/kg. The reported nickel levels at the other stream sample locations were below or comparable with the reference concentration with the exceptions of SB-5 (87.3 mg/kg), SB-7 (186 mg/kg), SC-1 (71 mg/kg), SE-1 (111 ug/kg), SE-11 (108 mg/kg), SE-12 (73.1 mg/kg), and SE-13 (77.1 mg/kg). There appears to be a trend of elevated nickel in the sediments down stream of the fly ash pile. The nickel also appears to be bonding to the sediments.

Silver was not detected in any of the stream surface water samples during either sampling round. The detection limits ranged from 2 to 5 ug/L, which is above the USEPA Water Quality Criteria (1.2 ug/L; at a hardness of 50 mg/L $CaCO_3$) and the Virginia Water Quality Criteria ranging from 0.11 to 1.9 ug/L (Calculated using: $2.71828^{0.76(\ln(hardness))+1.06} \times 0.01$). Since the detection limits for the surface water samples are above water quality criteria, any potential toxicity associate with silver in the water column can not be evaluated. However, since the silver levels are below 5 ug/L, there does not appear to be gross toxicity associated with silver in the water column. Silver was detected in the sediments at sample locations SB-1 (2.0 mg/kg), SB-4 (1.7

mg/kg), SB-5 (40.4 mg/kg), SB-6 (13.6 mg/kg), SB-7 (71.3 mg/kg), SE-1 (53.2 mg/kg), and the SE-1 duplicate (92.6 mg/kg). It appears that elevated levels of silver in the sediments tend to be located down stream of the fly ash pile.

Total zinc concentrations in stream surface water were detected above 47 ug/L at SB-4, SB-5, SB-6, SB-7, SE-1, and SF-1; ranging from 102 ug/L (SF-1) to 2,680 ug/L (SB-7). Only data from sample round one could be used for dissolved zinc in surface waters. Detected dissolved zinc ranged from 16.9 to 2,460 ug/L, with an average of 513 ug/L. Detected zinc in stream sediments ranged from 22.7 mg/kg (SA-1) to 129,000 mg/kg (SE-2), with an average being 24,400 mg/kg. The reference station had a zinc concentration of 19.7 mg/kg. The distribution of zinc is similar to that of manganese.

Organics - There were no volatile organics, semi-volatile organics or pesticides detected at elevated levels in the surface water of the streams during either of the sampling rounds. The only exception is the detection of bis(2-ethylhexyl)phthalate at SB-6 at a concentration of 210 ug/L.

There were no volatile organics or pesticides detected at elevated levels in the stream sediments. There were semi-volatiles detected in the sediments, of which, all were "J" values (values qualified as inaccurate or imprecise).

In the Stream A sediments, bis(2-ethylhexyl)phthalate and di-n-octylphthalate were detected at SA-4 at total concentration of 1,520 ug/kg. Bis(2-ethylhexyl)phthalate was detected at SA-5 and SA-6 (duplicate of SA-5) at concentrations of 400 and 1,900 ug/kg, respectively.

In the Stream B sediments, semi-volatiles were detected at SB-4, SB-5, SB-6 and SB-7. SB-4 had phenanthrene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, and benzo(g,h,i)perylene detected at a total concentration of 659 ug/kg. SB-5 had chrysene, benzo(b)fluoranthene, and benzo(k)fluoranthene detected at total concentration of 273 ug/kg. SB-6 had benzo(b)fluoranthene detected at a concentration of 47 ug/kg. SB-7 had chrysene, bis(2-ethylhexyl)phthalate, benzo(b)fluoranthene, and benzo(k)fluoranthene detected at a total concentration of 304 ug/kg.

In the Stream C sediments, benzoic acid was the only semi-volatile detected (2,000 ug/kg).

In the Stream E sediments, semi-volatiles were detected at SE-1 and SE-2. SE-1 had chrysene, benzo(b)fluoranthene, and benzo(a)pyrene detected at a total concentration of 870 ug/kg. SE-2 had fluoranthene, chrysene, bis(2-ethylhexyl)phthalate, benzo(b)fluoranthene, benzo(k)fluoranthene, and benzo(a)pyrene were detected at a total concentration of 2,330 ug/kg.

In the Stream F sediments, phenanthrene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, and benzo(g,h,i)perylene were detected at a total concentration of 803 ug/kg.

Miscellaneous Sampling - Surface water samples were taken at a nearby limestone quarry. All detected heavy metals were at background levels, however, barium was approximately twice that reported at the background location (SG-1). The hardness of the water was elevated (287 mg/L $CaCO_3$). The elevated hardness is not uncommon in limestone quarries.

6.2.3.3 Contaminant Characterization Summary

When comparing the water quality between sampling events, high-water conditions appear to be more consistent and of better quality than low-water conditions. Elevated TDS were detected during low-water conditions in sections of Streams A and B, and the leachate samples, and corresponded to areas where significant contamination was detected. Alkalinity was also elevated in the leachate samples during low-water conditions.

Heavy metals are the primary contaminants associated with the surface soils. Zinc, manganese, lead, and cadmium are the specific heavy metals that are above background levels (in order of severity). Acetone occurs widely on the southwestern portion of site in soils at low concentrations. Note that low concentrations of acetone were identified as laboratory contaminants. SWD-2 appears to be the "hot area" for semi-volatile compounds. Outside the vicinity of SWD-2, semi-volatile concentrations are not at elevated levels.

Barium, iron, and manganese, both total and dissolved, are at elevated levels in the leachate samples. In addition, aside from these, there is no inorganic contaminants at elevated levels.

Manganese was found at elevated levels in the old stream channel.

In the storm water run-off samples; aluminum, barium, lead, and copper at SR-1, and aluminum and iron at SR-2, were detected at elevated levels. Aluminum appears to be predominant. Low levels of semi-volatiles were also present.

In the stream surface water samples, zinc and manganese were the primary contaminants of concern. Aluminum, iron, and lead are also of concern. Although barium was reported at elevated levels, the concentrations reported were orders of magnitude below toxic levels (LeBlanc, 1980; Boutet and Chaisemartin, 1973). Elevated levels of semi-volatile organic compounds were detected in SA-4 and SA-5. Lower levels of semi-volatile organic compounds were detected in Stream B below the fly ash pile and in Stream E. Stream C had elevated levels of benzoic acid, however, benzoic acid does not appear at elevated levels anywhere else.

6.2.4 Toxicity Assessment

The following sections describe the toxicity characteristics associated with the potentially toxic parameters previously discussed. The parameters selected are those that were detected above background concentrations and may therefore pose an ecological threat.

6.2.4.1 Inorganics

Aluminum - Aluminum toxicity may be associated with both the terrestrial and aquatic community in the DCL site study area. The toxicity of aluminum to plants has been well documented. Roots exposed to toxic levels of aluminum are short, stubby, distorted, and discolored (Foy, 1984 and Moore, 1974 in Parker, et al., 1989). Root toxicity results in stunted plant growth, and is enhanced in acidic soil (Hartwell and Pember, 1918). Much of the observed site vegetation is that which is found in acidic soils.

Although aluminum is one of the most common metals found in the earths crust, it is not known to be involved in any animal metabolic process (Marquis, 1977). Symptoms of aluminum toxicity in mammals include skin lesions, nervous afflictions, gastrointestinal disturbances, growth retardation, perihepatic granulomas, and fibrous peritonitis. Aluminum toxicity is caused by aluminum affecting a number of metabolic functions using various forms of phosphate, such as, phosphate depletion in tissues, negative phosphorus balances, lower phosphate absorption from the digestive tract, and adverse alterations in phosphorylation reactions in the tissue (Luckey and Venugopal, 1977).

Aluminum is primarily a neurotoxin to terrestrial wildlife. Exposure to elevated levels of aluminum may result in neurofibrillary degeneration in the brain, softening of the bone (osteomalacia), dementia, and disease involving the selective membranes of the brain. This disease results in the abnormal separation of substances that go into true solution from substances which remain uniformly suspended in solution in brain fluids (dialysis encephalopathy; Marquis, 1989). Marquis also reported decreased brain ACHE (acetylcholinesterase, a hormone) activity in rat pups, 8, 15 and 22 days post-weaning, when exposed to 0.12% aluminum chlorohydrate.

Aluminum may be both physically and metabolically toxic to aquatic life, however, the dominant toxicological property has yet to be universally agreed upon. Dietrich and Schlatter (1989) reported two forms of toxicity occurring in rainbow trout when exposed to a pH of 5.4 and aluminum concentrations greater than 200 ug/L. Metabolic toxicity included electrolyte loss possibly due to the interaction of aluminum with enzymes at the epithelial tight junction in the surface lining of the gills. The physical toxicity was caused by labile aluminum (a modified form of aluminum) covering the gill epithelium resulting in the impairment of gas exchange.

Brown trout eggs appear to be tolerant to low pH and elevated levels of aluminum. The hatchlings, however, appear to be highly sensitive, with an acute LC_{50} of less than 20 ug/L aluminum (Weatherly et al., 1990). Cleveland et al. (1989) reported a 30 day no-observed-effect-level (NOEL) for juvenile brook trout to be 29 ug/L at pH 5.6, and 57 ug/L at pH 6.6. Aluminum will tend to flocculate when the pH reaches a critical value of 5.2 (Skelly and Loy, 1973). Thompson et al. (1988) reported a LC_{60} of 3800 ug/L for rainbow trout larvae in waters with a pH of 5.0.

Corn et al. (1989) investigated the effects of aluminum and pH on five amphibians (northern leopard frog, Rana pipiens; boreal toad, Bufo boreas; chorus frog, Pseudacris triseriata; tiger salamander, Ambystoma tigrinum; and the wood frog, Rana sylvatica). The 24 hr. LC_{50} pH for the various embryos ranged from 4.2 - 4.8. The 24 hr. LC_{50} Al for the various embryos ranged from 100 - 400 ug/L.

Cadmium - Cadmium toxicity may affect both the terrestrial and aquatic communities. Cadmium inhibits plant growth. Cadmium affects plant membranes, by inhibiting electron transfer and ATP synthesis (Jastrow and Koeppe, 1980). Carlson and Bazzaz (1977) reported affected photosynthesis and transpiration in the American sycamore with concentrations of 20 mg cadmium/kg soil. Bingham et al. (1976) reported lower yields of white clover when exposed to 17 mg/kg cadmium (dry weight).

Cadmium is toxic to all tissues in mammals. Cadmium is readily absorbed through the gut lining and fixed in tissues. Symptoms of chronic toxicity in mammals include growth retardation, impaired kidney function, poor reproductive capacities, hypertension, tumor formation, hepatic dysfunction, poor lactation, and low hematocrit levels. Acute toxicity results in excessive salivation, abdominal pains, diarrhea, vertigo, and loss of consciousness. Cadmium is a known teratogen and carcinogen, however, cadmium is not carcinogenic by oral doses (Luckey and Venugopal, 1977). the highest concentrations in the body can be found in the liver, kidney, spleen and hair (Jones, 1956). Cadmium is believed to inhibit sulphydryl enzymes which leads to the destruction of testicular tissue in rats (Parízek and Záhor, 1956).

Other noted affects include severe anemia, increases in the size of heart due to increased functional activity (cardiac hypertrophy), increase of the bone marrow due to cell multiplication (hyperplasia; Wilson, de Eds and Cox, 1941). Cattle have been noted to excrete 82% of cadmium intake in the feces (Miller et al., 1967).

Residues of 200 ppm cadmium in fresh weight kidney, or 5 ppm whole animal fresh weight, are considered life threatening to terrestrial organisms (Eisler, 1985).

Heinis et al. (1990) reported a concentration of 500 ug/L of cadmium causing changes in the feeding habits of Glyptotendipes pallens (Diptera). Bodor et al. (1988) reported a 25 day LC_{50} of approximately 10 mg/L for Daphnia magna. The Virginia Water Quality Criteria for protection of aquatic life (VAWQC) varies based on water hardness. For VAWQC specific to the sample locations see Table 6-45.

Copper - Toxicity of copper may be associated only with the terrestrial community in the DCL site study area. Copper is strongly bound to soils at exchange sites resulting in much of the copper found in soils not being able to be taken up in plants. Mineral soils offer greater uptake potential than peat, and lower pH facilitates uptake (Kabata-Pendias, 1963). Early stages of copper toxicity in plants result in reduced growth. Symptoms of plant toxicity include reduced branching, thickening, and abnormally dark coloration in rootlets (Reuther and Labanauskas, (1966). Blaschke (1977) states that concentrations as low as 26 mg/kg of copper added to soils is sufficient to cause reduce root growth in crops. Baker (1974) reported toxicity in plants when 150 to 400 mg/kg copper is added to soils over a period of time. Once copper toxicity occurs, it is practically incorrectable (Wallingford and

TABLE 6-45

SUMMARY OF VIRGINIA WATER QUALITY CRITERIA FOR PROTECTION OF AQUATIC LIFE (VAWQC)

CALCULATED CRITERIA

SAMPLE ROUND	1	1	1	1	2	2	2	2
SAMPLE LOCATIONS	HARDNESS* (mg/L)	pH	CADMIUM** (ug/L)	LEAD*** (ug/L)	HARDNESS* (mg/L)	pH	CADMIUM** (ug/L)	LEAD*** (ug/L)
SA-1	34.8	6.91	0.50	0.84	18.9	8.10	0.31	0.39
SA-2	54.8	7.80	0.71	1.50	22.5	8.05	0.35	0.49
SA-3	66.5	7.23	0.82	1.92	24.9	8.11	0.38	0.55
SA-4	121	6.42	1.32	4.10	27.8	8.17	0.42	0.64
SA-5	106	6.83	1.19	3.97	42.0	7.14	0.57	1.07
SB-1	26.7	7.38	0.40	0.60	11.7	8.18	0.21	0.21
SB-2	34.0	7.54	0.47	0.82	11.5	NS	0.21	0.21
SB-3	27.7	6.68	0.41	0.63	12.2	NS	0.22	0.22
SB-4	64.1	6.62	0.80	1.83	16.7	6.97	0.28	0.33
SB-5	68.6	6.76	0.84	2.00	18.1	6.88	0.30	0.37
SB-6	81.2	6.31	0.96	2.47	27.6	6.80	0.41	0.63
SB-7	83.2	6.30	0.98	2.55	28.2	6.72	0.42	0.65
SC-1	NS	NS	---	---	5.7	6.69	0.12	0.09
SD-1	24.2	6.52	0.37	0.53	14.5	6.82	0.25	0.28
SE-1	40.2	5.85	0.55	1.02	18.0	6.49	0.30	0.37
SF-1	NS	DRY	---	---	63.4	7.70	0.79	1.81
SG-1	53.1	7.50	0.69	1.44	19.0	8.66	0.31	0.39
Q-1	287	8.09	2.60	12.2	NS	NS	---	---

STANDARDIZED CRITERIA

PARAMETER	IRON	MANGANESE	ZINC	CYANIDE
VAWQC (ug/L)	1,000	100	47	5.2

* - Hardness (mg equivalent $CaCO_3$/L) = 2.497 [Ca, mg/L] + 4.118 [Mg, mg/L]

** - Chronic VAWQC for the Protection of Aquatic Life for Cadmium (ug/L) = $2.71828^{0.7852(\ln(hardness))-3.490}$

*** - Chronic VAWQC for the Protection of Aquatic Life for Lead (ug/L) = $2.71828^{1.266(\ln(hardness))-4.661}$

NS - No Sample Taken

Simkins, 1977).

Copper is a normal constituent in virtually all animal tissue. Copper is believed to be involved with iron metabolism (Browning, 1969).

Copper itself is less toxic than copper salts. Ingestion of the salts, such as copper acetate and especially copper sulfate, may be acutely toxic at relatively low doses (Browning, 1969). Copper poisoning causes acute liver and kidney damage, fluid in the lung and abdomen, and hemorrhaging into the digestive (alimentary) tracts (Ishmael et al., 1969). Sholl (1957) reported animals ingesting 3 ounces of one percent copper sulfate produced severe inflammation of the gastrointestinal tract resulting in abdominal pain, vomiting and diarrhea. Copper toxicity varies between mammals according to different physiological levels between species. Ruminants animals are more susceptible to copper toxicity than nonruminant animals (NAS, 1977). Cows possess a higher resistance (225 kg daily forms chronic toxicity) to copper then sheep (27 ppm fatal dose; Adamson et al., 1969, Tait et al., 1971). The toxic oral dose is typically 25-50 mg/kg for larger mammals (Sharman, 1969). Nonruminant animals, such as the rat and swine, have to be exposed to dietary level of copper in excess of 250 ppm before toxicosis is observed (Boyden et al., 1938; Suttle and Mills, 1966a,b).

Poultry appear to have a greater tolerance to copper than most animals. Smith (1967) reported day old chicks being fed 350 ppm for 25 days showing only slight reductions in rate of weight gain.

Iron - Toxicity of iron may occur in both the terrestrial and aquatic community in the DCL site study area. Iron is an essential trace element for the formation of hemoglobin, myoglobin (hemoglobin in muscle tissue), and other enzyme systems (NAS, 1980). High concentrations, however, are known to be toxic. Symptoms of chronic iron poisoning in mammals include hemorrhagic necrosis of the gastrointestinal tract, hepatotoxicosis, metabolic acidosis, prolonged blood clotting time, and elevation of serotonin and histamine. Symptoms of acute iron poisoning in mammals include increased respiration and pulse rates, with congestion of blood vessels leading to hypotension, pallor, and drowsiness. Prostration, coma and death resulting from peripheral cardiac failure may follow (Luckey and Venugopal, 1977).

Rabbits exposed to 750 mg ferrous sulfate/kg body weight showed acute hepatic (pertaining to the liver) congestion and fatal effects in 24-48 hours (Luongo and Bjornson, 1954). The acute oral LD_{50} in mice is 306 mg/kg for ferrous sulfate and 429 mg/kg for ferrous gluconate (NAS, 1980).

Several studies have been done on the toxic effects of iron on domestic birds. Chickens exposed to 200 mg/kg iron and 5 mg/kg copper in their diet showed decreased weight gain and increased mortality (McGhee et al., 1965 in NAS, 1980). Rickets was documented in young chickens exposed to 4500 mg/kg iron (Daebold and Elvehjem, 1935 in NAS, 1980). Turkeys showed no adverse affects at 440 mg/kg iron (Woerpel and Balloun, 1964 in NAS, 1980). NAS (1980) suggests that the maximum dietary level of iron in poultry to be 1000 mg/kg. Puls (1988) recommends a maximum concentration of iron in drinking water of 0.4 mg/L for livestock and poultry.

Iron is necessary for animal life. Ferrous (Fe^{+2}) and ferric (Fe^{+3}) iron are the important forms to aquatic life, with Fe^{+3} being dominant at lower pH. Ferrous iron is highly soluble while ferric iron has a low solubility. Precipitates of iron, typically iron hydroxide ($Fe[OH]_3$), can of coat the gills of fish and mechanically inhibit oxygen uptake. Iron precipitates can also cover sediments and vegetation, suffocating fish eggs and benthic organisms and limiting attachment sites for many aquatic insects. Tackett and Wieserman (1972) reported this mechanism being lethal to eggs and fry at a level of 1000 ug/L iron at low flow. Iron flocculates at the critical value of pH 4.3 (Skelly and Loy, 1973).

High iron concentrations have been known to decrease macroinvertebrate abundance and diversity (Letterman and Mitsch, 1978). Warnick and Bell (1969) reported an acute (96 hr.) LC_{50} value of 320 ug/L iron for the mayfly Ephemerella subvaria at a water hardness of 48 mg/L. The stonefly Acroneuria lycorias and the caddisfly Hydropsyche betteni have a reported 50% mortality rate when exposed for 7 days to 16 mg/L iron. This suggests that stoneflies and caddisflies are more tolerant to iron than mayflies.

The lowest concentration fatal to brook trout (within 24 hrs.) was 133 mg/L (Doudoroff and Katz, 1953). EPA (1985) reported a chronic value for brook trout of 9690 ug/L. Brenner et al. (1976) reported minor toxicity in the common shiner being exposed to ferric hydroxide. Toxicity was caused by initial changes in serum protein, glucose, sodium and potassium ions.

In contrast, many organisms have adapted to high ferric conditions. Euglena mutabilis is known to thrive in ferric waters and may be used to improve water quality in acidic and ferric waters by producing oxygen to reduce acidity (Lieb, 1971). The VAWQC for iron is 1,000 ug/L total iron.

Lead - Toxicity of lead is associated with both the terrestrial and aquatic community at the DCL site study area. Inorganic lead has a tendency to form highly insoluble salts and complexes with various anions. Lead also binds tightly with soils. These two characteristics drastically reduce the availability of lead to the roots of terrestrial plants. Translocation of lead to lead ions in plants is poor, resulting in the majority of the lead staying bound to root and leaf surfaces. High concentrations of lead, ranging from 100 to 1000 mg/kg in soil, are needed to effect photosynthesis, growth, and other metabolic activities (WHO, 1989).

Williamson and Evans (1972) reported no observed affects in millipedes and woodlice which had bioconcentrated 80 ppm and 700 ppm lead, respectively. Straalen and Meerendonk (1987) fed green algae, having a lead concentration ranging from 1600 to 2200 mg/kg dry weight, to adult Collembola (springtails), Orchesella cincta, for over four weeks. The springtails had a lead concentration of 0.2 mg/kg dry weight. Doelman et al. (1984) reported that ingestion of lead contaminated bacteria and fungi by nematodes (roundworms) leads to impaired reproduction.

Small mammals having whole body concentrations of 30 ppm lead showed no significant affect (Williamson and Evans, 1972). Williamson and Evans found no evidence of bioaccumulation of lead between trophic levels. Quarles et al. (1974) reported a greater tendency for lead to bioconcentrate in female meadow voles (Microtus pennsylvanicus) and shorttailed shrews (Blarina brevicauda) than in males. Lead also appeared to have a greater tendency to bioconcentrate in older meadow voles and white-footed mice (Peromyscus leucopus) than in young.

Toxicity to birds from lead salts occurs only at concentrations exceeding 100 mg/kg dietary dose (WHO, 1989). Organolead compounds appear to have the greatest toxicity to birds. Trialkyllead compounds produce chronic toxicity in starlings (Sturnus vulgaris) at dietary concentrations of 0.2 mg/day, and cause fatality at 2 mg/day (Osborn et al., 1983).

In laboratory tests, survival was reported reduced at acute oral lead doses of 5 mg/kg body weight (BW) in rats, at chronic oral doses of 5 mg/kg BW in dogs, and at dietary level of 1.7 mg/kg BW in horses (Eisler, 1988).

Adverse affects of lead on aquatic biota was reported at waterborne lead concentrations of 1.0 - 5.1 ug/L, and include reduced survival, impaired reproduction, reduced growth, and high bioconcentration from medium (Eisler, 1988).

Manganese - Toxicity of manganese may occur in both the terrestrial wildlife and aquatic life at the DCL site study area. Manganese in plants concentrates in the reproductive parts, especially in seeds (Browning, 1969). Plants absorb manganese in the divalent state. Generally, toxicity in plants is only observed when the soil pH is below 5.5, and/or in wet soils (Adams and Pearson, 1967). Dessureaux (1960) reported that higher temperatures increase manganese toxicity. Toxicity of soybeans can occur in wet acid soils at a concentration of 2.5 mg manganese/kg soil (Parker et al., 1969). Symptoms of manganese toxicity in plants include marginal chlorosis, cupping of young leaves, and speckling of older leaves.

Despite the potential toxicity of manganese, it is essential for the nutrition of both plants and animals (Browning, 1969). Manganese has been documented to be involved with formation of connective tissue and bone, growth, carbohydrate and lipid formation, the embryonic development of the ear, reproductive function, and probably brain function (WHO, 1981).

Divalent manganese (Mn^{2+}) is 2.5 to 3 times more toxic than trivalent manganese (Mn^{3+}) (WHO, 1981). Chronic poisoning in dogs, rabbits, rats and monkeys is known to cause gross pathology in the liver and diffuse lesions in the cerebrum (Turner, 1955). McKee and Wolf (1963) reported stunted growth and interference in bone development in rat when exposed to 500-600 mg/kg/day manganese. Chandra (1971) reported appreciable damage to the sperm producing tubules in the testes (seminiferous tubules) in rats after 150 days of daily doses of 8 mg/kg I.P. (I.P.: intraperitoneal - within the abdominal membrane). Levels of 50-125 mg/kg in the diet of baby pigs has caused manganese-iron antagonism, resulting in interference in hemoglobin formation.

Although manganese is associated with central nervous disturbance, relatively low concentration are found in the brain. Manganese tends to concentrate in the liver, kidney, and bone (Fore and Morton, 1952). Manganese is absorbed through the gastro-intestinal tract, however absorption is very slow due to the low solubility of manganese in gastric juices. Relatively high concentrations of manganese must be ingested before enough absorption can take place to cause toxicity (von Oettingen, 1935). Absorption through the lungs by inhalation of manganese dust typically is the route causing toxicity (Maynard and Fink, 1956). Symptoms of manganese toxicity include anemia, negative phosphorus balance, rickets, and renal degeneration (Luckey and Venugopal, 1977).

Little detailed information is available regarding manganese toxicity to aquatic life, although it is recognized as a toxic metal. Ludemann (1953) reported dragonfly larva (Sphaerium sp.) and crayfish (Cambarus affinis) to be unaffected when exposed to solutions of manganese chloride and manganese sulphate at a concentration of 1 g/L. Manganese is known to increase the mortality in fish eggs at levels of 1000 ug/L (Lewis, 1976). VAWQC for protection of aquatic life for manganese is 100 ug/L.

Zinc - Toxicity of zinc may occur in both the terrestrial and aquatic communities at the DCL site study area. Zinc concentrates in the foliage of plants. Zn^{2+} toxicity results in photosynthetic inhibition, by blocking the photosynthesis II cycle resulting in growth inhibition. Mature perennial species are more tolerant to surface soil zinc contamination for they have a deep root base, resulting in only a small percentage of the roots coming in contact with the surficial zinc present. Zinc also inhibits nitrification in many soils at a concentration of approximately 100 pppm. As a result, many plant species become unable to uptake required nitrogen from contaminated soils (Wilson, 1977).

Zinc is an essential constituent of carbonic anhydrase, which is vital to the respiration of most animal species (Keilin and Mann, 1940). Zinc ingestion is relatively non-toxic, however, chronic doses of soluble zinc salts may cause growth retardation, faulty reproduction, anemia, and pancreatic fibrosis. Symptoms of acute toxicity include lassitude, bloody enteritis, diarrhea, and depression of the central nervous system (Luckey and Venugopal, 1977). Heller and Burke (1927) reported zinc chloride or zinc carbonate at a concentration of 2,500 ppm of the diet of rats were completely without effects. Dogs can tolerate 2 mg/kg of zinc gluconate (Vallee, 1959). Calvery (1942) reported the LD^{50} for zinc chloride for rats, mice, and guinea pigs to be 350, 350, and 200 mg/kg, respectively. The toxicity of zinc varies between mammalian species. Large doses of zinc are required before toxicity generally occurs. Pigs are relatively sensitive zinc levels, with young animals more sensitive than adults (Grimmett et al., 1937). Sutton and Nelson (1937) suggested the limit of tolerance for zinc in animals ranges from 0.5 to 1.0 percent in diet, with the higher concentration resulting the potential inhibition of reproduction and the appearance of anemia.

Volatile Organics - There were no volatile organic compounds or pesticides detected at the DCL site study area at toxic levels.

Semi-Volatiles - Because of the numerous semi-volatile compounds detected and the limited amount of data present on any particular one, they will be typically discussed as a group. Furthermore, polycyclic aromatic hydrocarbons

(PAHs) are generally the more toxic subgroup, therefore, the focus of the toxicological discussion will be on the PAHs.

The molecular structure of PAHs consists of fused rings (2 or more) consisting of carbon and hydrogen. The double bonds of carbon are thought to be the active sites of the compounds, resulting in the potential for these compounds to cause acute toxicity and other adverse affects to a wide variety of organisms found in all trophic levels. Generally, the PAHs with molecular weights ranging from 128.16 (naphthalene) to 300.36 (coronene) are the most mobile compounds and constitute the greatest concern to the environment. Lower molecular weight compounds exhibit higher toxicity but are not carcinogenic, while higher molecular weight compounds are less toxic but often are carcinogenic (Eisler, 1987).

Plants are known to absorb PAHs through their roots and translocate them to other plant parts. Lower molecular weight PAHs are taken up more readily than higher molecular weight PAHs. PAHs can be absorbed though outer surfaces primarily when dust is deposited on plants. Phytotoxic effects on plants due to PAH contamination is low and not well documented. Some PAHs, such as benzo(a)pyrene, can be catabolized by higher plants (Eisler, 1987).

PAHs are readily soluble in animal lipids, however, due to their rapid metabolization by animals, they do not typically bioaccumulate (Eisler, 1987). Numerus PAHs are considered carcinogenic to mammals. In extreme cases tumors can form in as short a time as 4 to 8 weeks; typically, however, many months are needed for tumor development (EPA, 1980). Dipple (1985) described the carcinogenicity of PAHs. PAHs cause genetic injury through the metabolism of the parent compound to various diol epoxides, often by interacting with the mixed-function oxidase systems (a detoxifying system in mammals; Campbell et al., 1983; Lee and Grant, 1981). The diol epoxides cause cell transformations by forming adducts with DNA, RNA, proteins, and other cellular molecules. Target tissue is dependent on route of exposure, the particular compound, and the organism being exposed. For example, Dipple (1985) reported dietary benzo(a)pyrene in mice leads to leukemia, lung adenoma, and stomach tumors, while oral doses or intravenous doses of 7,12-dimethylbenz(a)anthracene to young female rats leads to mammary gland cancer. Both compounds, when injected shortly after birth, can lead to hepatomas in mice. PAHs with less than 4 condense rings do not show mutanogenic properties (Eisler, 1987).

Toxicity of PAHs to mammals also varies widely, dependent on species, compound and route of exposure. Hematopoietic and lymphoid system damage is a common observance in laboratory rats when exposed to various PAHs (EPA, 1980). Sims and Overcash (1978) conducted studies on rodents (Rattus spp. and Mus spp.) and reported the acute oral lethal dose (LD_{50}) for benzo(a)pyrene, phenanthrene, naphthalene, and fluoranthene being 50, 700, 1,780, and 2,000 mg/kg body weight, respectively, and a chronic oral carcinogenicity value for benzo(a)pyrene, dibenz(a,h)anthracene, benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, chrysene, and anthracene of 0.002, 0.006, 2.0, 40.0, 72.0, 72.0, 99.0, and 3,300.0 mg/kg body weight, respectively. The levels required for toxicity are similar, or greater, to those required to cause carcinogenicity. Therefore, the threat of malignancy predominates over the threat of toxicity (Eisler, 1987).

There is little information on PAH toxicity to birds. Patton and Dieter (1980) report no observed toxic affects to mallards (Anus platyrhynchus) when fed diets containing 4,000 mg PAHs/kg for a period of 7 months, however, there were significant increases in liver weight and blood flow to the liver. Embryotoxicity to mallard eggs has been documented (Hoffman and Gay, 1981). It is thought that higher levels of microsomal enzymes in bird embryos, when compared to adults, are present which metabolize PAHs into toxic intermediates making lower levels of PAHs (microliter concentrations) result in low mortality and reduced embryonic growth (Hoffman and Gay, 1981).

Reptiles and amphibians transform PAHs via cytochrome P-450-dependent monooxygenase systems (Stegman, 1981). This process is considerably slower when compared to mammalian hepatic microsomes (Schwen and Mannering, 1981). Anderson et al. (1982) reported amphibians to be quite resistant to PAH carcinogenesis when compared to mammals.

Neff (1979) stated that most PAHs do not reach toxic levels in surface water, even in incidence where contamination is considered high. This is primarily due to low solubility of PAHs. PAHs in sediment can obtain higher concentrations than in surface water, however, the concentrations which may be found at toxic levels have reduce availability due to their binding with the sediments. Benzo(a)anthracene has a reported 6 month Lethal Concentration for 87% (LC_{87}) for bluegills (Lepomis macrochirus) of 1,000 ug/L (EPA, 1980). The fluorene 96 hr LC_{50} for the bluegill, amphipod (Gammarus pseudoliminaeus), rainbow trout (Salmo gairdneri), mayfly (Hexagenia bilineata) and fathead minnow (Pimephales promelas) is 910 ug/L, 600 ug/L, 820 ug/L, 5,800 ug/L, and >100,000 ug/L, respectively (Finger et al., 1985). The naphthalene 96 hr LC_{50} for the amphipod (Elasmopus pectenicrus) and mosquitofish (Gambusia affinis) is 2,680 ug/L and 150,000 ug/L, respectively (Neff, 1979). The 1-methylnaphthalene 24 hr LC_{50} for the sheepshead minnow (Cyprinodon variegatus) is 3,400 ug/L (Neff, 1979).

6.2.5 Exposure Assessment

The purpose of the exposure assessment is to measure or estimate the potential intensity, frequency, and duration of exposures of an agent(s) of concern to identified receptors. Each identified route of exposure is evaluated separately, with the summation of the route(s) used to evaluate the total exposure of an agent to the appropriate receptor(s). Total exposure is then compared to known levels occurring in the environment from which potential ecological risk is evaluated.

6.2.5.1 Terrestrial Exposure Assessment

Potential exposure of terrestrial wildlife to contaminants on the DCL site is limited to the surface soils, surface water, and seeps. Direct and/or indirect ingestion and absorption through contact are the routes of exposure related to contaminants in surface soils, surface water, and seeps. Direct ingestion may occur by invertebrates, such as worms and some larva, consuming soil, or by birds and mammals preening feathers or pelts which have contaminated soil attached to them. Indirect ingestion may occur by mammals and birds feeding on invertebrates from the soil, emerging from surface waters and soils, feeding on plants which have taken contaminants into their tissue through the roots or that have dust on the foliage, and/or burrowing through contaminated soil. Absorption may occur through the skin by direct contact with contaminated soil, surface water, or seeps.

The terrestrial exposure will be evaluated by comparing on-site concentrations of organic and inorganic compounds in each media to that detected in the background samples. The maximum concentration detected of compounds that are detected above background concentration will be used to assumed worst case exposure. The toxicity of these compounds at the levels detected will be further evaluated during the toxicity assessment. The stream surface water will be discussed during the aquatic exposure assessment.

No detailed terrestrial sampling for mammals or birds was performed in the DCL site study area. Therefore, modeling of selected indigenous species will be performed to evaluate the terrestrial ecological risk. The selected species are the song sparrow (Melospiza melodia) and the shorttailed shrew (Blarina brevicauda). The song sparrow represents a strictly terrestrial species that is expected to have limited exposure to the surface water by ingestion and bathing. The song sparrow primarily feeds on vegetation (seeds). The shorttailed shrew is primarily an insectivore feeding on invertebrates in soils. By modeling the exposure pathways for these two species, the risks to the terrestrial community may be evaluated.

Calculating Daily Ingestion Rates

Water Ingestion - Calder and Braun (1983) developed an allometric equation for water ingestion for birds based on the measured body weights and drinking water values from Calder (1981) and Skadhauge (1975). The equation is as follows:

$$WI\ (L/day) = 0.059\ Wt^{0.67}(kg),$$

where "WI" is water ingestion in liters per day and "Wt" is the average weight of the bird in kilograms. The WI value includes water ingested through the consumption of vegetation and invertebrates. For the purpose of this evaluation, it will be assumed that the water intake will be solely from the surface water in order to evaluate the worst case scenario. This assumption will result in higher calculated exposure estimates than are likely to be actually occurring.

The average weight of a song sparrow is 0.0164 kg (Bartholomew and Cade, 1963). Using this value, the average water consumption of a song sparrow is calculated to be 3.8×10^{-3} L/day.

Similarly Calder and Braun (1983) developed an allometric equation for water ingestion for mammals. The equation is as follows:

$$WI\ (L/day) = 0.099\ Wt^{0.90}(kg)$$

The average weight of a shorttailed shrew is 0.0179 kg (Fergus, N.D.). Using this value, the average water consumption of a shorttailed shrew is calculated to be 2.6×10^{-3} L/day.

Food Ingestion - Nagy (1987) calculated the food ingestion rates (FI) for both passerine birds and mammals in grams dry matter per day, based on animal weight (Wt). The calculation for the song sparrow is as follows:

$$FI\ (g/day) = 0.398\ Wt^{0.850}(g).$$

The rate of food consumption of the shorttailed shrew can be calculated by dividing its free-living metabolic rate (FMR) by the metabolized energy (ME) in its food (Nagy, 1987). Nagy developed an equation based on doubly-labeled water measurements of CO_2 production in free-living carnivorous animals. The equation is as follows:

$$\log FMR\ (kcal/day) = -0.210 + 0.862 \log Wt\ (g).$$

From this equation the FMR for the shorttailed shrew is 7.41 kcal/day. From the data reported by Golley (1961) and Robbins (1983), Nagy (1987) calculated the average value for ME efficiency for insect eating mammals to be 4.47 kcal/g. By dividing the FMR by the ME, the rate of food consumption for a shorttailed shrew was calculated to be 1.66 X 10^{-3} kg/day. To address the worst case, it will be assumed that the ingested food is obtained solely from the sample locations of highest contamination.

Calculating Daily Exposure Rates

Surface Water Ingestion - Surface water ingestion rates were calculated only for the song sparrow. The shorttailed shrew, as well as many other small mammals, obtain the majority of their required water from the water content in their food and from sources other than water bodies, such as dew drops and puddles. To determine the daily exposure rates of water ingestion for the song sparrow and shorttail shrew, the daily intake rates will be multiplied by the levels of contaminants found at the locations of the highest concentrations of the contaminants of concern in Streams A, B, E and the leachate samples (SA-3, SB-6, SE-1, and SL-2). The daily exposure rate per body weight (DER/BW) by water ingestion is calculated by dividing the BW into DER. Table 6-46 summarizes the exposure calculations for surface water ingestion by the song sparrow and shorttailed shrew for streamwater and leachate.

Food Ingestion - To address food consumption, the estimated food contaminant concentration will be calculated by multiplying the contaminant levels found in the sediment by the appropriate bioaccumulation factor (BCF). When no BCF is available, contaminants will be multiplied by an estimated BCF. The daily exposure rate of food ingestion is then calculated by multiplying the estimated food contaminant concentrations by the daily food consumption rate. The daily rate per body weight (DER/BW) of food ingestion is calculated by dividing the BW into DER. Total semi-volatiles were modeled using concentrations detected at SWD-2. Metals were modeled using concentrations at FAP-3. These were the locations of greatest contamination concentrations for

TABLE 6-46

DAILY EXPOSURE RATE OF THE SONG SPARROW TO INGESTED SURFACE WATER CONTAMINANTS

PARAMETERS	VAWQC SA-3 (ug/L)	CONC. SA-3 (ug/L)	DAILY EXPOSURE RATE (DER) (ug/day)	DAILY EXPOSURE RATE/BW (DER/kg BW)	VAWQC SB-6 (ug/L)	CONC. SB-6 (ug/L)	DAILY EXPOSURE RATE (DER) (ug/day)	DAILY EXPOSURE RATE/BW (DER/kg BW)
TOTAL METALS	---	446	1.70	104	---	6,980	26.5	1,620
IRON	1,000	268	1.02	62.2	1,000	1,250	4.75	290
MANGANESE	100	10.7	0.041	2.50	100	2,730	10.4	634
ALUMINUM	---	1.39	0.528	32.2	---	290	1.10	67.1
CADMIUM	0.82	BDL	---	---	0.96	15.6	0.059	3.60
LEAD	1.92	UND	---	---	2.47	30.9	0.117	7.13
ZINC	47	28.8	0.109	6.65	47	2,660	10.1	616
bis(2-ETHYLHEXYL) PHTHALATE	---	BQL	---	---	---	210	0.798	48.7

PARAMETERS	VAWQC SE-1 (ug/L)	CONC. SE-1 (ug/L)	DAILY EXPOSURE RATE (DER) (ug/day)	DAILY EXPOSURE RATE/BW (DER/kg BW)	VAWQC SL-2 (ug/L)	CONC. SL-2 (ug/L)	DAILY EXPOSURE RATE (DER) (ug/day)	DAILY EXPOSURE RATE/BW (DER/kg BW)
TOTAL METALS	---	1,590	6.03	368	---	27,836	105	6,430
IRON	1,000	309	1.17	71.3	1,000	27,200	103	6,280
MANGANESE	100	575	2.19	134	100	636	2.42	148
ALUMINUM	---	BDL	---	---				
CADMIUM	0.55	5.8	0.022	1.34				
LEAD	0.37	7.2	0.027	1.65				
ZINC	47	691	2.63	160				
bis(2-ETHYLHEXYL) PHTHALATE	---	BQL	---	---				

BDL - Below Laboratory Detection Limits BQL - Below Laboratory Quantification Limits
UND - Laboratory Blank Contamination BW - Body Weight
VAWQC - Virginia Water Quality Criteria for the Protection of Aquatic Life

Calculation Values
Average BW of a Song Sparrow - 0.0164 kg
Estimated Daily Water Intake of a Song Sparrow - 3.8 x 10^{-3}L/day

semi-volatiles and metals respectively. Table 6-47 summarizes the exposure calculations for food ingestion by the song sparrow and shorttailed shrew.

Exposure Assessment for Terrestrial Receptors

Data Gaps - Numerous data gaps are inherent in the exposure modeling. The song sparrow may additionally be exposed to contaminants by bathing and incidental ingestion of soil invertebrates, potentially increasing exposure. The shorttailed shrew is expected to ingest soil directly when foraging and may absorb soil contaminants through the skin, potentially increasing exposure. Also the foraging range of both species naturally may taken them out of the areas of high contamination potentially decreasing their exposure. These variables can not be evaluated at this time. However, assuming that both animals spend all of their time living and feeding in the sample areas of highest contamination concentration, it is believed that the modeling will yield a conservative estimation of potential exposure.

Terrestrial Exposure Assessment - By comparing detected contaminant concentrations, estimated exposures, and toxicity information, a determination can be made as to the significance of potential exposure. Exposure related to the vegetation is based upon detected levels in soils without any modeling. Vegetation may be exposed to lead, manganese, and zinc, and to a lesser extent, cadmium at levels of potential concern, primarily around the fly ash pile. In addition, aluminum is naturally occurring at potentially toxic levels for some plants. Aluminum toxicity is most easily observed as stunted growth. Stunted growth of young pine species at the western portion of the site was observed, however, this may be due to the extremely arid conditions and poor soil present on the hillside. Annual plants are more susceptible to toxicity than perennials due to their rapid growth requirements and nutrient uptake, and their shallow root base.

Potential toxic exposure of bird species by ingesting plant material contaminated by lead and zinc (and to a lesser degree, cadmium and manganese) may be occurring near the fly ash pile. Exposure to cadmium through ingestion

TABLE 6-47

DAILY EXPOSURE RATES OF THE SONG SPARROW TO INGESTED CONTAMINANTED FOOD

PARAMETERS	CONCE. DETECTED (mg/kg)	LOCATION MODELED	ESTIMATED BIOACCUM. FACTOR	ESTIMATED FOOD CONC. (mg/kg)	DAILY EXPOSURE RATE (DER) (mg/day)	DAILY EXPOSURE RATE/BW (DER/kg BW)
CADMIUM	19.9	FAP-3	10	199	0.856	52.2
LEAD	395	FAP-3	10	3,950	17.0	1,040
MANGANESE	682	FAP-3	10	6,820	29.3	1,790
ZINC	3,520	FAP-3	10	35,200	151	9,210
TOTAL METALS	4,616	FAP-3	10	46,160	199	12,000
TOTAL SEMI-VOLATILES	10.635	SWD-2	100	106.35	4.56	278

DAILY EXPOSURE RATES OF THE SHORTTAILED SHREW TO INGESTED CONTAMINANTED FOOD

PARAMETERS	CONC. DETECTED (mg/kg)	LOCATION MODELED	ESTIMATED BIOACCUM. FACTOR	ESTIMATED FOOD CONC. (mg/kg)	DAILY EXPOSURE RATE (DER) (mg/day)	DAILY EXPOSURE RATE/BW (DER/kg BW)
CADMIUM	19.9	FAP-3	100	1,990	3.30	184
LEAD	395	FAP-3	100	39,500	65.6	3,670
MANGANESE	682	FAP-3	100	68,200	113	6,310
ZINC	3,520	FAP-3	100	352,000	584	32,600
TOTAL METALS	4,616	FAP-3	100	461,690	766	42,800
TOTAL SEMI-VOLATILES	10.635	SWD-2	1,000	10,635	17.7	989

DER - Daily Exposure Rate   BW - Body Weight

CALCULATION VALUES: Ave. Wt. of a Song Sparrow - 0.0164 kg; Ave. Wt. of a Shorttailed Shrew - 0.0179 kg; Est. Free-Living Metabolic Rate of a Shorttailed Shrew - 0.870 kcal/day; Est. Metabolic Energy of food for a Shorttailed Shrew - 4.47 kcal/g; Est. Required Food Intake for a Song Sparrow - 4.3 g dry matter/day; Est. Required Food Intake for a Shorttailed Shrew - 0.19 g dry matter/day.

of surface water near SB-6 may cause minor chronic toxicity to birds. Exposure to the levels of iron present at the leachate areas is sufficient to cause chronic toxicity. Exposures to semi-volatiles in the vicinity of SWD-2 are not likely to be toxic to birds, however, levels are potentially carcinogenic.

Potential toxic exposure to mammalian species ingesting soil invertebrates contaminated by lead, manganese, zinc, and to a lesser degree, cadmium may be occurring near the fly ash pile. Exposure to semi-volatile contamination in the vicinity of SWD-2 may be sufficient to cause both toxic and carcinogenic effects.

6.2.5.2 Aquatic Exposure Assessment

Contaminants in the water column offer two routes of exposure; the first being direct intake through mouthparts and gills, and the second through dermal absorption. Exposure to sediments may occur by two routes of exposure; the first being direct and incidental ingestion during feeding, and the second from dermal absorption. It will be assumed that the concentrations of compounds detected at the sample stations represent the average concentration in that stream section, and that the aquatic organisms are exposed to the detected concentrations continuously.

The aquatic exposure will be evaluated by comparing on-site surface water and sediment concentrations of organic and inorganic compounds to that detected in the background surface water and sediment samples taken at the reference station. The aquatic exposure is based upon the data from the benthic macroinvertebrate investigation (BMI) and the bioassay tests (Section 4.4).

Exposure Interpretation From Results - The results of the chronic surface water bioassay involving Ceriodaphnia dubia gave inconsistent results which were often contrary to the chemical and BMI data, therefore, these results were not used as part of the exposure assessment. All of the results from the 7 day chronic bioassays involving Pimephales promelas, the 10 day chronic sediment bioassay involving Hyallela azteca, and BMI indicated significant toxic exposure of the aquatic community to the sediments and surface water in Stream B. It should be noted that the 7 day surface water bioassay indicated that a 50% solution of the steam water sampled inhibited growth, and greater concentrations (100%) had no survival. The BMI also indicated significant exposure occurring in Stream E, although the exposure does not seem to be as pronounced as that of Stream B. This is most likely due to dilution resulting from the confluence of Stream D. Streams A, D and F showed no signs of contaminant exposure, although apparently natural elevated levels of iron, lead, and zinc were detected in Stream F. Elevated levels of benzoic acid were detected in the sediments of Stream C, however, Stream C appears to be temperate and the benzoic acid appears to be an isolated occurrence.

Parameters That Exceed The VAWQC - Aluminum, cadmium, iron, lead, manganese, nickel, zinc, and cyanide exceeded VAWQC or were present at elevated levels in at least one surface water sample. Aluminum was detected at a concentration of 1,880 ug/L at SB-2, however, the aluminum concentrations were significantly lower at all other locations. There is no VAWQC for barium. A literature search indicated that the barium concentrations are orders of magnitude below levels that have been documented to be toxic to most aquatic invertebrates and fish. Cadmium was elevated above VAWQC for all sample locations between SB-5 and SE-1. Iron was elevated above VAWQC in the majority of Stream B. Lead was elevated above VAWQC in most of the stream sample locations including the reference station. Elevated lead concentration, to a limited extent, may be naturally occurring, however, lead concentrations downstream from the fly ash pile were significantly higher than background samples. Manganese concentration were elevated above VAWQC throughout most of Stream B and SE-1. During the second sampling round, nickel was reported to be above VAWQC in Streams A, B, C, D, and E. However, all samples at locations where nickel was in exceedence were qualified as having detected levels similar to that found in the field blank, with the exception of SB-6. During the first sampling round, reported nickel concentrations were near or below detection limits that were well within the VAWQC, therefore it is unclear as to whether nickel is in exceedence or not. The laboratory detection limits for silver (5 ug/L) were above VAWQC, however, silver was not detected at this level. Zinc concentrations were elevated above VAWQC at all locations downstream of the fly ash pile, including SF-1. Cyanide was detected once at SB-4 at a concentration of 23.0 ug/L. Cyanide was not detected in any sediment sample. See Table 6-45 for VAWQC values.

6.2.5.3 Exposure Summary

Potential exposures of terrestrial vegetation and wildlife to contaminants at toxic and/or carcinogenic levels exists within the DCL site study area. Terrestrial vegetation is exposed to chronically toxic metal concentrations in the vicinity of the fly ash pile. Lead, manganese, and zinc are the primary contaminants of concern. Mammals are potentially exposed, both directly and through the food chain, to lead, manganese, cadmium and zinc at toxic levels in the vicinity of the fly ash pile. Mammals are also potentially exposed at toxic and carcinogenic levels of semi-volatile compounds in the vicinity of SWD-2. Avian species run a similar risk to similar contaminants. In addition, avian species run a potential exposure risk to direct and indirect exposure to surface water in the vicinity of SL-1, SL-2, and along Stream B.

There are significant exposure risks to aquatic organisms associated with Stream B adjacent to and downstream of the fly ash pile. Stream E also has exposure risks, however, the exposure risk is not as severe as that found in Stream B. Stream A does not appear to pose an exposure risk to aquatic organisms. Streams D and G have no risk of exposure to contaminants. Stream F has low levels of contaminants detected in both surface water and sediments but exposure levels do not appear to pose a risk to aquatic organisms.

6.2.6 Assessment of Risk

The assessment of risk integrates the results from the ecological investigation, contaminant location, toxicity data, receptors and exposure potential, and formulates the best estimate of ecological risk based on information and experience. Through the combination of these factors, a subjective risk estimation can be made. By applying the theoretical risks to actual conditions, a realistic risk assessment can be formed.

6.2.5.1 Threatened and Endangered Species

There were no Federal or State threatened, endangered, or species of special concern observed within the DCL site study area. This does not eliminate the possibility that they may exist on the site, but since no listed species are suspected to be on the site, these species will not be directly addressed in the risk assessment.

6.2.6.2 Terrestrial Assessment of Risk

Terrestrial Assessment of Risk - Toxicological information gained through literature searches and modeling of site contaminants indicated ecological risk associated with terrestrial vegetation and wildlife. The ecological risk is located in three areas: in the vicinity of the fly ash pile, in the vicinity of SWD-2, and at the leachate samples area.

The fly ash pile offer the greatest risk. Vegetation, especially annual species, are at risk due to the heavy metal contamination. Lead, manganese, zinc, and possibly cadmium are at toxic levels for some plants. Toxicity would most likely be chronic, and may be difficult to demonstrate in the field. Gross toxicity was not observed during the field investigation, however, limited vegetation was observed due to the season of the site visit. Mammals are at risk, primarily due to the lead, manganese, cadmium, and to a lesser extent, zinc contamination. Avian species are at lesser risk than the mammals from the same contaminants. Ecological risk has been modeled to potentially occur through both direct exposure and exposure through the food web.

Semi-volatile organic compounds, specifically PAHs, offer a significant risk to terrestrial wildlife in the vicinity of SWD-2. Vegetation is somewhat tolerant to the PAH levels. The PAH concentrations are at levels both toxic and carcinogenic to sensitive mammalian species exposed through both direct contact and ingestion of contaminants through the food chain. Small mammals are a greater risk due to their close contact with the soils. Avian species are not likely to be exposed to toxic levels of PAHs, however, levels are sufficient to potentially cause carcinogenicity to sensitive avian species.

The leachate areas pose a risk to large to medium sized mammalian species and to avian species that may directly ingest the surface water from these locations. Exposure to manganese and especially iron constitute the greatest potential risks.

Accuracy of the Models - The models used in determining the exposure of terrestrial organisms to contaminants do not consider a number of variables resulting in data gaps. These variables exist because of the lack of site specific information which is inherently unachievable or that is not practical to obtain. Incidental ingestion of soils while consuming soil invertebrates and burrowing, home ranges of species modeled, frequency of ingestion of contaminated food-stuff, metabolic variations between species (i.e. metabolic detoxification and excretion, hormone changes during reproduction, etc.), sensitivity to contaminants between species, duration of exposure, and actual uptake by organisms in food web are just a few of the variables. However, estimated ingestion rates can be determined to give a rough idea of exposures. By modelling using areas of highest concentration and assuming that the organism is solely ingesting that which has the greatest contamination, a conservative model may be developed. The actual exposure rate is most likely less then what is predicted, however, the conservatism helps to ensure that a false negative error (i.e. reporting "no risk" when a risk is present) does not occur.

6.2.6.3 Aquatic Assessment of Risk

Benthic Macroinvertebrate Investigation (BMI) - The aquatic investigation indicated an overall healthy aquatic community and habitat. Sensitive (EPT) organisms were usually dominate in the benthic collections. Diversity was high, and high numbers of organisms were generally collected. The exceptions were at SE-1 and SB-6 where ecological stress was evident. SB-6 appears to have significant impairment while SE-1 (located below the mixing zone at the confluence of Streams B and D) appears to be only mildly impaired. It should be noted that the habitat as well as site-related contaminants, may both contribute to the impairment at SB-6. For a more detailed description, see Section 4.5.

Bioassay Results - Significant toxicity was reported during each bioassay involving surface water and sediments taken from SB-7. This is in agreement with the results of the chemical analyses. On the other hand, the chronic bioassay using C. dubia indicated toxicity from surface water taken from all sample locations, results which are not collaborated. For example, both the BMI and chemical sampling results suggest a healthy reference area (Station SG-1) while the C. dubia results indicate toxicity. Aside from the bioassay involving SB-7, no toxicity was reported during the 7-day chronic bioassay using P. promelas or the 10-day chronic bioassay using H. azteca. The only exception being a statistically insignificant decrease in survival of H. azteca from sediments taken from SA-5. For a more detailed description, see Section 4.5.

Reference Station Evaluation - The reference station was determined to be representative of the natural stream habitat and community structure occurring in the area. High diversity, high numbers, and good EPT representation was observed at the reference station (SG-1). The community structure at station SG-1 was slightly different than that found at station SF-1. The difference can be attributed to the influence of the Roanoke River (a third-order stream, approximately 150 yards below SF-1), and that Stream F is a second-order stream as apposed to Stream G which is a first-order stream. Different order streams naturally have different community structures. As a result the more prevalent species from a particular order stream (e.g., 3rd Order, Roanoke River) may migrate into another order stream (E.g., 2nd Order, Stream F) in the stream sections that are in close proximity to their confluence, and vice versa.

Assessment of Risk - The VAWQC, BMI, and the bioassays either suggest and/or indicate severe impairment of the aquatic community in Stream B downstream of the fly ash pile. When compared to the reference station (SG-1), Stream B (SB-6) had low diversity, low number, low collector populations, low EPT populations, moderate dissimilarity, and low CPOM populations. The 7- day fathead minnow bioassay indicated reduced growth at 50% concentration and 100% mortality at 100% concentration of the surface water sample.

As illustrated in Figure 6-4, Stream B joins with Stream D to form Stream E. From the assessment performed, Stream E appears to be under stress. Generally lower numbers and EPT diversity were observed at SE-1 when compared to the reference station. It appears that "clean water" from Stream D is diluting the toxicity being introduced by Stream B. BMI did not reveal any significant toxicity in Stream D.

Elevated levels of zinc were detected in Stream F, although no impairment was indicated in either the BMI or bioassays. The zinc contamination may be responsible for the lack of periphyton and aquatic vegetation in Streams B and E.

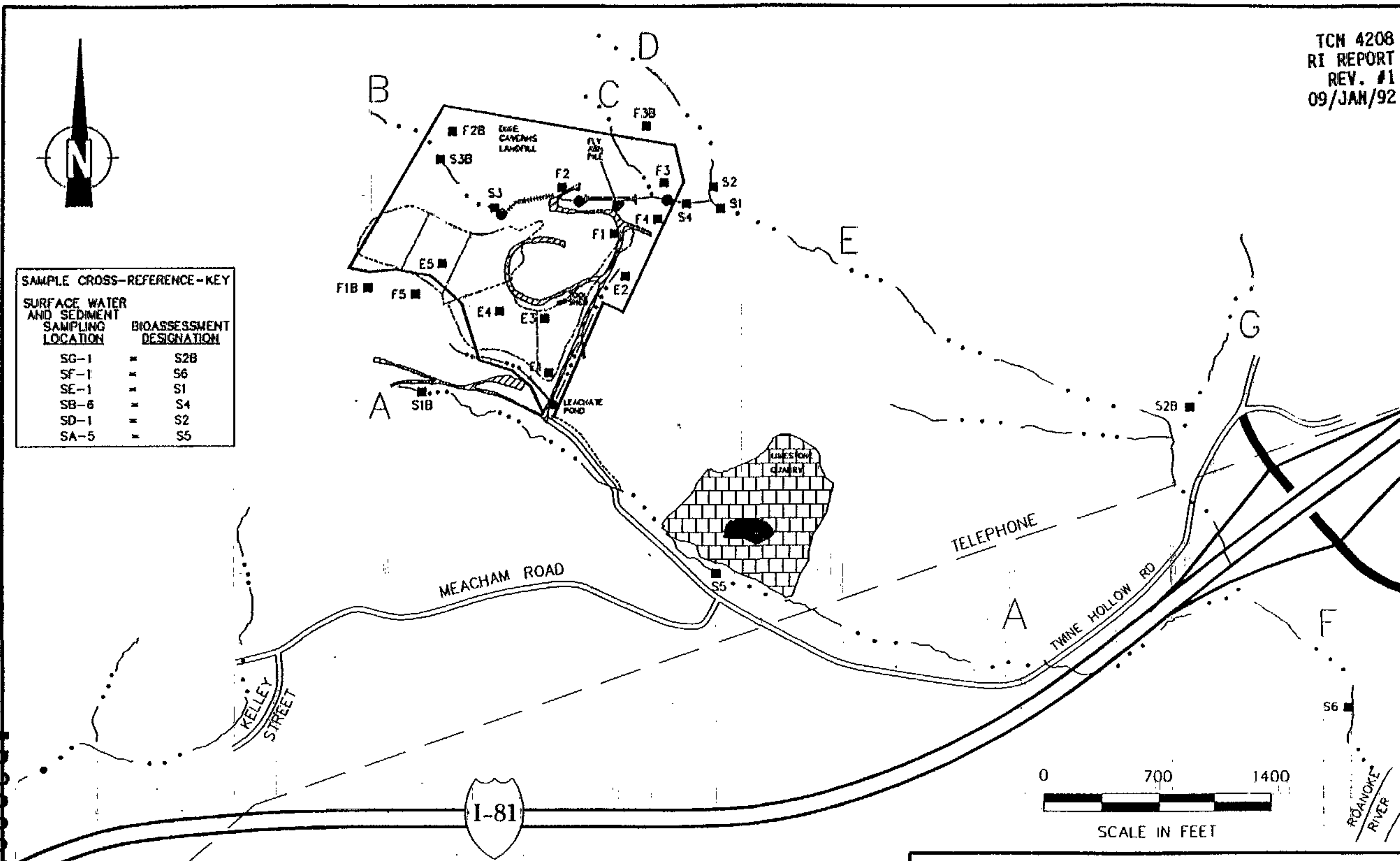
Streams A, D, and G appear to have a healthy aquatic community.

Source of Ecological Risk - The source of risk to aquatic life is the fly ash pile and historic contamination in the stream sediments. Presently there is a retention dam immediately downstream of the fly ash pile which acts as a settling pool for contaminated sediments. The dam greatly reduces the contaminant migration into the aquatic environment, however, dissolved contaminants in the water column and contaminated fine suspended contaminants are most likely still entering the system. In addition, the retention dam does not serve as a permanent solution for the protection of aquatic life. A significant quantity of fly ash appears to have entered Stream E prior to the installation of the retention dam. This historical contamination appears to be migrating down the tributaries, primarily in the sediments.

6.2.7 Conclusions of Ecological Assessment

Modeling has demonstrated the potential for ecological risk to terrestrial wildlife, both mammals and birds. The risk appears to be localized into three areas: the vicinity of the fly ash pile, leachate areas, and one of the five zones in the solid waste fill area SWD-2. The fly ash pile and leachate pose

TCM 4208
RI REPORT
REV. #1
09/JAN/92



SAMPLE CROSS-REFERENCE-KEY

SURFACE WATER AND SEDIMENT SAMPLING LOCATION		BIOASSESSMENT DESIGNATION
SG-1	=	S2B
SF-1	=	S6
SE-1	=	S1
SB-6	=	S4
SD-1	=	S2
SA-5	=	S5

LEGEND

- ROADWAY/WORK AREAS
- INTERMITTENT STREAMS
- DETENTION POND OR LAKE AREA
- OLD STREAM CHANNEL
- DIVERSION PIPE
- BIOASSESSMENT LOCATION
- DIVERSION CHANNEL

TETRA TECH, INC.

FIGURE 6-4
ECOLOGICAL SAMPLE LOCATIONS/QUADRANTS
DIXIE CAVERNS LANDFILL SITE

ecological risk due to the elevated heavy metal concentrations detected. Lead, manganese, zinc, cadmium, and iron are the contaminants of concern. Semi-volatile organic compounds, primarily PAHs, in the soil in the SWD-2 zone occur at levels that may cause chronic toxicity to mammals. Of greater concern is the carcinogenic potential the PAHs pose to both birds and mammals.

Vegetation is at risk in the vicinity of the fly ash pile. Zinc, lead, and manganese are the contaminants posing the greatest risk. No gross toxicity was observed during the site visit, however, the annual species were not present due to the season of the visit (early spring). The other vegetative areas observed appear to be typical of that expected to be present in the area. The emergent growth on the landfill appears to be undergoing the natural succession expected to occur.

The aquatic community is impaired in Stream B. Stress has been observed in Stream E near the confluence with Stream B. (It should be noted that the chemical data and observations from the sample station in Stream E is only representative of that particular section of the stream, and that the conclusions may not necessarily accurately characterize the condition of Stream E further downstream.) The fly ash migrating from the fly ash pile is considered the cause of the stream impairment. Stream F does not appear to be under stress related to the site. The remaining Streams (A, D, and G) have a healthy aquatic community.

Of special interest to the ecologic assessment is the nearby Roanoke River which contains threatened and endangered species. Presently, there is no stress observed in Stream F. Therefore, ecological impairment of the Roanoke River, where Stream F discharges, is not thought to be occurring. However, the Roanoke River was not sampled to confirm this conclusion. There does appear to be a "slug" of heavy metal contamination working its way down the tributaries associated with the site. The majority of the contamination appears to be historical contamination (i.e., previously transported off-site), although it is suspected that the on-site fly ash pile also contributes contaminants dissolved or suspended in the water column. Regardless, significantly contaminated sediment will eventually reach the Roanoke River if measures are not taken to arrest the contamination migration. It is not known to what extent the river could tolerate the contamination should the migration continue.

7.0 SUMMARY AND CONCLUSIONS

7.1.1 Nature and Extent of Contamination

A summary of the nature and extent of contamination for surface water, sediment, surface and subsurface soils, and groundwater in the vicinity of the DCL site follows:

Ground Water Investigation

- The analysis of groundwater flow direction (Section 4.7.2) has identified fracture-controlled, localized patterns of recharge/discharge to be typical of the clastic rock geohydrologic unit at the DCL site. The groundwater gradient is a subdued reflection of surface topography, in which surface water courses represent groundwater flow lines, indicating a local gradient to the southeast and a regional gradient to the east, parallel to the Roanoke River. These groundwater flow direction data, enhanced by local topographic data, indicate that the majority of residential wells along Meacham Road (PW-9 through PW-15) are not hydrologically connected to the DCL site.

- The comparison of site RIW data among themselves, to RIW-1, and to published water chemistry reference values indicate that RIW-11, 12, and 13 are chemically anomalous. Attempts to identify site-wide or localized groundwater contamination arising from past disposal practices has resulted in the recognition of widely distributed elevated levels of iron, magnesium, and manganese, and selected locations with elevated sodium and very low-level organics (largely pesticides) at the DCL site.

- Very few organics were detected in the private wells and those that were found were at extremely low concentrations in locations which were determined to not be downgradient of the site. The compounds detected and hydrologic evaluation performed indicates that these organic compounds did not originate from the DCL site. **None** of the eight different pesticides and semivolatiles found in those residential wells were detected in the soils, surface water, or sediment at the DCL site. Of the few, very low levels of semivolatiles and pesticides detected in those residential wells, only heptachlor epoxide and gamma chlordane were also detected in the on-site monitoring wells. **No** organic compounds were detected at well locations downgradient of the DCL site and the inorganic constituents detected do not indicate contamination of residential wells by the DCL site.

- A summary comparison of the residential well inorganic data set as a population versus the monitoring well inorganic data set shows the following trends. The on-site wells generally contain proportionally higher amounts of the following inorganics: aluminum, potassium, sodium, arsenic, chromium, cobalt, iron, and manganese. The residential wells generally contain proportionally higher amounts of calcium and magnesium. The two populations have roughly equivalent proportions of barium, copper, lead, and zinc. These trends are a direct reflection of the geologic setting of the two well groupings.

- Table 7-1 identifies the groundwater concerns by comparing on-site monitor wells data with health-based criteria (risk of $1X10^{-6}$ for ingestion and showering) and with State of Virginia regulatory standards. It should be noted that current Virginia State Solid Waste Regulations support corrective actions where groundwater contaminants exceed background levels. However, in the absence of DCL site background information, a comparison is made against maximum concentrations provided in the Virginia State <u>Hazardous</u> Waste Management Regulations (HWM regulations may or may not be applicable to the site).

<u>Surface Soil</u>

- A geotechnical evaluation of soils covering the solid waste fill zone found generally low moisture contents, low liquid limits, and low values of recompacted permeability. The latter characteristics indicate that

Table 7-1

Summary of Groundwater Exceedences of Standards

Constituent	Concentration Resulting in 1X 10^{-6} Risk or a Hazard Index of Unity (Dissolved Metals, µg/L)	Locations of Health-based Criteria Exceedence	Dissolved Concentrations at Locations where Criteria is exceeded (µg/L)	Virginia State Hazardous Waste Regulation Standards (Total Metals, µg/L)	Location of Standard Exceedences	Concentration at Location where standard is exceeded (Total Metals, µg/L)
Antimony (Non-cancer risk)	5.8	RIW-01-02 RIW-10-02 RIW-12-02 RIW-13-02	10.8 15.5 21.5 24.5	Background	?	?
Arsenic (Cancer risk)	0.02[1]	RIW-02-01 RIW-04-01 RIW-08-01 RIW-02-02 RIW-03-02 RIW-08-02 RIW-09-02	6.1 3.4 6.2 4.0 2.0 3.0 2.0	50	None	None
Barium	1017	RIW-06-01	1640	1000	RIW-06-01	1640
Chromium	72.7	None	None	50	RIW-06-01	65.7
Lead	15[2]	None	None	50	RIW-04-02	59.9
Manganese (Non-cancer risk)	1430	RIW-02-01 RIW-03-02	1780 1490	Background	?	?

Notes
[1] Note, current MCL is 50 µg/L
[2] 15 µg/L is proposed MCL for Lead

relatively little precipitation will infiltrate into the solid waste disposal area. It should be noted that the recompacted permeability values do not appear to be consistent with the textural data for these soil samples. Textural data suggest a higher level of permeability should exist. Recompacted permeability values obtained are considered suspect.

- There were low levels of organic contaminants found in surface soils. Acetone was the only volatile organic compound detected, and was found in the background sample (B-3) and SWD-2 at 130 μg/kg and 7 (J) μg/kg, respectively. In general, the concentrations of semi-volatile compounds were low. The majority of the semi-volatile organic compounds detected in the surface soils were detected in samples from the solid waste disposal area at location SWD-2. In all, seventeen semi-volatile organic compounds were identified, accounting for a total concentration of 10,635 μg/kg. Bis(2-ethylhexyl)phthalate was detected above background in samples SWD-1 and SWD-2 in concentrations of 110 and 150 μg/kg, respectively.

- No pesticides or PCB's were detected in any of the surface soil samples.

- There was a wide range of inorganic compounds (metals) encountered in the soils at the DCL site. The metals lead, manganese, nickel, and zinc appear to be distinctively elevated above background concentrations. The highest metal concentrations were encountered in the immediate vicinity of the fly ash pile. Surface soil samples taken <u>around</u> the edge of the fly ash contained less than 400 mg/kg of lead while samples of the fly ash contained an average of 45,000 mg/kg of lead.

<u>Subsurface Soil</u>

- Eight (8) subsurface soil samples (2 samples collected at 4 sample locations) taken in the drum disposal and sludge disposal waste areas were reviewed for concentrations of six indicator contaminants. Contaminant levels in these samples did not exceed clean-up standards used by Roanoke County in remediation efforts. These standards were judged to be protective of human health by USEPA. In fact, the maximum indicator chemical concentration detected at the DCL site in any of the surface and subsurface soil samples was less than half of the clean-up standard.

- No pesticides were detected in any of the subsurface soil samples. However, the PCB compound Aroclor 1254 was present in samples collected in the former drum disposal area. Sample DD-1/2-4 feet (bgs) and sample DD-1/4-6 feet (bgs) contained concentrations of 300 and 370 μg/kg, respectively.

Air Pathway

- The potential for organic emissions from the DCL site appears to be negligible. Volatile organics detected in surface soils, subsurface soils, and groundwater can be characterized as being very low in concentration.

- The airborne movement of fly ash particulates appears to be negligible. Surface soil sampling in the immediate vicinity of the fly ash pile indicated very low levels of dispersal of fly ash. Furthermore, the fly ash appears to have an average diameter similar to sand (between 2 and .85 microns), and is unlikely to move easily in the heavily sheltered ravine in which the fly ash pile resides.

Surface Water

- Inorganic analytes appear to the most common surface water contaminant at the DCL site. Aluminum, cadmium, copper, iron, lead, manganese, nickel, and zinc were detected above Virginia Water Quality Criteria (VAWQC) or were at levels above background for analytes for which no criteria exists. In the stream surface water samples, the levels of many inorganics (e.g., cadmium, lead, zinc, and manganese) are distributed in a similar pattern; the highest concentrations are found between a historic disposal area (the fly ash pile) and the confluence of Streams B and E.

- High levels of inorganics were found in leachate samples draining from the solid waste fill area. It should be noted that the leachate samples collected were **downstream** of an activated carbon filter operated by the County of Roanoke. Accordingly, the level of organic compounds in the leachate is unknown.

Sediments

- Polycylic Aromatic Hydrocarbons (PAHs) and Phthalate Esters are the predominate organic compounds found in sediments at the DCL site. In the southern drainage path, bis(2-ethylhexyl)phthalate and di-n-octylphthalate were detected at and downstream of Station SA-4 (first sampling station downstream of the site entrance). PAHs are the predominate semi-volatile compounds found in the Stream B sediments and include, Benzo(a)pyrene and Benzo(b)fluoranthene. PAHs were detected in sediments just downstream of a historic waste area (the drum disposal area) but not upstream of it.

- A variety of inorganics in sediments appear to originate from the DCL site. The major concentration of metals in sediments are found in the northern drainage path and appear to originate from the fly ash pile. Inorganic metals detected include lead, manganese, zinc, chromium, silver, cadmium, antimony and barium. The concentration of all of these metals increases dramatically at the toe of the fly ash pile, peaks in concentration near the confluence of Streams B and E, and then decreases as Stream E flows southeastward.

7.1.2 Data Limitations and Recommendations for Additional Work

Field sampling activities at the DCL site fulfilled all of the investigation objectives outlined in the site Work Plan. However, the evaluation of the wealth of data produced by field activities has introduced new questions regarding the DCL site. Areas where additional work may be warranted are as follows.

- Perform additional sediment sampling to identify the extent of migration of fly ash material in Stream E sediments. At this time it is uncertain at what distance upstream of the Roanoke River the lead and zinc levels are acceptable. In addition, little information exists on the depth of sediment deposits throughout the affected section of Stream E. Concurrent with the investigation of sediment, surveying of potential sites suitable for construction of sediment collection facilities should be performed.

7.2 FATE AND TRANSPORT

Based on field investigation results, there is a need to consider transportation mechanisms for organic compounds (PAHs and phthalate esters) and inorganic (metals) contaminants. The dominant fate processes associated with these compounds appear to sorption to soil and sediment, and groundwater advection. These compounds are relatively unsusceptible to biodegradation transformation. A summary of contamination migration pathways and contaminant fate and transport follows:

Sediment

- Field investigation efforts suggest a plume or slug of sediments with high metal concentrations is slowly moving away from the site in Stream E. Based on laboratory analysis of sediment samples, the slug has not reached the Roanoke River. Sampling along Stream E suggests the front of this slug is somewhere between 800 and 1600 feet upstream of the confluence of Streams E and G. Based on current information, the slug front has moved downstream between 100 and 200 feet per year, assuming movement started when the waste disposal ceased in 1976.

Surface Soils

- A significant potential for surface erosion and movement of contaminated surface soils exists in soils covering the solid waste disposal area. Current on-site sediment/erosion controls (detention ponds and grass swales) appear to have limited the movement of contaminated soils from the site, however, steep areas left bare by recent remediation efforts will erode and may exceed the capacity of existing sediment/erosion controls.

Ground Water

- Contaminants found at the DCL site do not indicate the presence of a concentrated contaminant plume. The extent to which any contaminant at the DCL site might migrate in the downgradient direction is difficult to quantify without complex numerical models. However, according to simple dilution calculations any contaminants introduced by the DCL site will be reduced to 1% of on-site levels by the time groundwater reaches the nearest downgradient residential wells (PW-1 through PW-6). This level of dilution estimate is supported by concentrations of metals in the detected in on-site (RIW) and residential (PW) wells.

7.3 RISK ASSESSMENT

Chemicals of Potential Concern

Of the chemicals detected at the DCL site, chemicals of potential concern were selected based on several criteria, including frequency of detection and the percent contribution of risk using derived risk factors. Note, chemicals found in residential wells not downgradient of the site were not considered as a site related problem. As such these residences are not included in the site risk assessment even though chemicals may be of concern to public health.

Over 20 compounds were selected as chemicals of potential concern at the DCL site, including carcinogenic and noncarcinogenic PAHs, phthalate esters, and several heavy metal compounds such as cadmium, lead, and zinc. From the groundwater monitoring results, arsenic and manganese appeared to be the primary contaminants of concern; however, the concentrations of these inorganics did not appear to be elevated. Residential wells in the area also did not appear impacted by the site based on a comparison of water chemistry.

In surface water, barium, cadmium, manganese, and zinc were the primary chemicals of potential concern. Lead released from the site did not appear to significantly impact groundwater, surface water, or soil at the DCL site. Both carcinogenic and noncarcinogenic PAHs were found in sediment, surface soil, and subsurface soil. Sediments in the northern drainage area appear to be significantly impacted from storm water runoff from the fly ash pile. Highly elevated levels of cadmium, lead, and zinc were found in sediment samples collected near the fly ash pile.

Exposure Assessment

The following **current** land-use exposure pathways were be quantitatively evaluated in this report:

- ingestion and dermal absorption of chemicals of potential concern in groundwater from private wells by off-site residents (assuming no treatment of groundwater);
- direct contact with surface soil by trespassers (i.e., children) playing at the DCL; and
- direct contact with surface water and sediments by children playing in various streams and groundwater seeps in the vicinity of the DCL site.

The following **future** land-use exposure pathways were quantitatively evaluated in this report:

- ingestion and dermal absorption of chemicals of potential concern in groundwater at the DCL site by hypothetical future residents.

Exposure point concentrations were estimated for each chemical of potential concern and exposure pathway. Exposure point concentrations and exposure parameter values were combined using a chemical intake equation to estimate exposure (i.e., chronic daily intake [CDI]) for the reasonable maximum exposure (RME) case for each chemical of potential concern and pathway.

Human Health Risk

Toxicity criteria (Section 6.1.4) and CDIs (Section 6.1.3) were combined to quantify potential carcinogenic risk and noncarcinogenic hazard associated with the exposure pathways quantitatively evaluated in the DCL baseline risk assessment.

Potential carcinogenic risk was quantified by multiplying the CDI by the slope factor when the cancer risk was below 10^{-2}. Chemical-specific cancer risks were summed in order to quantify the total cancer risk associated with exposure to a chemical mixture. Potential carcinogenic risks are expressed as an increased probability of developing cancer over a lifetime (i.e., excess individual lifetime cancer risk) (USEPA 1989a). For example, a 10^{-6} increased cancer risk can be interpreted as an increased risk of 1 in 1,000,000 for developing cancer over a lifetime if an individual is exposed as defined by the pathways presented in this report. A 10^{-6} increased cancer risk is the point of departure established in the NCP (USEPA 1990). In addition, the NCP (USEPA 1990) states that "for known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6}." Carcinogenic risks in excess of the acceptable risk range are likely to trigger a remedial response. Carcinogenic risks within the acceptable risk range, yet in excess of the point of departure (i.e., 10^{-6}), also may trigger a remedial response.

Noncarcinogenic effects associated with exposure to a contaminant was quantified by dividing its CDI with its reference dose (RfD). This ratio is called the hazard quotient. If the hazard quotient exceeds unity (i.e., 1), then an adverse health effect may occur. If the estimated hazard quotient is less than unity, then adverse noncarcinogenic effects are unlikely to occur. The potential risk from a chemical mixture was evaluated by calculating the hazard index which is the sum of the chemical-specific hazard quotients.

As discussed in Section 6.1.3.3, Section 6.1.5, and Section 6.1.6, conservative assumptions were used to estimate CDIs and risk in order that potential risk was not underestimated. The conservative assumptions were used because of the uncertainty associated with the risk assessment process. The assumptions discussed in this report should be considered when reviewing the risks presented in this section. In particular, the risk estimates presented for future use of groundwater should be interpreted as an evaluation of groundwater quality at the site for developing remediation strategies. Groundwater at DCL is currently not used as a drinking water resource.

A summary of the potential carcinogenic risks and noncarcinogenic hazards estimated for the exposure pathways quantitatively evaluated in the DCL baseline risk assessment is discussed below.

- Current Land-Use: Use of Groundwater from Residential Wells Downgradient of the DCL Site. No potential carcinogenic chemicals were detected in the 10 residential wells detected southeast of the DCL site. In addition, the hazard indices for all of the private residential wells were below unity (1). The highest hazard index of 0.3 was estimated for use of groundwater from PW-8. Therefore, noncarcinogenic effects associated with ingestion and dermal absorption of contaminants from these residential wells are unlikely to occur.

- Current Land-Use: Direct Contact with Surface Soil by Children Playing at the DCL Site. The total excess cancer risk associated with incidental ingestion and dermal absorption (i.e., $2x10^{-5}$) exceeded the NCP point of departure (i.e., 10^{-6}), but was below the upper-bound of the NCP acceptable risk range (i.e., 10^{-4}) (USEPA 1990). Potential carcinogens detected in surface soil include carcinogenic PAHs, beryllium, and arsenic. The only significant concentration of benzo(a)pyrene (equivalents) was found in the sample SWD-2 collected in the solid waste disposal area. Similar levels of arsenic and beryllium were found in both the solid waste disposal area and in **the vicinity** of the fly ash pile (does not consider direct contact with fly ash). All of the contaminant-specific hazard quotients, as well as the hazard index, were below unity. Therefore, noncarcinogenic effects associated with direct contact with surface soil while playing at the DCL are unlikely to occur.

- Current Land-Use: Children Playing in Streams in the Northern Drainage Area. The potential carcinogenic risk associated with dermal absorption of contaminants in surface water and sediments, and incidental ingestion of sediments in the northern disposal area was $8x10^{-6}$. Thus, the estimated carcinogenic risk exceeds the NCP point of departure of 10^{-6}, yet is below the upper-bound of the NCP acceptable risk range (i.e., $< 10^{-4}$) (USEPA 1990). The primary carcinogens of concern in the northern disposal area include: bis(2-ethylhexyl)phthalate in surface water and carcinogenic PAHs in sediments. These chemicals were detected near the fly ash pile. It should be noted, however, that risks associated with exposure to background levels of arsenic and beryllium in surface water and sediments are much higher than those estimated for the two organic compounds.

With respect to noncarcinogenic hazards, the hazard index exceeded unity (1) by a factor of 8. Chemicals that significantly contributed to this hazard index include: cadmium in surface water, and cadmium, silver, and zinc in sediments. Thus, noncarcinogenic effects associated with direct contact with surface water and sediments directly downstream of the fly ash pile may occur. In surface water, the highest detected concentrations of cadmium were found at Stations SB-5 and SB-6 which are located just downstream of the fly ash pile. The highest levels of cadmium, silver, and zinc are found in sediments between Stations SB-5 and SE-1.

The potential noncarcinogenic hazard associated with exposure to lead in sediments was evaluated using a pharmacokinetic approach. There is a 96% chance that a six year old child regularly playing in sediments near the fly ash pile (sample location SB-7) would have elevated blood-lead levels (i.e., > 10 ug/dL). The maximum detected concentration of lead (30,800 mg/kg) also exceeds the interim soil cleanup level for lead at Superfund sites by a factor of 60. This interim cleanup level is considered to be sufficiently protective for direct contact in residential settings (i.e., 500 mg/kg) (USEPA 1989d). In the northern drainage pathway, elevated lead concentrations are found in sediments from just below the fly ash pile to confluence of Streams E and G.

- Current Land-Use: Children Playing in Streams and Seeps in the Southern Drainage Area. The total potential carcinogenic risks associated with direct contact with surface water in the southern drainage area was below the NCP point of departure (i.e., 10^{-6}) (USEPA 1990). No potential carcinogenic compounds were selected as chemicals of potential concern in sediment in the southern drainage area.

  With respect to noncarcinogenic hazards, individual contaminant-specific hazard quotients and the hazard index for all chemicals of potential concern in surface water for the southern drainage area were below unity. Accordingly, noncarcinogenic effects are unlikely to occur. Di-n-octylphthalate was the only chemical of potential concern selected for sediment; however, toxicity criteria were not available for this chemical. Background levels of several inorganics detected in this stream may present a greater hazard than those estimated for the chemicals of potential concern which may or may not be related to the site. Therefore, it does not appear that the site has significantly impacted this stream from a human health stand point.

- Current Land-Use: Children Playing in Stream F. All chemicals detected in surface water at Stream F were found to be within natural background and were not selected as chemicals of potential concern. The total potential carcinogenic risks associated with direct contact with sediment in Stream F was below the NCP point of departure (i.e., 10^{-6}) (USEPA 1990). With respect to noncarcinogenic hazards, individual contaminant-specific hazard quotients and the hazard index for all chemicals of potential concern in sediment at Stream F were below unity; therefore, noncarcinogenic effects are unlikely to occur.

- Multimedia Assessment of Risk under Current Land-Use Conditions. For the multimedia exposure assessment, it was conservatively assumed that an individual is exposed via all exposure routes evaluated, as well as the highest risk estimated for any given location according to the RME case (i.e., highest risk estimated for direct contact with surface water and sediment, and use of untreated groundwater from PW-8). The total carcinogenic risk was $3x10^{-5}$ and the hazard index was 9. The highest carcinogenic risks were associated with direct contact with surface soil, while the highest noncarcinogenic hazards were estimated for direct contact with sediments and surface water in the northern drainage area. The most significant risk estimates associated with direct contact with streams occurred in the northern drainage area just downstream of the fly ash pile.

- Future Land-Use Conditions: Use of Groundwater by Hypothetical Residents at the DCL Site. The potential carcinogenic risk from using groundwater for ingestion and bathing was $3x10^{-4}$. This risk exceeded the NCP point of departure (i.e., 10^{-6}) and the upper-bound of the NCP acceptable risk range (i.e., 10^{-4}) (USEPA 1990). Arsenic was found in wells sunk near the fly ash pile and between the solid waste disposal area and Twine Hollow Road to the south. It should be noted, however, that the maximum detected concentration of arsenic was only 5 ug/L which is 10 times lower than the MCL for arsenic (50 ug/L). In addition, recent evidence suggest that the slope factor for arsenic is based on a non-lethal cancerous effect (i.e., skin rash). Also, exposure to arsenic may have a threshold (similar to a noncarcinogenic effect), for which the maximum concentration does not exceed.

The hazard index associated with ingestion of groundwater at the DCL site exceeded unity by a factor of 5, mainly due to antimony and manganese, the only contaminants with hazard quotients that exceeded one. Antimony was detected at four monitoring well locations: RIW-1, RIW-7, RIW-10, and RIW-12. Manganese was detected at all sample locations, with the highest levels found in RIW-2 and RIW-10. Therefore, noncarcinogenic effects from ingestion of groundwater from the DCL site may occur. It should be noted, however, that the RfD for antimony was derived using an uncertainty factor of 1,000. In addition, it is difficult to ascertain the level of antimony and manganese which is present from natural sources. RIW-1 was intended to serve as a background well but was found to be contaminated with volatile organic compounds.

Non-Site Related Human Health Risk

While evaluating human health risks associated with the DCL site, an assessment of non-site related health risk was performed on residential wells hydrogeologically isolated from the DCL site. Several potential carcinogenic organic chemicals and arsenic (which is a known human carcinogen), were detected in four residential wells (i.e., PW-9, PW-10, PW-12, and PW-14) located south/southwest of the DCL. A second round of residential well sampling was performed to verify the groundwater quality in some of these wells but only preliminary laboratory results are available at this time.

Based on the first round of residential well water sampling, a potential carcinogenic risk is associated with use of groundwater (i.e., ingestion and bathing) at PW-9 and PW-14. For these wells carcinogenic risks were estimated to be approximately 2×10^{-4}, which slightly exceeds the upper-bound of the NCP acceptable risk range (i.e., 10^{-4}). It should be noted that preliminary laboratory results indicate the carcinogenic chemical found in PW-9, bis(2-chloroethyl)ether, was not detected during the second round of sampling. In addition, the arsenic found in PW-14 was detected at a concentration 10 times below the current MCL of 50 ug/L.

The low detected concentrations of pesticides found in PW-10 and PW-12 resulted in carcinogenic risks of 1×10^{-6}, which equals the NCP point-of-departure. In addition, the level of lead in PW-10 (Round 1: 26 ug/L, Round 2: 16 ug/L [preliminary result]) is below the current MCL of 50 ug/L, but exceeds the proposed MCL of 15 ug/L. The levels of lead in PW-10 may be of concern, particularly to children, since the proposed MCL for lead of 15 ug/L was a more accurate health-based derivation.

Environmental Risk

The major conclusions regarding potential risks to aquatic and terrestrial habitats in the vicinity of the DCL site are as follows:

- The Roanoke River contains a federal endangered species and a candidate species. A slug of sediment containing high levels of metals is currently working its way from the site toward the Roanoke River along an intermittent stream. Currently, there is no visible impact of metal-enriched sediments on a tributary to the Roanoke River (Stream F). However, sediment related impairment of the aquatic community was identified in the northern drainage path near the site boundary (Stations SB-6 and SE-1). There are no threatened, endangered, or species of concern on the DCL site for plants, mammals, or insects.

- Contaminants found in three locations on the DCL site impose an ecologic risk to terrestrial wildlife (mammals and birds). Risk is found in the immediate area of the fly ash pile, in one zone of the solid waste fill area, and in areas where leachate discharges near the site entrance. At the fly ash pile, lead, manganese and zinc are the chemicals of concern. PAHs found in surface soils covering solid waste in the SWD-2 zone impose chronic toxicity to mammals. Finally, wildlife which come into contact with leachate draining from the solid waste fill zone are at risk due to elevated heavy metal concentrations.

- In general, the site does not appear to impose an ecologic risk to the terrestrial habitat. However, levels of heavy metals in the area immediately adjacent to the fly ash pile are sufficient to be toxic to vegetation.

7.4 RECOMMENDED REMEDIAL OBJECTIVES

Based on the results of this investigation, the following remedial objectives are recommended for each of the major media related to the site:

OBJECTIVES FOR SURFACE WATER - Recommended remedial action objectives for risks associated with surface water include:

- limit further surface water contamination by site related contaminants through mitigation of the fly ash pile.

OBJECTIVES FOR SURFACE SOILS - Recommended remedial action objectives for risks associated with surface soils include:

- inhibit further releases of any site related contaminants by way of erosion.

OBJECTIVES FOR SUBSURFACE SOILS - Recommended remedial action objectives for risks associated with subsurface soils include:

- inhibit further releases of any site related contaminants by limiting activities which would expose subsurface soils to transport processes.

OBJECTIVES FOR SEDIMENT - Recommended remedial action objectives for risks associated with sediments include:

- limit the impacts of contaminated sediment originating from the site to protect sensitive and valuable aquatic habitat.

OBJECTIVES FOR GROUND WATER - Recommended remedial action objectives for risks associated with ground water include:

- prevent the future ingestion of ground water at the site;

Screening and evaluation of specific remedial alternatives to meet these objectives will be addressed in detail in the Feasibility Study Report which will be submitted under separate cover.

8.0 REFERENCES

8.1 REFERENCES FOR SECTIONS 1-5 AND SECTION 7

Amato, R.V., 1968, Structural Geology of the Salem Area, Roanoke County, Virginia: unpublished M.S. Thesis, VPI & SU, Blacksburg, VA.

Blatt, H., Middleton, G., and Murray, R., 1980, Origin of Sedimentary Rocks, Prentice-Hall, Inc., Englewood Cliffs, N.J., 782 p.

Bouwer, H. and R.C. Rice, 1976, A slug test method for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells, Water Resources Research, Vol. 12., No. 3, pp. 423-428.

Breeding, N.K., and Dawson, J.W., 1976, Roanoke County Groundwater, Commonwealth of Virginia State Water Control Board, Bureau of Water Control Management, Planning Bulletin 301.

Callahan, M., Slimak, M., Gabel, N., May, I., Fowler, C. Freed, J., Jennings, P., durfee, R., Whitmore, F., Maestri, B., Mabey, W., Holt, B., and Gould, C., 1979, Water-Related Environmental Fate of 129 Priority Pollutants, Office of Water Standards and Office of Water and Waste Management, EPA/440/4-79-029b.

Casagrande, A., 1948, Classification and Identification of Soils, Trans. ASCE, volume 113, p. 901-991.

Cooper, H.H., J.D., Bredehoeft, and S.S. Papadopolous, 1967, Response of a finite-diameter well to an instantaneous charge of water, Water Resources Research, Vol. No. 1, pp. 263-269.

Eyre, F.H., 1980, Forest Cover Types of the United States and Canada, Society of American Foresters, Washington, D.C., 148 pp.

Freeze, R.A., and Cherry, J. A., 1979, Groundwater. Prentice-Hall, Inc. 604 pp.

Geraghty and Miller, 1991, AQTESOLV, Aquifer Test Solver, Version 1.0, 135 p.

Lowry, W.D., 1979, Introduction to Nature of Thrusting Along the Allegheny Forest Near Pearisburg and of Overthrusting in the Blacksburg-Radford Area of Virginia, pp. 1-26

McNair and Associates, 1973, Roanoke County Groundwater, Virginia State Water Control Board, Bureau of Water Control Management, Planning Bulletin 301.

Middletown, Norwood, August 19, 1991, verbal contact, Salem Historical Society, Salem, VA.

Murphy, D. J., 1968, Geology of the Glenvar Area, Roanoke County, Virginia: unpublished M.S. Thesis, VPI & SU, Blacksburg, VA.

NUS Corporation for USEPA, 1983, Final Preliminary Assessment for Dixie Caverns Landfill.

NUS Corporation for USEPA, 1985, Site Inspection Report of Dixie Caverns Landfill.

NUS Corporation for USEPA, 1986, Hazard Ranking System for Dixie Caverns Landfill.

Olver, Inc., 1989, Sampling and Analysis Report, Dixie Caverns Landfill.

Queisser, J.C., 1986, Qualitative Biological Survey (QL85-010), Unnamed Tributary to the Roanoke River.

Schwab, Frevert, Edminister and Baines, 1981, Journal of Soil and Water Conservation Engineering, 3rd Ed., John Wiley & Sons, pp. 100-111.

Smith, J.H., Mabey, W.R., Bohonos, N., Holt, B.R., Lee, S.S., Chou, T.W., Bomberger, D.C., and Mill, T., 1978, Environmental Pathways of Selected Chemicals in Freshwater Systems, Part II, Laboratory Studies, EPA-600/7-78-074.

Soil Conservation Service, U.S. Department of Agriculture, verbal and written communication, August, 1991.

USEPA, 1986, Test Methods for Evaluating Solid Waste, KSW-846, Third Edition, Volume 1A: Laboratory Manual - Physical/Chemical Methods (November, 1986).

USEPA, 1987, Compendium of Superfund Field Operations Methods. OSWER Directive 9355.0-14, EPA/540/P-87/001 (December 1987).

USEPA, 1988a, CERCLA Compliance with Other Laws Manual, OSWER Directive 9234.1-01, USEPA, Washington, DC, EPA/540/G89-006, August, 1988.

USEPA, 1988b, Guidance for Conducting Remedial Investigation and Feasibility Studies Under CERCLA, EPA, OSWER, HWERL, EPA Report #540/G-89-004, OSWER Directive 9355.3-01, USEPA, Cincinnati, Ohio, October, 1988.

USEPA, 1988c, User's Guide to the Contract Laboratory Program, December 1988.

USEPA, 1988d, Laboratory Data Validation Functional Guidelines for Evaluating Organics Analyses Modified for Region III, June, 1988.

USEPA, 1988e, Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses Modified for Region III, June, 1988.

USEPA, 1989, Soil Sampling Quality Assurance User's Guide, Second Edition, Environmental Monitoring Systems Laboratory, USEPA, March, 1989.

USEPA, 1991, Supporting Documentation for Fly Ash Remediation Plan.

USEPA, 1991, Proposed Plan, Dixie Caverns Landfill Site.

USEPA Internal Memorandum, April 4, 1989, Memo from Roy Smith, EPA Region III Toxicologist to Christopher Thomas, EPA Region III CERCLA Removal Enforcement Section, Regarding Soil Organic Threshold Levels.

USEPA Internal Memorandum, April 10, 1986, Memo from Richard Brunker, EPA Region III Toxicologist, to Darius Ostrauskas, EPA Region III Environmental Scientist, Regarding Lead Levels in Fly Ash Pile.

Waller, J.O., 1976, Geohydrology of the Upper Roanoke River Basin, Virginia, Virginia State Water Control Board, Bureau of Water Control Management, Planning Bulletin #302.

8.2 REFERENCES FOR SECTION 6.0

Human Health References

Baltrop, D. 1963. The prevalence of pica. American Journal of Diseases in Children. 112:116-123.

Binder, S., D. Sokal, and D. Maughan. 1986. Estimating soil ingestion: the use of tracer elements in estimating the amount of soil ingested by young children. Archives of Environmental Health 41(6):341-345.

Blank, I.H., J. Maloney, B.S. Alfred, I. Simon, and C. Apt. 1984. The Diffusion of Water Across the Stratum Corneum as a Function of its Water Content. J. Invest. Derm. 82:188-194.

Calabrese, E.J., P.T. Kostecki, and C.E. Gilbert. 1987. How much soil do children eat? An emerging consideration for environmental health risk assessment. In press (Comments in Toxicology).

Cantor, K.P., R. Hoover, P. Hartage, et al. 1987. Bladder cancer, drinking water source, and tap water consumption: A case-control study. J. National Cancer Institute 79(6):1269-1279.

Connor, J.J. and H. T. Shacklette. 1975. Background Geochemistry of Some Rocks, Soils, Plants, and Vegetables in the Conterminous United States. USGS, U.S. Department of the Interior, Washington, DC.

Dean, R.B. 1981. Use of Log-Normal Statistics in Environmental Monitoring. In: Chemistry in Water Reuse, Vol. I Ann. Arbor Science, Publishers, Inc. (Chapter 11).

Esmen, N.A. and Y.Y. Hammad. 1977. Log-normality of Environmental Sampling Data. J. Environ. Sci. Health. A12 (1 & 2): 29-41.

Gilbert, R.O. 1987. Statistical Methods for Environmental Pollution Monitoring. Van Nostrand Reinhold. New York.

Gillies, M.E. and H.V. Paulin. 1983. Variability of mineral intakes from drinking water: A possible explanation for the controversy over the relationship of water quality to cardiovascular disease. International J. Epidemiology 12(1):45-50.

ICF-Clement International Corporation. 1988. Comparative Potency Approach for Estimating the Cancer Risk Associated with Exposure to Mixtures of Polycyclic Aromatic Hydrocarbons. Interim Final Report.

Land, C.E. 1971. Confidence Intervals for Linear Functions of the Normal Mean and Variance. The Annals of Math Statistics. 42:1187-1205.

Land, C.E. 1975. Tables of Confidence Limits for Linear Functions of the Normal Mean and Variance. Mathematical Statistics. Vol. III. pp. 385-419.

Lourie, R.S., E.M. Layman, and F.K. Millican. 1963. Why children eat things that are not food. Children 10:143-146.

Lucier, G.W., R.C. Rumbauch, A. McCoy, R. Hass, D. Harvan, and K. Albro. 1986. Ingestion of soil contaminated with 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) alters hepatic enzyme activities in rats. Fund, and Appl. Toxicol. 6:364-481.

McConnell, E.E., G.W. Lucier, R.C. Rumbauch, P.W. Albro, D.J. Harvan, J.R. Hass, and M.W. Harris. 1984. Dioxin in soil: bioavailability after ingestion by rats and guinea pigs. Science. 233:1077=1079.

Ott, W.R. 1988. A Physical Explanation of the Log-normality of Pollutant Concentrations. Presented at the 81st Annual Meeting of APCA, Dallas, TX. June 19-24, 1988.

Paustenbach, D.J., H.P. Shu, and F.J. Murray. 1986. A critical examination of assumptions used in risk assessments of dioxin contaminated soil. Regulatory Toxicology and Pharmacology 6:284-307.

Poiger, H. and C. Schlatter. 1980. Influence of solvents and adsorbents on dermal and intestinal absorption of TCDD. Fd. Cosmet. Toxicol. 18:477-481.

Robischon, P. 1971. Pica practice and other hand-mouth behavior and children's developmental level. Nursing Research 20:4-16.

Skog, E. and J.E. Wahlberg. 1964. A comparative investigation of the percutaneous absorption of metal compounds in the guinea pig by means of the radioactive isotopes: ^{51}Cr, ^{58}Co, ^{65}Zn, ^{110m}Ag, ^{115m}Cd, ^{103}Hg, J. Investigative Dermatol. 36:187-200.

U.S. Environmental Protection Agency (USEPA). 1985a. Research and Development. Development of Statistical Distributions or Ranges of Standard Factors Used in Exposure Assessments. Office of Health and Environmental Assessment.

U.S. Environmental Protection Agency (USEPA). 1985b. Methodology for characterization of uncertainty in exposure assessments. Washington, DC: Office of Health and Environmental Assessment, Exposure Assessment Group.

U.S. Environmental Protection Agency (USEPA). 1985c. Techniques for the Assessment of the Carcinogenic Risk to the U.S. Population due to Exposure from Selected Volatile Organic Compounds from Drinking water via the Ingestion, Inhalation and Dermal Routes. Office of Drinking Water. U.S. EPA. September 1985.

U.S. Environmental Protection Agency (USEPA). 1986a. Guidelines for Carcinogen Risk Assessment. 51 Federal Register 33992 (September 24, 1986).

U.S. Environmental Protection Agency (USEPA). 1986b. Guidelines for the Health Risk Assessment of Chemical Mixtures. 51 Federal Register 34014 (September 24, 1986).

U.S. Environmental Protection Agency (USEPA). 1988. Superfund Exposure Assessment Manual. Office of Emergency and Remedial Response. OSWER Directive 9285.5-1.

U.S. Environmental Protection Agency (USEPA). 1989a. Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual (Part A). Interim Final. OSWER Directive 9285.7-01a. December 1989.

U.S. Environmental Protection Agency (USEPA). 1989b. Exposure Factors Handbook. Office of Health and Assessment.

U.S. Environmental Protection Agency (USEPA). 1989c. Exposure Assessments Methods Handbook. Draft. Office of Health and U.S. Environmental Assessment.

U.S. Environmental Protection Agency (USEPA). 1989d. Interim Final Guidance for Soil Ingestion Rates. Office of Solid Waste and Emergency Response. (OSWER Directive 9850.4)

U.S. Environmental Protection Agency (USEPA). 1989f. General Quantitative Risk Assessment Guidelines for Non-cancer Forum Technical Panel on Risk Assessment Guidelines for Non-cancer Health Effects. (ECAS-CIN-538.

U.S. Environmental Protection Agency (USEPA). 1989g. Reference Dose (RfD): Description and Use in Health Risk Assessment. Appendix A to the Integrated Risk Information System (IRIS).

U.S. Environmental Protection Agency (USEPA). 1990. Health Effects Assessment Summary Tables (HEAST). Fourth Quarter FY-1990. OSWER, U.S. EPA.

U.S. Environmental Protection Agency (USEPA). 1991a. Interim Risk Assessment Guidance for Evaluating Contaminant Concentrations in groundwater. USEPA Region III Staff Document. February 27, 1991.

U.S. Environmental Protection Agency (USEPA). 1991b. Integrated Risk Information System (IRIS). Health Criteria and Assessment Office, Washington, D.C. Revised February 1, 1991.

U.S. Environmental Protection Agency (USEPA). 1991c. Health Effects Assessment Summary Tables (HEAST). Fourth Quarter FY-1990. OSWER, U.S. EPA.

U.S. Environmental Protection Agency (USEPA). 1991d. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors." OSWER Directive 9285.6-03. Washington, D.C. March 25, 1991.

Van Den Berg, M., M. Van Greevedbroek, K. Olie, and O. Hutzinger. 1986. Bioavailability of PCDDs and PCDFs on fly ash after semi-chronic oral ingestion by rat. Chemosphere 15:509-518.

Van Den Berg, M., M. Sinke, and H. Wever. 1987. Vehicle dependent bioavailability of polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) in the rat. Chemosphere 8:1193-1203.

Van Wijnen, J.H., P. Clausing, and B. Brunekreef. 1990. Estimated Soil Ingestion by Children. Environmental Research 51:147-162.

Wahlberg, J.E. 1968a. Percutaneous absorption of radioactive strontium chloride Sr^{89} ($^{89}SrCl_2$): A comparison with 11 other metal compounds. Arch. Dermatol. 97:336-339.

Wahlberg, J.E. 1968b. Percutaneous absorption from chromium (^{51}Cr) solutions of different pH, 1.4-12.8. Dermatologica. 137:17-25.

Wendling, J., F. Hileman, R. Orth, T. Umbreit, E. Hesse, and M. Gallo. 1989. An analytical assessment of the bioavailability of dioxin contaminated soils to animals. Chemosphere 18:925-932.

Wester, R.C., M. Mobayen, and H.I. Maibach. 1987. In vivo and in vitro absorption and binding to powered stratum corneum as method to evaluate skin absorption of environmental chemical contaminants from round and surface water. J. toxicol. Environ. Health 21:367-374.

Yang, J.J., T.A. Roy, and C.R. Mackerer. 1986a. Percutaneous absorption of anthracene in the rat. Toxicol. and Indust. Health. 2:79-84.

Yang, J.J., T.A. Roy, and C.R. Mickerer. 1986b. Percutaneous absorption of benzo(a)pyrene in the rat. Toxicol. and Indus. Health. 2:409-415.

Ziai, M., 1983. Bedside Pediatrics. Rochester, NY: Moshen Ziai.

Ecological Assessment References

Adams, F, and R.W. Pearson. 1967. Crop response to lime in the southern United States and Puerto Rico. pp. 161-206 In: R.W. Pearson and F. Adams, eds. Soil Acidity and Liming. Number 12 in the series Agronomy, Madison WI.

Adamson, A.H., D.A. Volks, M.A. Appleton, and W.B. Shaw. 1969. Vet. Rec., 85:368.

Anderson, R.S., J.E. Doos, and F.L. Rose. 1982. Differential ability of Ambystoma tigrinum hepatic microsomes to produce mutagenic metabolites from polycyclic aromatic hydrocarbons and aromatic amines. Cancer Lett. 16:33-41.

Baker, D.E. 1974. Copper: Soil, Water, Plant Relationships. Fed. Proc. 31:1188-1193.

Bartholomew, G.A. and Cade, T.J. 1963. The water economy of land birds. Auk., 80:504-539.

Bingham, F.T., A.L. Page, R.J. Mahler, and T.J. Ganje. 1976. Yield and cadmium accumulation of forage species in relation to Cadmium content of sludge-amended soil. J. Environ. Qual. 5:57-60.

Blaschke, H. 1977. Influence of increased copper supply on root growth of some cultivated plants. (translated from german) Z. Acker-Pflanzenbau 144:222-229.

Bodor, C.W.M., C.J. Van Leeuwen, P.A. Voogt, and D.F. Zandee. 1988. Effects of cadmium on the reproductive strategy of Daphnia magna. Aquatic Tox., 12:301-310.

Boyden, R, Potter, V.R., and Elvehjem, C.A. 1938. Effects of feeding high levels of copper to albino rats. J. Nutr., 15:397-402.

Brenner, F.J., W.L. Cooper, and C.L. MacHose (Grove City College). 1976. Effect of ferric hydroxide suspension on blood chemistry in the common shiner, Notropus cornutus. Transactions of the American Fisheries Society, 105(3):450-455.

Browning, E. 1969. Toxicity of Industrial Metals. 2nd Ed. Butterworth & Co. Ltd., Toronto, Canada.

Calder, W.A. and Braun, E.J. 1983. Scaling of osmotic regulation in mammals and birds. Am. J. Physiol., 244:R601-R606.

Calder, W.A. 1981. Scaling of physiological processes in homeothermic animals. Ann. Rev. Physiol., 43:301-322.

Calvery, H.O. 1942. "Trace Elements In Food." (Cited by Hegsted, McKibben, and Drinker, 1945.) Food Research, 7:313.

Campbell, P.B.C., M. Bisson, R. Bougie, A. Tessier, and J.P. Villeneuve. 1983. Speciation of aluminum in acidic freshwaters. Anal. Chem. 55:2246-2252.

Carlson, R.W. and Bazzaz, F.A. 1977. Growth reduction in American Sycamore (Platanus occidentals L.) caused by Pd-Cd interaction. Environmental Pollution 13:243-253.

Chandra, S.V. 1971. Cellular changes induced by manganese in the rat testis -- preliminary results. Acta Pharmacol. Toxicol., 29:75-80.

Cleveland, L., E.E. Little, R.H. Wiedmeyer and D.R. Buckler. 1989. Chronic no-effect-level-concentration of aluminum for brook trout exposed in low calcium, dilute acid water. (In: Environmental Chemistry and Toxicology of Aluminum.) Lewis Publications, Inc., Chelsea, MI. pp. 229-246.

Corn, P.S., Stolzenburg, W., and Bury, R.B. 1989. Acid precipitation studies in Colorado and Wyoming: Interim report of surveys of montane amphibians and water chemistry. U.S. Fish Wildl. Serv. Biol. Rep., 80(40.26).

Courtemaunch, D.L. and S.P. Davies. 1987. A coefficient of community loss to assess detrimental change in aquatic communities. Water Res. 21(2):217-222.

Daebold and Elvehjem 1935 In Nas 1980

Dessureaux, L. 1960. The reaction of lucerne seedlings to high concentrations of manganese. Plant Soil 13:114-122.

Dietrich, D., and C. Schlatter. 1989. Aluminum toxicity to rainbow trout at low pH. Aquatic Tox., 15:197-212.

Dipple, A. 1985. Polycyclic aromatic hydrocarbon carcinogenesis: An introduction. p. 1-17 In: Polycyclic hydrocarbons and carcinogenesis. ACS Symp. Ser. 283. American Cancer Society, Washington, D.C.

Doelman, P., Nieboer, G., Schrooten, J., and Visser, M. 1984. Antagonistic and synergistic toxic effects of Pb and Cd in a simple food chain: Nematodes feeding on bacteria and fungi. Bull. Environ. Contam. Toxicol., 32:717-723.

Doudoroff, P., and Katz, M. 1953. Critical review of literature on the toxicity of industrial wastes and their components to fish, II. Metals as salts. Sewage Ind. Wastes, 25:802-839.

Eisler, R. 1988. Lead hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish and Wildl. Serv. Biol. Rep. 85 (1.14). 134 pp.

Eisler, R. 1987. Polycyclic aromatic hydrocarbon hazards to fish, wildlife, and invertebrates: A synoptic review. U.S. Fish and Wildlife Serv. Biol. Rep. 85(1.11). 81 pp.

Eisler, R. 1985. Cadmium Hazards to Fish, Wildlife and Invertebrates: A synoptic review. U.S. Fish and Wildlife Serv. Biol. Rep. 85(1.2). 46 pp.

Eyre, F.H. ed. 1980. Forest Cover Types of the United States and Canada. Society of American Foresters. Washington, D.C., 148 pp.

Federal Interagency Committee for Wetland Delineation. 1989. Federal Manual for Identifying and Delineating Jurisdictional Wetlands. U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, and U.S.D.A. Soil Conservation Service, Washington, D.C. Cooperative technical publication., 76 pp, plus appendices.

Fergus, C. N.D. Shrews. Pennsylvania Game Commission, Division of Information and Education. Wildlife Notes 175-31. 3 pp.

Finger, S.E., E.F. Little, M.G. Henry, J.F. Fairchild, and T.P. Boyle. 1985. Comparison of laboratory and field assessment of fluorene - part I: effects of fluorene on the survival, growth, reproduction and behavior of aquatic organisms in laboratory tests. Pp. 120-133. In: T.P. Boyle, ed. Validation and predictability of laboratory methods for assessing the fate and effects od contaminants in aquatic organisms. ASTM STP 865. American Society for Testing and Materials, Philadelphia, PA.

Fore, H., and Morton, R.A. 1952. Micro-determination of manganese in biological material. Biochem. J., 51:594.

Foy, C.D. 1984. Physiological effects of hydrogen, aluminum, and manganese toxicities in acid soil. pp. 57-97. In: Soil, Acidity and Liming, 2nd ed. F. Adams, ed. American Soc. OD Agronomy. Madison, WI.

Golley, 1961. (In: Nagy, 1987).

Grimmett, R.E.R., I.G. Macintosh, E.M. Wall, and C.S.M. Hopkirk. 1937. N.Z. J. Agric., 54:216.

Heinis, F., K.R. Timmermans, and W.R. Swain. 1990. Short-term sublethal effects of cadmium on the filter feeding chironomid larva Glyptotendipes pallens (Meigen)(Diptera). Aquatic Tox., 16:73-86.

Heller, V.G., and Burke, A.D. 1927. Toxicity of zinc. J. Biol. Chem., 74:85.

Hilsenhoff, W.L. 1982. Using a biotic index to evaluate water quality in streams. Technical Bulletin No. 132. Department of Natural Resources, Madison, Wisconsin.

Hoffman, D.J. and Gay, M.L. 1981. Embryotoxic effects of benzo(a)pyrene, chrysene, and 7,12-dimethylbenz(a)anthracene in petroleum hydrocarbon mixtures in mallard ducks. J. Toxicology Environ. Health 7:775-787.

Ishmael, J., J. McC. Howell, and P.J. Treeby. 1969. Vet. Rec., 85:205.

Jastrow, J.D. and D.E. Koppe. 1980. Uptake and effects of Cadmium in higher plants. pp. 607-638. In: Cadmium in the Environment. J.O. Nriagu, ed. John Wiley and Sons, New York.

Kabata-Pendias, A. 1963. Notes on chemical methods of determining available copper and cobalt in soils. Pam. Pulawski 9:31-39.

Keilin, D., and Mann, T. 1940. Carbonic anhydrase. Purification and nature of the enzyme. Biochem. J., 34:1163.

Kitchel, L.E. 1991. Department of Game and Inland Fisheries. Letter to John Swanson, dated May 3, 1991. (804) 367-8747.

Lee, S.D. and L. Grant, eds. 1981. Health and ecological assessment of polycyclic aromatic hydrocarbons. Pathotex Publ., Park Forest South, Ill. 364 pp.

Letterman, R.D., and W.J. Mitsch (Illinois Institute of Technology, Pritzker Dept. of Environmental Engineering). 1978. Impact of mine drainage on a mountain stream in Pennsylvania. Environmental Pollution, 17(1):53-73.

Lewis, M. (Arizona State University, Dept. of Zoology). 1976. Effects of low concentrations of manganous sulfate on eggs and fry of rainbow trout. The Progressive Fish-Culturist, 38(2):63-65.

Lieb, J.A. 1971. Biochemical function of Euglena mutabilis in acid mine drainage. West Virginia University, Ph. D. Thesis. 85 pp. University Microfilms, 71-26, 662.

Likins, M. May 29, 1991. Endangered species specialist, Office of Plant Protection, VA Department of Agriculture.

Luckey, T.D. and B. Venugopal. 1977. Metal Toxicity in Mammals. Plenum Press, New York. 238 pp.

Ludemann, D. 1953. The toxicity of manganese to fish, crabs, and animals forming the food of fish. Schr. Reihe Ver. Wasserhyg., 7:18.

Luongo, M.A., and Bjornson, S.S. 1954. The liver in ferrous sulfate poisoning. A report of three fatal cases in children and an experimental study. N. Engl. J. Med., 251:995.

Marquis, J.K. 1989. "Neurotoxicity of Aluminum." pp. 289-298. In: Environmental Chemistry and Toxicology of Aluminum. T.E. Lewis, ed. Lewis Publications, Inc., Chelsea, MI.

Maynard, L.S., and Fink, S. 1956. The influence of chelation on radiomanganese excretion in man and mouse. J. Clin. Invest., 35:831.

McGhee et al. 1965. (In: NAS, 1980).(McGeer et al. 1965 listed in manganese:NAS, 1973)

McKee, J.E., and Wolf, H.W. (ed.). 1963. Water Quality Criteria. The Resource Agency of California, State Water Quality Control Board, No. 3-A, 584 pp.

Miller, J.E., J.J. Hassett, and D.E. Koppe. 1967. Uptake of Cadmium by soybeans as influenced by soil cation exchange capacity, pH, and available phosphorus. J. Environ. Quality 5:157-160.

Moore, D.P. 1974. Physiological effect of pH on Roots. pp. 135-151. In: The Plant Root and Its Environment. E.W. Carson, ed. University Press of Virginia, Charlottesville, VA.

Nagy, K.A. 1987. Field metabolic rate and food requirement scaling in mammals and birds. Ecol. Mono., 57:111-128.

National Academy of Sciences (NAS). 1977. Medical and Biological Effects of Environmental Pollutants: Copper. Printing and Publishing Office, National Academy of Sciences, 109 pp.

National Academy of Science (NAS). 1980. Mineral Tolerance of Domestic Animals. Subcommittee on mineral toxicity in animals. National Research Council, Washington, D.C.

Neff, J.M. 1979. Polycyclic aromatic hydrocarbons in the aquatic environment. Applied Science Publications, Ltd., London. 262 pp.

Newton, L.G. 1941. Aust. Vet. J. 17:232. In: Veterinary Toxicology. Clarke, E.G.C. and M. Clarke. 1975.

Osborn, D., Every, W.J., and Bull, K.R. 1983. The toxicity of trialkyllead compounds to birds. Environ. Pollut., 31:261-275.

Parízek, J. and Z. Záhor. 1956. Nature (Lond.), 177:1036.

Parker, D.R., L.W. Zelazny, and T.B. Kinraide. 1989. Chemical Speciation and Plant Toxicity of Aqueous Aluminum. pp. 117-145. In: T.E. Lewis. 1989. Environmental Chemistry and Toxicology of Aluminum. Lewis Publishers, Inc., Chelsea, MI.

Patton, J.F. and M.P. Dieter. 1980. Effects of petroleum hydrocarbons on hepatic function in the duck. Comp. Biochem. Physiol. 65C:33-36.

Pennsylvania Natural Diversity Inventory (PNDI). 1983. Classification of Natural Communities in Pennsylvania. Mimeo, 23 pp.

Puls, R. 1988. Mineral levels in animal health. Sherpa International. Clearbrook, British Columbia, Canada. 240 pp.

Quarles, H.O., Hanawalt, R.B., and Odum, W.E. 1974. Lead in small mammals, plants, and soils at varying distances from a highway. J. Appl. Ecol., 11:937-950.

Reed, P.B. Jr. 1988. National List Of Plant Species That Occur In Wetlands: 1988 National Summary. U.S. Fish and Wildlife Service, U.S. Government Printing Office.

Reschke, C. 1990. Ecological Communities of New York State. New York Natural Heritage Program, N.Y. State Department of Environmental Conservation, Latham, New York, 96 pp.

Reuther, W. and C.K. Labanauskas. 1966. Copper. pp. 157-179 In: Diagnostic criteria for plants and soils. H.D. Chapman, ed. University of California, Riverside.

Robbins, C.T. 1983. Wildlife Feeding and Nutrition. New York, NY: Academy Press.

Schwen, R.J. and G.J. Mannering. 1981. PAH

Sharman, J.R. 1969. N.Z. Vet. J., 17:67.

Sholl, L.B. 1957. Acute copper poisoning in feeder lambs. J. Amer. Vet. Med. Ass., 130:12.

Sims, R.C. and R. Overcash. 1978. PAH

Skadhauge, R. 1975. Renal and cloacal transport of salt and water. Symp. Zool. Soc. London 35:97-106.

Skelly and Loy (Consultants) and PA Envir. Cons. 1973. Processes, procedures and methods from mining activities: Surface mining. EPA Publication No. EPA-430/9-73-011, Washington, 390 pp.

Smith, H. 1967. The distribution of antimony, arsenic, copper, and zinc in human tissue. J. Forensic Sci. Soc., 7:97-102.

Stegman, J. 1981. Polynuclear aromatic hydrocarbons and their metabolism in the marine environment. pp. 1-60 In: Polycyclic Hydrocarbons and Cancer, vol 3. H.V. Gelboin and P.O. Ts'o, eds. Academic Press, New York.

Straalen and Meerendonk. 1987. As cited in World Health Organization (WHO), 1989. Lead - Environmental Aspects. (Environmental Health Criteria No. 85), Geneva, 106 pp. (Complete citation not given)

Suttle, N.F., and Mills, C.F. 1966b. Studies of the toxicity of pigs. 2. Effects of protein source and other dietary components on the response to high and moderate intakes of copper. Brit. J. Nutr., 20:149-161.

Suttle, N.F., and Mills, C.F. 1966a. Studies of the toxicity of pigs. 1. Effects of oral supplements of zinc and iron salts on the development of copper toxicosis. Brit. J. Nutr., 20:135-148.

Sutton, W.R., and Nelson, V.E. 1937. Studies on zinc. Proc. Soc. Exp. Biol. Med. (N.Y.), 36:211.

Tackett, S.L. and L.F. Wieserman (Indiana University of Pennsylvania). 1972. Simultaneous polarographic determination of iron (II) and iron (III) in coal mine waste water. Analytical Letters, 5(9):643-651.

Tait, R.M., C.R. Krishnamurti, E.W. Gilchrist, and K. MacDonald. 1971. Can. Vet. J., 12:73.

Tetra Tech. 1990. Remedial Investigation/Feasibility Study: Dixie Caverns Landfill Site, Salem, Virginia. Contract #68-W8-0092, Work Assignment #92-08-3LR9.

Thompson, A., B. Korsgaard, and J. Johnson. 1988. Effect of aluminum and calcium ions on survival and physiology of rainbow trout, Salmo gairdneri (Richardson) eggs and larvae exposed to acid stress. Aquatic Tox., 12:291-300.

Turner. 1955. J.W.A., Lancet, j:661.

United States Environmental Protection Agency (USEPA). 1980. Ambient water quality for arsenic. U.S. Environ. Protection Agency Rep. 440/5-80-021, 205 pp.

United States Environmental Protection Agency (USEPA). 1985. Environmental profiles and hazard indices for constituents of municipal sludge: Iron. Office of Water Regulations and Standards. Washington, D.C. June 1985.

Vallee, B.L. 1959. Biochemistry, physiology and pathology of zinc. Physiol. Rev., 39:443.

von Oettingen, W.F. 1935. Manganese: Its distribution, pharmacology and health hazards. Physiol. Rev., 15:175.

Wallingford, G.W. and Simkins, C.A. 1977. Copper for organic Soils. University of Minnesota agric. Ext. Serv., Ext. Folder 347.

Warnick, S.C. and H.C. Bell. 1969. The acute toxicity of some heavy metals to different species of aquatic insects. J. of the Water Poll. Control Federation, 41:280-289.

Weatherly, N.S., A.P. Rogers, X. Goenaga, and S.J. Ormerod. 1990. The survival of early life stages of brown trout (Salmo trutta L.) in relation to aluminum speciation in upland Welsh streams. Aquatic Tox., 17:213-230.

WHO (World Health Organization). 1981. Summary of Manganese. (Environmental Health Criteria No. 17), Geneva, 110 pp.

WHO (World Health Organization). 1989. Lead - Environmental Aspects. (Environmental Health Criteria No. 85), Geneva, 106 pp.

Williamson, P., and Evans, P.R. 1972. Lead: Levels in roadside invertebrates and small mammals. Bull. Environ. Contam. Toxicol., 8:280-288.

Wilson, R.H., F. de Eds, and A.J. Cox. 1941. J. Pharmac. Exp. Ther., 71:22.

Woerpel and Balloun. 1964. (In: NAS, 1980).

Zar, J.H. 1984. Biostatistical Analysis. Prentice-Hall, Inc., Englewood Cliffs, N.J. 718 pp.

ENVIRONMENTAL PROTECTION AGENCY

ALTERNATIVE REMEDIAL CONTRACTING STRATEGY (ARCS)

REGION III

CONTRACT #68-W8-0092

WORK ASSIGNMENT #92-08-3LR9

REMEDIAL INVESTIGATION REPORT

APPENDICES

JANUARY, 1992

DIXIE CAVERNS LANDFILL

SALEM
ROANOKE COUNTY, VIRGINIA

TETRA TECH, INC.

TCN 4208

TABLE OF CONTENTS

APPENDIX A SITE SURVEY INFORMATION

Sample Location Coordinates
Solid Waste Fill Calculations
Population Survey Details

APPENDIX B SEDIMENT/SURFACE WATER INVESTIGATION INFORMATION

Grain Size Data
TCL/TAL Sample Results

APPENDIX C ECOLOGICAL ASSESSMENT INFORMATION

Detailed Ecologic Investigation Results
Stream Sampling Data Sheets
Benthic Sample Organisms Data Sheets
Benthic Sample Organisms QA/QC Sheets
Forest Vegetation Data Sheets
Emergent Vegetation Data Sheets
Streamside Vegetation Data Sheets
Vegetation Calculations Summary Sheets
Bioassay Results
Photodocumentation

APPENDIX D SOIL INVESTIGATION INFORMATION

Grain Size Data
Test Boring Logs
TCL/TAL Sample Results

APPENDIX E GEOLOGIC/HYDROGEOLOGIC INVESTIGATION INFORMATION

Well Construction Log
Analysis of Slug Test Data
Residential Well Data Sheets
TCL/TAL Sample Results

APPENDIX F RISK ASSESSMENT INFORMATION

Toxilogical Profiles

APPENDIX A

SITE SURVEY INFORMATION

Sample Location Coordinates
Solid Waste Fill Calculations
Population Survey Details

Sample Location Coordinates

EPA REGION III
SUPERFUND DOCUMENT MANAGEMENT SYSTEM

DOC ID 137611
PAGE # AR 300415

IMAGERY COVER SHEET
UNSCANNABLE ITEM

SITE NAME DIXIE CAVERNS

OPERABLE UNIT OU2

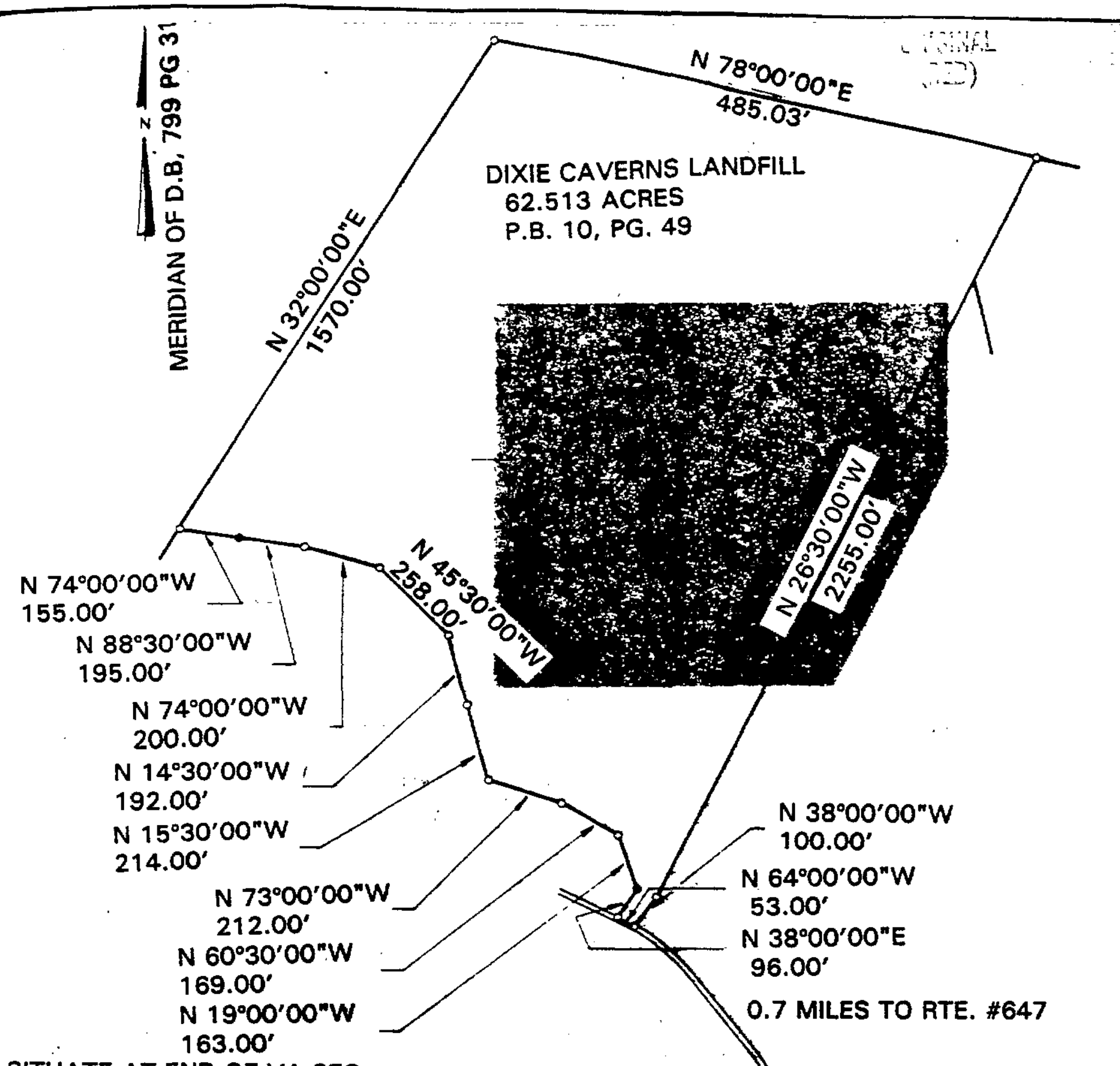
ADMINISTRATIVE RECORDS- SECTION 111 VOLUME A

REPORT OR DOCUMENT TITLE REMEDIAL INVESTIGATION REPORT – PART 2 OF 3

DATE OF DOCUMENT 01-JANUARY 1992

DESCRIPTON OF IMAGERY SITE BOUNDARY LINE

NUMBER AND TYPE OF IMAGERY ITEM(S) 1 OVERSIZED MAP



SITUATE AT END OF VA SEC
RTE # 778
CATAWBA MAGISTERIAL DISTRICT
ROANOKE COUNTY, VIRGINIA

KEY PLAN

SCALE: 1" = 400'-0"

• - CORNER FOUND
○ - CORNER OF RECORD

TETRA TECH, INC.

Source: Road Improvement Plan by Olver Incorporated, May 11, 1988

AR300416

Surface Soil Samples and Remedial Investigation
Well Coordinates - Dixie Caverns Landfill Site
(Coordinates Given for Site Specific Grid System)

Well Location	Northing (feet)	Easting (feet)
RIW-1	12605	8208
RIW-2	12501	8604
RIW-3	12582	9056
RIW-4	12680	9332
RIW-6	12343	8535
RIW-7	12253	8982
RIW-8	12405	9237
RIW-9	11843	8040
RIW-10	11682	9033
RIW-11	11383	7743
RIW-12	11277	8474
RIW-13	11266	8834

Sample Location	Northing (feet)	Easting (feet)
SWD1A	12586	7962
SWD1B	12480	7891
SWD1C	12402	7941
SWD1D	12311	7890
SWD2A	12440	8191
SWD2B	12379	8162
SWD2C	12720	8020
SWD2D	12187	7938
SWD3A	12235	8588
SWD3B	12033	8320
SWD3C	11945	8154
SWD3D	11892	8095
SWD4A	11765	8331
SWD4B	11758	8411
SWD4C	11704	8464
SWD4D	11831	8559
SWD5A	12246	9204
SWA5B	11901	8919
SWD5C	11500	8840
SWD5D	11442	8782

TCN 4208
RI REPORT
REV. #1
09/JAN/92

Solid Waste Fill Calculations

ORIGINAL
(RED)

DIXIE CAVERNS
SOLID WASTE THICKNESS

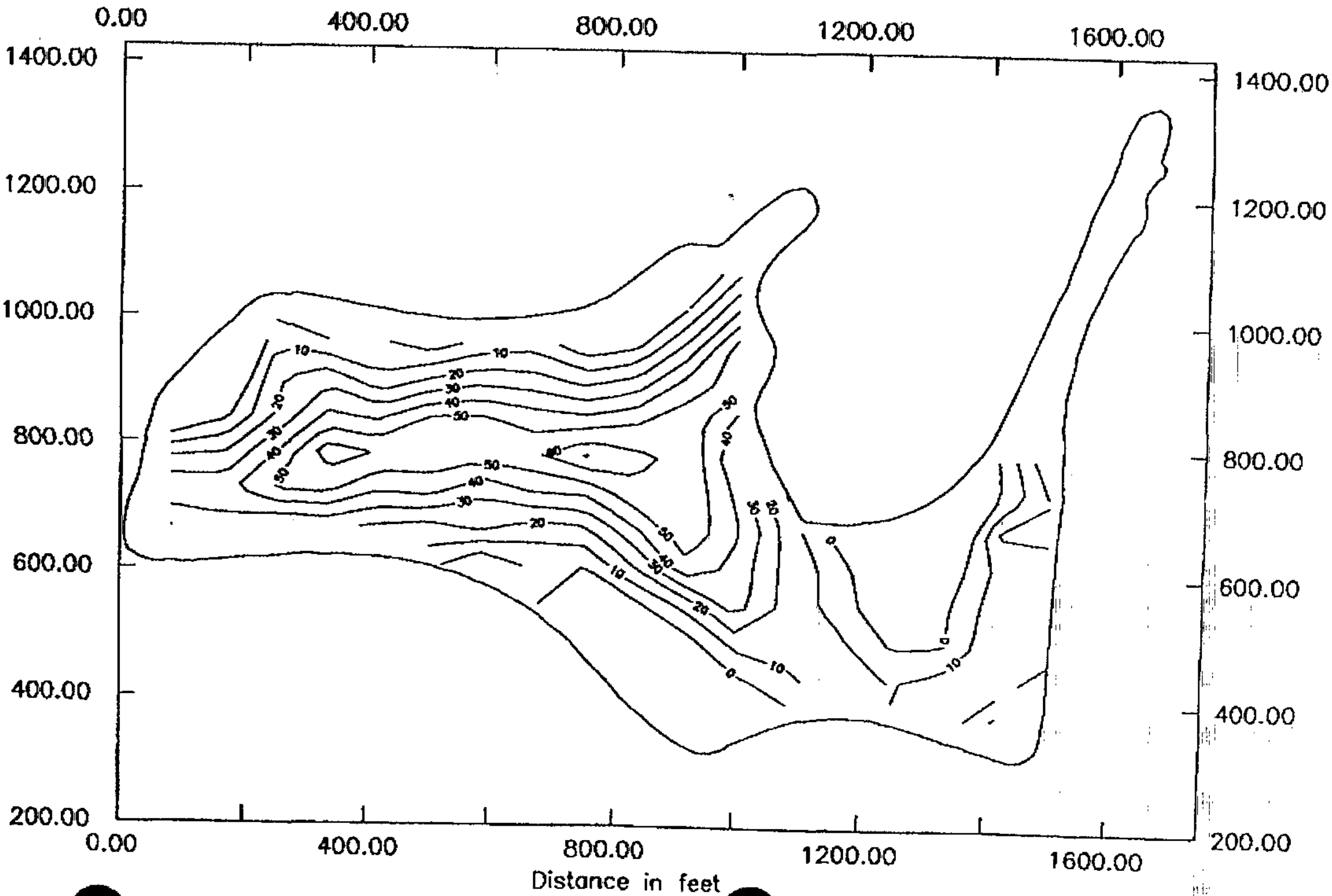
As part of the Dixie Caverns landfill project, an estimate of the volume of solid waste was prepared. This was accomplished by computing the surface integral between the present day topography, and the pre-existing topography before landfill operations. The present day surface topography was acquired from a 1990 2-foot contour map of a scale of 1 foot = 50 feet, developed by aerial photogrammetric means by T.P. Parker & Sons surveyors. The pre-landfill topography (1964) was obtained from the 1963, Virginia, 7.5 foot Glenvar, topographic map.

Both maps were digitized at 20-foot contour intervals over the solid waste area (delineated on Plate 2-1, in Figure 1-1, located in the Dixie Caverns field sampling plan). The 1963 map was photo-enlarged to a 1-inch ≃ 340-feet scale to ease the digitization process. Digitizing for both maps was performed using AutoCAD. The common buildings labeled A, B, and C (south of the site) on both maps were used as horizontal control to tie both map areas to the same coordinate system. Equivalent elevation contours for these three common buildings, indicated that vertical control was the same for both maps (at the 20 ft contour level). Additionally, the solid waste border was digitized.

SURFER was used to determine the volume of the solid waste area. The appropriate contour elevations (z-values) were appended to the digitized data, and transformed into data ASCII files. Each file was used as input for interpolation by the GRID subprogram to create a 100 x 100 block grid, using kriging and a 10 point octant search criteria. Afterwards, the area outside of the, border solid waste line was blanked from each grid. A topo map of each surface was made, with all the data points plotted, for a visual check of the process.

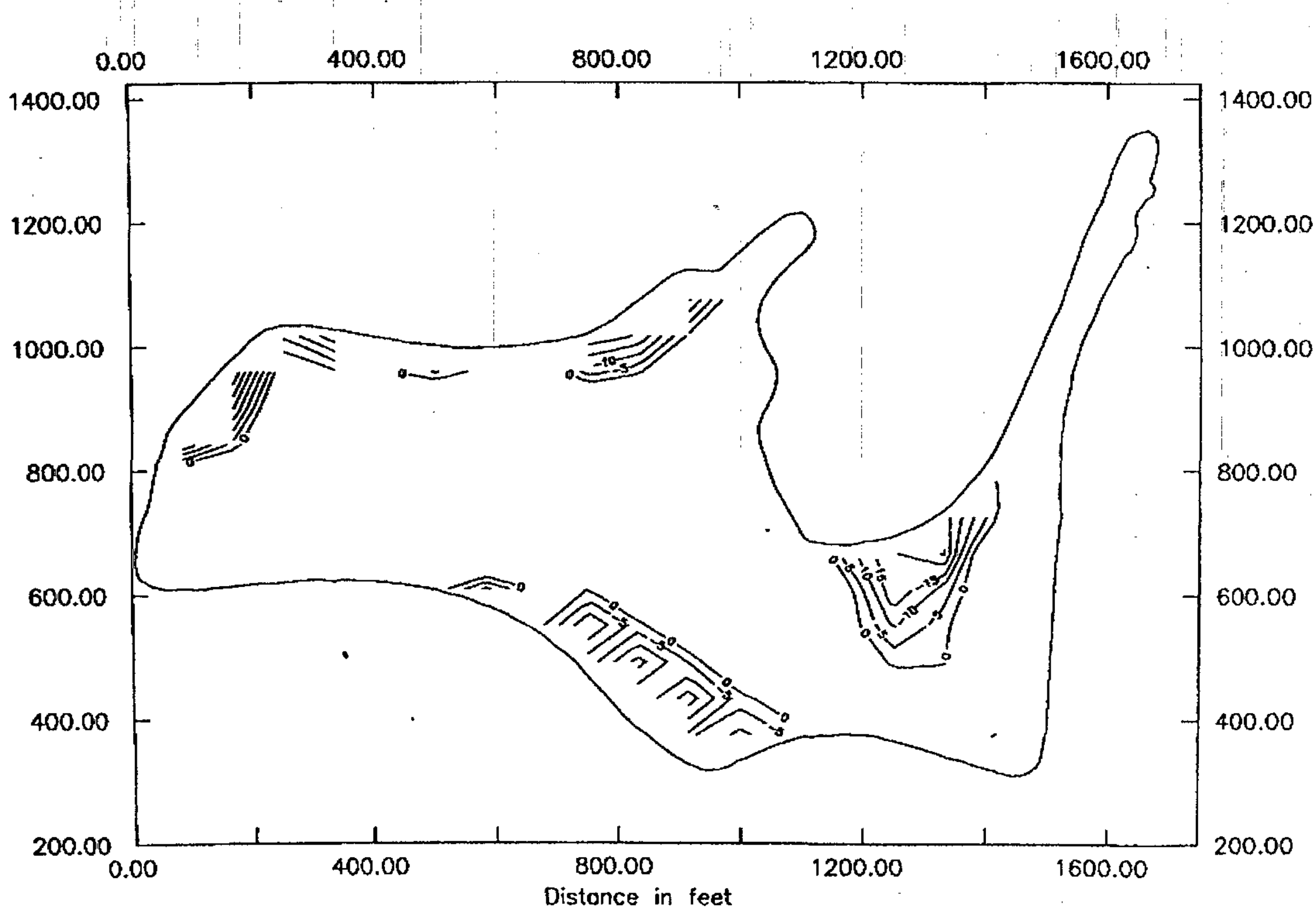
To compute the actual volume of the waste area (the volume between the 1990 and 1963 maps) a utility subprogram of SURFER was used. Specifying the 1990 grid for the upper surface, and the 1962 grid for the lower surface, the volume calculation was performed using the net volume and cuts and fills options.

Thickness of Fill Material at Dixie Caverns Landfill (ft)



AR300420

Depth of Material Removed at Dixie Caverns Landfill (ft)



[Volume] UpperSurface LowerSurface NetVolume Cuts&Fills ResultsLog
Calculate volume between surfaces, plus cuts and fills volumes

UPPER SURFACE		LOWER SURFACE	
Grid File:	A:\DCUPBL.GRD	Grid File:	A:\DCLOBL.GRD
Rows:	1 to 32767	Rows:	1 to 32767
Cols:	1 to 32767	Cols:	1 to 32767
Grid Size:	100 by 100	Grid Size:	100 by 100
Delta X:	23.2323	Delta X:	23.2323
Delta Y:	14.1414	Delta Y:	14.1414
X-Range:	-300 to 2000	X-Range:	-300 to 2000
Y-Range:	100 to 1500	Y-Range:	100 to 1500
Z-Range:	1439.99 to 1640.85	Z-Range:	1435.77 to 1663.02

Volume approximated by
Trapezoidal Rule : 1.18921E+007
Simpson's Rule : 1.18765E+007
Simpson's 3/8 Rule: 1.18733E+007

Positive Volume [Cuts]:	1.43119E+007	+ Area:	2952430
Negative Volume [Fills]:	2419850	- Area:	267574
Cuts minus Fills:	1.18921E+007	Total:	3220000

F1=Help F3=Main F4=StoreAll F5=Directory Esc=Backup Arrow keys=Move pointer

Absolute Error:

Cuts = 14311900 ± 15,600 ft³
Fills = 2419850 ± 15,600 ft³
Cuts - Fills = 11892100 ± 15,600 ft³

Relative Error

Cuts = 14311900 ± 0.11% ft³
Fills = 2419850 ± 0.64% ft³
Cuts-Fills = 11892100 ± 0.13% ft³

AR300422

[Volume] UpperSurface LowerSurface NetVolume Cuts&Fills ResultsLog
Calculate volume between surfaces

UPPER SURFACE
Grid File: A:\DCUPBL.GRD
Rows: 1 to 32767
Cols: 1 to 32767

Grid Size: 100 by 100
Delta X: 23.2323
Delta Y: 14.1414
X-Range: -300 to 2000
Y-Range: 100 to 1500
Z-Range: 1439.99 to 1640.85

LOWER SURFACE
Grid File: A:\DCLOBL.GRD
Rows: 1 to 32767
Cols: 1 to 32767

Grid Size: 100 by 100
Delta X: 23.2323
Delta Y: 14.1414
X-Range: -300 to 2000
Y-Range: 100 to 1500
Z-Range: 1435.77 to 1663.02

Volume approximated by
Trapezoidal Rule : 1.18921E+007 — 11,892,100 ft^3 = 440,448 yd^3
Simpson's Rule : 1.18765E+007
Simpson's 3/8 Rule: 1.18733E+007

F1=Help F3=Main F4=StoreAll F5=Directory Esc=Backup Arrow keys=Move pointer

Absolute error = (Largest result − Smallest result)
= 11 892 100 − 11 873 300
= 18,800 ft^3

Net Volume = Average of all results ± Absolute error
= 11,880,633 ± 18,800 ft^3

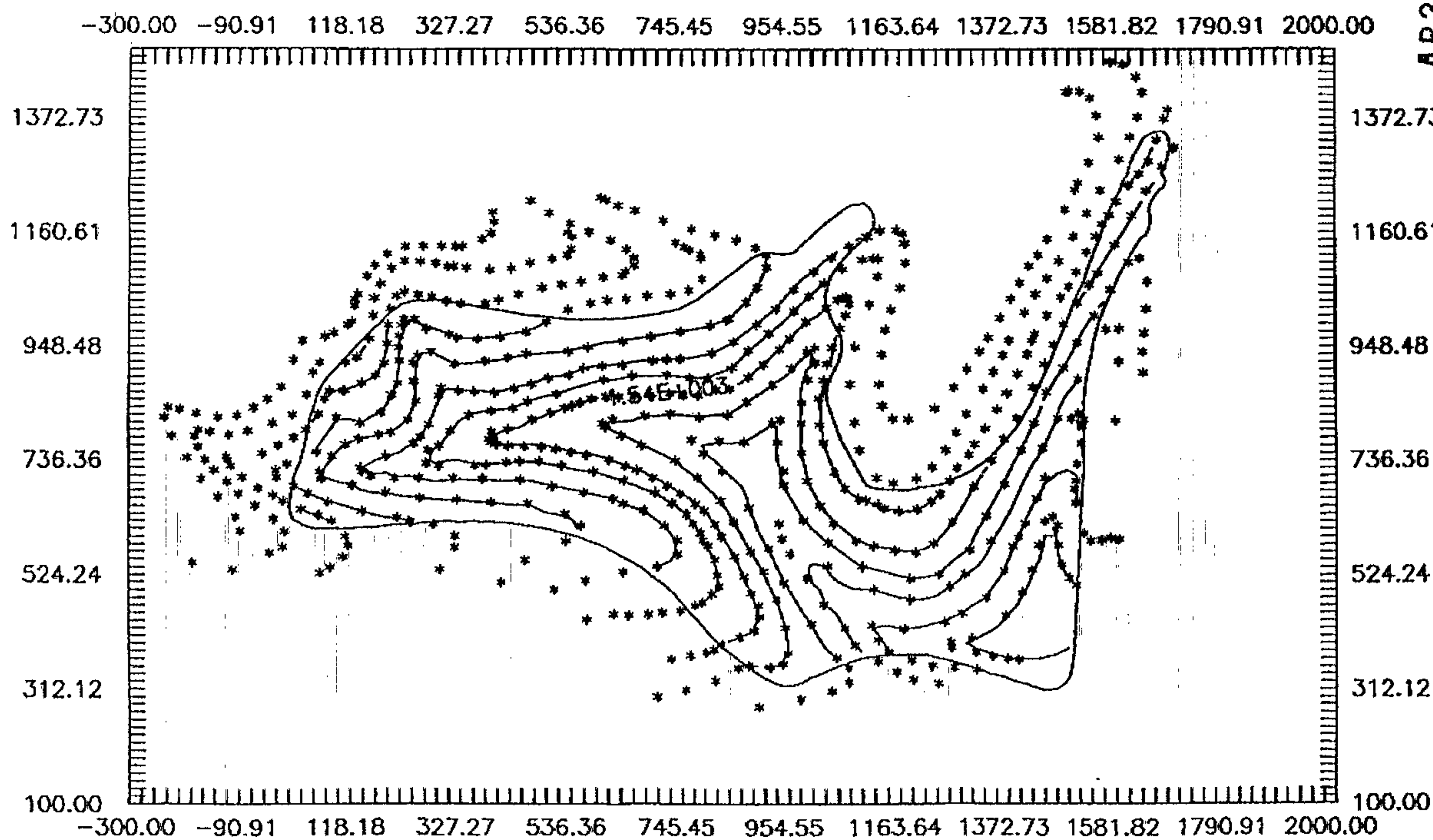
Relative Error = $\frac{(\text{Largest Result} - \text{Smallest Result})(100)}{\text{Average of All Results}}$

= $\frac{(11\,892\,100 - 11\,873\,300)(100)}{11\,880\,633}$ = 0.16%

Net Volume = Average ± Relative Error
= 11 880 633 ± 0.16% ft^3

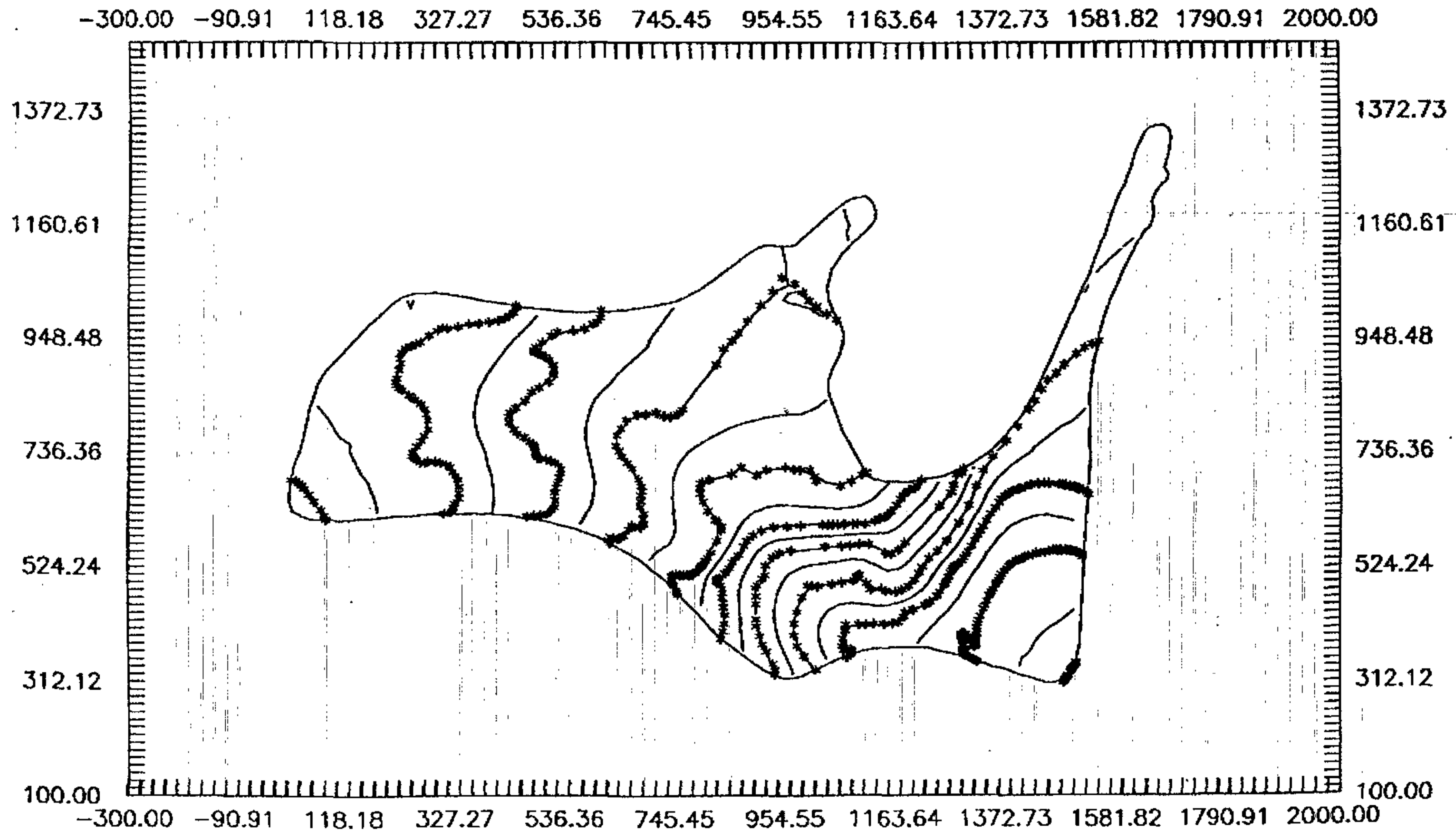
AR300423

Dixie Caverns Solid Waste Surface 1962



AR300424

Dixie Caverns Solid Waste Surface Topography 1990



AR300425

Population Survey Details

RESIDENTIAL POPULATION ADJACENT TO THE SITE

One Mile Radius Population

Using the 1990 Preliminary Census map of Roanoke County [Tract 303.98, BG (Block Group) 9] the entire population within a one mile radius of the Dixie Caverns Landfill can be determined. The table below indicates the various population blocks which are found within a one mile radius of the site.

Block	Total Population	Population 18 years & older	Block	Total Population	Population 18 years & older
955	---	---	968	---	---
964A	141	103	969	---	---
964B	---	---	972*	92	74
965	---	---			
966	---	---			
967	2	2	Totals	235	179

*25 percent of households were located outside 1 mile radius.

Based on Block Group 9, the population within a 1 mile radius of the Dixie Caverns site is:

Total Population	= 235 people
Population 18 years and over	= 179 people

This population estimate is dependent upon the accuracy of the 1990 Census data, and does not reflect possible population shifts since the census was taken. Furthermore, since the Block Group boundaries, as well as spacial variations within the block groups were not provided, estimates of the percentage of the population of a Block Group which straddle the one mile radius line were used.

Three Mile Radius Population

The process used to estimate the population within a three mile radius is similar to that of the one mile population estimate. However, the three mile survey contains limitations in addition to those noted above. A three mile radius from the site extends to the west into Montgomery County where 1990 Census data is not available. Since no 1990 census data currently exists, an estimate of the Montgomery population was made using 1972 Census data. Note, Montgomery County comprises approximately 30% of the area within the 3 mile radius survey area.

Through the process described in detail below, the combined 1990 Roanoke and Montgomery County populations within 3 miles of the site is 2497, of which 1909 are 18 years old or older.

The following table documents the summation of population blocks in the Roanoke county section of the survey area based on the 1990 Census.

Block	Total Population	Population 18 Years & Older	Block	Total Population	Population 18 Years & Older
908	--	--	121	1	1
932A	1017	748	122	13	11
932B	--	--	123	15	10
938	--	--	124	23	15
954	--	--	126	2	2
941	32	28	127	5	5
931	31	22	128	1	1
949	15	12	129	2	2
984	--	--	130	--	--
970	6	6	131	--	--
973	6	6	132	10	10
974	--	--	133	--	--
975	--	--	134	--	--
958	59	46	135	--	--
994	--	--	136	--	--
981	--	--	137	4	4
980	4	4	138	10	8
975	--	--	139	--	--
974	--	--	140	--	--
976	6	5	141	--	--
977	19	15	142	--	--
978	--	--	143	38	30
984	--	--	144	--	--
985	--	--	145	6	4
983	4	4	146	--	--
956	10	8	147	--	--
964A	141	90	148	--	--
964B	--	--	149	3	3
965	--	--	150	--	--
966	--	--	151	--	--
960	15	14	152	--	--
957	262	220	153	10	9
989	--	--	155A	9	6

990	--	--	159	4	2
991	--	--	156	2	2
992	--	--	157	11	8
993	7	5	158	--	--
341	20	18	160	--	--
111	69	51	161	--	--
112	13	131	162	--	--
114	9	9	972	123	99
116	5	5	967	2	2
117	7	7	Cherokee Hill	50	30
120	1	1	TOTAL of all blocks	2110	1601

In addition to the above population estimates for Roanoke County, the Montgomery County population within a three mile radius must be also determined. The process used to determine the Montgomery County population relies on the 1972 Census data and information taken from the most recent topographic quadrangle of this area (1972 Elliston, Virginia USGS quadrangle). The Roanoke County population within a 3-mile radius is known, as well as the number of houses existing there in 1972. Also known is the number of houses existing in 1972 within the section of Montgomery County included in the 3-mile survey. Assuming a similar population growth in both counties existed over this small area since 1972, then the ratio:

$$\frac{\text{1990 population of Roanoke Co.}}{\text{\# of houses in 1972 in Ro. Co.}} = \frac{\text{1990 population of Montgomery Co.}}{\text{\# of houses in 1972 in Mont. Co.}}$$

holds for the sector areas in question. Using the 1990 Pre-Census map of Roanoke County, Track 303.98 BG 9, Track 305.98 BG 1, the population within a 3 mile radius of the Dixie Caverns landfill can be determined.

1990 population of Montgomery County inside the sector =

$$= \frac{(\textit{No. of houses} \in 1972\ ;\ \textit{Montgomery Co.})\ (1990\ \textit{population of Roanoke Co.})}{\textit{No. of houses} \in 1972\ ;\ \textit{Roanoke Co.}} = \frac{(220)\ (354)}{201}$$

so the total Montgomery County population within three miles = 387,

and the adult Montgomery County population within three miles =

$$= \frac{(220\ )\ (281)}{201}$$

so Montgomery County population, 18 years and over = 308

From the calculations above, the combined 3 mile populations of Roanoke and Montgomery counties is:

2110 + 387 = <u>2497</u>	Total Population
and	
1601 + 308 = <u>1909</u>	Population, 18 years & over

APPENDIX B

SEDIMENT/SURFACE WATER INVESTIGATION INFORMATION

Grain Size Data
TCL/TAL Sample Results

Grain Size Data

Stream Sediment Grain Size Analysis
(percent passing)

Sieve Analysis

Seive Size	24 SA-6	D24 SA-6	26 SA-5	27 SA-4	28 SA-3	29 SA-2	30 SA-1	34 SB-6	35 SB-7	36 SB-5	37 SB-4	38 SB-2	39 SB-1	41 SB-3
GRAVEL														
a) 0.75in (19.0mm)	100	100	100	100	100	100	100	100	100	100	100	100	100	100
b) 0.375in (9.5mm)	100	100	100	100	91	90.1	100	100	100	100	100	93.9	100	91.9
c) No.4 (4.75mm)	83.7	83	85.6	93.3	53.9	30.2	80.2	98.4	79	76.2	97	43.1	79.7	71.5
SAND														
d) No.10 (2.00mm)	44.1	48.8	56.2	83.5	18.1	7.9	45.2	74.9	53.5	49.1	85.6	12.5	21	50.7
e) No.20 (850um)	25.3	25.9	38	67.9	14.3	4.4	24.1	73.6	44	25.8	83.8	8.7	5.6	49
f) No.40 (425um)	18.2	15.6	24	44.1	11.6	3.2	13.3	70.4	37.9	12.9	82	7.2	2.9	46
g) No.60 (250um)	12.3	10.9	17.6	29.1	10.6	2.8	9.9	65.7	32.7	6.5	80.9	6.4	2.4	43.4
h) No.140 (106um)	8.4	7	12.5	20.6	9.5	2.5	7.5	58.2	27.8	1.6	79.3	5.6	2	39.9
i) No.200 (75um)	7.9	6.4	11.6	19.4	9.1	2.4	6.9	55	26.7	1.2	78.6	5.3	1.9	38.6

Hydrometer Analysis

SILT														
j) (74um)	13	13	17.5	17.5	25	13.5	9.7	73	27	0.8	100	47.5	17.5	79
k) (5um)	2.2	0	7	2	3	0	2	17	12.5	0	21	0	0	13
CLAY														
l) (1um)	0.1	0	2.2	1	0	0	0	10.3	3.4	0	8.7	0	0	4.5

Stream Sediment Grain Size Analysis
(percent passing)

Sieve Analysis

Seive Size	40 SC-1	31 SE-2	32 SE-1	46 SF-1	25 SG-1	42 OS-1	43 OS-2	D43 OS-2	44 SR-1	45 SR-2
GRAVEL										
a) 0.75in (19.0mm)	100	100	100	100	100	100	100	100	100	100
b) 0.375in (9.5mm)	89.6	98.5	100	100	100	89.6	84.8	94	100	100
c) No.4 (4.75mm)	74.6	86.6	96	99.2	75.1	60.1	52.1	63.2	98.9	100
SAND										
d) No.10 (2.00mm)	50	71.1	89.4	96.9	57.7	35.1	23.9	35.3	95.9	97.9
e) No.20 (850um)	47.3	67.8	86.5	90.1	53.9	19.3	14	21.6	94.3	96.7
f) No.40 (425um)	39.8	61.1	78.6	69.5	48	10.6	7.5	12.1	92.6	93.1
g) No.60 (250um)	37.1	55.5	71.3	53.1	40.2	7.4	5.3	8.5	91.7	89.4
h) No.140 (106um)	34.8	49.3	59	38.5	26.7	4.7	4.2	6.4	88.9	82
i) No.200 (75um)	34.4	47.9	54.5	35.3	22.9	4.2	3.9	5.9	87.4	79.3

Hydrometer Analysis

SILT										
j) (74um)	85	43	62	47	32	16	18.5	6.8	96	100
k) (5um)	6	7.5	13	9	7	0	0	0	56	26
CLAY										
l) (1um)	0	2.4	4.5	4.5	2.5	0	0	0	31	12

TCL/TAL Sample Results

GLOSSARY OF DATA QUALIFIER CODES

CODES RELATING TO IDENTIFICATION
(confidence concerning presence or absence of compounds):

U = Not detected. The associated number indicates approximate sample concentration necessary to be detected.

(NO CODE) = Confirmed identification.

B = Not detected substantially above the level reported in laboratory or field blanks.

R = Unreliable result. Analyte may or may not be present in the sample. Supporting data necessary to confirm result.

N = Tentative identification. Consider present. Special methods may be needed to confirm its present or absence in future sampling efforts.

CODES RELATED TO QUANTITATION
(can be used for both positive results and sample quantitation limits):

J = Analyte present. Reported value may not be accurate or precise.

K = Analyte present. Reported value may be biased high. Actual value is expected to be lower.

L = Analyte present. Reported value may be biased low. Actual value is expected to be higher.

UJ = Not detected, quantitation may be inaccurate or imprecise.

UL = Not detected, quantitation limit is probably higher.

OTHER CODES

Q = No analytical result.

D = Compound identified in an analysis at a secondary dilution factor.

X = Additional flags defined separately.

Summary of Chemicals Detected in Surface Water - Round 1
in the Vicinity of Dixie Caverns
--- Volatile ---

Chemical	Q-1-01 CED23	SA-1-01 CED01	SA-2-01 CED02	SA-3-01 CED08	SA-4-01 CED06	SA-4-01 CED05 (Duplicate)	SA-5-01 CED07	SB-1-01 CED19
1,1,1-Trichloroethane (ug/L)	5.00 U	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 U
1,1,2,2-Tetrachloroethane (ug/L)	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ
1,1,2-Trichloroethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
1,1-Dichloroethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
1,1-Dichloroethene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
1,2-Dichloroethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
1,2-Dichloropropane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
2-Butanone (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Hexanone (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 UJ
4-Methyl-2-pentanone (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Acetone (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Bromodichloromethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Bromoform (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Bromomethane (ug/L)	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ
Carbon Disulfide (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Carbon Tetrachloride (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 R
Chlorobenzene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Chloroethane (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 UJ
Chloroform (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Chloromethane (ug/L)	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ
Cis-1,3-Dichloropropane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Dibromochloromethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Ethylbenzene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Methylene Chloride (ug/L)	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 U
Styrene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Tetrachloroethene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Toluene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Total 1,2-Dichloroethene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Total xylenes (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Trans-1,3-Dichloropropene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Trichloroethene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 UJ
Vinyl Acetate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Vinyl Chloride (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U

Summary of Chemicals Detected in Surface Water - Round 1
in the Vicinity of Dixie Caverns
--- Semi-Volatile ---

Chemical	Q-1-01 CED23	SA-1-01 CED01	SA-2-01 CED02	SA-3-01 CED08	SA-4-01 CED06	SA-4-01 CED05 (Duplicate)	SA-5-01 CED07	SB-1-01 CED19
1,2,4-Trichlorobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
1,2-Dichlorobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
1,3-Dichlorobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
1,4-Dichlorobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2,4,5-Trichlorophenol (ug/L)	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U
2,4,6-Trichlorophenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2,4-Dichlorophenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2,4-Dimethylphenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2,4-Dinitrophenol (ug/L)	50.00 U	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 U
2,4-Dinitrotoluene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2,6-Dinitrotoluene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Chloronaphthalene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Chlorophenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Methylnaphthalene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Methylphenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Nitroaniline (ug/L)	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U
2-Nitrophenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
3,3'-Dichlorobenzidine (ug/L)	20.00 U	20.00 U	20.00 U	20.00 U	20.00 U	20.00 U	20.00 U	20.00 U
3-Nitroaniline (ug/L)	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ
4,6-Dinitro-2-methylphenol (ug/L)	50.00 U	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 U
4-Bromophenyl-phenylether (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
4-Chloro-3-methylphenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
4-Chloroaniline (ug/L)	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ
4-Chlorophenyl-phenylether (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
4-Methylphenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
4-Nitroaniline (ug/L)	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ
4-Nitrophenol (ug/L)	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U
Acenaphthene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Acenaphthylene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Anthracene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzo(a)anthracene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzo(a)pyrene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzo(b)fluoranthene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzo(g,h,i)perylene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzo(k)fluoranthene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzoic Acid (ug/L)	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U
Benzyl alcohol (ug/L)	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ

Summary of Chemicals Detected in Surface Water - Round 1
in the Vicinity of Dixie Caverns
--- Semi-Volatile ---

Chemical	Q-1-01 CED23	SA-1-01 CED01	SA-2-01 CED02	SA-3-01 CED08	SA-4-01 CED06	SA-4-01 CED05 (Duplicate)	SA-5-01 CED07	SB-1-01 CED19
Butylbenzylphthalate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Chrysene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Di-n-butylphthalate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Di-n-octylphthalate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Dibenzo(a,h)anthracene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Dibenzofuran (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Diethylphthalate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Dimethylphthalate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Fluoranthene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Fluorene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Hexachlorobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Hexachlorobutadiene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Hexachlorocyclopentadiene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Hexachloroethane (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Indeno(1,2,3-cd)pyrene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Isophorone (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
N-Nitro-di-n-propylamine (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
N-Nitrosodiphenylamine (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Naphthalene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Nitrobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Pentachlorophenol (ug/L)	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U
Phenanthrene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Phenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Pyrene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
bis(2-Chloroethoxy)methane (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
bis(2-Chloroethyl)ether (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
bis(2-Chloroisopropyl)ether (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
bis(2-Ethylhexyl)phthalate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U

Summary of Chemicals Detected in Surface Water - Round 1
in the Vicinity of Dixie Caverns
--- Pesticides and PCBs ---

Chemical	Q-1-01 CED23	SA-1-01 CED01	SA-2-01 CED02	SA-3-01 CED08	SA-4-01 CED06	SA-4-01 CED05 (Duplicate)	SA-5-01 CED07	SB-1-01 CED19
4,4'-DDD (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
4,4'-DDE (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
4,4'-DDT (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
Aldrin (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
Aroclor-1016 (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
Aroclor-1221 (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
Aroclor-1232 (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
Aroclor-1242 (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
Aroclor-1248 (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
Aroclor-1254 (ug/L)	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Aroclor-1260 (ug/L)	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Dieldrin (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
Endosulfan I (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
Endosulfan II (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
Endosulfan Sulfate (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
Endrin (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
Endrin Ketone (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
Heptachlor (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
Heptachlor Epoxide (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
Methoxychlor (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
Toxaphene (ug/L)	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
alpha-BHC (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
alpha-Chlordane (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
beta-BHC (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
delta-BHC (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
gamma-BHC (Lindane) (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
gamma-Chlordane (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U

Summary of Chemicals Detected in Surface Water - Round 1
in the Vicinity of Dixie Caverns
--- Total Metals and Cyanide ---

Chemical	Q-1-01 MCFA23	SA-1-01 MCFA01	SA-2-01 MCFA02	SA-3-01 MCFA08	SA-4-01 MCFA05 (Duplicate)	SA-4-01 MCFA06	SA-5-01 MCFA07	SB-1-01 MCFA19
Aluminum (ug/L)	55.60 B	47.80 B	26.00 U	135.00 B	26.00 U	40.40 B	26.00 U	618.00
Antimony (ug/L)	30.00 U	24.00 U	24.00 U	24.00 U	24.00 U	24.00 U	24.00 U	24.00 U
Arsenic (ug/L)	2.00 U	2.20	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
Barium (ug/L)	50.30	34.40 J	36.00 J	47.20 J	85.10	74.90 J	64.50 J	34.30 J
Beryllium (ug/L)	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Cadmium (ug/L)	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U
Calcium (ug/L)	69,700.00	9,280.00	14,600.00	16,900.00	29,700.00	27,400.00	27,000.00	7,090.00
Chromium (ug/L)	5.00 U	6.00 U	6.00 U	6.00 U	6.00 U	6.00 U	6.00 U	6.00 U
Cobalt (ug/L)	7.00 U	4.00 U	4.00 U	4.00 U	4.00 U	4.00 U	4.00 U	4.00 U
Copper (ug/L)	3.00 U	3.00 U	3.00 U	3.90 B	3.00 U	3.00 U	3.00 U	4.80 B
Cyanide (ug/L)	10.00 U	10.00 UL	10.00 UL	10.00 UL	10.00 UL	10.00 UL	10.00 UL	10.00 UL
Iron (ug/L)	37.90	65.40 B	33.20 B	268.00 J	82.50 B	97.50 B	73.60 B	744.00 J
Lead (ug/L)	1.00 U	2.20 J	2.30 J	2.00 U	2.70 J	2.00 U	2.00 U	2.40 J
Magnesium (ug/L)	27,500.00	2,830.00	4,550.00	5,890.00	11,300.00	10,300.00	9,320.00	2,180.00
Manganese (ug/L)	5.00 B	2.90 B	4.30 B	10.70 B	18.40	13.10 J	4.30 B	38.60
Mercury (ug/L)	.20 U	.20 U	.20 U	.20 U	.20 U	.20 U	.20 U	.20 U
Nickel (ug/L)	6.00 U	6.00 U	6.00 U	6.00 U	6.00 U	6.00 U	6.00 U	6.00 U
Potassium (ug/L)	5,060.00 U	1,210.00	1,270.00	1,540.00	3,450.00	3,080.00	2,350.00	1,880.00
Selenium (ug/L)	3.00 U	2.00 UL	2.00 UL	2.00 UL	2.00 UL	2.00 UL	2.00 UL	2.00 UL
Silver (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Sodium (ug/L)	15,200.00 U	1,930.00	2,430.00	3,820.00	9,720.00	8,390.00	5,780.00	2,700.00
Thallium (ug/L)	3.00 UL	2.00 UL	2.00 U	2.00 UL	2.00 UL	2.00 UL	2.00 UL	2.00 UL
Vanadium (ug/L)	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U
Zinc (ug/L)	29.90 B	26.60 B	18.70 B	28.80 B	18.10 B	21.50 B	26.60 B	28.80 B

Summary of Chemicals Detected in Surface Water - Round 1
in the Vicinity of Dixie Caverns
--- Dissolved Metals ---

Chemical	Q-1-01 MCAS23	SA-1-01 MCAS01	SA-2-01 MCAS02	SA-3-01 MCAS08	SA-4-01 MCAS05 (Duplicate)	SA-4-01 MCAS06	SA-5-01 MCAS07	SB-1-01 MCAS19
Aluminum (ug/L)	26.00 U	26.00 U	26.00 U	26.00 U	26.00 U	26.00 U	26.00 U	26.00 U
Antimony (ug/L)	24.00 U	24.00 U	24.00 U	24.00 U	24.00 U	24.00 U	24.00 U	24.00 U
Arsenic (ug/L)	2.00 U	2.20	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
Barium (ug/L)	53.30 J	35.60 J	35.10 J	42.40 J	62.10	64.00	68.80 J	24.10 J
Beryllium (ug/L)	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Cadmium (ug/L)	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U
Calcium (ug/L)	66,000.00	9,080.00	14,100.00	16,700.00	24,100.00	24,700.00	28,800.00	6,790.00
Chromium (ug/L)	6.00 U	6.00 U	6.00 U	6.00 U	92.80	84.10	6.00 U	6.00 U
Cobalt (ug/L)	4.00 U	4.00 U	4.00 U	4.00 U	4.00 U	4.00 U	4.00 U	4.00 U
Copper (ug/L)	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.40	3.60	3.00 U
Cyanide (ug/L)	.00 Q	.00 Q	.00 Q	.00 Q	.00 Q	.00 Q	.00 Q	.00 Q
Iron (ug/L)	21.60 B	20.00 U	30.50 B	28.80 B	304.00	252.00	28.50 B	25.80 B
Lead (ug/L)	3.00 U	1.80 J	1.20 K	1.00 U	1.70 J	1.20 J	1.00 U	1.10 K
Magnesium (ug/L)	27,800.00	2,850.00	4,440.00	5,720.00	8,430.00	8,990.00	10,300.00	1,940.00
Manganese (ug/L)	2.00 U	2.00 U	2.00 U	4.20 J	34.40	13.20	3.70 J	6.90 J
Mercury (ug/L)	.20 U	.20 UL	.20 UL	.20 UL	.20 UL	.20 UL	.20 UL	.20 U
Nickel (ug/L)	6.00 U	6.00 U	6.00 U	6.00 U	69.00	59.20	6.00 U	6.00 U
Potassium (ug/L)	5,200.00	1,280.00	1,310.00	1,470.00	2,300.00	2,650.00	2,300.00	1,620.00
Selenium (ug/L)	3.00 U	3.00 UL	3.00 UL	3.00 UL	3.00 UL	3.00 UL	3.00 UL	3.00 UL
Silver (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Sodium (ug/L)	15,900.00	1,990.00	2,400.00	3,660.00	6,200.00	7,040.00	5,730.00	2,500.00
Thallium (ug/L)	10.00 UL	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 UL	3.00 U
Vanadium (ug/L)	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U
Zinc (ug/L)	19.10 B	23.20	16.90 J	19.40 J	27.20	23.50	33.80	23.80

Summary of Chemicals Detected in Surface Water - Round 1
in the Vicinity of Dixie Caverns
--- Volatile ---

Chemical	SB-2-01 CED20	SB-3-01 CED22	SB-4-01 CED03	SB-5-01 CED18	SB-6-01 CED16	SB-7-01 CED17	SD-1-01 CED12	SE-1-01 CED15
1,1,1-Trichloroethane (ug/L)	5.00 U	5.00 U	5.00 UJ	5.00 U	5.00 U	5.00 U	5.00 UJ	5.00 UJ
1,1,2,2-Tetrachloroethane (ug/L)	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ
1,1,2-Trichloroethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
1,1-Dichloroethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
1,1-Dichloroethene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
1,2-Dichloroethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
1,2-Dichloropropane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
2-Butanone (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Hexanone (ug/L)	10.00 UJ	10.00 UJ	10.00 U	10.00 UJ	10.00 UJ	10.00 UJ	10.00 U	10.00 U
4-Methyl-2-pentanone (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Acetone (ug/L)	10.00 U	10.00 U	10.00 U	7.00 J	10.00 U	7.00 J	10.00 U	10.00 U
Benzene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Bromodichloromethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Bromoform (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Bromomethane (ug/L)	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ
Carbon Disulfide (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Carbon Tetrachloride (ug/L)	5.00 R	5.00 R	5.00 U	5.00 R	5.00 R	5.00 R	5.00 U	5.00 U
Chlorobenzene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Chloroethane (ug/L)	10.00 UJ	10.00 UJ	10.00 U	10.00 UJ	10.00 UJ	10.00 UJ	10.00 U	10.00 U
Chloroform (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Chloromethane (ug/L)	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ
Cis-1,3-Dichloropropane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Dibromochloromethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Ethylbenzene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Methylene Chloride (ug/L)	5.00 U	5.00 U	5.00 UJ	5.00 U	5.00 U	5.00 U	5.00 UJ	5.00 UJ
Styrene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Tetrachloroethene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Toluene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Total 1,2-Dichloroethene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Total xylenes (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Trans-1,3-Dichloropropene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Trichloroethene (ug/L)	5.00 UJ	5.00 UJ	5.00 U	5.00 UJ	5.00 UJ	5.00 UJ	5.00 U	5.00 U
Vinyl Acetate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Vinyl Chloride (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U

Summary of Chemicals Detected in Surface Water - Round 1
in the Vicinity of Dixie Caverns
--- Semi-Volatile ---

Chemical	SB-2-01 CED20	SB-3-01 CED22	SB-4-01 CED03	SB-5-01 CED18	SB-6-01 CED16	SB-7-01 CED17	SD-1-01 CED12	SE-1-01 CED15
1,2,4-Trichlorobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
1,2-Dichlorobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
1,3-Dichlorobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
1,4-Dichlorobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2,4,5-Trichlorophenol (ug/L)	50.00 U	50.00 U	50.00 R	50.00 R	50.00 R	50.00 R	50.00 U	50.00 U
2,4,6-Trichlorophenol (ug/L)	10.00 U	10.00 U	10.00 R	10.00 R	10.00 R	10.00 R	10.00 U	10.00 U
2,4-Dichlorophenol (ug/L)	10.00 U	10.00 U	10.00 R	10.00 R	10.00 R	10.00 R	10.00 U	10.00 U
2,4-Dimethylphenol (ug/L)	10.00 U	10.00 U	10.00 R	10.00 R	10.00 R	10.00 R	10.00 U	10.00 U
2,4-Dinitrophenol (ug/L)	50.00 U	50.00 U	50.00 R	50.00 R	50.00 R	50.00 R	50.00 U	50.00 U
2,4-Dinitrotoluene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2,6-Dinitrotoluene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Chloronaphthalene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Chlorophenol (ug/L)	10.00 U	10.00 U	10.00 R	10.00 R	10.00 R	10.00 R	10.00 U	10.00 U
2-Methylnaphthalene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Methylphenol (ug/L)	10.00 U	10.00 U	10.00 R	10.00 R	10.00 R	10.00 R	10.00 U	10.00 U
2-Nitroaniline (ug/L)	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U
2-Nitrophenol (ug/L)	10.00 U	10.00 U	10.00 R	10.00 R	10.00 R	10.00 R	10.00 U	10.00 U
3,3'-Dichlorobenzidine (ug/L)	20.00 U	20.00 U	20.00 U	20.00 U	20.00 U	20.00 U	20.00 U	20.00 U
3-Nitroaniline (ug/L)	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ
4,6-Dinitro-2-methylphenol (ug/L)	50.00 U	50.00 U	50.00 R	50.00 R	50.00 R	50.00 R	50.00 UJ	50.00 UJ
4-Bromophenyl-phenylether (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
4-Chloro-3-methylphenol (ug/L)	10.00 U	10.00 U	10.00 R	10.00 R	10.00 R	10.00 R	10.00 U	10.00 U
4-Chloroaniline (ug/L)	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ
4-Chlorophenyl-phenylether (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
4-Methylphenol (ug/L)	10.00 U	10.00 U	10.00 R	10.00 R	10.00 R	10.00 R	10.00 U	10.00 U
4-Nitroaniline (ug/L)	50.00 UJ	50.00 UJ	50.00 UJ	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U
4-Nitrophenol (ug/L)	50.00 U	50.00 U	50.00 R	50.00 R	50.00 R	50.00 R	50.00 U	50.00 U
Acenaphthene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Acenaphthylene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Anthracene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzo(a)anthracene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzo(a)pyrene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzo(b)fluoranthene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzo(g,h,i)perylene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzo(k)fluoranthene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzoic Acid (ug/L)	50.00 U	50.00 U	50.00 R	50.00 R	50.00 R	50.00 R	50.00 U	50.00 U
Benzyl alcohol (ug/L)	10.00 UJ	10.00 UJ	10.00 R	10.00 R	10.00 R	10.00 R	10.00 U	10.00 U

Summary of Chemicals Detected in Surface Water - Round 1
in the Vicinity of Dixie Caverns
--- Semi-Volatile ---

Chemical	SB-2-01 CED20	SB-3-01 CED22	SB-4-01 CED03	SB-5-01 CED18	SB-6-01 CED16	SB-7-01 CED17	SD-1-01 CED12	SE-1-01 CED15
Butylbenzylphthalate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Chrysene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Di-n-butylphthalate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Di-n-octylphthalate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Dibenzo(a,h)anthracene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Dibenzofuran (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Diethylphthalate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Dimethylphthalate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Fluoranthene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Fluorene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Hexachlorobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Hexachlorobutadiene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Hexachlorocyclopentadiene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Hexachloroethane (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Indeno(1,2,3-cd)pyrene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Isophorone (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
N-Nitro-di-n-propylamine (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
N-Nitrosodiphenylamine (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Naphthalene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Nitrobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Pentachlorophenol (ug/L)	50.00 U	50.00 U	50.00 R	50.00 R	50.00 R	50.00 R	50.00 U	50.00 U
Phenanthrene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Phenol (ug/L)	10.00 U	10.00 U	10.00 R	10.00 R	10.00 R	10.00 R	10.00 U	10.00 U
Pyrene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
bis(2-Chloroethoxy)methane (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
bis(2-Chloroethyl)ether (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
bis(2-Chloroisopropyl)ether (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
bis(2-Ethylhexyl)phthalate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U

Summary of Chemicals Detected in Surface Water - Round 1
in the Vicinity of Dixie Caverns
--- Pesticides and PCBs ---

Chemical	SB-2-01 CED20	SB-3-01 CED22	SB-4-01 CED03	SB-5-01 CED18	SB-6-01 CED16	SB-7-01 CED17	SD-1-01 CED12	SE-1-01 CED15
4,4'-DDD (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
4,4'-DDE (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
4,4'-DDT (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
Aldrin (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
Aroclor-1016 (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
Aroclor-1221 (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
Aroclor-1232 (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
Aroclor-1242 (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
Aroclor-1248 (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
Aroclor-1254 (ug/L)	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Aroclor-1260 (ug/L)	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Dieldrin (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
Endosulfan I (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
Endosulfan II (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
Endosulfan Sulfate (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
Endrin (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
Endrin Ketone (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
Heptachlor (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
Heptachlor Epoxide (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
Methoxychlor (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
Toxaphene (ug/L)	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
alpha-BHC (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
alpha-Chlordane (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
beta-BHC (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
delta-BHC (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
gamma-BHC (Lindane) (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
gamma-Chlordane (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U

Summary of Chemicals Detected in Surface Water - Round 1
in the Vicinity of Dixie Caverns
--- Total Metals and Cyanide ---

Chemical	SB-2-01 MCFA20	SB-3-01 MCFA22	SB-4-01 MCFA03	SB-5-01 MCFA18	SB-6-01 MCFA16	SB-7-01 MCFA17	SD-1-01 MCFA12	SE-1-01 MCFA15
Aluminum (ug/L)	1,880.00	116.00 B	47.60 B	147.00 B	126.00 B	68.50 B	28.70 B	26.00 U
Antimony (ug/L)	24.00 U	24.00 U	24.00 U	24.00 U	24.00 U	24.00 U	30.00 U	24.00 U
Arsenic (ug/L)	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
Barium (ug/L)	53.80 J	28.20	61.20 J	76.80 J	87.30 J	87.40 J	21.00 J	37.60 J
Beryllium (ug/L)	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Cadmium (ug/L)	3.00 U	3.00 U	3.00 U	19.20	15.60	18.60	3.00 U	5.80
Calcium (ug/L)	8,480.00	7,220.00	15,300.00	15,300.00	16,800.00	17,300.00	7,130.00	9,950.00
Chromium (ug/L)	6.00 U	6.00 U	6.00 U	6.00 U	6.00 U	6.00 U	5.00 U	6.00 U
Cobalt (ug/L)	4.00 U	4.00 U	22.50	14.20	12.00	9.70	7.00 U	4.00 U
Copper (ug/L)	5.60 B	2.40 B	3.00 U	3.00 U	3.00 U	3.70 B	3.00 U	3.00 U
Cyanide (ug/L)	10.00 UL	10.00 UL	10.00 UL	10.00 UL	10.00 UL	10.00 UL	.00 Q	10.00 UL
Iron (ug/L)	2,520.00 J	268.00 J	1,740.00 J	998.00 J	1,250.00 J	483.00 J	13.60	112.00 B
Lead (ug/L)	5.80	4.30	3.60	45.10	30.80	41.50	1.10 J	6.20
Magnesium (ug/L)	2,380.00	2,350.00	6,290.00	7,380.00	9,530.00	9,710.00	1,550.00	3,730.00
Manganese (ug/L)	304.00	34.10	2,550.00	2,690.00	2,730.00	2,450.00	1.00 U	575.00
Mercury (ug/L)	.20 U	.20 U	.20 U	.20 U	.20 U	.20 U	.20 U	.20 U
Nickel (ug/L)	6.00 U	6.00 U	6.00 U	6.00 U	6.40	6.00 U	6.00 U	6.00 U
Potassium (ug/L)	1,960.00	1,940.00	2,780.00	23,300.00	21,500.00	21,600.00	1,400.00	6,500.00
Selenium (ug/L)	2.00 UL	2.00 UL	2.00 UL	2.00 UL	2.00 UL	2.00 UL	3.00 U	2.00 UL
Silver (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Sodium (ug/L)	3,150.00	3,110.00	4,370.00	19,700.00	20,300.00	20,400.00	3,070.00	7,770.00
Thallium (ug/L)	2.00 U	2.00 U	2.00 U	2.00 UL	10.00 UL	10.00 UL	3.00 UL	2.00 UL
Vanadium (ug/L)	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U
Zinc (ug/L)	31.40 B	26.00 B	105.00	2,210.00	2,660.00	2,680.00	26.90 B	691.00

Summary of Chemicals Detected in Surface Water - Round 1
in the Vicinity of Dixie Caverns
--- Dissolved Metals ---

Chemical	SB-2-01 MCAS20	SB-3-01 MCAS22	SB-4-01 MCAS03	SB-5-01 MCAS18	SB-6-01 MCAS16	SB-7-01 MCAS17	SD-1-01 MCAS12	SE-1-01 MCAS15
Aluminum (ug/L)	26.00 U	27.90	26.00 U	26.00 U	26.00 U	26.00 U	26.00 U	26.00 U
Antimony (ug/L)	24.00 U	24.00 U	24.00 U	24.00 U	24.00 U	24.00 U	24.00 U	24.00 U
Arsenic (ug/L)	2.00 U	2.00 U	2.20	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
Barium (ug/L)	24.50	28.20 J	56.70 J	369.00	87.30 J	84.20 J	18.50 J	36.30 J
Beryllium (ug/L)	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Cadmium (ug/L)	3.00 U	3.00 U	3.00 U	41.30	12.30	16.00	3.00 U	3.20 J
Calcium (ug/L)	8,080.00	6,410.00	15,200.00	15,400.00	16,300.00	17,400.00	7,490.00	9,470.00
Chromium (ug/L)	6.00 U	6.00 U	6.00 U	6.00 U	6.00 U	6.00 U	6.00 U	6.00 U
Cobalt (ug/L)	4.00 U	4.00 U	21.80	13.50	9.30	8.40	4.00 U	4.00 U
Copper (ug/L)	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.80	3.00 U	3.00 U
Cyanide (ug/L)	.00 Q	.00 Q	.00 Q	.00 Q	.00 Q	.00 Q	.00 Q	.00 Q
Iron (ug/L)	20.00 U	65.60 B	600.00	149.00	278.00	44.20 B	20.00 U	52.50 B
Lead (ug/L)	1.00 U	3.00 U	2.80 K	10.80 K	4.20 K	5.00 K	1.00 U	2.00 K
Magnesium (ug/L)	2,100.00	2,230.00	6,130.00	7,000.00	9,480.00	9,550.00	1,640.00	3,640.00
Manganese (ug/L)	7.30	22.20	2,490.00	2,380.00	2,620.00	2,410.00	2.00 U	546.00
Mercury (ug/L)	.20 U	.20 U	.20 U	.20 U	.20 U	.20 U	.20 U	.20 U
Nickel (ug/L)	6.00 U	6.00 U	6.00 U	6.00 U	6.90	6.00 U	6.00 U	6.00 U
Potassium (ug/L)	1,590.00	2,020.00	2,690.00	20,700.00	21,700.00	21,300.00	1,380.00	6,480.00
Selenium (ug/L)	3.00 UL	3.00 U	3.00 UL	3.00 UL	3.00 UL	3.00 UL	3.00 UL	3.00 UL
Silver (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Sodium (ug/L)	2,960.00	3,040.00	4,220.00	26,300.00	20,400.00	20,000.00	3,240.00	7,710.00
Thallium (ug/L)	3.00 U	2.00 UL	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U
Vanadium (ug/L)	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U
Zinc (ug/L)	28.20	32.60 B	90.10	1,880.00	2,360.00	2,460.00	28.80	644.00

Summary of Chemicals Detected in Surface Water - Round 1
in the Vicinity of Dixie Caverns
--- Volatile ---

Chemical	SG-1-01 CED14	SG-1-01 CED11	SL-1-01 CED09	SL-2-01 CED10	SR-1-01 CED13	SR-2-01 CED24	SB-4B CEC21 (Rinsate)	SE-1B CEC28 (Rinsate)
1,1,1-Trichloroethane (ug/L)	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 U	5.00 U	5.00 U
1,1,2,2-Tetrachloroethane (ug/L)	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ
1,1,2-Trichloroethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
1,1-Dichloroethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
1,1-Dichloroethene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
1,2-Dichloroethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
1,2-Dichloropropane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
2-Butanone (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Hexanone (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 UJ	10.00 UJ
4-Methyl-2-pentanone (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Acetone (ug/L)	10.00 U	10.00 U	9.00 J	9.00 J	10.00 U	10.00 U	10.00 U	10.00 U
Benzene (ug/L)	5.00 U	5.00 U	3.00 J	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Bromodichloromethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Bromoform (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Bromomethane (ug/L)	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ
Carbon Disulfide (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Carbon Tetrachloride (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 R	5.00 R	5.00 R
Chlorobenzene (ug/L)	5.00 U	5.00 U	5.00 U	4.00 J	5.00 U	5.00 U	5.00 U	5.00 U
Chloroethane (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 UJ	10.00 UJ	10.00 UJ
Chloroform (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	4.00 J	5.00 J
Chloromethane (ug/L)	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ
Cis-1,3-Dichloropropane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Dibromochloromethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Ethylbenzene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Methylene Chloride (ug/L)	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 U	3.00 J	3.00 J
Styrene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Tetrachloroethene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Toluene (ug/L)	5.00 U	5.00 U	11.00 J	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Total 1,2-Dichloroethene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Total xylenes (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Trans-1,3-Dichloropropene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Trichloroethene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 UJ	5.00 UJ	5.00 UJ
Vinyl Acetate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Vinyl Chloride (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U

Summary of Chemicals Detected in Surface Water - Round 1
in the Vicinity of Dixie Caverns
--- Semi-Volatile ---

Chemical	SG-1-01 CED14	SG-1-01 CED11	SL-1-01 CED09	SL-2-01 CED10	SR-1-01 CED13	SR-2-01 CED24	SB-4B CEC21 (Rinsate)	SE-1B CEC28 (Rinsate)
1,2,4-Trichlorobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
1,2-Dichlorobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
1,3-Dichlorobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
1,4-Dichlorobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2,4,5-Trichlorophenol (ug/L)	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U
2,4,6-Trichlorophenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2,4-Dichlorophenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2,4-Dimethylphenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2,4-Dinitrophenol (ug/L)	50.00 U	50.00 UJ	50.00 UJ	50.00 U	50.00 U	50.00 U	50.00 UJ	50.00 UJ
2,4-Dinitrotoluene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2,6-Dinitrotoluene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Chloronaphthalene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Chlorophenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Methylnaphthalene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Methylphenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Nitroaniline (ug/L)	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U
2-Nitrophenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
3,3'-Dichlorobenzidine (ug/L)	20.00 U	20.00 U	20.00 U	20.00 U	20.00 U	20.00 U	20.00 U	20.00 U
3-Nitroaniline (ug/L)	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ
4,6-Dinitro-2-methylphenol (ug/L)	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 U	50.00 U	50.00 UJ	50.00 UJ
4-Bromophenyl-phenylether (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
4-Chloro-3-methylphenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
4-Chloroaniline (ug/L)	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ
4-Chlorophenyl-phenylether (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
4-Methylphenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
4-Nitroaniline (ug/L)	50.00 U	50.00 UJ	50.00 UJ	50.00 U	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ
4-Nitrophenol (ug/L)	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U
Acenaphthene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Acenaphthylene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Anthracene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzo(a)anthracene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzo(a)pyrene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzo(b)fluoranthene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzo(g,h,i)perylene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzo(k)fluoranthene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzoic Acid (ug/L)	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U
Benzyl alcohol (ug/L)	10.00 U	10.00 UJ	10.00 UJ	10.00 U	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ

Summary of Chemicals Detected in Surface Water - Round 1
in the Vicinity of Dixie Caverns
--- Semi-Volatile ---

Chemical	SG-1-01 CED14	SG-1-01 CED11	SL-1-01 CED09	SL-2-01 CED10	SR-1-01 CED13	SR-2-01 CED24	SB-4B CEC21 (Rinsate)	SE-1B CEC28 (Rinsate)
Butylbenzylphthalate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Chrysene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Di-n-butylphthalate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Di-n-octylphthalate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Dibenzo(a,h)anthracene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Dibenzofuran (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Diethylphthalate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Dimethylphthalate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Fluoranthene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Fluorene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Hexachlorobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Hexachlorobutadiene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Hexachlorocyclopentadiene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Hexachloroethane (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Indeno(1,2,3-cd)pyrene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Isophorone (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
N-Nitro-di-n-propylamine (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
N-Nitrosodiphenylamine (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Naphthalene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Nitrobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Pentachlorophenol (ug/L)	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U
Phenanthrene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Phenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Pyrene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
bis(2-Chloroethoxy)methane (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
bis(2-Chloroethyl)ether (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
bis(2-Chloroisopropyl)ether (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
bis(2-Ethylhexyl)phthalate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U

Summary of Chemicals Detected in Surface Water - Round 1
in the Vicinity of Dixie Caverns
--- Pesticides and PCBs ---

Chemical	SG-1-01 CED14	SG-1-01 CED11	SL-1-01 CED09	SL-2-01 CED10	SR-1-01 CED13	SR-2-01 CED24	SB-4B CEC21 (Rinsate)	SE-1B CEC28 (Rinsate)
4,4'-DDD (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
4,4'-DDE (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
4,4'-DDT (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
Aldrin (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
Aroclor-1016 (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
Aroclor-1221 (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
Aroclor-1232 (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
Aroclor-1242 (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
Aroclor-1248 (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
Aroclor-1254 (ug/L)	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Aroclor-1260 (ug/L)	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Dieldrin (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
Endosulfan I (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
Endosulfan II (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
Endosulfan Sulfate (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
Endrin (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
Endrin Ketone (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
Heptachlor (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
Heptachlor Epoxide (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
Methoxychlor (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
Toxaphene (ug/L)	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
alpha-BHC (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
alpha-Chlordane (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
beta-BHC (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
delta-BHC (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
gamma-BHC (Lindane) (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
gamma-Chlordane (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U

Summary of Chemicals Detected in Surface Water - Round 1
in the Vicinity of Dixie Caverns
--- Total Metals and Cyanide ---

Chemical	SG-1-01 MCFA11	SG-1-01 MCFA14	SL-1-01 MCFA09	SL-2-01 MCFA10	SR-1-01 MCFA13	SR-2-01 MCFA24	SB-5A-01 MCFA21 (Rinsate)	SL-1A-01 MCFA04 (Rinsate)
Aluminum (ug/L)	37.40 B	57.20 B	60.40 B	171.00 B	4,450.00	1,270.00	26.00 U	26.00 U
Antimony (ug/L)	30.00 U	24.00 U	24.00 U	24.00 U	24.00 U	30.00 U	24.00 U	24.00 U
Arsenic (ug/L)	2.00 U	2.00 U	2.00 U	6.80	2.00 U	2.00 U	2.00 U	2.00 UL
Barium (ug/L)	22.00	22.40	668.00	519.00	27.20 J	40.40 J	2.00 U	2.00 U
Beryllium (ug/L)	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Cadmium (ug/L)	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U
Calcium (ug/L)	14,200.00	14,000.00	55,700.00	55,400.00	19,200.00	31,600.00	143.00 B	382.00 B
Chromium (ug/L)	5.00 U	6.00 U	6.00 U	6.00 U	6.00 U	5.00 U	6.00 U	6.00 U
Cobalt (ug/L)	7.00 U	4.00 U	4.00 U	4.00 U	4.00 U	7.00 U	4.00 U	4.00 U
Copper (ug/L)	3.00 U	3.00 U	3.00 U	3.00 U	16.30 B	3.00 U	3.00 U	3.00 U
Cyanide (ug/L)	10.00 U	10.00 UL	10.00 UL	10.00 UL	10.00 UL	10.00 U	10.00 UL	10.00 UL
Iron (ug/L)	22.70	76.50 B	23,000.00 J	27,200.00 J	715.00 J	1,300.00	20.00 UJ	33.50 B
Lead (ug/L)	1.10 J	2.00 U	3.90	7.50	3.40	2.80 J	2.00 U	2.10 J
Magnesium (ug/L)	4,280.00	4,410.00	38,300.00	33,700.00	8,530.00	9,800.00	34.40 B	37.10 B
Manganese (ug/L)	1.00 U	2.10 B	811.00	636.00	27.50	20.70	2.80 B	2.00 U
Mercury (ug/L)	.20 U	.20 U	.20 U	.20 U	.20 U	.20 U	.20 U	.20 U
Nickel (ug/L)	6.00 U	6.00 U	8.00	6.00 U	6.00 U	6.00 U	6.00 U	6.00 U
Potassium (ug/L)	1,190.00	1,230.00	58,500.00	42,200.00	5,620.00	2,530.00	72.00 U	72.00 U
Selenium (ug/L)	3.00 U	2.00 UL	2.00 UL	2.00 UL	2.00 UL	3.00 U	2.00 UL	2.00 UL
Silver (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Sodium (ug/L)	1,810.00	1,830.00	124,000.00	83,500.00	1,530.00	1,340.00	50.00 U	50.00 U
Thallium (ug/L)	3.00 U	2.00 U	10.00 UL	10.00 UL	2.00 UL	3.00 U	2.00 U	2.00 U
Vanadium (ug/L)	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U
Zinc (ug/L)	23.00 B	17.00 B	32.30 B	38.60 B	33.80 B	40.30 B	19.20 B	23.80 B

Summary of Chemicals Detected in Surface Water - Round 1
in the Vicinity of Dixie Caverns
--- Dissolved Metals ---

Chemical	SG-1-01 MCAS11	SG-1-01 MCAS14	SL-1-01 MCAS09	SL-2-01 MCAS10	SR-1-01 MCAS13	SB-5A-01 MCAS21 (Rinsate)	SL-1A-01 MCAS04 (Rinsate)
Aluminum (ug/L)	34.70	26.00 U	26.00 U	26.00 U	42.80 B	26.00 U	26.00 U
Antimony (ug/L)	24.00 U	24.00 U	24.00 U	24.00 U	24.00 U	24.00 U	24.00 U
Arsenic (ug/L)	2.00 U	2.00 U	2.00 U	7.20	2.00 U	2.00	2.00 U
Barium (ug/L)	25.60 J	21.70 J	558.00	495.00	27.20 J	2.00	2.00 U
Beryllium (ug/L)	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Cadmium (ug/L)	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U
Calcium (ug/L)	13,000.00	13,100.00	52,900.00	54,400.00	18,100.00	180.00 B	141.00 B
Chromium (ug/L)	6.00 U	6.00 U	6.00 U	6.00 U	6.00 U	6.00 U	6.00 U
Cobalt (ug/L)	4.00 U	4.00 U	4.00 U	4.60	4.00 U	4.00 U	4.00 U
Copper (ug/L)	3.00 U	3.00 U	3.00 U	3.30	4.60	3.00 U	3.00 U
Cyanide (ug/L)	.00 Q	.00 Q	.00 Q	.00 Q	.00 Q	.00 Q	.00 Q
Iron (ug/L)	34.10 B	23.10 B	13,400.00	25,400.00	95.20 B	25.30 B	20.00 U
Lead (ug/L)	3.00 U	4.50 K	1.30 KJ	1.50 J	1.00 U	2.90 L	1.00 U
Magnesium (ug/L)	4,300.00	4,150.00	36,900.00	32,900.00	8,100.00	30.00 U	30.00 U
Manganese (ug/L)	2.00 U	2.00 U	761.00	617.00	27.50	2.90	2.40 J
Mercury (ug/L)	.20 U	.20 UL	.20 U	.20 U	.20 U	.20 u	.20 U
Nickel (ug/L)	6.00 U	6.00 U	6.00 U	6.00 U	6.00 U	6.00 U	6.00 U
Potassium (ug/L)	1,270.00	1,180.00	57,100.00	41,300.00	5,690.00	72.00 U	72.00 U
Selenium (ug/L)	3.00 U	3.00 UL	3.00 UL	3.00 UL	3.00 UL	3.00 UL	3.00 UL
Silver (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Sodium (ug/L)	1,830.00	1,900.00	120,000.00	80,800.00	1,520.00	78.20	50.00 U
Thallium (ug/L)	2.00 UL	3.00 U	3.00 U	3.00 UL	3.00 U	3.00 UL	3.00 U
Vanadium (ug/L)	3.00 U	3.00 U	3.00 U	3.90 J	3.00 U	3.00 U	3.00 U
Zinc (ug/L)	25.80 B	30.70	22.80	45.10	33.80 B	24.40	15.70 J

Summary of Chemicals Detected in Surface Water - Round 1
in the Vicinity of Dixie Caverns
--- Volatile ---

Chemical	SL-1A-01 CED04 (Rinsate)	SB-5A CED21 (Rinsate)	TRIPBLANK CED96 (Trip Blank)	TRIPBLANK CED97 (Trip Blank)	TRIPBLANK CED99 (Trip Blank)
1,1,1-Trichloroethane (ug/L)	5.00 UJ	5.00 U	5.00 U	5.00 U	5.00 U
1,1,2,2-Tetrachloroethane (ug/L)	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ
1,1,2-Trichloroethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
1,1-Dichloroethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
1,1-Dichloroethene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
1,2-Dichloroethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
1,2-Dichloropropane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
2-Butanone (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Hexanone (ug/L)	10.00 U	10.00 UJ	10.00 UJ	10.00 U	10.00 UJ
4-Methyl-2-pentanone (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Acetone (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Bromodichloromethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Bromoform (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Bromomethane (ug/L)	10.00 UJ	10.00 UJ	10.00 UJ	10.00 U	10.00 UJ
Carbon Disulfide (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Carbon Tetrachloride (ug/L)	5.00 U	5.00 R	5.00 R	5.00 U	5.00 R
Chlorobenzene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Chloroethane (ug/L)	10.00 U	10.00 UJ	10.00 UJ	10.00 U	10.00 UJ
Chloroform (ug/L)	4.00 J	4.00 J	4.00 J	3.00 J	4.00 J
Chloromethane (ug/L)	10.00 UJ	10.00 UJ	10.00 UJ	10.00 U	10.00 UJ
Cis-1,3-Dichloropropane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Dibromochloromethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Ethylbenzene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Methylene Chloride (ug/L)	6.00 J	4.00 J	4.00 J	4.00 J	5.00 J
Styrene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Tetrachloroethene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Toluene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Total 1,2-Dichloroethene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Total xylenes (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Trans-1,3-Dichloropropene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Trichloroethene (ug/L)	5.00 U	5.00 UJ	5.00 UJ	5.00 U	5.00 UJ
Vinyl Acetate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Vinyl Chloride (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U

Summary of Chemicals Detected in Surface Water - Round 1
in the Vicinity of Dixie Caverns
--- Semi-Volatile ---

Chemical	SL-1A-01 CED04	SB-5A CED21 (Rinsate)
1,2,4-Trichlorobenzene (ug/L)	10.00 U	10.00 U
1,2-Dichlorobenzene (ug/L)	10.00 U	10.00 U
1,3-Dichlorobenzene (ug/L)	10.00 U	10.00 U
1,4-Dichlorobenzene (ug/L)	10.00 U	10.00 U
2,4,5-Trichlorophenol (ug/L)	50.00 U	50.00 U
2,4,6-Trichlorophenol (ug/L)	10.00 U	10.00 U
2,4-Dichlorophenol (ug/L)	10.00 U	10.00 U
2,4-Dimethylphenol (ug/L)	10.00 U	10.00 U
2,4-Dinitrophenol (ug/L)	50.00 UJ	50.00 U
2,4-Dinitrotoluene (ug/L)	10.00 U	10.00 U
2,6-Dinitrotoluene (ug/L)	10.00 U	10.00 U
2-Chloronaphthalene (ug/L)	10.00 U	10.00 U
2-Chlorophenol (ug/L)	10.00 U	10.00 U
2-Methylnaphthalene (ug/L)	10.00 U	10.00 U
2-Methylphenol (ug/L)	10.00 U	10.00 U
2-Nitroaniline (ug/L)	50.00 U	50.00 U
2-Nitrophenol (ug/L)	10.00 U	10.00 U
3,3'-Dichlorobenzidine (ug/L)	20.00 U	20.00 U
3-Nitroaniline (ug/L)	50.00 UJ	50.00 UJ
4,6-Dinitro-2-methylphenol (ug/L)	50.00 UJ	50.00 U
4-Bromophenyl-phenylether (ug/L)	10.00 U	10.00 U
4-Chloro-3-methylphenol (ug/L)	10.00 U	10.00 U
4-Chloroaniline (ug/L)	10.00 UJ	10.00 UJ
4-Chlorophenyl-phenylether (ug/L)	10.00 U	10.00 U
4-Methylphenol (ug/L)	10.00 U	10.00 U
4-Nitroaniline (ug/L)	50.00 UJ	50.00 UJ
4-Nitrophenol (ug/L)	50.00 U	50.00 U
Acenaphthene (ug/L)	10.00 U	10.00 U
Acenaphthylene (ug/L)	10.00 U	10.00 U
Anthracene (ug/L)	10.00 U	10.00 U
Benzo(a)anthracene (ug/L)	10.00 U	10.00 U
Benzo(a)pyrene (ug/L)	10.00 U	10.00 U
Benzo(b)fluoranthene (ug/L)	10.00 U	10.00 U
Benzo(g,h,i)perylene (ug/L)	10.00 U	10.00 U
Benzo(k)fluoranthene (ug/L)	10.00 U	10.00 U
Benzoic Acid (ug/L)	50.00 U	50.00 U
Benzyl alcohol (ug/L)	10.00 UJ	10.00 UJ

Summary of Chemicals Detected in Surface Water - Round 1
in the Vicinity of Dixie Caverns
--- Semi-Volatile ---

Chemical	SL-1A-01 CED04	SB-5A CED21 (Rinsate)
Butylbenzylphthalate (ug/L)	10.00 U	10.00 U
Chrysene (ug/L)	10.00 U	10.00 U
Di-n-butylphthalate (ug/L)	10.00 U	10.00 U
Di-n-octylphthalate (ug/L)	10.00 U	10.00 U
Dibenzo(a,h)anthracene (ug/L)	10.00 U	10.00 U
Dibenzofuran (ug/L)	10.00 U	10.00 U
Diethylphthalate (ug/L)	10.00 U	10.00 U
Dimethylphthalate (ug/L)	10.00 U	10.00 U
Fluoranthene (ug/L)	10.00 U	10.00 U
Fluorene (ug/L)	10.00 U	10.00 U
Hexachlorobenzene (ug/L)	10.00 U	10.00 U
Hexachlorobutadiene (ug/L)	10.00 U	10.00 U
Hexachlorocyclopentadiene (ug/L)	10.00 U	10.00 U
Hexachloroethane (ug/L)	10.00 U	10.00 U
Indeno(1,2,3-cd)pyrene (ug/L)	10.00 U	10.00 U
Isophorone (ug/L)	10.00 U	10.00 U
N-Nitro-di-n-propylamine (ug/L)	10.00 U	10.00 U
N-Nitrosodiphenylamine (ug/L)	10.00 U	10.00 U
Naphthalene (ug/L)	10.00 U	10.00 U
Nitrobenzene (ug/L)	10.00 U	10.00 U
Pentachlorophenol (ug/L)	50.00 U	50.00 U
Phenanthrene (ug/L)	10.00 U	10.00 U
Phenol (ug/L)	10.00 U	10.00 U
Pyrene (ug/L)	10.00 U	10.00 U
bis(2-Chloroethoxy)methane (ug/L)	10.00 U	10.00 U
bis(2-Chloroethyl)ether (ug/L)	10.00 U	10.00 U
bis(2-Chloroisopropyl)ether (ug/L)	10.00 U	10.00 U
bis(2-Ethylhexyl)phthalate (ug/L)	10.00 U	10.00 U

Summary of Chemicals Detected in Surface Water - Round 1
in the Vicinity of Dixie Caverns
--- Pesticides and PCBs ---

Chemical	SL-1A-01 CED04	SB-5A CED21 (Rinsate)
4,4'-DDD (ug/L)	.10 U	.10 U
4,4'-DDE (ug/L)	.10 U	.10 U
4,4'-DDT (ug/L)	.10 U	.10 U
Aldrin (ug/L)	.05 U	.05 U
Aroclor-1016 (ug/L)	.50 U	.50 U
Aroclor-1221 (ug/L)	.50 U	.50 U
Aroclor-1232 (ug/L)	.50 U	.50 U
Aroclor-1242 (ug/L)	.50 U	.50 U
Aroclor-1248 (ug/L)	.50 U	.50 U
Aroclor-1254 (ug/L)	1.00 U	1.00 U
Aroclor-1260 (ug/L)	1.00 U	1.00 U
Dieldrin (ug/L)	.10 U	.10 U
Endosulfan I (ug/L)	.05 U	.05 U
Endosulfan II (ug/L)	.10 U	.10 U
Endosulfan Sulfate (ug/L)	.10 U	.10 U
Endrin (ug/L)	.10 U	.10 U
Endrin Ketone (ug/L)	.10 U	.10 U
Heptachlor (ug/L)	.05 U	.05 U
Heptachlor Epoxide (ug/L)	.05 U	.05 U
Methoxychlor (ug/L)	.50 U	.50 U
Toxaphene (ug/L)	1.00 U	1.00 U
alpha-BHC (ug/L)	.05 U	.05 U
alpha-Chlordane (ug/L)	.50 U	.50 U
beta-BHC (ug/L)	.05 U	.05 U
delta-BHC (ug/L)	.05 U	.05 U
gamma-BHC (Lindane) (ug/L)	.05 U	.05 U
gamma-Chlordane (ug/L)	.50 U	.50 U

Summary of Chemicals Detected in Surface Water - Round 2
in the Vicinity of Dixie Caverns
--- Volatile ---

Chemical	SA-1-02 CBM50	SA-2-02 CBM51	SA-3-02 CBM52	SB-3-02 CBM49 (Duplicate)	SA-4-02 CBM53	SA-5-02 CBM54	SB-1-02 CBM42	SB-2-02 CBM43
1,1,1-Trichloroethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
1,1,2,2-Tetrachloroethane (ug/L)	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ
1,1,2-Trichloroethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
1,1-Dichloroethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
1,1-Dichloroethene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
1,2-Dichloroethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
1,2-Dichloropropane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
2-Butanone (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Hexanone (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
4-Methyl-2-pentanone (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Acetone (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	4.00 B	10.00 U
Benzene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Bromodichloromethane (ug/L)	5.00 UJ	5.00 UJ	5.00 U	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ
Bromoform (ug/L)	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 U
Bromomethane (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Carbon Disulfide (ug/L)	5.00 UJ	3.00 B	5.00 U	18.00 J	7.00 B	5.00 UJ	5.00 UJ	2.00 B
Carbon Tetrachloride (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Chlorobenzene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Chloroethane (ug/L)	10.00 U	10.00 UJ	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Chloroform (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Chloromethane (ug/L)	10.00 UJ	10.00 U	10.00 U	10.00 UJ	10.00 UJ	10.00 U	10.00 U	10.00 U
Cis-1,3-Dichloropropane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Dibromochloromethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Ethylbenzene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Methylene Chloride (ug/L)	5.00 U	5.00 U	5.00 U	7.00 B	3.00 B	5.00 U	3.00 B	4.00 B
Styrene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Tetrachloroethene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Toluene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Total 1,2-Dichloroethene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Total xylenes (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Trans-1,3-Dichloropropene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Trichloroethene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Vinyl Acetate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Vinyl Chloride (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U

Summary of Chemicals Detected in Surface Water - Round 2
in the Vicinity of Dixie Caverns
--- Semi-Volatile ---

Chemical	SA-1-02 CBM50	SA-2-02 CBM51	SA-3-02 CBM52	SB-3-02 CBM49 (Duplicate)	SA-4-02 CBM53	SA-5-02 CBM54	SB-1-02 CBM42	SB-2-02 CBM43
1,2,4-Trichlorobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
1,2-Dichlorobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
1,3-Dichlorobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
1,4-Dichlorobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2,4,5-Trichlorophenol (ug/L)	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U
2,4,6-Trichlorophenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2,4-Dichlorophenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2,4-Dimethylphenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2,4-Dinitrophenol (ug/L)	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 UJ	50.00 U
2,4-Dinitrotoluene (ug/L)	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 U	10.00 U	10.00 UJ
2,6-Dinitrotoluene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Chloronaphthalene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Chlorophenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Methylnaphthalene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Methylphenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Nitroaniline (ug/L)	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 UJ	50.00 U	50.00 U
2-Nitrophenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
3,3'-Dichlorobenzidine (ug/L)	20.00 UJ	20.00 UJ	20.00 UJ	20.00 UJ	20.00 UJ	20.00 U	20.00 UJ	20.00 UJ
3-Nitroaniline (ug/L)	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U
4,6-Dinitro-2-methylphenol (ug/L)	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 U	50.00 UJ	50.00 UJ
4-Bromophenyl-phenylether (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
4-Chloro-3-methylphenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
4-Chloroaniline (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
4-Chlorophenyl-phenylether (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
4-Methylphenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
4-Nitroaniline (ug/L)	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ
4-Nitrophenol (ug/L)	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U
Acenaphthene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Acenaphthylene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Anthracene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzo(a)anthracene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzo(a)pyrene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzo(b)fluoranthene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzo(g,h,i)perylene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzo(k)fluoranthene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzoic Acid (ug/L)	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U
Benzyl alcohol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U

Summary of Chemicals Detected in Surface Water - Round 2
in the Vicinity of Dixie Caverns
--- Semi-Volatile ---

Chemical	SA-1-02 CBM50	SA-2-02 CBM51	SA-3-02 CBM52	SB-3-02 CBM49 (Duplicate)	SA-4-02 CBM53	SA-5-02 CBM54	SB-1-02 CBM42	SB-2-02 CBM43
Butylbenzylphthalate (ug/L)	10.00 UJ	10.00 UJ	10.00 U	10.00 UJ	10.00 UJ	10.00 U	10.00 UJ	10.00 U
Chrysene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Di-n-butylphthalate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Di-n-octylphthalate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Dibenzo(a,h)anthracene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Dibenzofuran (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Diethylphthalate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 UJ	10.00 U	10.00 U	10.00 U
Dimethylphthalate (ug/L)	10.00 UJ	10.00 UJ	10.00 U	10.00 UJ	10.00 U	10.00 U	10.00 U	10.00 UJ
Fluoranthene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Fluorene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Hexachlorobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Hexachlorobutadiene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Hexachlorocyclopentadiene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Hexachloroethane (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Indeno(1,2,3-cd)pyrene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Isophorone (ug/L)	10.00 U	10.00 U	10.00 U	10.00 UJ	10.00 U	10.00 U	10.00 U	10.00 U
N-Nitro-di-n-propylamine (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
N-Nitrosodiphenylamine (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Naphthalene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Nitrobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Pentachlorophenol (ug/L)	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U
Phenanthrene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Phenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Pyrene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 UJ
bis(2-Chloroethoxy)methane (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
bis(2-Chloroethyl)ether (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
bis(2-Chloroisopropyl)ether (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 UJ
bis(2-Ethylhexyl)phthalate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U

Summary of Chemicals Detected in Surface Water - Round 2
in the Vicinity of Dixie Caverns
--- Pesticides and PCBs ---

Chemical	SA-1-02 CBM50	SA-2-02 CBM51	SA-3-02 CBM52	SB-3-02 CBM49 (Duplicate)	SA-4-02 CBM53	SA-5-02 CBM54	SB-1-02 CBM42	SB-2-02 CBM43
4,4'-DDD (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
4,4'-DDE (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
4,4'-DDT (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
Aldrin (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
Aroclor-1016 (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
Aroclor-1221 (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
Aroclor-1232 (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
Aroclor-1242 (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
Aroclor-1248 (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
Aroclor-1254 (ug/L)	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Aroclor-1260 (ug/L)	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Dieldrin (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
Endosulfan I (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
Endosulfan II (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
Endosulfan Sulfate (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
Endrin (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
Endrin Ketone (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
Heptachlor (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
Heptachlor Epoxide (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
Methoxychlor (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
Toxaphene (ug/L)	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
alpha-BHC (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
alpha-Chlordane (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
beta-BHC (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
delta-BHC (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
gamma-BHC (Lindane) (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
gamma-Chlordane (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U

Summary of Chemicals Detected in Surface Water - Round 2
in the Vicinity of Dixie Caverns
--- Total Metals and Cyanide ---

Chemical	SA-1-02 MCCZ26	SA-2-02 MCCZ28	SA-3-02 MCCZ30	SA-4-02 MCCZ32	SA-5-02 MCCZ34	SB-1-02 MCCZ10	SB-2-02 MCCZ12	SB-3-02 MCCZ24
Aluminum (ug/L)	155.00 B	149.00 B	139.00 B	154.00 B	83.30 B	148.00 B	77.50 B	91.90 B
Antimony (ug/L)	22.00 U	22.00 U	22.00 U	22.00 U	22.00 U	22.00 U	22.00 U	22.00 U
Arsenic (ug/L)	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
Barium (ug/L)	24.60	22.90	24.60	26.00	35.00	16.00 B	14.70 B	14.90 B
Beryllium (ug/L)	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Cadmium (ug/L)	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U
Calcium (ug/L)	5,260.00	6,120.00	6,600.00	7,260.00	10,500.00	2,930.00	2,940.00	3,030.00
Chromium (ug/L)	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.30 B	3.00 U	3.00 U
Cobalt (ug/L)	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00	3.00 U	3.00 U
Copper (ug/L)	7.70 B	4.20 B	4.20 B	9.50 B	3.50 B	29.00 B	9.10 B	24.50 B
Cyanide (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Iron (ug/L)	132.00 B	129.00 B	155.00 B	242.00	166.00 B	169.00 B	115.00 B	128.00 B
Lead (ug/L)	1.20 B	1.10 B	1.10 B	1.50 B	1.20 B	1.10 B	1.00 U	1.20 B
Magnesium (ug/L)	1,410.00	1,760.00	2,040.00	2,340.00	3,830.00	1,070.00	1,010.00	1,050.00
Manganese (ug/L)	13.50 B	5.90 B	6.30 B	10.10 B	19.40	4.20 B	5.60 B	10.30 B
Mercury (ug/L)	.20 U	.20 U	.20 U	.20 U	.20 U	.20 U	.20 U	.20 U
Nickel (ug/L)	52.40 B	11.20 B	12.60 B	24.10 B	15.80 B	27.30 B	47.20 B	49.30 B
Potassium (ug/L)	1,170.00	958.00	1,080.00	1,160.00	2,190.00	1,380.00	1,300.00	1,530.00
Selenium (ug/L)	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
Silver (ug/L)	4.00 U	4.00 U	4.00 U	4.00 U	4.00 U	4.00 U	4.00 U	4.00 U
Sodium (ug/L)	1,420.00	1,480.00	1,730.00	1,930.00	3,520.00	1,470.00	1,530.00	1,520.00
Thallium (ug/L)	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
Vanadium (ug/L)	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U
Zinc (ug/L)	27.90 B	13.80 B	10.70 B	22.60 B	6.50 B	6.40 B	7.90 B	18.20 B

Summary of Chemicals Detected in Surface Water - Round 2
in the Vicinity of Dixie Caverns
--- Dissolved Metals ---

Chemical	SA-1-02 MCCZ27	SA-2-02 MCCZ29	SA-3-02 MCCZ31	SA-4-02 MCCZ33	SA-5-02 MCCZ35	SB-1-02 MCCZ11	SB-2-02 MCCZ13	SB-3-02 MCCZ25
Aluminum (ug/L)	67.60 B	52.60 B	60.10 B	40.10 B	33.80 B	73.90 B	56.30 B	70.10 B
Antimony (ug/L)	15.00 U	15.00 U	15.00 U	15.00 U	15.00 U	15.00 U	15.00 U	15.00 U
Arsenic (ug/L)	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
Barium (ug/L)	21.80	21.20	22.90	23.60	31.80	13.50 B	13.70 B	13.70 B
Beryllium (ug/L)	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
Cadmium (ug/L)	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.40 B	2.60 B	2.00 U
Calcium (ug/L)	5,100.00	5,930.00	6,400.00	6,860.00	9,960.00	2,830.00	3,070.00	3,010.00
Chromium (ug/L)	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
Cobalt (ug/L)	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
Copper (ug/L)	60.80 B	124.00 B	36.70 B	31.90 B	34.30 B	22.40 B	94.40 B	114.00 B
Cyanide (ug/L)	.00 Q	.00 Q	.00 Q	.00 Q	.00 Q	.00 Q	.00	.00 Q
Iron (ug/L)	91.70 B	120.00 B	66.90 B	60.50 B	79.80 B	86.80 B	80.60 B	207.00 B
Lead (ug/L)	10.80	1.00 U	4.50 B	1.00 U	10.90	26.50	2.20 B	4.60 B
Magnesium (ug/L)	1,380.00	1,700.00	1,980.00	2,200.00	3,610.00	1,050.00	1,030.00	1,010.00
Manganese (ug/L)	10.30 B	4.60 B	5.10 B	5.10 B	15.90	5.60 B	17.20	27.40
Mercury (ug/L)	.20 U	.20 U	.20 U	.20 U	.20 U	.20 U	.20 U	.20 U
Nickel (ug/L)	21.30 B	27.90 B	19.30 B	20.60 B	58.50 B	17.90 B	28.90 B	57.50 B
Potassium (ug/L)	969.00	940.00	1,010.00	953.00	1,790.00	1,400.00	1,360.00	1,190.00
Selenium (ug/L)	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.80
Silver (ug/L)	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
Sodium (ug/L)	1,500.00	1,540.00	1,720.00	1,920.00	3,440.00	1,480.00	1,520.00	1,550.00
Thallium (ug/L)	4.00 R	4.00 R	4.00 R	4.00 R	4.00 R	4.00 R	4.00 R	4.00 R
Vanadium (ug/L)	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
Zinc (ug/L)	139.00 B	165.00 B	87.50 B	32.70 B	43.70 B	32.00 B	110.00 B	145.00 B

Summary of Chemicals Detected in Surface Water - Round 2
in the Vicinity of Dixie Caverns
--- Volatile ---

Chemical	SB-3-02 CBM44	SB-4-02 CBM45	SB-5-02 CBM46	SB-6-02 CBM47	SB-7-02 CBM48	SC-1-02 CBM55	SD-1-02 CBM56	SE-1-02 CBM57
1,1,1-Trichloroethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
1,1,2,2-Tetrachloroethane (ug/L)	5.00 U	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ
1,1,2-Trichloroethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
1,1-Dichloroethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
1,1-Dichloroethene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
1,2-Dichloroethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
1,2-Dichloropropane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
2-Butanone (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Hexanone (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
4-Methyl-2-pentanone (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Acetone (ug/L)	10.00 U	7.00 B	10.00 U	7.00 B	10.00 U	10.00 U	10.00 U	6.00 B
Benzene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Bromodichloromethane (ug/L)	5.00 UJ	5.00 UJ	5.00 U	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ
Bromoform (ug/L)	5.00 UJ	5.00 UJ	5.00 U	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ
Bromomethane (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Carbon Disulfide (ug/L)	52.00 J	5.00 U	5.00 UJ	5.00 UJ	5.00 UJ	5.00 UJ	67.00 J	5.00 UJ
Carbon Tetrachloride (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Chlorobenzene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Chloroethane (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Chloroform (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Chloromethane (ug/L)	10.00 U	10.00 U	10.00 U	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ	10.00 UJ
Cis-1,3-Dichloropropane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Dibromochloromethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Ethylbenzene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Methylene Chloride (ug/L)	9.00 B	2.00 B	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Styrene (ug/L)	5.00 UJ	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Tetrachloroethene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Toluene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Total 1,2-Dichloroethene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Total xylenes (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Trans-1,3-Dichloropropene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Trichloroethene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Vinyl Acetate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Vinyl Chloride (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U

Summary of Chemicals Detected in Surface Water - Round 2
in the Vicinity of Dixie Caverns
--- Semi-Volatile ---

Chemical	SB-3-02 CBM44	SB-4-02 CBM45	SB-5-02 CBM46	SB-6-02 CBM47	SB-7-02 CBM48	SC-1-02 CBM55	SD-1-02 CBM56	SE-1-02 CBM57
1,2,4-Trichlorobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
1,2-Dichlorobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
1,3-Dichlorobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
1,4-Dichlorobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2,4,5-Trichlorophenol (ug/L)	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U
2,4,6-Trichlorophenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2,4-Dichlorophenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2,4-Dimethylphenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2,4-Dinitrophenol (ug/L)	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U
2,4-Dinitrotoluene (ug/L)	10.00 U	10.00 UJ	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2,6-Dinitrotoluene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Chloronaphthalene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Chlorophenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Methylnaphthalene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Methylphenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Nitroaniline (ug/L)	50.00 U	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ
2-Nitrophenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
3,3'-Dichlorobenzidine (ug/L)	20.00 U	20.00 UJ	20.00 U	20.00 U	20.00 U	20.00 U	20.00 U	20.00 U
3-Nitroaniline (ug/L)	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U
4,6-Dinitro-2-methylphenol (ug/L)	50.00 U	50.00 UJ	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U
4-Bromophenyl-phenylether (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
4-Chloro-3-methylphenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
4-Chloroaniline (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
4-Chlorophenyl-phenylether (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
4-Methylphenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 UJ	10.00 U
4-Nitroaniline (ug/L)	50.00 U	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 UJ	50.00 U	50.00 UJ
4-Nitrophenol (ug/L)	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U
Acenaphthene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Acenaphthylene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Anthracene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzo(a)anthracene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzo(a)pyrene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzo(b)fluoranthene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzo(g,h,i)perylene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzo(k)fluoranthene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzoic Acid (ug/L)	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U
Benzyl alcohol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U

Summary of Chemicals Detected in Surface Water - Round 2
in the Vicinity of Dixie Caverns
--- Semi-Volatile ---

Chemical	SB-3-02 CBM44	SB-4-02 CBM45	SB-5-02 CBM46	SB-6-02 CBM47	SB-7-02 CBM48	SC-1-02 CBM55	SD-1-02 CBM56	SE-1-02 CBM57
Butylbenzylphthalate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Chrysene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Di-n-butylphthalate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Di-n-octylphthalate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Dibenzo(a,h)anthracene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Dibenzofuran (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Diethylphthalate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Dimethylphthalate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Fluoranthene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Fluorene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Hexachlorobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Hexachlorobutadiene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Hexachlorocyclopentadiene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Hexachloroethane (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Indeno(1,2,3-cd)pyrene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Isophorone (ug/L)	10.00 U	10.00 UJ	10.00 U	10.00 U	10.00 UJ	10.00 U	10.00 UJ	10.00 U
N-Nitro-di-n-propylamine (ug/L)	10.00 U	10.00 UJ	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 UJ
N-Nitrosodiphenylamine (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Naphthalene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Nitrobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Pentachlorophenol (ug/L)	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U
Phenanthrene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Phenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Pyrene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
bis(2-Chloroethoxy)methane (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
bis(2-Chloroethyl)ether (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
bis(2-Chloroisopropyl)ether (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
bis(2-Ethylhexyl)phthalate (ug/L)	10.00 U	10.00 U	10.00 U	210.00	10.00 U	10.00 U	10.00 U	10.00 U

Summary of Chemicals Detected in Surface Water - Round 2
in the Vicinity of Dixie Caverns
--- Pesticides and PCBs ---

Chemical	SB-3-02 CBM44	SB-4-02 CBM45	SB-5-02 CBM46	SB-6-02 CBM47	SB-7-02 CBM48	SC-1-02 CBM55	SD-1-02 CBM56	SE-1-02 CBM57
4,4'-DDD (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
4,4'-DDE (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
4,4'-DDT (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
Aldrin (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
Aroclor-1016 (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
Aroclor-1221 (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
Aroclor-1232 (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
Aroclor-1242 (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
Aroclor-1248 (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
Aroclor-1254 (ug/L)	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Aroclor-1260 (ug/L)	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Dieldrin (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
Endosulfan I (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
Endosulfan II (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
Endosulfan Sulfate (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
Endrin (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
Endrin Ketone (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U	.10 U
Heptachlor (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
Heptachlor Epoxide (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
Methoxychlor (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
Toxaphene (ug/L)	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
alpha-BHC (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
alpha-Chlordane (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U
beta-BHC (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
delta-BHC (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
gamma-BHC (Lindane) (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U	.05 U
gamma-Chlordane (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U	.50 U

Summary of Chemicals Detected in Surface Water - Round 2
in the Vicinity of Dixie Caverns
--- Total Metals and Cyanide ---

Chemical	SB-3-02 MCCZ14	SB-4-02 MCCZ16	SB-5-02 MCCZ18	SB-6-02 MCCZ20	SB-7-02 MCCZ22	SC-1-02 MCCZ36	SD-1-02 MCCZ38	SE-1-02 MCCZ40
Aluminum (ug/L)	105.00 B	119.00 B	339.00	296.00	398.00	132.00 B	108.00 B	18.00 U
Antimony (ug/L)	22.00 U	22.00 U	22.00 U	22.00 U	22.00 U	22.00 U	22.00 U	22.00 U
Arsenic (ug/L)	2.60	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
Barium (ug/L)	14.30 B	15.60 B	19.40	27.00	26.80	11.50 B	12.30 B	16.70
Beryllium (ug/L)	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Cadmium (ug/L)	3.00 U	3.00 U	3.00 U	4.50	5.60	3.00 U	3.00 U	3.00 U
Calcium (ug/L)	3,130.00	4,090.00	4,330.00	5,890.00	6,100.00	904.00	4,270.00	4,710.00
Chromium (ug/L)	3.00 U	3.00 U	3.00 U	3.00 U	4.10 B	3.00 U	3.00 U	3.00 U
Cobalt (ug/L)	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U
Copper (ug/L)	6.30 B	6.30 B	6.00 B	13.00 B	12.30 B	4.20 B	3.50 B	5.60 B
Cyanide (ug/L)	10.00 U	23.00	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Iron (ug/L)	207.00	272.00	550.00	628.00	1,080.00	137.00 B	118.00 B	329.00
Lead (ug/L)	1.70 B	1.50 B	5.70 B	9.30	55.70	1.40 B	1.00 U	9.20
Magnesium (ug/L)	1,060.00	1,580.00	1,760.00	3,120.00	3,160.00	845.00	944.00	1,510.00
Manganese (ug/L)	10.80 B	97.40	164.00	311.00	315.00	2.40 B	1.60 B	73.60
Mercury (ug/L)	.20 U	.20 U	.20 U	.20 U	.20 U	.20 U	.20 U	.20 U
Nickel (ug/L)	17.50 B	14.00 B	11.20 B	110.00	16.40 B	20.30 B	22.40 B	37.10 B
Potassium (ug/L)	1,550.00	1,470.00	3,120.00	6,440.00	6,450.00	1,270.00	1,040.00	2,500.00
Selenium (ug/L)	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
Silver (ug/L)	4.00 U	4.00 U	4.00 U	4.00 U	4.00 U	4.00 U	4.00 U	4.00 U
Sodium (ug/L)	1,530.00	1,840.00	3,270.00	6,640.00	6,430.00	1,210.00	1,610.00	2,830.00
Thallium (ug/L)	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
Vanadium (ug/L)	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U
Zinc (ug/L)	8.00 B	14.60 B	138.00 B	552.00 B	762.00	18.00 B	18.40 B	212.00 B

Summary of Chemicals Detected in Surface Water - Round 2
in the Vicinity of Dixie Caverns
--- Dissolved Metals ---

Chemical	SB-3-02 MCCZ15	SB-4-02 MCCZ17	SB-5-02 MCCZ19	SB-6-02 MCCZ21	SB-7-02 MCCZ23	SC-1-02 MCCZ37	SD-1-02 MCCZ39	SE-1-02 MCCZ41
Aluminum (ug/L)	52.60 B	50.10 B	52.60 B	51.40 B	47.60 B	47.40 B	17.20 B	31.60 B
Antimony (ug/L)	15.00 U	15.00 U	15.00 U	15.00 U	15.00 U	15.00 U	15.00 U	15.00 U
Arsenic (ug/L)	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
Barium (ug/L)	15.40 B	14.10 B	16.10 B	24.00	24.90	8.20 B	11.20 B	13.90 B
Beryllium (ug/L)	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
Cadmium (ug/L)	2.80 B	2.00 U	4.00 B	4.30 B	6.80 B	2.00 U	2.00 U	2.00 U
Calcium (ug/L)	2,980.00	4,240.00	4,120.00	5,620.00	5,830.00 B	946.00	4,210.00	4,620.00
Chromium (ug/L)	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
Cobalt (ug/L)	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
Copper (ug/L)	84.60 B	11.90 B	76.10 B	33.70 B	30.60 B	89.20 B	65.10 B	58.40 B
Cyanide (ug/L)	.00 Q	.00 Q	.00 Q	.00 Q	.00 Q	.00 Q	.00 Q	.00 Q
Iron (ug/L)	212.00 B	120.00 B	142.00 B	204.00 B	138.00 B	96.20 B	247.00 B	104.00 B
Lead (ug/L)	4.70 B	8.20 B	11.40	9.70	22.90	11.40	9.50 B	12.40
Magnesium (ug/L)	1,020.00	1,650.00	1,690.00	2,990.00	2,990.00	841.00	952.00	1,470.00
Manganese (ug/L)	11.10 B	135.00	155.00	299.00	260.00	10.20 B	2.00 U	66.30
Mercury (ug/L)	.20 U	.20 U	.20 U	.20 U	.20 U	.20 U	.20 U	.20 U
Nickel (ug/L)	71.10 B	11.30 B	31.60 B	21.90 B	13.00 B	38.40 B	18.20 B	29.40 B
Potassium (ug/L)	1,090.00	1,360.00	2,890.00	6,350.00	6,170.00	1,320.00	1,180.00	2,510.00
Selenium (ug/L)	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U	3.00 U
Silver (ug/L)	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
Sodium (ug/L)	1,570.00	1,900.00	3,430.00	6,610.00	6,440.00	1,290.00	1,660.00	2,890.00
Thallium (ug/L)	4.00 R	4.00 R	4.00 R	4.00 R	4.00 R	4.00 R	4.00 R	4.00 R
Vanadium (ug/L)	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
Zinc (ug/L)	249.00 B	425.00 B	182.00 B	545.00 B	604.00 B	107.00 B	193.00 B	281.00 B

Summary of Chemicals Detected in Surface Water - Round 2
in the Vicinity of Dixie Caverns
--- Volatile ---

Chemical	SF-1-02 CBM58	SG-1-02 CBM59	SP-1-02 CEJ01	SP-2-01 CEJ02	FB CBM60 (Field Blank)	TRIPBLANK CEJ03 (Trip Blank)	TB-2-02 CBM63 (Trip Blank)	TB-1-02 CBM61 (Trip Blank)
1,1,1-Trichloroethane (ug/L)	5.00 U	5.00 U	10.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
1,1,2,2-Tetrachloroethane (ug/L)	5.00 U	5.00 UJ	5.00 U	5.00 U	5.00 UJ	5.00 U	5.00 U	5.00 U
1,1,2-Trichloroethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
1,1-Dichloroethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
1,1-Dichloroethene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
1,2-Dichloroethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
1,2-Dichloropropane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
2-Butanone (ug/L)	10.00 U	10.00 U	5.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Hexanone (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
4-Methyl-2-pentanone (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Acetone (ug/L)	7.00 B	10.00 U	9.00 B	10.00 B	4.00 B	5.00 J	10.00 U	9.00 U
Benzene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Bromodichloromethane (ug/L)	5.00 U	5.00 UJ	10.00 U	5.00 U	5.00 UJ	1.00 J	5.00 U	5.00 U
Bromoform (ug/L)	5.00 U	5.00 UJ	5.00 U	5.00 U	5.00 UJ	5.00 U	5.00 U	5.00 U
Bromomethane (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Carbon Disulfide (ug/L)	5.00 U	5.00 UJ	5.00 U	5.00 U	5.00 UJ	5.00 U	5.00 U	5.00 U
Carbon Tetrachloride (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Chlorobenzene (ug/L)	5.00 U	5.00 U	5.00 U	.50 J	5.00 U	5.00 U	5.00 U	5.00 U
Chloroethane (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 UJ	10.00 U	10.00 U	10.00 U
Chloroform (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	3.00 J	5.00	4.00 U	4.00 U
Chloromethane (ug/L)	10.00 U	10.00 UJ	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Cis-1,3-Dichloropropane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Dibromochloromethane (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	.50 J	5.00 U	5.00 U
Ethylbenzene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Methylene Chloride (ug/L)	4.00 B	4.00 B	1.00 B	.50 B	5.00 B	5.00 B	4.00 U	4.00 U
Styrene (ug/L)	5.00 U	5.00 UJ	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Tetrachloroethene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Toluene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Total 1,2-Dichloroethene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Total xylenes (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Trans-1,3-Dichloropropene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Trichloroethene (ug/L)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
Vinyl Acetate (ug/L)	10.00 U	10.00 U	5.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Vinyl Chloride (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U

Summary of Chemicals Detected in Surface Water - Round 2
in the Vicinity of Dixie Caverns
--- Semi-Volatile ---

Chemical	SF-1-02 CBM58	SG-1-02 CBM59	SP-1-02 CEJ01	SP-2-01 CEJ02	FB CBM60 (Field Blank)
1,2,4-Trichlorobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
1,2-Dichlorobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
1,3-Dichlorobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
1,4-Dichlorobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2,4,5-Trichlorophenol (ug/L)	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U
2,4,6-Trichlorophenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2,4-Dichlorophenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2,4-Dimethylphenol (ug/L)	10.00 U	10.00 U	10.00 UJ	10.00 UJ	10.00 U
2,4-Dinitrophenol (ug/L)	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U
2,4-Dinitrotoluene (ug/L)	10.00 U	10.00 UJ	10.00 U	10.00 U	10.00 UJ
2,6-Dinitrotoluene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Chloronaphthalene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Chlorophenol (ug/L)	10.00 U	10.00 U	10.00 UJ	10.00 UJ	10.00 U
2-Methylnaphthalene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Methylphenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
2-Nitroaniline (ug/L)	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U
2-Nitrophenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
3,3'-Dichlorobenzidine (ug/L)	20.00 U	20.00 UJ	20.00 UJ	20.00 UJ	20.00 UJ
3-Nitroaniline (ug/L)	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U
4,6-Dinitro-2-methylphenol (ug/L)	50.00 U	50.00 UJ	50.00 U	50.00 U	50.00 UJ
4-Bromophenyl-phenylether (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
4-Chloro-3-methylphenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
4-Chloroaniline (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
4-Chlorophenyl-phenylether (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
4-Methylphenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
4-Nitroaniline (ug/L)	50.00 U	50.00 UJ	50.00 U	50.00 U	50.00 UJ
4-Nitrophenol (ug/L)	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U
Acenaphthene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Acenaphthylene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Anthracene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzo(a)anthracene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzo(a)pyrene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzo(b)fluoranthene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzo(g,h,i)perylene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzo(k)fluoranthene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Benzoic Acid (ug/L)	50.00 U	50.00 U	50.00 U	2.00 J	50.00 U
Benzyl alcohol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U

Summary of Chemicals Detected in Surface Water - Round 2
in the Vicinity of Dixie Caverns
--- Semi-Volatile ---

Chemical	SF-1-02 CBM58	SG-1-02 CBM59	SP-1-02 CEJ01	SP-2-01 CEJ02	FB CBM60 (Field Blank)
Butylbenzylphthalate (ug/L)	10.00 U	10.00 UJ	10.00 U	10.00 U	10.00 UJ
Chrysene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Di-n-butylphthalate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Di-n-octylphthalate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Dibenzo(a,h)anthracene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Dibenzofuran (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Diethylphthalate (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Dimethylphthalate (ug/L)	10.00 U	10.00 UJ	10.00 U	10.00 U	10.00 UJ
Fluoranthene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Fluorene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Hexachlorobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Hexachlorobutadiene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Hexachlorocyclopentadiene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Hexachloroethane (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Indeno(1,2,3-cd)pyrene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Isophorone (ug/L)	10.00 U	10.00 UJ	10.00 U	10.00 U	10.00 UJ
N-Nitro-di-n-propylamine (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
N-Nitrosodiphenylamine (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Naphthalene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Nitrobenzene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Pentachlorophenol (ug/L)	50.00 U	50.00 U	50.00 U	50.00 U	50.00 U
Phenanthrene (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Phenol (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Pyrene (ug/L)	10.00 U	10.00 UJ	10.00 U	10.00 U	10.00 U
bis(2-Chloroethoxy)methane (ug/L)	10.00 U	10.00 U	10.00 UJ	10.00 UJ	10.00 U
bis(2-Chloroethyl)ether (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
bis(2-Chloroisopropyl)ether (ug/L)	10.00 U	10.00 UJ	10.00 UJ	10.00 UJ	10.00 U
bis(2-Ethylhexyl)phthalate (ug/L)	10.00 UJ	10.00 UJ	10.00 U	4.00 J	10.00 U

Summary of Chemicals Detected in Surface Water - Round 2
in the Vicinity of Dixie Caverns
--- Pesticides and PCBs ---

Chemical	SF-1-02 CBM58	SG-1-02 CBM59	SP-1-02 CEJ01	SP-2-01 CEJ02	FB CBM60 (Field Blank)
4,4'-DDD (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U
4,4'-DDE (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U
4,4'-DDT (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U
Aldrin (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U
Aroclor-1016 (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U
Aroclor-1221 (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U
Aroclor-1232 (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U
Aroclor-1242 (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U
Aroclor-1248 (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U
Aroclor-1254 (ug/L)	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Aroclor-1260 (ug/L)	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Dieldrin (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U
Endosulfan I (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U
Endosulfan II (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U
Endosulfan Sulfate (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U
Endrin (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U
Endrin Ketone (ug/L)	.10 U	.10 U	.10 U	.10 U	.10 U
Heptachlor (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U
Heptachlor Epoxide (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U
Methoxychlor (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U
Toxaphene (ug/L)	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
alpha-BHC (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U
alpha-Chlordane (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U
beta-BHC (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U
delta-BHC (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U
gamma-BHC (Lindane) (ug/L)	.05 U	.05 U	.05 U	.05 U	.05 U
gamma-Chlordane (ug/L)	.50 U	.50 U	.50 U	.50 U	.50 U

Summary of Chemicals Detected in Surface Water - Round 2
in the Vicinity of Dixie Caverns
--- Total Metals and Cyanide ---

Chemical	SF-1-02 MCCZ42	SG-1-02 MCCZ44	SP-1-02 MCEL19	SP-2-01 MCEL20	FIELDBLANK MCCZ46 (Field Blank)	EQR MCCZ48 (Rinsate)
Aluminum (ug/L)	154.00 B	174.00 B	30.80 B	537.00	20.10 B	28.70 B
Antimony (ug/L)	22.00 U	22.20	15.00 U	15.00 U	22.00 U	22.00 U
Arsenic (ug/L)	2.00 U	2.00 U	3.00 U	3.90	2.00 U	2.00 U
Barium (ug/L)	26.00	12.50 B	411.00	518.00	1.00 U	1.00 U
Beryllium (ug/L)	1.00 U	1.00 U	2.00 U	2.00 U	1.00 U	1.00 U
Cadmium (ug/L)	3.00 U	3.00 U	2.00 U	2.00 U	3.00 U	3.00 U
Calcium (ug/L)	16,200.00	5,090.00	60,800.00	63,400.00	73.30 B	72.70 B
Chromium (ug/L)	3.00 U	3.00 U	2.00 U	2.00 U	3.00 U	3.00 U
Cobalt (ug/L)	3.00 U	3.00 U	2.00 U	2.00 U	3.00 U	3.00 U
Copper (ug/L)	10.20 B	4.90 B	6.40 B	6.00 B	30.80 B	5.20 B
Cyanide (ug/L)	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U	10.00 U
Iron (ug/L)	444.00	270.00	277.00	4,120.00	20.20 B	20.20 B
Lead (ug/L)	5.50 B	1.50 B	7.90 K	5.00 K	1.00 U	1.00 B
Magnesium (ug/L)	5,570.00	1,510.00	45,500.00	46,700.00	22.00 U	22.00 U
Manganese (ug/L)	5.30 B	6.20 B	79.80	498.00	1.00 U	1.00 U
Mercury (ug/L)	.20 U	.20 U	.20 U	.20 U	.20 U	.20 U
Nickel (ug/L)	22.40 B	18.90 B	8.90	8.00 U	17.10 B	18.50 B
Potassium (ug/L)	1,730.00	1,150.00	50,500.00	51,500.00	290.00 U	290.00 U
Selenium (ug/L)	2.00 U	2.00 U	3.00 UL	3.00 UL	2.00 U	2.00 U
Silver (ug/L)	4.00 U	4.00 U	2.00 U	2.00 U	4.00 U	4.00 U
Sodium (ug/L)	2,700.00	1,280.00	61,500.00	62,600.00	110.00 B	36.10 B
Thallium (ug/L)	2.00 U	2.00 U	4.00 U	4.00 U	2.00 U	2.00 U
Vanadium (ug/L)	3.00 U	3.00 U	2.00 U	2.00 U	3.00 U	3.00 U
Zinc (ug/L)	102.00 B	18.40 B	37.70 J	30.00 J	36.80 B	134.00

ORIGINAL (Red)

Summary of Chemicals Detected in Surface Water - Round 2
in the Vicinity of Dixie Caverns
--- Dissolved Metals ---

Chemical	SF-1-02 MCCZ43	SG-1-02 MCCZ45	SP-1-02 MCFA38	SP-2-02 MCFA39	EQR MCCZ49 (Rinsate)	FIELDBLANK MCCZ47 (Field Blank)
Aluminum (ug/L)	25.90 B	12.00 U	21.40 B	20.20 B	18.70 B	18.70 B
Antimony (ug/L)	15.00 U	15.00 U	15.80 B	17.20 B	15.00 U	15.00 U
Arsenic (ug/L)	2.70 B	2.00 U	3.00 U	3.00 U	2.00 U	2.00 U
Barium (ug/L)	25.70	10.20 B	403.00	470.00	1.00 U	1.00 U
Beryllium (ug/L)	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
Cadmium (ug/L)	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
Calcium (ug/L)	16,300.00	4,920.00	60,900.00	62,600.00	65.40 B	62.00 B
Chromium (ug/L)	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
Cobalt (ug/L)	2.00 U	2.00 U	5.20 B	5.90 B	2.00 U	2.00 U
Copper (ug/L)	73.40 B	47.60 B	8.50 B	9.80 B	42.70 B	103.00 B
Cyanide (ug/L)	.00 Q	.00 Q	.00 Q	.00 Q	.00 Q	.00 Q
Iron (ug/L)	73.50 B	72.10 B	82.10 B	60.50 B	53.60 B	39.30 B
Lead (ug/L)	9.00 B	1.00 U	3.00 U	3.00 B	1.70 B	1.00 B
Magnesium (ug/L)	5,620.00	1,430.00	45,300.00	46,500.00	17.00 U	17.00 U
Manganese (ug/L)	5.60 B	5.60 B	75.90	355.00	2.00 U	2.00 U
Mercury (ug/L)	.20 U	.20 U	.20 U	.20 U	.20 U	.20 U
Nickel (ug/L)	19.20 B	20.60 B	14.80	14.50	16.80 B	18.20 B
Potassium (ug/L)	1,740.00	1,020.00	50,100.00	51,700.00	266.00 U	266.00 U
Selenium (ug/L)	3.00 U	3.00 U	2.00 U	2.00 U	3.00 U	3.00 U
Silver (ug/L)	2.00 U	2.00 U	2.00	2.00 U	2.00 U	2.00 U
Sodium (ug/L)	2,890.00	1,330.00	62,400.00	63,900.00	82.00 B	47.40 B
Thallium (ug/L)	4.00 R	4.00 R	4.00 UL	4.00 UL	4.00 R	4.00 U
Vanadium (ug/L)	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
Zinc (ug/L)	243.00 B	86.10 B	33.20	35.80	59.20 B	164.00

Summary of Chemicals Detected in Surface Water - Round 2
in the Vicinity of Dixie Caverns
--- Volatile ---

Chemical	EQR CBM62 (Rinsate)
1,1,1-Trichloroethane (ug/L)	5.00 U
1,1,2,2-Tetrachloroethane (ug/L)	5.00 UJ
1,1,2-Trichloroethane (ug/L)	5.00 U
1,1-Dichloroethane (ug/L)	5.00 U
1,1-Dichloroethene (ug/L)	5.00 U
1,2-Dichloroethane (ug/L)	5.00 U
1,2-Dichloropropane (ug/L)	5.00 U
2-Butanone (ug/L)	10.00 U
2-Hexanone (ug/L)	10.00 U
4-Methyl-2-pentanone (ug/L)	10.00 U
Acetone (ug/L)	10.00 U
Benzene (ug/L)	5.00 U
Bromodichloromethane (ug/L)	5.00 UJ
Bromoform (ug/L)	5.00 UJ
Bromomethane (ug/L)	10.00 U
Carbon Disulfide (ug/L)	2.00 J
Carbon Tetrachloride (ug/L)	5.00 U
Chlorobenzene (ug/L)	5.00 U
Chloroethane (ug/L)	10.00 U
Chloroform (ug/L)	3.00 J
Chloromethane (ug/L)	10.00 UJ
Cis-1,3-Dichloropropane (ug/L)	5.00 U
Dibromochloromethane (ug/L)	5.00 U
Ethylbenzene (ug/L)	5.00 U
Methylene Chloride (ug/L)	3.00 B
Styrene (ug/L)	5.00 U
Tetrachloroethene (ug/L)	5.00 U
Toluene (ug/L)	5.00 U
Total 1,2-Dichloroethene (ug/L)	5.00 U
Total xylenes (ug/L)	5.00 U
Trans-1,3-Dichloropropene (ug/L)	5.00 U
Trichloroethene (ug/L)	5.00 U
Vinyl Acetate (ug/L)	10.00 U
Vinyl Chloride (ug/L)	10.00 U

Summary of Chemicals Detected in Surface Water - Round 2
in the Vicinity of Dixie Caverns
--- Semi-Volatile ---

Chemical	EQR CBM62 (Rinsate)
1,2,4-Trichlorobenzene (ug/L)	10.00 U
1,2-Dichlorobenzene (ug/L)	10.00 U
1,3-Dichlorobenzene (ug/L)	10.00 U
1,4-Dichlorobenzene (ug/L)	10.00 U
2,4,5-Trichlorophenol (ug/L)	50.00 U
2,4,6-Trichlorophenol (ug/L)	10.00 U
2,4-Dichlorophenol (ug/L)	10.00 U
2,4-Dimethylphenol (ug/L)	10.00 U
2,4-Dinitrophenol (ug/L)	50.00 U
2,4-Dinitrotoluene (ug/L)	10.00 U
2,6-Dinitrotoluene (ug/L)	10.00 U
2-Chloronaphthalene (ug/L)	10.00 U
2-Chlorophenol (ug/L)	10.00 U
2-Methylnaphthalene (ug/L)	10.00 U
2-Methylphenol (ug/L)	10.00 U
2-Nitroaniline (ug/L)	50.00 UJ
2-Nitrophenol (ug/L)	10.00 U
3,3'-Dichlorobenzidine (ug/L)	20.00 U
3-Nitroaniline (ug/L)	50.00 U
4,6-Dinitro-2-methylphenol (ug/L)	50.00 U
4-Bromophenyl-phenylether (ug/L)	10.00 U
4-Chloro-3-methylphenol (ug/L)	10.00 U
4-Chloroaniline (ug/L)	10.00 U
4-Chlorophenyl-phenylether (ug/L)	10.00 U
4-Methylphenol (ug/L)	10.00 U
4-Nitroaniline (ug/L)	50.00 UJ
4-Nitrophenol (ug/L)	50.00 U
Acenaphthene (ug/L)	10.00 U
Acenaphthylene (ug/L)	10.00 U
Anthracene (ug/L)	10.00 U
Benzo(a)anthracene (ug/L)	10.00 U
Benzo(a)pyrene (ug/L)	10.00 U
Benzo(b)fluoranthene (ug/L)	10.00 U
Benzo(g,h,i)perylene (ug/L)	10.00 U
Benzo(k)fluoranthene (ug/L)	10.00 U
Benzoic Acid (ug/L)	50.00 U
Benzyl alcohol (ug/L)	10.00 U

Summary of Chemicals Detected in Surface Water - Round 2
in the Vicinity of Dixie Caverns
--- Semi-Volatile ---

Chemical	EQR CBM62 (Rinsate)
Butylbenzylphthalate (ug/L)	10.00 UJ
Chrysene (ug/L)	10.00 U
Di-n-butylphthalate (ug/L)	10.00 U
Di-n-octylphthalate (ug/L)	10.00 U
Dibenzo(a,h)anthracene (ug/L)	10.00 U
Dibenzofuran (ug/L)	10.00 U
Diethylphthalate (ug/L)	10.00 U
Dimethylphthalate (ug/L)	10.00 U
Fluoranthene (ug/L)	10.00 U
Fluorene (ug/L)	10.00 U
Hexachlorobenzene (ug/L)	10.00 U
Hexachlorobutadiene (ug/L)	10.00 U
Hexachlorocyclopentadiene (ug/L)	10.00 U
Hexachloroethane (ug/L)	10.00 U
Indeno(1,2,3-cd)pyrene (ug/L)	10.00 U
Isophorone (ug/L)	10.00 UJ
N-Nitro-di-n-propylamine (ug/L)	10.00 UJ
N-Nitrosodiphenylamine (ug/L)	10.00 U
Naphthalene (ug/L)	10.00 U
Nitrobenzene (ug/L)	10.00 U
Pentachlorophenol (ug/L)	50.00 U
Phenanthrene (ug/L)	10.00 U
Phenol (ug/L)	10.00 U
Pyrene (ug/L)	10.00 U
bis(2-Chloroethoxy)methane (ug/L)	10.00 U
bis(2-Chloroethyl)ether (ug/L)	10.00 U
bis(2-Chloroisopropyl)ether (ug/L)	10.00 U
bis(2-Ethylhexyl)phthalate (ug/L)	10.00 U

Summary of Chemicals Detected in Surface Water - Round 2
in the Vicinity of Dixie Caverns
--- Pesticides and PCBs ---

Chemical	EQR CBM62 (Rinsate)
4,4'-DDD (ug/L)	.10 U
4,4'-DDE (ug/L)	.10 U
4,4'-DDT (ug/L)	.10 U
Aldrin (ug/L)	.05 U
Aroclor-1016 (ug/L)	.50 U
Aroclor-1221 (ug/L)	.50 U
Aroclor-1232 (ug/L)	.50 U
Aroclor-1242 (ug/L)	.50 U
Aroclor-1248 (ug/L)	.50 U
Aroclor-1254 (ug/L)	1.00 U
Aroclor-1260 (ug/L)	1.00 U
Dieldrin (ug/L)	.10 U
Endosulfan I (ug/L)	.05 U
Endosulfan II (ug/L)	.10 U
Endosulfan Sulfate (ug/L)	.10 U
Endrin (ug/L)	.10 U
Endrin Ketone (ug/L)	.10 U
Heptachlor (ug/L)	.05 U
Heptachlor Epoxide (ug/L)	.05 U
Methoxychlor (ug/L)	.50 U
Toxaphene (ug/L)	1.00 U
alpha-BHC (ug/L)	.05 U
alpha-Chlordane (ug/L)	.50 U
beta-BHC (ug/L)	.05 U
delta-BHC (ug/L)	.05 U
gamma-BHC (Lindane) (ug/L)	.05 U
gamma-Chlordane (ug/L)	.50 U

Summary of Chemicals Detected in Sediment in the Vicinity
of Dixie Caverns
--- Volatile ---

Chemical	OS-1 CEC11	OS-2 CEC12	SA-1 CEC02	SA-2 CEC03	SA-3 CEC04	SA-4 CEC05	SA-5 CEC06	SA-5 CEC07
1,1,1-Trichloroethane (ug/Kg)	6.00 U	6.00 U	6.00 U	7.00 U	6.00 UJ	7.00 UJ	6.00 U	7.00 U
1,1,2,2-Tetrachloroethane (ug/Kg)	6.00 U	6.00 U	6.00 U	7.00 U	6.00 U	7.00 U	6.00 U	7.00 U
1,1,2-Trichloroethane (ug/Kg)	6.00 U	6.00 U	6.00 U	7.00 U	6.00 U	7.00 U	6.00 U	7.00 U
1,1-Dichloroethane (ug/Kg)	6.00 U	6.00 U	6.00 U	7.00 U	6.00 U	7.00 U	6.00 U	7.00 U
1,1-Dichloroethene (ug/Kg)	6.00 U	6.00 U	6.00 U	7.00 U	6.00 U	7.00 U	6.00 U	7.00 U
1,2-Dichloroethane (ug/Kg)	6.00 U	6.00 U	6.00 UJ	7.00 UJ	6.00 U	7.00 U	6.00 U	7.00 U
1,2-Dichloropropane (ug/Kg)	6.00 U	6.00 U	6.00 U	7.00 U	6.00 U	7.00 U	6.00 U	7.00 U
2-Butanone (ug/Kg)	12.00 R	12.00 R	12.00 U	14.00 U	13.00 R	14.00 R	11.00 R	13.00 R
2-Hexanone (ug/Kg)	12.00 UJ	12.00 U	12.00 U	14.00 U	13.00 U	14.00 U	11.00 U	13.00 U
4-Methyl-2-pentanone (ug/Kg)	12.00 U	12.00 UJ	12.00 U	14.00 U	13.00 U	14.00 U	11.00 U	13.00 UJ
Acetone (ug/Kg)	12.00 UJ	12.00 U	12.00 U	14.00 U	13.00 UJ	14.00 UJ	11.00 UJ	13.00 U
Benzene (ug/Kg)	6.00 UL	6.00 UL	6.00 UL	7.00 UL	6.00 UL	7.00 UL	6.00 UL	7.00 UL
Bromodichloromethane (ug/Kg)	6.00 U	6.00 U	6.00 U	7.00 U	6.00 U	7.00 U	6.00 U	7.00 U
Bromoform (ug/Kg)	6.00 U	6.00 U	6.00 U	7.00 U	6.00 U	7.00 U	6.00 U	7.00 U
Bromomethane (ug/Kg)	12.00 UJ	12.00 U	12.00 U	14.00 U	13.00 UJ	14.00 UJ	11.00 UJ	13.00 U
Carbon Disulfide (ug/Kg)	6.00 UJ	6.00 UJ	6.00 U	7.00 U	6.00 UJ	7.00 UJ	6.00 UJ	7.00 UJ
Carbon Tetrachloride (ug/Kg)	6.00 U	6.00 U	6.00 UJ	7.00 UJ	6.00 U	7.00 U	6.00 U	7.00 U
Chlorobenzene (ug/Kg)	6.00 UL	6.00 UL	6.00 UL	7.00 UL	6.00 UL	7.00 UL	6.00 UL	7.00 UL
Chloroethane (ug/Kg)	12.00 U	12.00 U	12.00 U	14.00 U	13.00 U	14.00 U	11.00 U	13.00 U
Chloroform (ug/Kg)	6.00 U	6.00 U	6.00 U	7.00 U	6.00 U	7.00 U	6.00 U	7.00 U
Chloromethane (ug/Kg)	12.00 U	12.00 U	12.00 U	14.00 U	13.00 U	14.00 U	11.00 U	13.00 U
Cis-1,3-Dichloropropane (ug/Kg)	6.00 U	6.00 U	6.00 U	7.00 U	6.00 UJ	7.00 UJ	6.00 UJ	7.00 U
Dibromochloromethane (ug/Kg)	6.00 U	6.00 U	6.00 U	7.00 U	6.00 U	7.00 U	6.00 U	7.00 U
Ethylbenzene (ug/Kg)	6.00 UL	6.00 UL	6.00 UL	7.00 UL	6.00 UL	7.00 UL	6.00 UL	7.00 UL
Methylene Chloride (ug/Kg)	6.00 U	6.00 U	2.00 B	7.00 U	6.00 U	7.00 U	6.00 U	7.00 U
Styrene (ug/Kg)	6.00 UL	6.00 UL	6.00 UL	7.00 UL	6.00 UL	7.00 UL	6.00 UL	7.00 UL
Tetrachloroethene (ug/Kg)	6.00 U	6.00 U	6.00 UJ	7.00 UJ	6.00 U	7.00 U	6.00 U	7.00 U
Toluene (ug/Kg)	6.00 UL	6.00 UL	6.00 UL	7.00 UL	6.00 UL	7.00 UL	6.00 UL	7.00 UL
Total 1,2-Dichloroethene (ug/Kg)	6.00 U	6.00 U	6.00 U	7.00 U	6.00 U	7.00 U	6.00 U	7.00 U
Total xylenes (ug/Kg)	6.00 UL	6.00 UL	6.00 UL	7.00 UL	6.00 UL	7.00 UL	6.00 UL	7.00 UL
Trans-1,3-Dichloropropene (ug/Kg)	6.00 UJ	6.00 UJ	6.00 UJ	7.00 UJ	6.00 UJ	7.00 UJ	6.00 UJ	7.00 UJ
Trichloroethene (ug/Kg)	6.00 U	6.00 U	6.00 U	7.00 U	6.00 U	7.00 U	6.00 U	7.00 U
Vinyl Acetate (ug/Kg)	12.00 U	12.00 U	12.00 U	14.00 U	13.00 UJ	14.00 UJ	11.00 UJ	13.00 U
Vinyl Chloride (ug/Kg)	12.00 U	12.00 U	12.00 U	14.00 U	13.00 U	14.00 U	11.00 U	13.00 U

Summary of Chemicals Detected in Sediment in the Vicinity
of Dixie Caverns
--- Volatile ---

Chemical	TRIPBLANK CEC85 (Trip Blank)	TRIPBLANK CED98 (Trip Blank)
1,1,1-Trichloroethane (ug/Kg)	5.00 U	5.00 U
1,1,2,2-Tetrachloroethane (ug/Kg)	5.00 U	5.00 U
1,1,2-Trichloroethane (ug/Kg)	5.00 U	5.00 U
1,1-Dichloroethane (ug/Kg)	5.00 U	5.00 U
1,1-Dichloroethene (ug/Kg)	5.00 U	5.00 U
1,2-Dichloroethane (ug/Kg)	5.00 U	5.00 U
1,2-Dichloropropane (ug/Kg)	5.00 U	5.00 U
2-Butanone (ug/Kg)	10.00 U	10.00 R
2-Hexanone (ug/Kg)	10.00 U	10.00 U
4-Methyl-2-pentanone (ug/Kg)	10.00 U	10.00 U
Acetone (ug/Kg)	10.00 UJ	15.00
Benzene (ug/Kg)	5.00 U	5.00 U
Bromodichloromethane (ug/Kg)	5.00 U	5.00 U
Bromoform (ug/Kg)	5.00 U	5.00 UJ
Bromomethane (ug/Kg)	10.00 U	10.00 U
Carbon Disulfide (ug/Kg)	5.00 U	5.00 U
Carbon Tetrachloride (ug/Kg)	5.00 UJ	5.00 UJ
Chlorobenzene (ug/Kg)	5.00 U	5.00 U
Chloroethane (ug/Kg)	10.00 U	10.00 U
Chloroform (ug/Kg)	4.00 J	3.00 J
Chloromethane (ug/Kg)	10.00 U	10.00 U
Cis-1,3-Dichloropropane (ug/Kg)	5.00 U	5.00 U
Dibromochloromethane (ug/Kg)	5.00 U	5.00 UJ
Ethylbenzene (ug/Kg)	5.00 U	5.00 U
Methylene Chloride (ug/Kg)	6.00 U	4.00 J
Styrene (ug/Kg)	5.00 U	5.00 U
Tetrachloroethene (ug/Kg)	5.00 U	5.00 U
Toluene (ug/Kg)	.50 J	5.00 U
Total 1,2-Dichloroethene (ug/Kg)	5.00 U	5.00 U
Total xylenes (ug/Kg)	5.00 U	5.00 U
Trans-1,3-Dichloropropene (ug/Kg)	5.00 U	5.00 U
Trichloroethene (ug/Kg)	.60 J	5.00 U
Vinyl Acetate (ug/Kg)	10.00 U	10.00 U
Vinyl Chloride (ug/Kg)	10.00 U	10.00 U

Summary of Chemicals Detected in Sediment in the Vicinity
of Dixie Caverns
--- Semi-Volatile ---

Chemical	OS-1 CEC11	OS-2 CEC12	SA-1 CEC02	SA-2 CEC03	SA-3 CEC04	SA-4 CEC05	SA-5 CEC06	SA-5 CEC07
1,2,4-Trichlorobenzene (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
1,2-Dichlorobenzene (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
1,3-Dichlorobenzene (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
1,4-Dichlorobenzene (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
2,4,5-Trichlorophenol (ug/Kg)	1,800.00 UJ	1,800.00 UJ	1,800.00 UJ	1,800.00 UJ	1,700.00 UJ	1,700.00 UJ	2,100.00 UJ	1,800.00 UJ
2,4,6-Trichlorophenol (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
2,4-Dichlorophenol (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
2,4-Dimethylphenol (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
2,4-Dinitrophenol (ug/Kg)	1,800.00 UJ	1,800.00 UJ	1,800.00 UJ	1,800.00 UJ	1,700.00 UJ	1,700.00 UJ	2,100.00 UJ	1,800.00 UJ
2,4-Dinitrotoluene (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
2,6-Dinitrotoluene (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
2-Chloronaphthalene (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
2-Chlorophenol (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
2-Methylnaphthalene (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
2-Methylphenol (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
2-Nitroaniline (ug/Kg)	1,800.00 UJ	1,800.00 UJ	1,800.00 UJ	1,800.00 UJ	1,700.00 UJ	1,700.00 UJ	2,100.00 UJ	1,800.00 UJ
2-Nitrophenol (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
3,3'-Dichlorobenzidine (ug/Kg)	760.00 UJ	730.00 UJ	730.00 UJ	730.00 UJ	690.00 UJ	690.00 UJ	860.00 UJ	730.00 UJ
3-Nitroaniline (ug/Kg)	1,800.00 UJ	1,800.00 UJ	1,800.00 UJ	1,800.00 UJ	1,700.00 UJ	1,700.00 UJ	2,100.00 UJ	1,800.00 UJ
4,6-Dinitro-2-methylphenol (ug/Kg)	1,800.00 UJ	1,800.00 UJ	1,800.00 UJ	1,800.00 UJ	1,700.00 UJ	1,700.00 UJ	2,100.00 UJ	1,800.00 UJ
4-Bromophenyl-phenylether (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
4-Chloro-3-methylphenol (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
4-Chloroaniline (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
4-Chlorophenyl-phenylether (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
4-Methylphenol (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
4-Nitroaniline (ug/Kg)	1,800.00 UJ	1,800.00 UJ	1,800.00 UJ	1,800.00 UJ	1,700.00 UJ	1,700.00 UJ	2,100.00 UJ	1,800.00 UJ
4-Nitrophenol (ug/Kg)	1,800.00 UJ	1,800.00 UJ	1,800.00 UJ	1,800.00 UJ	1,700.00 UJ	1,700.00 UJ	2,100.00 UJ	1,800.00 UJ
Acenaphthene (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
Acenaphthylene (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
Anthracene (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
Benzo(a)anthracene (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
Benzo(a)pyrene (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
Benzo(b)fluoranthene (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
Benzo(g,h,i)perylene (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
Benzo(k)fluoranthene (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ

Summary of Chemicals Detected in Sediment in the Vicinity
of Dixie Caverns
--- Semi-Volatile ---

Chemical	OS-1 CEC11	OS-2 CEC12	SA-1 CEC02	SA-2 CEC03	SA-3 CEC04	SA-4 CEC05	SA-5 CEC06	SA-5 CEC07
Benzoic Acid (ug/Kg)	1,800.00 UJ	1,800.00 UJ	1,800.00 UJ	1,800.00 UJ	1,700.00 UJ	1,700.00 UJ	2,100.00 UJ	1,800.00 UJ
Benzyl alcohol (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
Butylbenzylphthalate (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
Chrysene (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
Di-n-butylphthalate (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
Di-n-octylphthalate (ug/Kg)	63.00 J	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	220.00 J	430.00 UJ	370.00 UJ
Dibenzo(a,h)anthracene (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
Dibenzofuran (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
Diethylphthalate (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
Dimethylphthalate (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
Fluoranthene (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
Fluorene (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
Hexachlorobenzene (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
Hexachlorobutadiene (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
Hexachlorocyclopentadiene (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
Hexachloroethane (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
Indeno(1,2,3-cd)pyrene (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
Isophorone (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
N-Nitro-di-n-propylamine (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
N-Nitrosodiphenylamine (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
Naphthalene (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
Nitrobenzene (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
Pentachlorophenol (ug/Kg)	1,800.00 UJ	1,800.00 UJ	1,800.00 UJ	1,800.00 UJ	1,700.00 UJ	1,700.00 UJ	2,100.00 UJ	1,800.00 UJ
Phenanthrene (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
Phenol (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
Pyrene (ug/Kg)	49.00 J	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
bis(2-Chloroethoxy)methane (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
bis(2-Chloroethyl)ether (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
bis(2-Chloroisopropyl)ether (ug/Kg)	380.00 UJ	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	350.00 UJ	430.00 UJ	370.00 UJ
bis(2-Ethylhexyl)phthalate (ug/Kg)	190.00 J	370.00 UJ	360.00 UJ	360.00 UJ	350.00 UJ	1,300.00 J	400.00 J	1,900.00 J

Summary of Chemicals Detected in Sediment in the Vicinity
of Dixie Caverns
--- Pesticides and PCBs ---

Chemical	OS-1 CEC11	OS-2 CEC12	SA-1 CEC02	SA-2 CEC03	SA-3 CEC04	SA-4 CEC05	SA-5 CEC06	SA-5 CEC07
4,4'-DDD (ug/Kg)	18.00 UJ	18.00 UJ	17.00 UJ	23.00 UJ	17.00 UJ	26.00 UJ	21.00 UJ	18.00 UJ
4,4'-DDE (ug/Kg)	18.00 UJ	18.00 UJ	17.00 UJ	23.00 UJ	17.00 UJ	26.00 UJ	21.00 UJ	18.00 UJ
4,4'-DDT (ug/Kg)	18.00 UJ	18.00 UJ	17.00 UJ	23.00 UJ	17.00 UJ	26.00 UJ	21.00 UJ	18.00 UJ
Aldrin (ug/Kg)	9.20 UJ	8.80 UJ	8.70 UJ	11.00 UJ	8.30 UJ	13.00 UJ	10.00 UJ	8.90 UJ
Aroclor-1016 (ug/Kg)	92.00 UJ	88.00 UJ	87.00 UJ	110.00 UJ	83.00 UJ	130.00 UJ	100.00 UJ	89.00 UJ
Aroclor-1221 (ug/Kg)	92.00 UJ	88.00 UJ	87.00 UJ	110.00 UJ	83.00 UJ	130.00 UJ	100.00 UJ	89.00 UJ
Aroclor-1232 (ug/Kg)	92.00 UJ	88.00 UJ	87.00 UJ	110.00 UJ	83.00 UJ	130.00 UJ	100.00 UJ	89.00 UJ
Aroclor-1242 (ug/Kg)	92.00 UJ	88.00 UJ	87.00 UJ	110.00 UJ	83.00 UJ	130.00 UJ	100.00 UJ	89.00 UJ
Aroclor-1248 (ug/Kg)	92.00 UJ	88.00 UJ	87.00 UJ	110.00 UJ	83.00 UJ	130.00 UJ	100.00 UJ	89.00 UJ
Aroclor-1254 (ug/Kg)	180.00 UJ	180.00 UJ	170.00 UJ	230.00 UJ	170.00 UJ	260.00 UJ	210.00 UJ	180.00 UJ
Aroclor-1260 (ug/Kg)	180.00 UJ	180.00 UJ	170.00 UJ	230.00 UJ	170.00 UJ	260.00 UJ	210.00 UJ	180.00 UJ
Dieldrin (ug/Kg)	18.00 UJ	18.00 UJ	17.00 UJ	23.00 UJ	17.00 UJ	26.00 UJ	21.00 UJ	18.00 UJ
Endosulfan I (ug/Kg)	9.20 UJ	8.80 UJ	8.70 UJ	11.00 UJ	8.30 UJ	13.00 UJ	10.00 UJ	8.90 UJ
Endosulfan II (ug/Kg)	18.00 UJ	18.00 UJ	17.00 UJ	23.00 UJ	17.00 UJ	26.00 UJ	21.00 UJ	18.00 UJ
Endosulfan Sulfate (ug/Kg)	18.00 UJ	18.00 UJ	17.00 UJ	23.00 UJ	17.00 UJ	26.00 UJ	21.00 UJ	18.00 UJ
Endrin (ug/Kg)	18.00 UJ	18.00 UJ	17.00 UJ	23.00 UJ	17.00 UJ	26.00 UJ	21.00 UJ	18.00 UJ
Endrin Ketone (ug/Kg)	18.00 UJ	18.00 UJ	17.00 UJ	23.00 UJ	17.00 UJ	26.00 UJ	21.00 UJ	18.00 UJ
Heptachlor (ug/Kg)	9.20 UJ	8.80 UJ	8.70 UJ	11.00 UJ	8.30 UJ	13.00 UJ	10.00 UJ	8.90 UJ
Heptachlor Epoxide (ug/Kg)	9.20 UJ	8.80 UJ	8.70 UJ	11.00 UJ	8.30 UJ	13.00 UJ	10.00 UJ	8.90 UJ
Methoxychlor (ug/Kg)	92.00 UJ	88.00 UJ	87.00 UJ	110.00 UJ	83.00 UJ	130.00 UJ	100.00 UJ	89.00 UJ
Toxaphene (ug/Kg)	180.00 UJ	180.00 UJ	170.00 UJ	230.00 UJ	170.00 UJ	260.00 UJ	210.00 UJ	180.00 UJ
alpha-BHC (ug/Kg)	9.20 UJ	8.80 UJ	8.70 UJ	11.00 UJ	8.30 UJ	13.00 UJ	10.00 UJ	8.90 UJ
alpha-Chlordane (ug/Kg)	92.00 UJ	88.00 UJ	87.00 UJ	110.00 UJ	83.00 UJ	130.00 UJ	100.00 UJ	89.00 UJ
beta-BHC (ug/Kg)	9.20 UJ	8.80 UJ	8.70 UJ	11.00 UJ	8.30 UJ	13.00 UJ	10.00 UJ	8.90 UJ
delta-BHC (ug/Kg)	9.20 UJ	8.80 UJ	8.70 UJ	11.00 UJ	8.30 UJ	13.00 UJ	10.00 UJ	8.90 UJ
gamma-BHC (Lindane) (ug/Kg)	9.20 UJ	8.80 UJ	8.70 UJ	11.00 UJ	8.30 UJ	13.00 UJ	10.00 UJ	8.90 UJ
gamma-Chlordane (ug/Kg)	92.00 UJ	88.00 UJ	87.00 UJ	110.00 UJ	83.00 UJ	130.00 UJ	100.00 UJ	89.00 UJ

Summary of Chemicals Detected in Sediment in the Vicinity
of Dixie Caverns
--- Total Metals and Cyanide ---

Chemical	OS-1 MCEH11	OS-2 MCEH12	SA-1 MCEH02	SA-2 MCEH45	SA-3 MCEH04	SA-4 MCEH05	SA-5 MCEH06	SA-5 MCEH07
Aluminum (mg/Kg)	8,210.00	8,730.00	2,280.00	7,120.00	6,110.00	4,670.00	7,510.00	5,590.00
Antimony (mg/Kg)	4.90 UL	5.10 UL	4.80 UL	6.70 UL	5.00 UL	5.80 UL	5.60 UL	5.30 UL
Arsenic (mg/Kg)	4.40	6.50	4.50	15.50 L	13.30	6.10	8.90	10.40
Barium (mg/Kg)	206.00 J	127.00 J	89.80 J	141.00 J	87.80 J	93.40 J	110.00 J	75.50 J
Beryllium (mg/Kg)	.47	.62	.30	.65 B	.56	.37	.57	.46
Cadmium (mg/Kg)	.61 U	.64 U	.60 U	.67 U	.62 U	.73 U	.70 U	.66 U
Calcium (mg/Kg)	157,000.00 J	86,300.00 J	129,000.00 J	25,700.00 J	14,300.00 J	118,000.00 J	50,900.00 J	63,900.00 J
Chromium (mg/Kg)	509.00 L	176.00 L	5.10 L	14.40	11.90 L	138.00 L	50.30 L	43.40 L
Cobalt (mg/Kg)	4.20	13.40	3.90	10.20	8.20	3.80	9.00	5.60
Copper (mg/Kg)	46.70	25.10	13.30	12.30	15.10	18.80	17.80	13.90
Cyanide (mg/Kg)	1.10 U	1.20 U	1.10 U	1.10 U	1.20 U	1.30 U	1.30 U	1.10 U
Iron (mg/Kg)	32,800.00	32,700.00	8,770.00	28,100.00	25,100.00	17,800.00	24,700.00	18,800.00
Lead (mg/Kg)	35.60	25.00	4.60	16.00 L	13.60	18.90	21.20	16.10
Magnesium (mg/Kg)	52,900.00 J	48,900.00 J	63,300.00 J	15,900.00 J	6,780.00 J	54,900.00 J	26,100.00 J	31,600.00 J
Manganese (mg/Kg)	6,140.00	2,710.00	190.00	494.00	416.00	1,780.00	834.00	753.00
Mercury (mg/Kg)	.10 U	.11 U	.09 U	.10 U	.10 U	.12 U	.11 U	.10 U
Nickel (mg/Kg)	13.40	15.00	6.60	15.40	12.50	8.00	12.60	9.20
Potassium (mg/Kg)	570.00	1,030.00	554.00	1,130.00	895.00	623.00	999.00	800.00
Selenium (mg/Kg)	.62 UL	.66 UL	.65 UL	.65 UL	.69 UL	.66 UL	.71 UL	.64 UL
Silver (mg/Kg)	1.00 U	1.10 U	.99 U	1.10 UL	1.00 U	1.20 U	1.20 U	1.10 U
Sodium (mg/Kg)	210.00 B	168.00 B	122.00 B	73.20 B	43.90 B	123.00 B	89.70 B	93.10 B
Thallium (mg/Kg)	.41 U	.44 U	.44 UL	.43 U	.46 U	.44 U	.47 U	.43 U
Vanadium (mg/Kg)	77.10	35.70	7.80 J	14.00	19.70	23.30	24.20	17.50
Zinc (mg/Kg)	152.00 J	101.00 J	22.70 J	50.40	48.10 J	72.90 J	67.10 J	51.20 J

AR300487

Summary of Chemicals Detected in Sediment in the Vicinity
of Dixie Caverns
--- Volatile ---

Chemical	SB-1 CEC17	SB-2 CEC18	SB-3 CEC19	SB-4 CEC20	SB-5 CEC23	SB-6 CEC26	SB-7 CEC27	SC-1 CEC22
1,1,1-Trichloroethane (ug/Kg)	6.00 U	7.00 U	7.00 U	6.00 UJ	8.00 U	7.00 U	7.00 U	12.00 U
1,1,2,2-Tetrachloroethane (ug/Kg)	6.00 U	7.00 U	7.00 U	6.00 U	8.00 U	7.00 U	7.00 U	12.00 U
1,1,2-Trichloroethane (ug/Kg)	6.00 U	7.00 U	7.00 U	6.00 U	8.00 U	7.00 U	7.00 U	12.00 U
1,1-Dichloroethane (ug/Kg)	6.00 U	7.00 U	7.00 U	6.00 U	8.00 U	7.00 U	7.00 U	12.00 U
1,1-Dichloroethene (ug/Kg)	6.00 U	7.00 U	7.00 U	6.00 U	8.00 U	7.00 U	7.00 U	12.00 U
1,2-Dichloroethane (ug/Kg)	6.00 U	7.00 U	7.00 U	6.00 U	8.00 U	7.00 U	7.00 U	12.00 U
1,2-Dichloropropane (ug/Kg)	6.00 U	7.00 U	7.00 U	6.00 U	8.00 U	7.00 U	7.00 U	12.00 U
2-Butanone (ug/Kg)	11.00 R	14.00 R	15.00 R	13.00 R	15.00 R	14.00 U	14.00 R	24.00 R
2-Hexanone (ug/Kg)	11.00 U	14.00 U	15.00 UJ	13.00 U	15.00 UJ	14.00 U	14.00 UJ	24.00 UJ
4-Methyl-2-pentanone (ug/Kg)	11.00 UJ	14.00 UJ	15.00 U	13.00 U	15.00 U	14.00 UJ	14.00 U	24.00 U
Acetone (ug/Kg)	11.00 U	14.00 U	15.00 UJ	13.00 UJ	44.00 J	14.00 U	14.00 UJ	24.00 UJ
Benzene (ug/Kg)	6.00 UL	7.00 UL	7.00 UL	6.00 UL	8.00 UL	7.00 UL	7.00 UL	12.00 UL
Bromodichloromethane (ug/Kg)	6.00 U	7.00 U	7.00 U	6.00 U	8.00 U	7.00 U	7.00 U	12.00 U
Bromoform (ug/Kg)	6.00 U	7.00 U	7.00 U	6.00 U	8.00 U	7.00 UJ	7.00 U	12.00 U
Bromomethane (ug/Kg)	11.00 U	14.00 U	15.00 UJ	13.00 UJ	15.00 UJ	14.00 U	14.00 UJ	24.00 UJ
Carbon Disulfide (ug/Kg)	6.00 UJ	7.00 UJ	7.00 UJ	6.00 UJ	8.00 UJ	7.00 U	7.00 UJ	12.00 UJ
Carbon Tetrachloride (ug/Kg)	6.00 U	7.00 U	7.00 U	6.00 U	8.00 U	7.00 UJ	7.00 U	12.00 U
Chlorobenzene (ug/Kg)	6.00 UL	7.00 UL	7.00 UL	6.00 UL	8.00 UL	7.00 UL	7.00 UL	12.00 UL
Chloroethane (ug/Kg)	11.00 U	14.00 U	15.00 U	13.00 U	15.00 U	14.00 U	14.00 U	24.00 U
Chloroform (ug/Kg)	6.00 U	7.00 U	7.00 U	6.00 U	8.00 U	7.00 U	7.00 U	12.00 U
Chloromethane (ug/Kg)	11.00 U	14.00 U	15.00 U	13.00 U	15.00 U	14.00 U	14.00 U	24.00 U
Cis-1,3-Dichloropropane (ug/Kg)	6.00 U	7.00 U	7.00 U	6.00 UJ	8.00 U	7.00 U	7.00 U	12.00 U
Dibromochloromethane (ug/Kg)	6.00 U	7.00 U	7.00 U	6.00 U	8.00 U	7.00 UJ	7.00 U	12.00 U
Ethylbenzene (ug/Kg)	6.00 UL	7.00 UL	7.00 UL	6.00 UL	8.00 UL	7.00 UL	7.00 UL	12.00 UL
Methylene Chloride (ug/Kg)	6.00 U	7.00 U	7.00 U	6.00 U	8.00 U	3.00 B	3.00 B	12.00 U
Styrene (ug/Kg)	6.00 UL	7.00 UL	7.00 UL	6.00 UL	8.00 UL	7.00 UL	7.00 UL	12.00 UL
Tetrachloroethene (ug/Kg)	6.00 U	7.00 U	7.00 U	6.00 U	8.00 U	7.00 U	7.00 U	12.00 U
Toluene (ug/Kg)	6.00 UL	7.00 UL	7.00 UL	6.00 UL	8.00 UL	7.00 UL	7.00 UL	12.00 UL
Total 1,2-Dichloroethene (ug/Kg)	6.00 U	7.00 U	7.00 U	6.00 U	8.00 U	7.00 UJ	7.00 U	12.00 U
Total xylenes (ug/Kg)	6.00 UL	7.00 UL	7.00 UL	6.00 UL	8.00 UL	7.00 UL	7.00 UL	12.00 UL
Trans-1,3-Dichloropropene (ug/Kg)	6.00 UJ	7.00 UJ	7.00 UJ	6.00 UJ	8.00 UJ	7.00 UJ	7.00 UJ	12.00 UJ
Trichloroethene (ug/Kg)	6.00 U	7.00 U	7.00 U	6.00 U	8.00 U	7.00 U	7.00 U	12.00 U
Vinyl Acetate (ug/Kg)	11.00 U	14.00 U	15.00 U	13.00 UJ	15.00 U	14.00 UJ	14.00 U	24.00 U
Vinyl Chloride (ug/Kg)	11.00 U	14.00 U	15.00 U	13.00 U	15.00 U	14.00 U	14.00 U	24.00 U

Summary of Chemicals Detected in Sediment in the Vicinity
of Dixie Caverns
--- Semi-Volatile ---

Chemical	SB-1 CEC17	SB-2 CEC18	SB-3 CEC19	SB-4 CEC20	SB-5 CEC23	SB-6 CEC26	SB-7 CEC27	SC-1 CEC22
1,2,4-Trichlorobenzene (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
1,2-Dichlorobenzene (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
1,3-Dichlorobenzene (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
1,4-Dichlorobenzene (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
2,4,5-Trichlorophenol (ug/Kg)	1,800.00 UJ	2,100.00 UJ	2,200.00 UJ	2,000.00 UJ	2,300.00 UJ	2,300.00 UJ	2,300.00 UJ	6,400.00 UJ
2,4,6-Trichlorophenol (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
2,4-Dichlorophenol (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
2,4-Dimethylphenol (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
2,4-Dinitrophenol (ug/Kg)	1,800.00 UJ	2,100.00 UJ	2,200.00 UJ	2,000.00 UJ	2,300.00 UJ	2,300.00 UJ	2,300.00 UJ	6,400.00 UJ
2,4-Dinitrotoluene (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
2,6-Dinitrotoluene (ug/Kg)	370.00 UJ	420.00 UJ	460;00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
2-Chloronaphthalene (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
2-Chlorophenol (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
2-Methylnaphthalene (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
2-Methylphenol (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
2-Nitroaniline (ug/Kg)	1,800.00 UJ	2,100.00 UJ	2,200.00 UJ	2,000.00 UJ	2,300.00 UJ	2,300.00 UJ	2,300.00 UJ	6,400.00 UJ
2-Nitrophenol (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
3,3'-Dichlorobenzidine (ug/Kg)	730.00 UJ	850.00 UJ	920.00 UJ	840.00 UJ	960.00 UJ	940.00 UJ	960.00 UJ	2,600.00 UJ
3-Nitroaniline (ug/Kg)	1,800.00 UJ	2,100.00 UJ	2,200.00 UJ	2,000.00 UJ	2,300.00 UJ	2,300.00 UJ	2,300.00 UJ	6,400.00 UJ
4,6-Dinitro-2-methylphenol (ug/Kg)	1,800.00 UJ	2,100.00 UJ	2,200.00 UJ	2,000.00 UJ	2,300.00 UJ	2,300.00 UJ	2,300.00 UJ	6,400.00 UJ
4-Bromophenyl-phenylether (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
4-Chloro-3-methylphenol (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
4-Chloroaniline (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
4-Chlorophenyl-phenylether (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
4-Methylphenol (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
4-Nitroaniline (ug/Kg)	1,800.00 UJ	2,100.00 UJ	2,200.00 UJ	2,000.00 UJ	2,300.00 UJ	2,300.00 UJ	2,300.00 UJ	6,400.00 UJ
4-Nitrophenol (ug/Kg)	1,800.00 UJ	2,100.00 UJ	2,200.00 UJ	2,000.00 UJ	2,300.00 UJ	2,300.00 UJ	2,300.00 UJ	6,400.00 UJ
Acenaphthene (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
Acenaphthylene (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
Anthracene (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
Benzo(a)anthracene (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	67.00 J	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
Benzo(a)pyrene (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	64.00 J	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
Benzo(b)fluoranthene (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	67.00 J	110.00 J	47.00 J	110.00 J	1,300.00 UJ
Benzo(g,h,i)perylene (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
Benzo(k)fluoranthene (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	71.00 J	70.00 J	470.00 UJ	55.00 J	1,300.00 UJ

Summary of Chemicals Detected in Sediment in the Vicinity
of Dixie Caverns
--- Semi-Volatile ---

Chemical	SB-1 CEC17	SB-2 CEC18	SB-3 CEC19	SB-4 CEC20	SB-5 CEC23	SB-6 CEC26	SB-7 CEC27	SC-1 CEC22
Benzoic Acid (ug/Kg)	1,800.00 UJ	2,100.00 UJ	2,200.00 UJ	2,000.00 UJ	2,300.00 UJ	2,300.00 UJ	2,300.00 UJ	2,000.00 J
Benzyl alcohol (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
Butylbenzylphthalate (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
Chrysene (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	72.00 J	93.00 J	470.00 UJ	58.00 J	1,300.00 UJ
Di-n-butylphthalate (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
Di-n-octylphthalate (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
Dibenzo(a,h)anthracene (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
Dibenzofuran (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
Diethylphthalate (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
Dimethylphthalate (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
Fluoranthene (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	120.00 J	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
Fluorene (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
Hexachlorobenzene (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
Hexachlorobutadiene (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
Hexachlorocyclopentadiene (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
Hexachloroethane (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
Indeno(1,2,3-cd)pyrene (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	44.00 J	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
Isophorone (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
N-Nitro-di-n-propylamine (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
N-Nitrosodiphenylamine (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
Naphthalene (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
Nitrobenzene (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
Pentachlorophenol (ug/Kg)	1,800.00 UJ	2,100.00 UJ	2,200.00 UJ	2,000.00 UJ	2,300.00 UJ	2,300.00 UJ	2,300.00 UJ	6,400.00 UJ
Phenanthrene (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	62.00 J	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
Phenol (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
Pyrene (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	92.00 J	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
bis(2-Chloroethoxy)methane (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
bis(2-Chloroethyl)ether (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
bis(2-Chloroisopropyl)ether (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	480.00 UJ	1,300.00 UJ
bis(2-Ethylhexyl)phthalate (ug/Kg)	370.00 UJ	420.00 UJ	460.00 UJ	420.00 UJ	480.00 UJ	470.00 UJ	81.00 J	1,300.00 UJ

Summary of Chemicals Detected in Sediment in the Vicinity
of Dixie Caverns
--- Pesticides and PCBs ---

Chemical	SB-1 CEC17	SB-2 CEC18	SB-3 CEC19	SB-4 CEC20	SB-5 CEC23	SB-6 CEC26	SB-7 CEC27	SC-1 CEC22
4,4'-DDD (ug/Kg)	18.00 UJ	21.00 UJ	22.00 UJ	20.00 UJ	23.00 UJ	23.00 UJ	23.00 UJ	63.00 UJ
4,4'-DDE (ug/Kg)	18.00 UJ	21.00 UJ	22.00 UJ	20.00 UJ	23.00 UJ	23.00 UJ	23.00 UJ	63.00 UJ
4,4'-DDT (ug/Kg)	18.00 UJ	21.00 UJ	22.00 UJ	20.00 UJ	23.00 UJ	23.00 UJ	23.00 UJ	63.00 UJ
Aldrin (ug/Kg)	8.80 UJ	10.00 UJ	11.00 UJ	10.00 UJ	11.00 UJ	11.00 UJ	11.00 UJ	31.00 UJ
Aroclor-1016 (ug/Kg)	88.00 UJ	100.00 UJ	110.00 UJ	100.00 UJ	110.00 UJ	110.00 UJ	110.00 UJ	310.00 UJ
Aroclor-1221 (ug/Kg)	88.00 UJ	100.00 UJ	110.00 UJ	100.00 UJ	110.00 UJ	110.00 UJ	110.00 UJ	310.00 UJ
Aroclor-1232 (ug/Kg)	88.00 UJ	100.00 UJ	110.00 UJ	100.00 UJ	110.00 UJ	110.00 UJ	110.00 UJ	310.00 UJ
Aroclor-1242 (ug/Kg)	88.00 UJ	100.00 UJ	110.00 UJ	100.00 UJ	110.00 UJ	110.00 UJ	110.00 UJ	310.00 UJ
Aroclor-1248 (ug/Kg)	88.00 UJ	100.00 UJ	110.00 UJ	100.00 UJ	110.00 UJ	110.00 UJ	110.00 UJ	310.00 UJ
Aroclor-1254 (ug/Kg)	180.00 UJ	210.00 UJ	220.00 UJ	200.00 UJ	230.00 UJ	230.00 UJ	230.00 UJ	630.00 UJ
Aroclor-1260 (ug/Kg)	180.00 UJ	210.00 UJ	220.00 UJ	200.00 UJ	230.00 UJ	230.00 UJ	230.00 UJ	630.00 UJ
Dieldrin (ug/Kg)	18.00 UJ	21.00 UJ	22.00 UJ	20.00 UJ	23.00 UJ	23.00 UJ	23.00 UJ	63.00 UJ
Endosulfan I (ug/Kg)	8.80 UJ	10.00 UJ	11.00 UJ	10.00 UJ	11.00 UJ	11.00 UJ	11.00 UJ	31.00 UJ
Endosulfan II (ug/Kg)	18.00 UJ	21.00 UJ	22.00 UJ	20.00 UJ	23.00 UJ	23.00 UJ	23.00 UJ	63.00 UJ
Endosulfan Sulfate (ug/Kg)	18.00 UJ	21.00 UJ	22.00 UJ	20.00 UJ	23.00 UJ	23.00 UJ	23.00 UJ	63.00 UJ
Endrin (ug/Kg)	18.00 UJ	21.00 UJ	22.00 UJ	20.00 UJ	23.00 UJ	23.00 UJ	23.00 UJ	63.00 UJ
Endrin Ketone (ug/Kg)	18.00 UJ	21.00 UJ	22.00 UJ	20.00 UJ	23.00 UJ	23.00 UJ	23.00 UJ	63.00 UJ
Heptachlor (ug/Kg)	8.80 UJ	10.00 UJ	11.00 UJ	10.00 UJ	11.00 UJ	11.00 UJ	11.00 UJ	31.00 UJ
Heptachlor Epoxide (ug/Kg)	8.80 UJ	10.00 UJ	11.00 UJ	10.00 UJ	11.00 UJ	11.00 UJ	11.00 UJ	31.00 UJ
Methoxychlor (ug/Kg)	88.00 UJ	100.00 UJ	110.00 UJ	100.00 UJ	110.00 UJ	110.00 UJ	110.00 UJ	310.00 UJ
Toxaphene (ug/Kg)	180.00 UJ	210.00 UJ	220.00 UJ	200.00 UJ	230.00 UJ	230.00 UJ	230.00 UJ	630.00 UJ
alpha-BHC (ug/Kg)	8.80 UJ	10.00 UJ	11.00 UJ	10.00 UJ	11.00 UJ	11.00 UJ	11.00 UJ	31.00 UJ
alpha-Chlordane (ug/Kg)	88.00 UJ	100.00 UJ	110.00 UJ	100.00 UJ	110.00 UJ	110.00 UJ	110.00 UJ	310.00 UJ
beta-BHC (ug/Kg)	8.80 UJ	10.00 UJ	11.00 UJ	10.00 UJ	11.00 UJ	11.00 UJ	11.00 UJ	31.00 UJ
delta-BHC (ug/Kg)	8.80 UJ	10.00 UJ	11.00 UJ	10.00 UJ	11.00 UJ	11.00 UJ	11.00 UJ	31.00 UJ
gamma-BHC (Lindane) (ug/Kg)	8.80 UJ	10.00 UJ	11.00 UJ	10.00 UJ	11.00 UJ	11.00 UJ	11.00 UJ	31.00 UJ
gamma-Chlordane (ug/Kg)	88.00 UJ	100.00 UJ	110.00 UJ	100.00 UJ	110.00 UJ	110.00 UJ	110.00 UJ	310.00 UJ

Summary of Chemicals Detected in Sediment in the Vicinity
of Dixie Caverns
--- Total Metals and Cyanide ---

Chemical	SB-1 MCEH17	SB-2 MCEH18	SB-3 MCEH19	SB-4 MCEH20	SB-5 MCEH23	SB-6 MCEH26	SB-7 MCEH27	SC-1 MCEH22
Aluminum (mg/Kg)	10,200.00	6,700.00	10,300.00	11,100.00	7,240.00	7,970.00	5,520.00	10,000.00
Antimony (mg/Kg)	4.90 UL	6.50 UL	6.80 UL	6.40 UL	18.20 L	6.00 UL	36.50 L	16.40 UL
Arsenic (mg/Kg)	20.00	9.80	8.80	13.80	30.20	15.90	63.10	5.30
Barium (mg/Kg)	126.00 J	96.60 J	57.60 J	54.80 J	119.00 J	130.00 J	136.00 J	475.00 J
Beryllium (mg/Kg)	1.20	.59	.53	.96	.41	.38	.32	1.70
Cadmium (mg/Kg)	.61 U	.81 U	.85 U	.80 U	385.00	109.00	605.00	3.10 J
Calcium (mg/Kg)	1,070.00 J	2,280.00 J	937.00 J	636.00 J	10,700.00 J	18,200.00 J	9,230.00 J	7,940.00 J
Chromium (mg/Kg)	23.70 L	9.90 L	11.80 L	15.60 L	378.00 L	129.00 L	822.00 L	12.80 L
Cobalt (mg/Kg)	19.10	9.60	16.10	12.10	15.80	8.80	19.90	38.90
Copper (mg/Kg)	11.40	8.10	10.30	15.80	839.00	270.00	1,720.00	21.70
Cyanide (mg/Kg)	1.10 U	1.40 U	1.50 U	1.40 U	1.30 U	1.50 U	1.40 U	3.80 U
Iron (mg/Kg)	53,700.00	19,300.00	23,600.00	30,200.00	89,300.00	40,300.00	166,000.00	19,300.00
Lead (mg/Kg)	22.30	16.90	21.20	21.70	14,000.00	3,760.00	30,800.00	145.00
Magnesium (mg/Kg)	1,660.00 J	1,130.00 J	1,550.00 J	804.00 J	7,860.00 J	8,000.00 J	12,500.00 J	2,910.00 J
Manganese (mg/Kg)	1,030.00	828.00	269.00	202.00	9,710.00	3,170.00	20,000.00	3,320.00
Mercury (mg/Kg)	.11 U	.13 U	.13 U	.13 U	.10 U	.12 U	.12 U	.31 U
Nickel (mg/Kg)	27.70	16.90	16.60	12.40	87.30	33.60	186.00	71.00
Potassium (mg/Kg)	1,730.00	1,070.00	1,600.00	1,670.00	1,100.00	1,130.00	849.00	1,760.00
Selenium (mg/Kg)	.61 UL	.72 UL	.78 UL	.83 UL	2.80 J	1.30	4.90 J	2.00 U
Silver (mg/Kg)	2.00	1.30 U	1.40 U	1.70	40.40	13.60	71.30	3.40 U
Sodium (mg/Kg)	48.10 B	52.30 B	45.10 B	56.60 B	376.00 B	128.00 B	594.00	171.00 B
Thallium (mg/Kg)	.41 U	.48 U	.52 U	.55 U	.51 U	.56 U	.55 UL	1.40 U
Vanadium (mg/Kg)	33.00	13.10 J	17.90	23.50	32.10	20.00	43.80	18.50 J
Zinc (mg/Kg)	75.60 J	42.80 J	52.30 J	60.30 J	67,100.00 J	18,400.00 J	127,000.00 J	423.00 J

Summary of Chemicals Detected in Sediment in the Vicinity of Dixie Caverns
--- Volatile ---

Chemical	SD-1 CEC29	SE-1 CEC24	SE-1 CEC25 (Duplicate)	SF-1 CEC09	SG-1 CEC10	SR-1 CEC13	SR-2 CEC14	TRIPBLANK CEC57 (Trip Blank)
1,1,1-Trichloroethane (ug/Kg)	11.00 U	7.00 U	7.00 U	8.00 UJ	6.00 U	7.00 U	7.00 UJ	5.00 U
1,1,2,2-Tetrachloroethane (ug/Kg)	11.00 U	7.00 U	7.00 U	8.00 U	6.00 U	7.00 U	7.00 U	5.00 U
1,1,2-Trichloroethane (ug/Kg)	11.00 U	7.00 U	7.00 U	8.00 U	6.00 U	7.00 U	7.00 U	5.00 U
1,1-Dichloroethane (ug/Kg)	11.00 U	7.00 U	7.00 U	8.00 U	6.00 U	7.00 U	7.00 U	5.00 U
1,1-Dichloroethene (ug/Kg)	11.00 U	7.00 U	7.00 U	8.00 U	6.00 U	7.00 U	7.00 U	5.00 U
1,2-Dichloroethane (ug/Kg)	11.00 U	7.00 UJ	7.00 U	8.00 U	6.00 U	7.00 U	7.00 U	5.00 UJ
1,2-Dichloropropane (ug/Kg)	11.00 U	7.00 U	7.00 U	8.00 U	6.00 U	7.00 U	7.00 U	5.00 U
2-Butanone (ug/Kg)	22.00 R	14.00 U	14.00 U	16.00 R	13.00 R	14.00 R	14.00 R	10.00 U
2-Hexanone (ug/Kg)	22.00 UJ	14.00 U	14.00 U	16.00 U	13.00 U	14.00 U	14.00 U	10.00 UJ
4-Methyl-2-pentanone (ug/Kg)	22.00 U	14.00 U	14.00 UJ	16.00 U	13.00 UJ	14.00 UJ	14.00 U	10.00 U
Acetone (ug/Kg)	22.00 UJ	12.00 B	14.00 U	16.00 UJ	13.00 U	14.00 U	14.00 UJ	10.00 UJ
Benzene (ug/Kg)	11.00 UL	7.00 UL	7.00 UL	8.00 UL	6.00 UL	7.00 UL	7.00 UL	5.00 U
Bromodichloromethane (ug/Kg)	11.00 U	7.00 U	7.00 U	8.00 U	6.00 U	7.00 U	7.00 U	5.00 U
Bromoform (ug/Kg)	11.00 U	7.00 UJ	7.00 UJ	8.00 U	6.00 U	7.00 U	7.00 U	5.00 U
Bromomethane (ug/Kg)	22.00 UJ	14.00 U	14.00 U	16.00 UJ	13.00 U	14.00 U	14.00 UJ	10.00 U
Carbon Disulfide (ug/Kg)	11.00 UJ	7.00 U	7.00 U	8.00 UJ	6.00 UJ	7.00 UJ	7.00 UJ	5.00 U
Carbon Tetrachloride (ug/Kg)	11.00 U	7.00 UJ	7.00 UJ	8.00 U	6.00 U	7.00 U	7.00 U	5.00 U
Chlorobenzene (ug/Kg)	11.00 UL	7.00 UL	7.00 UL	8.00 UL	6.00 UL	7.00 UL	7.00 UL	5.00 U
Chloroethane (ug/Kg)	22.00 U	14.00 U	14.00 U	16.00 U	13.00 U	14.00 U	14.00 U	10.00 U
Chloroform (ug/Kg)	11.00 U	7.00 U	7.00 U	8.00 U	6.00 U	7.00 U	7.00 U	7.00 UJ
Chloromethane (ug/Kg)	22.00 U	14.00 U	14.00 U	16.00 U	13.00 U	14.00 U	14.00 U	10.00 UJ
Cis-1,3-Dichloropropane (ug/Kg)	11.00 U	7.00 U	7.00 U	8.00 UJ	6.00 U	7.00 U	7.00 UJ	5.00 U
Dibromochloromethane (ug/Kg)	11.00 U	7.00 UJ	7.00 UJ	8.00 U	6.00 U	7.00 U	7.00 U	5.00 U
Ethylbenzene (ug/Kg)	11.00 UL	7.00 UL	7.00 UL	8.00 UL	6.00 UL	7.00 UL	7.00 UL	5.00 U
Methylene Chloride (ug/Kg)	11.00 U	4.00 B	3.00 B	8.00 U	6.00 U	7.00 U	7.00 U	4.00 J
Styrene (ug/Kg)	11.00 UL	7.00 UL	7.00 UL	8.00 UL	6.00 UL	7.00 UL	7.00 UL	5.00 U
Tetrachloroethene (ug/Kg)	11.00 U	7.00 U	7.00 U	8.00 U	6.00 U	7.00 U	7.00 U	5.00 U
Toluene (ug/Kg)	11.00 UL	7.00 UL	7.00 UL	8.00 UL	6.00 UL	7.00 UL	7.00 UL	5.00 U
Total 1,2-Dichloroethene (ug/Kg)	11.00 U	7.00 U	7.00 UJ	8.00 U	6.00 U	7.00 U	7.00 U	5.00 U
Total xylenes (ug/Kg)	11.00 UL	7.00 UL	7.00 UL	8.00 UL	6.00 UL	7.00 UL	7.00 UL	5.00 U
Trans-1,3-Dichloropropene (ug/Kg)	11.00 UJ	7.00 UJ	7.00 UJ	8.00 UJ	6.00 UJ	7.00 UJ	7.00 UJ	5.00 U
Trichloroethene (ug/Kg)	11.00 U	7.00 U	7.00 U	8.00 U	6.00 U	7.00 U	7.00 U	5.00 U
Vinyl Acetate (ug/Kg)	22.00 U	14.00 UJ	14.00 UJ	16.00 UJ	13.00 U	14.00 U	14.00 UJ	10.00 J
Vinyl Chloride (ug/Kg)	22.00 U	14.00 U	14.00 U	16.00 U	13.00 U	14.00 U	14.00 U	10.00 U

Summary of Chemicals Detected in Sediment in the Vicinity
of Dixie Caverns
--- Semi-Volatile ---

Chemical	SD-1 CEC29	SE-1 CEC24	SE-1 CEC25 (Duplicate)	SF-1 CEC09	SG-1 CEC10	SR-1 CEC13	SR-2 CEC14
1,2,4-Trichlorobenzene (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
1,2-Dichlorobenzene (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
1,3-Dichlorobenzene (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
1,4-Dichlorobenzene (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
2,4,5-Trichlorophenol (ug/Kg)	2,300.00 UJ	2,900.00 UJ	4,700.00 UJ	2,000.00 UJ	2,300.00 UJ	2,400.00 UJ	2,500.00 UJ
2,4,6-Trichlorophenol (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
2,4-Dichlorophenol (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
2,4-Dimethylphenol (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
2,4-Dinitrophenol (ug/Kg)	2,300.00 UJ	2,900.00 UJ	4,700.00 UJ	2,000.00 UJ	2,300.00 UJ	2,400.00 UJ	2,500.00 UJ
2,4-Dinitrotoluene (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
2,6-Dinitrotoluene (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
2-Chloronaphthalene (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
2-Chlorophenol (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
2-Methylnaphthalene (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
2-Methylphenol (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
2-Nitroaniline (ug/Kg)	2,300.00 UJ	2,900.00 UJ	4,700.00 UJ	2,000.00 UJ	2,300.00 UJ	2,400.00 UJ	2,500.00 UJ
2-Nitrophenol (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
3,3'-Dichlorobenzidine (ug/Kg)	930.00 UJ	1,200.00 UJ	1,900.00 UJ	810.00 UJ	940.00 UJ	1,000.00 UJ	1,000.00 UJ
3-Nitroaniline (ug/Kg)	2,300.00 UJ	2,900.00 UJ	4,700.00 UJ	2,000.00 UJ	2,300.00 UJ	2,400.00 UJ	2,500.00 UJ
4,6-Dinitro-2-methylphenol (ug/Kg)	2,300.00 UJ	2,900.00 UJ	4,700.00 UJ	2,000.00 UJ	2,300.00 UJ	2,400.00 UJ	2,500.00 UJ
4-Bromophenyl-phenylether (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
4-Chloro-3-methylphenol (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
4-Chloroaniline (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
4-Chlorophenyl-phenylether (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
4-Methylphenol (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
4-Nitroaniline (ug/Kg)	2,300.00 UJ	2,900.00 UJ	4,700.00 UJ	2,000.00 UJ	2,300.00 UJ	2,400.00 UJ	2,500.00 UJ
4-Nitrophenol (ug/Kg)	2,300.00 UJ	2,900.00 UJ	4,700.00 UJ	2,000.00 UJ	2,300.00 UJ	2,400.00 UJ	2,500.00 UJ
Acenaphthene (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
Acenaphthylene (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
Anthracene (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
Benzo(a)anthracene (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	80.00 J	470.00 UJ	500.00 UJ	510.00 UJ
Benzo(a)pyrene (ug/Kg)	460.00 UJ	250.00 J	480.00 J	77.00 J	470.00 UJ	500.00 UJ	510.00 UJ
Benzo(b)fluoranthene (ug/Kg)	460.00 UJ	480.00 J	730.00 J	81.00 J	470.00 UJ	500.00 UJ	510.00 UJ
Benzo(g,h,i)perylene (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	42.00 J	470.00 UJ	500.00 UJ	510.00 UJ
Benzo(k)fluoranthene (ug/Kg)	460.00 UJ	590.00 UJ	280.00 J	87.00 J	470.00 UJ	500.00 UJ	510.00 UJ

Summary of Chemicals Detected in Sediment in the Vicinity
of Dixie Caverns
--- Semi-Volatile ---

Chemical	SD-1 CEC29	SE-1 CEC24	SE-1 CEC25 (Duplicate)	SF-1 CEC09	SG-1 CEC10	SR-1 CEC13	SR-2 CEC14
Benzoic Acid (ug/Kg)	2,300.00 UJ	2,900.00 UJ	4,700.00 UJ	2,000.00 UJ	2,300.00 UJ	2,400.00 UJ	2,500.00 UJ
Benzyl alcohol (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
Butylbenzylphthalate (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
Chrysene (ug/Kg)	460.00 UJ	140.00 J	340.00 J	91.00 J	470.00 UJ	500.00 UJ	510.00 UJ
Di-n-butylphthalate (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
Di-n-octylphthalate (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
Dibenzo(a,h)anthracene (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
Dibenzofuran (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
Diethylphthalate (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
Dimethylphthalate (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
Fluoranthene (ug/Kg)	460.00 UJ	590.00 UJ	120.00 J	160.00 J	470.00 UJ	500.00 UJ	510.00 UJ
Fluorene (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
Hexachlorobenzene (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
Hexachlorobutadiene (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
Hexachlorocyclopentadiene (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
Hexachloroethane (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
Indeno(1,2,3-cd)pyrene (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
Isophorone (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
N-Nitro-di-n-propylamine (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
N-Nitrosodiphenylamine (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
Naphthalene (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
Nitrobenzene (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
Pentachlorophenol (ug/Kg)	2,300.00 UJ	2,900.00 UJ	4,700.00 UJ	2,000.00 UJ	2,300.00 UJ	2,400.00 UJ	2,500.00 UJ
Phenanthrene (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	45.00 J	470.00 UJ	500.00 UJ	510.00 UJ
Phenol (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
Pyrene (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	140.00 J	470.00 UJ	500.00 UJ	510.00 UJ
bis(2-Chloroethoxy)methane (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
bis(2-Chloroethyl)ether (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
bis(2-Chloroisopropyl)ether (ug/Kg)	460.00 UJ	590.00 UJ	970.00 UJ	400.00 UJ	470.00 UJ	500.00 UJ	510.00 UJ
bis(2-Ethylhexyl)phthalate (ug/Kg)	460.00 UJ	590.00 UJ	380.00 J	400.00 UJ	470.00 UJ	140.00 J	57.00 J

Summary of Chemicals Detected in Sediment in the Vicinity
of Dixie Caverns
--- Pesticides and PCBs ---

Chemical	SD-1 CEC29	SE-1 CEC24	SE-1 CEC25 (Duplicate)	SF-1 CEC09	SG-1 CEC10	SR-1 CEC13	SR-2 CEC14
4,4'-DDD (ug/Kg)	22.00 UJ	28.00 UJ	47.00 UJ	19.00 UJ	23.00 UJ	24.00 UJ	25.00 UJ
4,4'-DDE (ug/Kg)	22.00 UJ	28.00 UJ	47.00 UJ	19.00 UJ	23.00 UJ	24.00 UJ	25.00 UJ
4,4'-DDT (ug/Kg)	22.00 UJ	28.00 UJ	47.00 UJ	19.00 UJ	23.00 UJ	24.00 UJ	25.00 UJ
Aldrin (ug/Kg)	11.00 UJ	14.00 UJ	23.00 UJ	9.70 UJ	11.00 UJ	12.00 UJ	12.00 UJ
Aroclor-1016 (ug/Kg)	110.00 UJ	140.00 UJ	230.00 UJ	97.00 UJ	110.00 UJ	120.00 UJ	120.00 UJ
Aroclor-1221 (ug/Kg)	110.00 UJ	140.00 UJ	230.00 UJ	97.00 UJ	110.00 UJ	120.00 UJ	120.00 UJ
Aroclor-1232 (ug/Kg)	110.00 UJ	140.00 UJ	230.00 UJ	97.00 UJ	110.00 UJ	120.00 UJ	120.00 UJ
Aroclor-1242 (ug/Kg)	110.00 UJ	140.00 UJ	230.00 UJ	97.00 UJ	110.00 UJ	120.00 UJ	120.00 UJ
Aroclor-1248 (ug/Kg)	110.00 UJ	140.00 UJ	230.00 UJ	97.00 UJ	110.00 UJ	120.00 UJ	120.00 UJ
Aroclor-1254 (ug/Kg)	220.00 UJ	280.00 UJ	470.00 UJ	190.00 UJ	230.00 UJ	240.00 UJ	250.00 UJ
Aroclor-1260 (ug/Kg)	220.00 UJ	280.00 UJ	470.00 UJ	190.00 UJ	230.00 UJ	240.00 UJ	250.00 UJ
Dieldrin (ug/Kg)	22.00 UJ	28.00 UJ	47.00 UJ	19.00 UJ	23.00 UJ	24.00 UJ	25.00 UJ
Endosulfan I (ug/Kg)	11.00 UJ	14.00 UJ	23.00 UJ	9.70 UJ	11.00 UJ	12.00 UJ	12.00 UJ
Endosulfan II (ug/Kg)	22.00 UJ	28.00 UJ	47.00 UJ	19.00 UJ	23.00 UJ	24.00 UJ	25.00 UJ
Endosulfan Sulfate (ug/Kg)	22.00 UJ	28.00 UJ	47.00 UJ	19.00 UJ	23.00 UJ	24.00 UJ	25.00 UJ
Endrin (ug/Kg)	22.00 UJ	28.00 UJ	47.00 UJ	19.00 UJ	23.00 UJ	24.00 UJ	25.00 UJ
Endrin Ketone (ug/Kg)	22.00 UJ	28.00 UJ	47.00 UJ	19.00 UJ	23.00 UJ	24.00 UJ	25.00 UJ
Heptachlor (ug/Kg)	11.00 UJ	14.00 UJ	23.00 UJ	9.70 UJ	11.00 UJ	12.00 UJ	12.00 UJ
Heptachlor Epoxide (ug/Kg)	11.00 UJ	14.00 UJ	23.00 UJ	9.70 UJ	11.00 UJ	12.00 UJ	12.00 UJ
Methoxychlor (ug/Kg)	110.00 UJ	140.00 UJ	230.00 UJ	97.00 UJ	110.00 UJ	120.00 UJ	120.00 UJ
Toxaphene (ug/Kg)	220.00 UJ	280.00 UJ	470.00 UJ	190.00 UJ	230.00 UJ	240.00 UJ	250.00 UJ
alpha-BHC (ug/Kg)	11.00 UJ	14.00 UJ	23.00 UJ	9.70 UJ	11.00 UJ	12.00 UJ	12.00 UJ
alpha-Chlordane (ug/Kg)	110.00 UJ	140.00 UJ	230.00 UJ	97.00 UJ	110.00 UJ	120.00 UJ	120.00 UJ
beta-BHC (ug/Kg)	11.00 UJ	14.00 UJ	23.00 UJ	9.70 UJ	11.00 UJ	12.00 UJ	12.00 UJ
delta-BHC (ug/Kg)	11.00 UJ	14.00 UJ	23.00 UJ	9.70 UJ	11.00 UJ	12.00 UJ	12.00 UJ
gamma-BHC (Lindane) (ug/Kg)	11.00 UJ	14.00 UJ	23.00 UJ	9.70 UJ	11.00 UJ	12.00 UJ	12.00 UJ
gamma-Chlordane (ug/Kg)	110.00 UJ	140.00 UJ	230.00 UJ	97.00 UJ	110.00 UJ	120.00 UJ	120.00 UJ

Summary of Chemicals Detected in Sediment in the Vicinity
of Dixie Caverns
--- Total Metals and Cyanide ---

Chemical	SD-1 MCEH29	SE-1 MCEH24	SE-1 MCEH25	SF-1 MCEH09	SG-1 MCEH10	SR-1 MCEH13	SR-2 MCEH14	SE-10 01
Aluminum (mg/Kg)	9,280.00	4,590.00	10,200.00	7,560.00	6,850.00	11,200.00	9,770.00	- - -
Antimony (mg/Kg)	10.70 UL	33.30 L	45.20 L	5.60 UL	5.80 UL	6.50 UL	6.20 UL	- - -
Arsenic (mg/Kg)	10.70 K	39.00 K	53.30	8.30	16.30	15.10	11.50	- - -
Barium (mg/Kg)	141.00	204.00	209.00 J	76.50 J	63.40 J	78.90 J	66.20 J	- - -
Beryllium (mg/Kg)	1.00	.34 U	.61	.70	.93	.75	.72	- - -
Cadmium (mg/Kg)	1.30 U	443.00	474.00	8.90	.73 U	.81 U	.78 U	12.60
Calcium (mg/Kg)	1,890.00	3,110.00	15,900.00 J	12,900.00 J	878.00 J	5,090.00 J	8,230.00 J	- - -
Chromium (mg/Kg)	13.60 B	453.00	831.00 L	24.00 L	12.40 L	14.80 L	14.50 L	30.90
Cobalt (mg/Kg)	12.10	11.10	20.50	10.70	10.10	13.40	13.30	- - -
Copper (mg/Kg)	17.70	1,220.00	1,910.00	37.30	12.70	20.60	19.40	- - -
Cyanide (mg/Kg)	2.20 U	1.70 U	2.90 U	1.30 U	1.20 U	1.40 U	1.40 U	- - -
Iron (mg/Kg)	25,000.00	10,700.00	184,000.00	22,400.00	22,900.00	29,000.00	21,800.00	- - -
Lead (mg/Kg)	28.40	22,100.00	26,500.00	457.00	27.70	39.90	30.20	648.00
Magnesium (mg/Kg)	1,680.00	16,400.00	16,800.00 J	8,700.00 J	2,980.00 J	3,930.00 J	5,290.00 J	- - -
Manganese (mg/Kg)	184.00	12,100.00	21,000.00	754.00	536.00	196.00	274.00	- - -
Mercury (mg/Kg)	.19 U	.16 U	.27 U	.12 U	.11 U	.14 U	.13 U	- - -
Nickel (mg/Kg)	21.40	111.00	199.00	19.40	22.40	12.90	11.00	23.30
Potassium (mg/Kg)	1,780.00	753.00	1,600.00	1,290.00	1,320.00	1,690.00	1,710.00	- - -
Selenium (mg/Kg)	.85 L	3.00 L	9.20 J	.77 UL	.67 UL	.82 UL	.80 UL	- - -
Silver (mg/Kg)	2.20 U	53.20	92.60	1.20 U	1.20 U	1.30 U	1.30 U	- - -
Sodium (mg/Kg)	50.00	400.00	749.00	47.90 B	42.30 B	73.50 B	72.70 B	- - -
Thallium (mg/Kg)	.82 U	.67 U	1.00 U	.52 U	.45 U	.55 U	.53 U	- - -
Vanadium (mg/Kg)	14.20 J	31.30	55.00	22.00	19.70	22.80	21.10	- - -
Zinc (mg/Kg)	132.00 J	95,000.00 J	129,000.00 J	1,610.00 J	62.70 J	75.50 J	84.40 J	2,100.00

Summary of Chemicals Detected in Sediment in the Vicinity
of Dixie Caverns
--- Total Metals and Cyanide ---

Chemical	SE-11 02	SE-12 03	SE-13 04
Aluminum (mg/Kg)	- - -	- - -	- - -
Antimony (mg/Kg)	- - -	- - -	- - -
Arsenic (mg/Kg)	- - -	- - -	- - -
Barium (mg/Kg)	- - -	- - -	- - -
Beryllium (mg/Kg)	- - -	- - -	- - -
Cadmium (mg/Kg)	187.00	120.00	132.00
Calcium (mg/Kg)	- - -	- - -	- - -
Chromium (mg/Kg)	470.00	289.00	297.00
Cobalt (mg/Kg)	- - -	- - -	- - -
Copper (mg/Kg)	- - -	- - -	- - -
Cyanide (mg/Kg)	- - -	- - -	- - -
Iron (mg/Kg)	- - -	- - -	- - -
Lead (mg/Kg)	17,200.00	11,400.00	11,900.00
Magnesium (mg/Kg)	- - -	- - -	- - -
Manganese (mg/Kg)	- - -	- - -	- - -
Mercury (mg/Kg)	- - -	- - -	- - -
Nickel (mg/Kg)	108.00	73.10	77.10
Potassium (mg/Kg)	- - -	- - -	- - -
Selenium (mg/Kg)	- - -	- - -	- - -
Silver (mg/Kg)	- - -	- - -	- - -
Sodium (mg/Kg)	- - -	- - -	- - -
Thallium (mg/Kg)	- - -	- - -	- - -
Vanadium (mg/Kg)	- - -	- - -	- - -
Zinc (mg/Kg)	75,900.00	48,600.00	52,600.00

APPENDIX C

ECOLOGICAL ASSESSMENT INFORMATION

Detailed Ecologic Investigation Results
Stream Sampling Data Sheets
Benthic Sample Organisms Data Sheets
Benthic Sample Organisms QA/QC Sheets
Forest Vegetation Data Sheets
Emergent Vegetation Data Sheets
Streamside Vegetation Data Sheets
Vegetation Calculations Summary Sheets
Bioassay Results
Photodocumentation

Detailed Ecologic Investigation Results

Detailed Ecologic Investigation Results

ECOLOGICAL ASSESSMENT

An ecological investigation was performed along the streams and stream banks in the vicinity of Dixie Caverns Landfill (DCL) site to evaluate the potential environmental impacts of the site. Six (6) sample stations were designated for the ecological evaluation, including one reference station. The terrestrial and aquatic flora and fauna at each sample station was described, and then were compared to the reference station. Measurements of all sampling locations and detailed site descriptions are given on the stream data sheets (Appendix C). Additional stations were designated for terrestrial vegetation analysis in both the landfill and the adjacent forest. A summary of the benthic macroinvertebrates collected and stream community evaluations are found in Table 1 and Table 2, respectively. Details of the vegetation analysis are given in the vegetation data sheets (Appendix C). Photo-documentation for all sampling stations is also found in Appendix C. No formal wetland evaluation was performed in the study area, because it was believed that wetland occurring within the study area seemed unlikely due to the mountainous topography. The USEPA RPM concurred that if during the site visit potential wetland areas, aside from the streams, were found, a formal delineation would be performed. This was not the case.

TERRESTRIAL INVESTIGATION

Vegetative data was taken from a total of 22 quadrats (Figure 1). Nine of the quadrats were located in riparian (streamside) areas along the designated tributaries in the study area. Six of the riparian quadrats were located in areas where potential site related impacts were expected to be found. The remaining three riparian quadrats were located in areas that were expected to be unaffected by the DCL site, and were used as reference quadrats. Each of the riparian quadrats were designated with a "S" followed by a number (e.g S1). Each riparian quadrat was bisected by one of the tributaries. Five of the 22 quadrats were located in emergent (field) areas on-site. Each of the

TABLE 1

BENTHIC MACROINVERTEBRATE COLLECTION SUMMARY

STATION (ECOL-)	SA5 R	SA5 C	SB6 R	SB6 C	SD1 R	SD1 C	SE1 R	SE1 C	SF1 R	SF1 C	SG1 R	SG1 C
Annelida												
Oligochaeta	4	13							4	15		3
Mollusca												
undetermined									1			
Gastropod									1			
Planorbidae												
Arachnida												
Acari									1			
Araneae		1		1								
Crustacea												
Decapoda						2						
Isopoda									1	1	1	
Diplopoda		1							2			2
Insecta												
Collembola												
Entomobryidae								1				1
Sminthuridae									1			
Ephemeroptera												
S.O. Schistonota												
Siphlonuridae	20	3	2	2	4	8	20	45	11	54	7	25
Baetidae	1									1		1
Heptageniidae	49	3	1		26	2	46	7	3	1	102	6
	1			1	5	17		5		17		1
Leptophlebiidae												
S.O. Pannota	3	6	1		2		10	1	1	1	6	23
Ephemerellidae												
Odonata												
Gomphidae									1			
Plecoptera												
"Group" Euholognatha												
	1											
Taeniopterygidae	4	6	3	4	1			1	72	78	1	9
Nemouridae						1						
Leuctridae												
"Group"												1
Systellognatha	1	3		1		2		2	33	12	4	24
Pteronarcyidae					2		3	4	1	1	2	2
Perlodidae												
Chloroperlidae												
Hemiptera												
Corixidae								4				
Gerridae			1				3					

C - CPOM Sample; R - Riffle/Run Sample; S.O. - Suborder

TABLE 1 cont'd

BENTHIC MACROINVERTEBRATE COLLECTION SUMMARY

STATION (ECOL-)	SA5 R	SA5 C	SB6 R	SB6 C	SD1 R	SD1 C	SE1 R	SE1 C	SF1 R	SF1 C	SG1 R	SG1 C
Insecta cont'd												
Megaloptera												
Corydalidae				1	1							1
Coleoptera												
Dytiscidae		1	1							4		
Staphylinidae										1		
Hydrophilidae		1										1
Chrysomelidae												1
Diptera												
S.O. Nematocera												
Tipulidae	4	25					2	3	5	5	1	5
											1	
Blephariceridae				3			17	1	6	6	23	9
Simuliidae	1	1	1	6		1	2	1	29	4	1	1
Chironomidae												
S.O. Brachycera						1			1			
Empididae												
Trichoptera												
Hydropsychidae					2	1	1	2			1	2
Philopotamidae									1	1		
					1	1	1	1		2		4
Rhyacophilidae			1	1		4		1		2	10	
Limnephilidae					2	14		6			1	
Lepidostomatidae												
Lepidoptera												
Noctuidae									1			
Hymenoptera												
Formicidae									3	2		
Amphibia												
Desmognathus sp.						1					1	
Other:												
Eggs									5			

C - CPOM Sample; R - Riffle/Run Sample; S.O. - Suborder.

TABLE 2

METRIC VALUES, PERCENT COMPARISON, AND BIOASSESSMENT SCORES
FOR THE BENTHIC MACROINVERTEBRATE INVESTIGATION

Metric Values

STATIONS	SA5	SB6	SD1	SE1	SF1	SG1 (REF)
Taxa Richness	11	8	10	10	14	13
Modified Family Biotic Index[a]	4.57	3.89	3.43	4.52	3.40	4.17
Scrapers/Filterers Collectors	1/74 = 0.014	0/5 = 0.000	5/34 = 0.147	0/96 = 0.000	1/51 = 0.020	1/140 =0.007
EPT/Chironomid Abundance	80/1 = 80.0	8/1 = 8.0	45/0 = ∞	81/2 = 40.5	122/29 = 4.2	134/1 =134.0
% Contrib. Dominant Family[b]	55%	30%	57%	45%	41%	64%
EPT Index	8	5	9	6	7	9
Community Loss Index[c]	0.54	0.88	0.60	0.50	0.29	REF
Shredders/Total Individuals	44/62 = 0.71	5/19 = 0.26	19/54 = 0.35	11/84 = 0.14	100/204 =0.49	18/118 =0.15

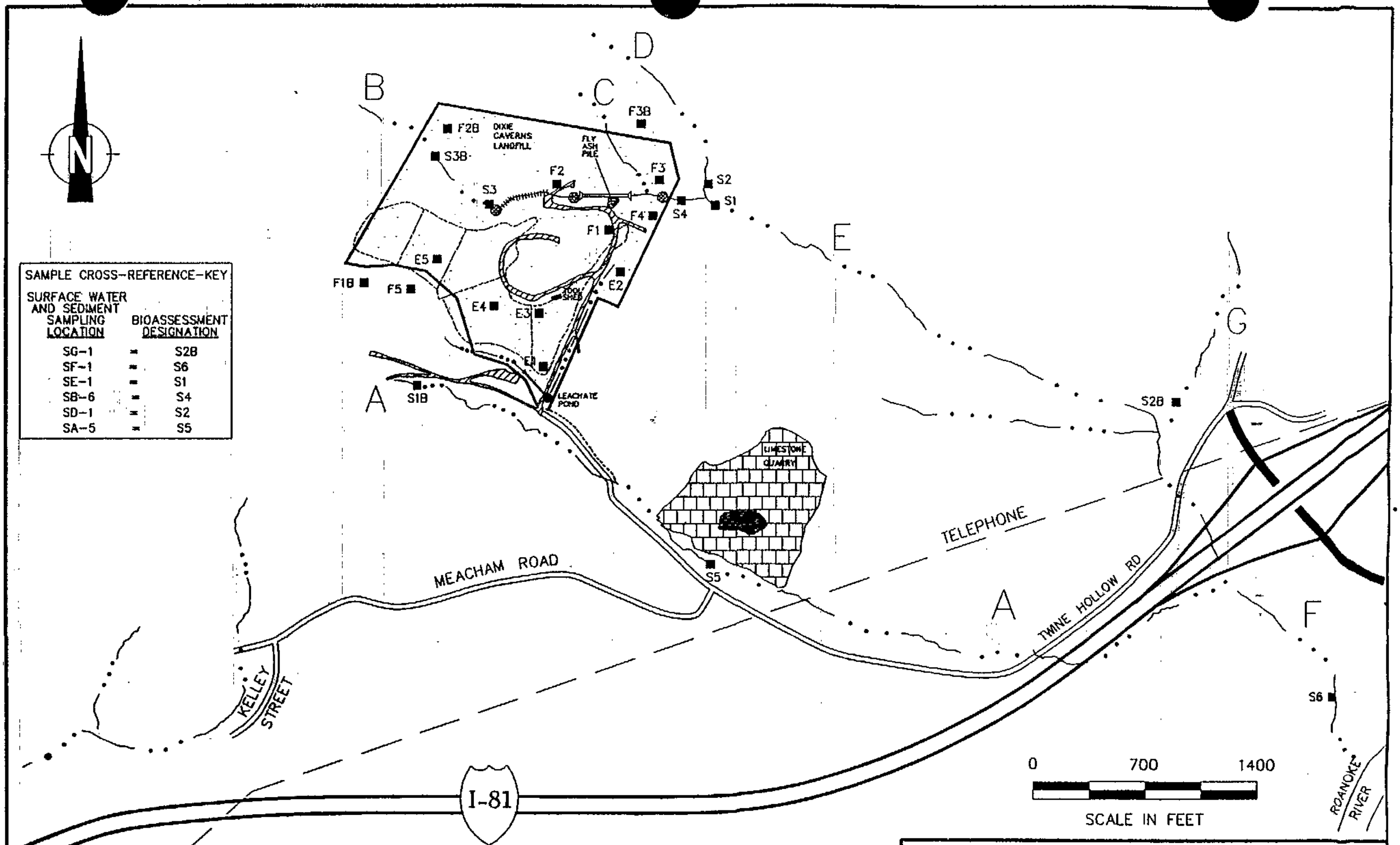
Percent Comparison

STATIONS	SA5	SB6	SD1	SE1	SF1	SG1 (REF)
Taxa Richness	85	62	77	77	108	100
Modified Family Biotic Index[a]	91	107	122	92	122	100
Scrapers/Filterers Collectors	200	0	2100	0	286	100
EPT/Chironomid Abundance	60	6	∞	30	3	100
% Contrib. Dominant Family[b]	55	30	57	45	41	64
EPT Index	89	56	100	67	78	100
Community Loss Index[c]	0.54	0.88	0.60	0.50	0.29	REF
Shredders/Total Individuals	473	173	233	93	327	100

Bioassessment Scores

STATIONS	SA5	SB6	SD1	SE1	SF1	SG1 (REF)
Taxa Richness	6	3	3	3	6	6
Modified Family Biotic Index[a]	6	6	6	6	6	6
Scrapers/Filterers Collectors	6	0	6	0	6	6
EPT/Chironomid Abundance	3	0	6	3	0	6
% Contrib. Dominant Family[b]	0	3	0	3	3	0
EPT Index	3	0	6	0	3	6
Community Loss Index[c]	3	3	3	3	6	6
Shredders/Total Individuals	6	6	6	6	6	6
Total Score	33	21	36	24	36	42
Percent Comparison to Reference	79	50	86	57	86	100
Community Assessment	Non-Impaired	Moderately Impaired[e]	Non-Impaired[d]	Moderately Impaired	Non-Impaired	Reference

a - Ratio of reference station to station of comparison.
b - Actual percent contribution evaluated, not percent comparability.
c - Range of values evaluated, not percent comparability.
d - Non-impaired community exists, however, community structure and/or habitat is different from reference station.
e - Metric calculations resulted in mod. impairment, however, considering the low number collected, significant impairment exists.



SAMPLE CROSS-REFERENCE-KEY

SURFACE WATER AND SEDIMENT SAMPLING LOCATION		BIOASSESSMENT DESIGNATION
SG-1	=	S2B
SF-1	=	S6
SE-1	=	S1
SB-6	=	S4
SD-1	=	S2
SA-5	=	S5

LEGEND

- ROADWAY/WORK AREAS
- INTERMITTENT STREAMS
- DETENTION POND OR LAKE AREA
- OLD STREAM CHANNEL
- DIVERSION PIPE
- BIOASSESSMENT LOCATION
- DIVERSION CHANNEL

SITE BOUNDARY FROM ROANOKE COUNTY PROPERTY IDENTIFICATION MAP-NO. 63.00

TETRA TECH, INC.

FIGURE 1
ECOLOGICAL SAMPLE LOCATIONS/QUADRANTS
DIXIE CAVERNS LANDFILL SITE

emergent quadrats were designated with an "E" followed by a number (e.g E1). There were no known areas in the vicinity of the study area that could be considered an appropriate reference. The remaining eight quadrats were located in upland forested areas on and surrounding the DCL site. Five of the forested quadrats were located in areas where potential site related impacts were expected to be found. The remaining three forested quadrats were located in areas that were expected to be unaffected by the DCL site, and were used as reference quadrats. Each of the forested quadrats were designated with a "F" followed by a number (e.g F1). If a quadrat was used as a reference, a letter "B" was added to a quadrat designation (e.g. S2B).

The terrestrial sample stations consisted of a 40' X 40' quadrat. Within this 40' X 40' quadrat, four subsamples of the herbaceous vegetation were taken, one in each corner of the quadrat. These subsamples were obtained by tossing a 40" X 40" frame into the quadrat to obtain a representative random sample and identifying all of the herbaceous plants that fell within the frame. All of the woody vegetation layers (woody vines, shrubs, saplings and trees) within the quadrat were identified and recorded using protocols from the "Federal Manual for Identifying and Delineating Jurisdictional Wetlands" (Federal Interagency Committee for Wetland Delineation 1989). From this information, the dominance and average abundance of each plant species was determined. Wetland indicator status of individual plant species was also determined (Reed, 1988). A summary of the vegetation analysis, including the scientific names of all plants identified on the site, is given in Table 3.

Vegetation analysis was performed on six (6) riparian quadrats (designated S1 to S6), plus five (5) forest stations (designated F1 to F5), and five (5) emergent field stations (designated E1 to E5), which were located on the landfill itself. The riparian sample quadrats were bisected by one of the tributaries. Each riparian and forest quadrat was compared to the average vegetation obtained from three riparian and three forest reference quadrats. The three reference forest quadrats were designated F1B, F2B, and F3B, and the

TABLE 3

Plants Observed in the Dixie Caverns Study Area

Common Name	Scientific Name	Station No.
ASH, GREEN	Fraxinus pennsylvanica	SA5,SE1,SG1
AZALEA	Rhododendron spp.	SB1,SE1
BEDSTRAW	Gallium spp.	E1,F1,SG1
BEECH, AMERICAN	Fagus grandifolia	SE1
BEECH-DROPS	Epifagus virginiana	SE1
BIRCH, BLACK	Betula nigra	S1B,SE1
BITTER-CRESS, PENNSYLVANIA	Cardamine pensylvanica	E4,E5,SA5
BLUEBERRY	Vaccinium spp.	F1,F1B,F2B,F3,F3B,F4, F5,SB5, SD1
CHICKWEED	Stellaria spp.	SA2
CLOVER, HOP	Trifolium agrarium	E2
COLTSFOOT	Tussilago farfara	SE1
DANDELION	Taraxacum officinale	SA5
DOGWOOD	Cornus spp.	S3B,SB5
DOGWOOD, ALTERNATE-LEAF	Cornus alternifolia	S1B
DOGWOOD, FLOWERING	Cornus florida	F1,F3B,F4,F5,S3,SB5, SD1,SE1,SG1
FERN, CHRISTMAS	Polystichum acrostichoides	S3B,S3
FORGET-ME-NOT	Myosotis scorpioides	S3B
GALAX	Galax aphylla	S3B,SB1
GARLIC, WILD	Allium vineale	SA5,SF1
GILL-ON-THE-GROUND	Glecoma hederacea	SG1
GRAPE	Vitis spp.	S1B,SG1
GREENBRIER	Smilex spp.	F1,F1B,F2B,F4,F5,S1B, SB5,SD1,S3,S3B,SE1, SG1
HAZEL, WITCH	Hamamelis virginiana	F3,F4,S1B,S3,S3B,SB5, SD1,SE1,SG1
HEMLOCK, CAROLINA	Tsuga carolinensis	F1,SB5
HICKORY	Carya spp.	S3B,SIB,F5,S3
HICKORY, BITTERNUT	Carya cordiformis	SG1
HONEYSUCKLE, JAPANESE	Lonicera japonica	SA5,SG1
HOPS, WILD	Humulus lupulus	SF1
IRIS	Iris spp.	F2B
IRONWOOD	Ostrya virginiana	SD1
IVY, POISON	Toxicodendron radicans	SA5,SG1
LAUREL, MOUNTAIN	Kalmia latifolia	F1,F1B,F2,F2B,F3,F3B, F4,F5,S1B,S3B,SB5, SD1,SE1
MAPLE, RED	Acer rubrum	E5,F1,F2B,F3B,F4,F5, S1B,S3,S3B,SB5,SD1, SE1
MAYFLOWER	Epigaea repens	F2B
OAK	Quercus spp.	F1B,F2,F3B,F4,S1B S3B,SB5,SD1
OAK, BLACK	Quercus velutina	S3B
OAK, BLACKJACK	Quercus marilandica	F2
OAK, CHESTNUT	Quercus prinus	F1B,F2,F2B,F3,F3B F4,S1B,S3B,SB5,SD1
OAK, RED	Quercus rubra	F1,F3B,F4,SB3,SB5
OAK, SCARLET	Quercus coccinea	F1B,F2B,F5
OAK, SWAMP WHITE	Quercus bicolor	SG1
OAK, WHITE	Quercus alba	F1,F2,F4,F5,S3, S3B,SB5,SE1
ONION, WILD	Allium canadense	SA5,SF1,SG1

TABLE 3 cont'd

Plants Observed in the Dixie Caverns Study Area

Common Name	Scientific Name	Station No.
PARSLEY, HEMLOCK	Conioselinum chinense	SG1
PINE, PITCH	Pinus rigida	E5,F1,F1B,F2,F2B, F3,F5
PINE, TABLE-MOUNTAIN	Pinus pungens	E5
PINE, VIRGINIA	Pinus virginia	E5,F2,F3B
PINE, WHITE	Pinus strobus	SE1
RASPBERRY, BLACK	Rubus occidentalis	SA5
REDCEDAR, EASTERN	Juniperus virginiana	SG1
SASSAFRAS	Sassafras albidum	F1,F2,F2B,F3,F3B, F5
SERVICEBERRY	Amelanchier spp.	F3,F4,S1B,S3,S3B
SORREL, WOOD	Oxalis stricta	E4
SPEEDWELL	Veronica spp.	SG1
SPEEDWELL, CORN	Veronica arvensis	E1,E3
SPICEBUSH	Lindera benzoin	S3B,SE1,SG1
STRAWBERRY	Fragaria canadense	S3B,SG1
SYCAMORE	Platanus occidentalis	SB1,SG1
TREFOIL, BIRDSFOOT	Lotus corniculatus	SA5
TUPELO, BLACK	Nyssa sylvatica	F1,F1B,F2,F2B,F3, F3B,F5
TULIP-TREE	Liriodendron tulipifera	F1,S3,SB1,SB5,SD1
VETCH	Vicia spp.	E1
VIOLET, ROUNDLEAF	Viola rotundifolia	S1B
WALNUT, BLACK	Juglans nigra	SA5
WATERCRESS	Nasturtium officinale	E1
WINTERGREEN, STRIPED	Chimaphila maculata	F1,F2,F2B,F4,S3B

three reference riparian quadrats were designated S1B, S2B, and S3B. See Figure 1 for the location of the riparian, forest and emergent vegetation sample sites. Because the vegetation analysis was performed in March, many herbaceous plant species had yet to develop sufficiently for identification, particularly in the case of composites which typically flower from early summer to fall. Trees and shrubs were in winter condition, or in early stages of bud-break, which occasionally hampered the identification of less familiar species. Detailed information on the observed vegetation can be found in Appendix C.

The vegetation observed at the forested areas, emergent areas, and riparian areas will be discussed, respectively. The reference areas, where applicable, will be discussed first, followed by the sample quadrats for each of the vegetative types above.

Forested Quadrats - The herb layer at reference quadrat F1B consisted of seedlings of woody species, with blueberry dominant. There were no bryophytesobserved. The shrub layer consisted of blueberry and mountain laurel. Greenbrier was the only woody vine observed. Sapling species included black tupelo, pitch pine, scarlet oak, and chestnut oak. The tree species observed were pitch pine, chestnut oak, and scarlet oak.

The herbs identified at reference quadrat F2B were mayflower, striped wintergreen, an iris species, and various seedlings of woody plants. Moss and lichens were the bryophytes observed. The shrub species were mountain laurel and blueberry. Greenbrier was the only woody vine. Sapling species observed were tupelo, sassafras, and chestnut oak. The trees species observed were scarlet oak, chestnut oak, and pitch pine.

The herb layer at reference station F3B consisted of strawberry and seedlings of woody plants, with blueberry dominant. Moss and lichens were the bryophytes observed. The shrub layer consisted of blueberry and mountain laurel. There were no woody vines. Sapling species observed were red maple, black tupelo, sassafras, flowering dogwood, Virginia pine, and an oak species. The trees observed were pitch pine, chestnut oak, and scarlet oak.

The herbs identified at quadrat F1 consisted of striped wintergreen and a grass. Lichens were the only bryophyte observed. The shrub species included mountain laurel and blueberry. Greenbrier was the only vine. Saplings included pitch pine, red maple, black tupelo, flowering dogwood, red oak, sassafras, Carolina hemlock, and tulip-tree. Pitch pine and white oak were the tree species.

The only herb observed at quadrat F2 was striped wintergreen. Moss and lichens were the bryophytes observed. Shrub species include blueberry and mountain laurel. There were no woody vines observed. Sapling species included sassafras, Virginia pine, black tupelo, and an oak species, and tree species included white oak, pitch pine, chestnut oak, and blackjack oak.

There were no herbs or bryophytes observed at sample quadrat F3, but the herb layer was occupied by an often thick layer of lowbush blueberry and mountain laurel. Shrubs observed included sassafras and witch hazel, along with mountain laurel and blueberry. There were no woody vines observed. Saplings included serviceberry, black tupelo, and pitch pine. The trees observed were pitch pine and chestnut oak.

The only herb observed at quadrat F4 was striped wintergreen. There were no bryophytes observed. The shrubs observed were witch hazel, blueberry and mountain laurel. The only woody vine observed was greenbrier. Sapling species included serviceberry, red maple, flowering dogwood, and an oak species. Trees species observed were red oak, chestnut oak, red maple, and white oak.

There were no herbs or bryophytes observed to be at quadrat F5. The herb layer was occupied by an often thick layer of lowbush blueberry, in combination with mountain laurel and some greenbrier. These same species also comprised the shrub and woody vine layers. Saplings include black tupelo, sassafras, red maple, flowering dogwood and a hickory species. Trees included pitch pine, scarlet oak, and white oak.

Emergent (Field) Quadrats - The herbs observed at quadrat E1 include watercress, corn speedwell, grass, a vetch species, and a bedstraw species. Grasses dominated the site. Moss was the only bryophyte observed. There were no woody species observed.

The herbs observed at quadrat E2 include grass and hop clover. Grass was dominant. Moss was the only bryophyte observed. There were no woody species observed. This site appeared to have been disturbed within the last two or three years.

The herbs at quadrat E3 include grass, corn speedwell, an unknown mustard and an unknown composite. Moss was the only bryophyte observed. There were no woody species observed.

The herbs at quadrat E4 included wood sorrel, bittercress, two undetermined composites, broomsedge, and two other grass species. Lichen and moss were the bryophytes observed. There were no woody plants observed. Broomsedge was dominant at this site.

The herbs at quadrat E5 consisted of bedstraw, broomsedge, bittercress, an undetermined mustard species, and an undetermined composite. There were no shrubs or woody vines. The sapling species consisted of pitch pine, Virginia pine, and red maple. The tree species consisted of table-mountain pine, Virginia pine, and pitch pine.

Riparian Quadrats - Herbs observed at reference station S1B include galax and round-leaf violet. Moss was the only bryophyte observed. Shrub species observed were witch hazel, alternate-leaf dogwood, and mountain laurel. Grape and greenbrier were the woody vines observed. Saplings observed were red maple, serviceberry, an oak, and a hickory species. Trees observed were black birch, chestnut oak, sycamore, tulip-tree, and serviceberry.

Herbs observed at reference quadrat S2B (same location as SG-1) consisted of wild onion, ground ivy, bedstraw, grass, hemlock parsley, strawberry, and a speedwell. Moss was the only bryophyte observed. Japanese honeysuckle was the dominant groundcover. Grape, poison ivy and greenbrier were the woody vines observed. Spicebush and witch hazel were the only shrubs observed. Flowering dogwood, bitternut hickory, sycamore and eastern redcedar were the saplings observed, and green ash, sycamore, and swamp white oak were the trees.

Herbs observed at reference station S3B included galax, christmas fern, striped wintergreen, a grass, and forget-me-not. Moss and lichens were the bryophytes observed. Shrub species observed were spicebush, witch hazel, dogwood, blueberry and mountain laurel. Greenbrier was the only woody vine observed. Sapling species observed were serviceberry, red maple, an oak, and a hickory species. Trees observed were chestnut oak, black oak and a hickory.

The herbs at S1 (same location as SE-1) consisted of pennywort, coltsfoot and beechdrops. Moss and lichens were the bryophytes observed. Witch hazel, spicebush, azalea, mountain laurel, and blueberry were the shrubs observed. Greenbrier was the only woody vine. Saplings included flowering dogwood, black birch, red maple, green ash, white pine, and beech, and white oak, beech, chestnut oak, and red maple were the tree species.

Lichens were the only bryophytes observed at quadrat S2 (same location as SD-1). The herb layer consisted of seedlings of the various woody species from the shrub and tree layers. Greenbrier and mountain laurel were the dominant seedlings in the herb layer. Shrubs consisted of witch hazel, blueberry, and mountain laurel. Greenbrier was the only woody vine observed. Ironwood, tulip-tree, and flowering dogwood were the saplings observed, and red maple and red oak were the only trees observed.

The herb layer observed at S4 (same location as SB-6) consisted of grass, two species of lilies, and several woody seedling species. Moss and lichens were the bryophytes observed. Witch hazel and blueberry were the shrub species identified, and greenbrier was the only woody vine. Sapling species included red maple, tulip-tree, flowering dogwood, and an unidentified oak. Tree species include tulip-tree, red oak, chestnut oak, and white oak. Red oak was the dominant tree.

The herb layer at S3 was dominated by Christmas fern and greenbrier. Other species in the herb layer were young red maple, mosses, grass, and an unidentified mint and fern. Witchhazel was the only shrub observed. Greenbrier was the only woody vine. Saplings included tulip-tree, flowering dogwood, serviceberry, white oak, and hickory. Tree species included tulip-tree, and red maple.

The vegetation at S5 (same location as SA-5) did not include a shrub layer or tree canopy. The herbaceous layer includes japanese honeysuckle, common dandelion, chickweed, wild onion, grass, bittercress, wild garlic, birdsfoot trefoil, and a lily. Japanese honeysuckle was the dominant groundcover. Moss was also observed. Woody species in the herbaceous layer include green ash, black walnut, and red raspberry. The vegetation at this sample quadrat was strongly influenced by roadside maintenance to the south and quarry-related activities to the north.

The herbs at quadrat S6 (same location as SF-1) consisted primarily of wild hops, with some field garlic and wild onion. No woody vegetation or bryophytes were observed.

Comparison of Vegetation to Reference - The abundance, distribution, and diversity of the forest and riparian quadrats were statistically compared to those of the reference quadrats. The emergent quadrats were not statistically analyzed because there was no appropriate reference vegetation in the vicinity of the study area. The average values obtained from the three reference stations ($\bar{x}_R$) will be used for the statistical comparisons. Each of the five vegetative subgroups (trees, shrubs, saplings, vines, and herbs) had the following three tests performed.

Species Diversity:

Large species diversity in a plant community is not necessarily indicative of a "good" habitat quality. For example, a mature red oak forest may have a relatively low diversity but still be good habitat. In contrast, relatively high diversities may be found in disturbed areas having many opportunistic species. The key is the relative diversity of a reference station(s) compared to the diversity of the station of comparison.

The species diversity comparison will involve the following equation:

$$D_v = |D_{rx} - D_x|.$$

Where:

D_v = diversity comparison value

D_{rx} = average number of different species in the reference stations

D_x = number of different species in the on-site station.

Community Loss Index:

The Community Loss Index (CLI) measures the loss of plant species at a quadrat by comparing the quadrat diversity with that of the average of the reference quadrats. This index is a variant of the community loss index developed by Courtemaunch and Davies (1987), adapted for vegetative analysis. The index measures plant community dissimilarity between a test quadrat and reference quadrats, with index values increasing as the dissimilarity from the reference station increases.

The formula is:

$$CLI = \frac{d_{rx} - a}{e}$$

d_{rx} = total average number of species present in the reference quadrats

a = number of species common to both the reference quadrats and the quadrat of comparison

e = total number of species present in the quadrat of comparison

CHI-SQUARE Goodness-of-Fit:

The Chi-Square compares the distribution of species populations of the average of the reference quadrats to the test quadrats (Zar, 1984, pp. 40-60). Shifts in distribution may suggest ecological stress. The following formula will be used:

$$X^2 = \sum_{i=1}^{k} \frac{(f_i - f_{irx})^2}{f_{irx}}.$$

f_i = number of the i species occurrences at the quadrat of comparison

f_{irx} = average number of the i species occurrences at the reference quadrats

Once the X^2 value is obtained, the associated probability of occurrence value (α) is determined (Zar 1984) and recorded. The α will be used for test scoring.

Scoring of Tests:

Once all the calculations were performed, the scores were totaled and compared to the average score of the reference quadrats. Scoring values ranged from 0 to 5, with five being the best score. The percent comparison between the total scores provides a final evaluation of the vegetative condition at the quadrats of comparison. The Values obtained may fall between established ranges. In these cases, the professional judgement of the ecologist(s) will be used in determining the final evaluation. Details of the calculations can be found in Appendix C.

Results of Forested Vegetation:

All forest quadrats were found to be minimally comparable (60-70% comparability) to the average of the reference quadrats. The primary difference among forest quadrats was related to the distribution of the vegetation in the middle and lower vegetative layers (herb, woody vine, and shrub layers). The difference can be attributed to the location of the quadrats and the stage of succession the forest quadrats appeared. The reference quadrats appear to be at or approaching the climax stage of the forest type earlier described. The forest quadrats of comparison appear to be in a slightly earlier stage. Differences do not appear to be related to site contamination, but may be related to human disturbance in the vicinity of the quadrats.

Results of Riparian Vegetation:

Quadrats S1 and S4 were found to be slightly comparable to the average of the reference quadrats. Quadrats S2, S3, S5, and S6 were found to be non-comparable (<59% comparability) to the average of the reference quadrats. Differences between quadrats S1 and S4 and the reference quadrats were primarily related to the distribution in the middle and lower vegetative layers. Quadrats S5 and S6 lacked a shrub, sapling and tree layer, which accounts for the non-comparability. Quadrats S2 and S3 were at slightly higher elevations and appeared to be undisturbed areas. The differences may also be related to the lower quality soils found at this location. "Lower quality soils" refers to the dry, thin layer of soil that is low in nutrients, typical of that found in the present forest type.

Although differences were found among the vegetative quadrats, there does not appear to be any site related stress. The only exception may occur in the vicinity of the hillside pine growth on the western portion of the site, where what appeared to be stunted growth was observed. The stunted growth can not be definitively linked to the site, because poor soil and arid conditions are present at this location.

Site Terrestrial Wildlife - It is more appropriate to discuss terrestrial wildlife in terms of the entire study area than to separate forest, field, and stream wildlife because many vertebrates are quite mobile and can be found in all of these habitat types. This tends to make the discussion of the wildlife of the separate habitat types redundant.

Bird species observed on the site property included the turkey vulture, Red-tailed hawk, mourning dove, common flicker, pileated woodpecker, downy woodpecker, hairy woodpecker, eastern phoebe, American crow, Carolina chickadee, tufted titmouse, Carolina wren, northern mockingbird, eastern bluebird, brown thrasher, European starling, common grackle, northern cardinal, rufous-sided towhee, slate-colored junco, nuthatch, and the song sparrow. Also detected was a warbler that was thought to be a chestnut-sided warbler. The presence of the red-tailed hawk suggests the presence of a small-mammal population, although the vegetation on the landfill is sparse in many areas, offering limited cover for small mammals. The pileated woodpecker is an uncommon species associated with the surrounding woods. Woodpeckers and the eastern phoebe tend to be associated more with forest than with open areas, while bluebirds, song sparrows, and starlings are more associated with open areas. The chestnut-sided warblers were probably beginning their northward migration. Their presence indicates that the site may be used by any of a large variety of migrant birds. The birds observed are typical of those found in the habitats described and season of the visit.

Deer and small mammal signs were observed both in the wooded area and on the disturbed portions on the site. Dusky salamanders were observed at stream stations S3 and S2B. Domestic dogs were also observed on the landfill.

AQUATIC INVESTIGATION

Six stations were sampled for the aquatic phase of the investigation. Benthic macroinvertebrate collections taken at each of the six stations were on the unnamed tributaries to the Roanoke River, and were designated with an "S," plus the letter assigned to the tributary, and a number (e.g. SD-1). In addition, aquatic and riparian habitat evaluations were performed at each station. SG-1 was used as the reference station. Each of the six sample stations were located in the center of one of the riparian quadrats (SG-1 = S2B, SF-1 = S6, SA-5 = S5, SE-1 = S1, SD-1 = S2, and SB-6 = S4; Figure 1). The aquatic communities at the stream sample stations were evaluated. Eight metrics were used for the comparison. The results are presented below, with the reference station being discussed first. A discussion of the bioassays follows the stream evaluation discussion.

<u>Benthic Macroinvertebrate Investigation</u>

Station SG-1 (Reference): Sample station SG-1 was located approximately 200 yards upstream of it's confluence with stream F. The area surrounding the station consisted primarily of woodland, plus a maintained residence and small sections of field.

The stream habitat analysis indicated excellent habitat qualities at the reference station. The stream section sampled had excellent substrate and instream cover, channel morphology, and riparian and bank cover typically found in mountain streams.

Estimated stream flow was 8 ft^3/s. The stream consisted of approximately 20% riffle, 70% run, and 10% pool. Cobble was the dominant inorganic substrate, and detritus was the dominant organic substrate. Evidence of detritus decomposition was observed. Detritus decomposition is often indicative of a population of microorganisms present in an unimpaired stream. The stream had an approximately 75% canopy cover.

Periphyton at SG-1 was common. No filamentous algae, slime or macrophytes were observed.

The riffle/run sample at the reference station had a diversity of fifteen (13) taxa, ten (10) of which were representative of Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa. EPT organisms constituted 83% of the total invertebrates collected. Filterers/collectors constituted 88% of the total number of organisms, while scrapers constituted approximately 0.6% of the organisms. Chironomids made up 0.6% of the organisms identified. A dusky salamander was present at this station. A significant percentage of the organisms collected are considered pollution sensitive. No fish were observed.

The Coarse Particulate Organic Material (CPOM) sample had a diversity of seventeen (17) taxa, twelve (12) of which were representative of EPT taxa.

EPT organisms constituted 84% of the total population identified. Shredders constituted 15% of the total CPOM population identified. Chironomids constituted 0.8% of the total CPOM population identified. No amphibians or fish were observed.

Stream community evaluations for the each of the ecological sampling stations were made by comparing various community parameters at the sampling stations of comparison against those of the reference station. Eight (8) metrics are used for community comparisons, as per Plafkin *et al.* (1989). The first seven (7) metrics compare the riffle/run community of a given station of comparison against the reference station riffle/run community. The eighth metric compares the CPOM community of a given station of comparison against the reference station CPOM community. The eight metrics are: (1) taxa richness, (2) the modified Family Biotic Index (FBI), (3) the ratio of scrapers to filterers, (4) the ratio of EPT (Ephemeroptera, Plecoptera and Trichoptera) to Chironomidae, (5) percent contribution of dominant family, (6) the EPT index, (7) the Community Loss Index (CLI), and (8) the ratio of shredders to total number of organisms collected. The results of all tests are scored as follows: 6 = Non-Impaired; 3 = Moderately Impaired; and 0 = Severely Impaired. The final assessment of potential impairment is made based on the percent comparison of the total score of a given station of comparison to the total score of the reference station. More detailed scoring data can be found in Table 2.

1. Taxa richness is simply defined as the number of taxa found at the site. A diverse community (10 taxa or more) is an indicator of a healthy community. The reference station (SG1) had a diversity of thirteen (13) taxa, indicating a healthy riffle/run community existing in headwaters of this area.

2. The Family Biotic Index metric, modified from Hilsenhoff (1982), is indicative of the sensitivity of the aquatic community, with a value of

zero (0) being most sensitive and a value of ten (10) being most tolerant. The FBI value at the reference station was 4.17, which indicates a fairly sensitive aquatic community.

3. The ratio of scraper and filtering collector functional feeding groups ("scrapers" and "filterers," respectively) reflect the riffle/run community food base. Scrapers are more abundant when there is an abundant periphyton community. Filterers are dominant when there are abundant attachment sites and fine particulate organic material (FPOM). The reference station had one (1) scraper and 140 filterers (value = 0.007). The scraper population is lower than expected based on the abundance of periphyton, the food source of scrapers. Scraper populations were, however, relatively low at all stations and relatively low scraper populations could be a general characteristic of the streams of this area.

4. The ratio of EPT to Chironomid abundance is a metric of community structure. Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) are sensitive to water quality. The Chironomidae (midges) can be quite tolerant to poor water quality, but are found in healthy waters constituting a relatively lower ratio of the organisms in healthy streams. In other words, a strong representation of EPT indicates a healthy community, but a strong representation of Chironomidae suggests impairment. The reference station had a ratio of 134/1 (value = 134.0) indicating a healthy community structure.

5. The percent contribution of the dominant family is a metric that indicates community balance. In many cases a community with few dominant taxa is indicative of environmental stress. A low percent contribution of the dominant family (< 30%) typically suggests a healthy community. Heptageniidae, a mayfly family, was dominant at the reference station, and comprised 64% of the total number of organisms.

This is a rather strong representation of the dominant family, but Heptageniidae is a sensitive family, and a strong representation of a sensitive family often suggests healthy conditions.

6. The EPT index is a metric that increases as water quality improves. The EPT index value summarizes the taxa richness within the insect groups that are generally pollution sensitive. An EPT index value of 7 or more is usually indicative of a health community. The reference station has an EPT index value of nine (9), which is excellent.

7. The CLI is a measure of dissimilarity that assesses the loss of benthic taxa between the reference and the station of comparison. Increased dissimilarity reflects a community shift that could potentially be brought on by the loss of sensitive taxa due to ecological stress. A higher CLI value indicates greater dissimilarity. A CLI value can not be calculated for the reference station alone because it is a relative value.

8. The ratio of individuals in the shredder functional feeding group ("shredders") versus total individuals collected in the CPOM sample is a metric used to measure impairment of the CPOM shredder community. A lower value indicates greater impairment. The ratio at the reference station was 18/118 (value = 0.15). This is considered a fair ratio. Little detritus was present at this station, which would explain the low shredder numbers.

The metrics at the reference station are indicative of a healthy aquatic community. Much of the population observed is considered sensitive to poor water quality. The percent contribution of the dominate family is high (64%), but the dominant family is sensitive to water quality and the relatively high value of this metric, and low value of the scraper-to-filterer ratio is probably a function of the habitat.

Station SF-1: Station SF-1 was located on stream F, about 50 yards upstream from Route 460, about 150 yards upstream from its confluence with the Roanoke River. The area surrounding the station was open, mostly maintained as a lawn except along the stream banks themselves. The stream banks had a steep grade, and the bank vegetation was cut back often enough to be maintained as herbaceous growth.

The stream habitat at SF-1 was comparable to the reference station, although SF1 lacks canopy cover. Good to excellent substrate, stream cover, channel morphology, and riparian and bank structure were observed.

Estimated stream flow was 23.0 ft^3/s. The stream consisted of approximately 20% riffle, 55% run, and 25% pool. Cobble was the dominant inorganic substrate, and detritus was the dominant organic substrate. Evidence of detritus decomposition was observed. The stream had no canopy cover.

Filamentous algae at SF-1 was common, and periphyton was present. No slime or macrophytes were observed.

The riffle/run sample at SF-1 had a diversity of fourteen (14) taxa, seven (7) of which were EPT representatives. EPT organisms constituted 72% of the total population identified. Filterers/collectors constituted 29% of the total population, while scrapers constituted approximately 0.6% of the population. Chironomids made up 17% of the population. A significant percentage of the organisms collected are considered sensitive to pollution. No fish or amphibians were observed, although numerus fish eggs were present.

The CPOM sample had a diversity of sixteen (16) taxa, twelve (12) of which were representative of EPT taxa. EPT organisms constituted 84% of the total population identified. Shredders constituted 49% of the total CPOM population identified. Chironomids constituted 2% of the total CPOM population identified. No amphibians or fish were observed.

1. Many of the fourteen (14) families of macroinvertebrates in the riffle/run sample are sensitive to poor water quality. The taxa richness of this station indicates a healthy aquatic community.

2. The modified FBI gave a value of 3.40. The FBI at this station indicates a sensitive aquatic community.

3. One (1) scraper and forty-nine (49) collectors (value = 0.02) were present at the sample station, suggesting the presence of FPOM needed for a healthy collector population.

4. The EPT:Chironomidae ratio was 122/29 (value = 4.2), indicating an extremely healthy community.

5. The percent contribution of the dominant family (Nemouridae) was 41%. This indicates fair community balance, with the dominant family being sensitive to pollution.

6. The EPT index value was seven (7), indicating a healthy aquatic community.

7. The CLI value was 0.29, which is indicative of a aquatic community similar to that of the reference station.

8. The ratio of shredders to total organisms collected was 100/204 (value = 0.49). This ratio indicates a healthy community structure in the CPOM.

The overall ecological assessment of the aquatic community indicates healthy conditions.

Station SA-5: Sample station SA-5 was located along Twine Hollow Road, immediately south of the limestone quarry. The area surrounding the sample station consisted of the road, the quarry, and shrubs and small trees on the banks of the stream. The south bank at the sample station had large, flat blocks of concrete on the stream bank. The northern streambank was adjacent to the Twine Hollow Road. The shrubs and trees had been removed from along the streambanks.

The habitat at SA-5 was found to be comparable to the reference station. Good substrate and instream cover, channel morphology, and riparian and bank structure were observed.

Estimated stream flow was 4.5 ft^3/s. The stream consisted of approximately 25% riffle, 50% run, and 25% pool. Cobble and bedrock were the dominant inorganic substrates, and detritus was the dominant organic substrate. Evidence of detritus decomposition was observed. The stream had no canopy cover.

Filamentous algae and periphyton was present at this station. No macrophytes or slime were observed.

The riffle/run sample at SA-5 had a diversity of eleven (11) taxa, eight (8) of which were representative of EPT taxa. EPT organisms constituted 90% of the total population identified. Filterers/collectors constituted 80% of the total population, while scrapers constituted approximately 1% of the population. Chironomids made up 1% of the population. Many of the organisms collected are considered sensitive to pollution. No amphibians or fish were observed.

The CPOM sample had a diversity of ten (10) taxa, five (5) of which were representative of EPT taxa. EPT organisms constituted 34% of the total population identified. Shredders constituted 71% of the total CPOM population identified. Chironomids constituted 2% of the total CPOM population identified. No amphibians or fish were observed.

1. Many of the eleven (11) families of macroinvertebrates in the riffle run sample are sensitive to poor water quality. The taxa richness of this station indicates a healthy aquatic community.

2. The modified FBI gave a value of 4.57. The FBI at this station indicates a moderately tolerant aquatic community.

3. One (1) scraper and seventy-four (74) collectors (value = 0.014) were present at the sample station, suggesting the presence of FPOM needed for a healthy collector population.

4. The EPT:Chironomidae ratio was 80/1 (value = 80.0), indicating a healthy community.

5. The percent contribution of the dominant family (Heptageniidae) was 55%. This is a relatively high value, however, the dominant family is sensitive to pollution.

6. The EPT index value was eight (8), indicating a healthy aquatic community.

7. The CLI value was 0.54, which is indicative of a moderately similar aquatic community, when compared to the reference station. Dissimilarity appears to be caused by seasonal fluctuations in flow and habitat shifts (i.e., large amounts of bedrock, etc.).

8. The ratio of shredders to total organisms collected was 44/62 (value = 0.71). The metric is evaluated to be indicative of a good community structure in this stream type.

The overall ecological assessment of the aquatic community indicates healthy conditions.

Station SE-1: Sample station SE-1 was located on stream E, immediately downstream of the mixing zone, below the confluence of streams B and D.

The habitat at SE-1 was somewhat different from the reference station. However, good substrate and instream cover, channel morphology, and riparian and bank structure were observed.

Estimated stream flow was 3.4 ft^3/s. The stream consisted of approximately 30% riffle, 30% run, and 40% pool. Cobble was the dominant inorganic substrate, and detritus was the dominant organic substrate. Evidence of detritus decomposition was observed. The stream had an approximately 55% canopy cover.

Macrophytes and filamentous algae at SE-1 were common and little periphyton was present. No slime was observed.

The riffle/run sample at SE-1 had a diversity of ten (10) taxa, six (6) of which were representative of EPT taxa. EPT organisms constituted 77% of the total population identified. Filterers/collectors constituted 94% of the total population, while scrapers were not represented. Chironomids made up 0.2% of the population. No amphibians or fish were observed.

The CPOM sample had a diversity of fifteen (15) taxa, eleven (11) of which were representative of EPT taxa. EPT organisms constituted 89% of the total population identified. Shredders constituted 13% of the total CPOM population identified. Chironomids constituted 1.2% of the total CPOM population identified. No fish or amphibians were observed.

The diversity of organisms in the riffle/run sample was lower than found at the reference, but a high percentage of the organisms collected are considered sensitive to pollution.

1. Many of the ten (10) families of macroinvertebrates in the riffle run sample are sensitive to poor water quality. The taxa richness of this station indicates a moderately healthy aquatic community.

2. The modified FBI gave a value of 4.52. The FBI at this station indicates a moderately sensitive aquatic community.

3. No scrapers and twenty-five (25) collectors (value = 0.0) were present at the sample station, suggesting the presence of FPOM needed for a healthy collector population, and little periphyton.

4. The EPT:Chironomidae ratio was 81/2 (value = 40.5), indicating a healthy community.

5. The percent contribution of the dominant family (Heptageniidae) was 45%. This value is relatively high, but the dominant family is sensitive to pollution.

6. The EPT index value was six (6). When compared to the reference station, this metric indicates potential stress.

7. The CLI value was 0.57, which is indicative of an aquatic community moderately similar to the reference station.

8. The ratio of shredders to total organisms collected was 11/84 (value = 0.14). This value is very similar to the reference. This indicates a CPOM community structure similar to that found at the reference.

The overall ecological assessment of the aquatic community indicates moderate stress.

Station SB-6: Sample station SB-6 was located on stream B, 200 feet upstream of it's confluence with steam E. The area surrounding station SB6 was forested.

The habitat at SB-6 was found to be somewhat different from the reference station. Estimated stream flow was 1.15 ft^3/s. The stream consisted of approximately 40% riffle, 40% run, and 20% pool. Sand and silt were the dominant inorganic substrata, and detritus was the dominant organic substrate. Little evidence of detritus decomposition was observed. The stream had an approximately 50% canopy cover.

Slime was dominant at this station. No macrophytes, filamentous algae, or periphyton was observed.

The riffle/run sample at SB-6 had a diversity of eight (8) taxa, five (5) of which were representative of EPT taxa. EPT organisms constituted 72% of the total population identified. Filterers/collectors constituted 45% of the total population, while scrapers constituted approximately 9% of the population. Chironomids made up 9% of the population. No amphibians or fish were observed.

The CPOM sample had a diversity of eight (8) taxa, five (5) of which were representative of EPT taxa. EPT organisms constituted 47% of the total population identified. Shredders constituted 26% of the total CPOM population identified. Chironomids constituted 32% of the total CPOM population identified. No fish or amphibians were observed. Low numbers of organisms were collected at this station.

1. Many of the eight (8) families of macroinvertebrates in the riffle run sample are sensitive to poor water quality. The taxa richness of this station indicates a moderately impaired community.

2. The modified FBI gave a value of 3.89. The FBI at this station indicates a moderately sensitive aquatic community. This metric may be misleading due to the low number of organisms collected.

3. No scrapers and five (5) collectors (value = 0.0) were collected at the sample station, suggesting a decrease of FPOM needed for collectors, and a lack of periphyton.

4. The EPT:Chironomidae ratio was 8/1 (value = 8.0), indicating a healthy community.

5. The percent contribution of the dominant family (Nemouridae) was 30%. This indicates good community balance.

6. The EPT index value was five (5), indicating a moderately unhealthy aquatic community.

7. The CLI value was 0.88, which is indicative of a aquatic community shift from that of the reference station, suggesting potential impairment.

8. The ratio of shredders to total organisms collected was 5/19 (value = 0.26). The metric is evaluated to be indicative of a healthy aquatic community in this stream type.

The overall ecological assessment of the aquatic community indicates that impairment exists when compared to the reference station. The habitat does appear to be somewhat different from the reference station (lacking attachment sites). The diversity and especially the numbers of collected benthics are low compared to the reference station.

Station SD-1: Sample station SD-1 was located on stream D, approximately 50 yards upstream from it's confluence with stream E. The area surrounding the station consisted of woodlands.

The habitat at SD-1 was found to be comparable to the reference station. Good to excellent substrate and instream cover, channel morphology, and riparian and bank structure were observed. Estimated stream flow was 2.25 ft^3/s. The stream consisted of approximately 45% riffle, 35% run, and 20% pool. Cobble was the dominant inorganic substrate, and detritus was the dominant organic substrate. Evidence of detritus decomposition was observed. The stream had an approximately 60% canopy cover.

Macrophytes at SD-1 were common, and filamentous algae was rare. No slime or periphyton was observed.

The riffle/run sample at SD-1 had a diversity of ten (10) taxa, nine (9) of which were representative of EPT taxa. EPT organisms constituted 98% of the total population identified. Filterers/collectors constituted 74% of the total population, while scrapers constituted approximately 11% of the population. Chironomidae was not represented in the sample. A significant percentage of the organisms collected are considered sensitive to pollution.

The CPOM sample had a diversity of twelve (12) taxa, nine (9) of which were representative of EPT taxa. EPT organisms constituted 93% of the total population identified. Shredders constituted 35% of the total CPOM population identified. Chironomids constituted 2% of the total CPOM population identified. A dusky salamanders was observed.

1. Most of the ten (10) families of macroinvertebrates in the riffle run sample are sensitive to poor water quality. The taxa richness of this station indicates a healthy aquatic community.

2. The modified FBI gave a value of 3.43. The FBI at this station indicates a sensitive aquatic community.

3. Five (5) scrapers and thirty-four (34) collectors (value = 0.147) were present at the sample station, suggesting that the scrapers are using the macrophytes as a food source, and the presence of FPOM for a good collector population.

4. The EPT:Chironomidae ratio was 45/0 (value = ∞). This indicates a healthy community. The absence of chironomids is not especially surprising given that they are at relatively low abundances at most of the stations.

5. The percent contribution of the dominant family (Heptageniidae) was 57%. This is relatively high, but the dominant family is relatively sensitive to pollution.

6. The EPT index value was nine (9), indicating a healthy aquatic community.

7. The CLI value was 0.60, which is indicative of a moderately different aquatic community, when compared to the reference station. The community shift may be caused by a difference in food sources.

8. The ratio of shredders to total organisms collected was 19/54 (value = 0.35). The metric is evaluated to be indicative of a moderately healthy aquatic community in this stream type.

The overall ecological assessment of the aquatic community indicates good conditions. The numbers collected at station SD-1 were reduced compared to the reference, however, the stream flow is affected by seasonal changes which could account for the lower numbers.

<u>Toxicity Test Results</u> - There were three toxicity tests performed at the DCL site study area. The tests were performed using samples collected from SG-1, SF-1, SA-5, and SB-7. A copy of the bioassay results is found in Appendix C.

Surface Water: Two toxicity tests were performed using surface water samples. The first test performed was a static, chronic bioassay using *Ceriodaphnia dubia*. Results of the surface water sample taken from SG-1 indicated 20% survival rate when exposed to a 100% concentration of solution. 100% concentration of surface water taken from SF-1 resulted in 0% survival. There were no data received on any possible dilutions involving surface water from SG-1 or SF-1. A dilution series factor of 0.5 was performed on surface water collected from SA-5 and SB-7. Results involving SA-5 surface water indicated a lowest observable effect concentration (LOEC) at 100% sample concentration, and a no observable effect concentration (NOEC) at 50% sample concentration. Results from the test of the surface water collected from SB-7 indicated the survival and reproduction LOEC to be 6.25% and the NOEC to be 3.1% concentration. However, 100% mortality was reported at 1.5% which was reported to be non-site related. While this test was being performed, laboratory equipment malfunctions occurred resulting in multiple restarts of tests. Additionally, the sample locations which have been reported to be uncontaminated through chemical sampling and benthic investigation were reported toxic to the test organism. Possible explanations may be that poor laboratory procedures were employed or that the test organism was not compatible with the medium. Results of this test will not be used in the risk assessment because of the uncertainties involved.

The second surface water test was a 7 day chronic bioassay using *Pimephales promelas* (fathead minnow). During these tests, surface water collected from SA-5 and SB-7 were tested using 0.5 dilution factor. Results using surface water collected from SG-1, SF-1, and SA-5 indicated no significant toxicity. Results using surface water collected at SB-7 indicated a LOEC of 50% concentration and a NOEC at 25% concentration.

Sediments: One test was performed to evaluate the ten day chronic toxicity of the sediments using *Hyalella azteca*. No toxicity was reported related to the sediments taken from stations SG-1 and SF-1. Survival was slightly decreased at SA-5. No organisms survived during the test using the sediments collected at SB-7.

THREATENED AND ENDANGERED SPECIES

There were no threatened or endangered species observed during the site visit. This does mean that these species do not exist in the study area, however, there is no evidence suggesting otherwise.

SUMMARY OF ECOLOGICAL INVESTIGATION

Summary of Terrestrial Investigation

Vegetation - The ecological community on the disturbed portions of the landfill is a successional field (PNDI, 1983; Reschke, 1990). A "successional field" or "successional old field" is a disturbed ecological community where the original vegetation was removed and repopulated by fast growing, opportunistic species. Most of the landfill has been disturbed recently, so succession is at an early stage in which the site vegetation is comprised mostly of herbaceous plants. The composition of the herbaceous plant species over various parts of the landfill is determined mostly by the amount of time that has passed since the last major disturbance, but also partly by micro-site characteristics. Generally speaking, as a greater amount of time has passed since disturbance, the plant species at a specific site will tend to diversify, stratify vertically and horizontally, and tend to become skewed towards longer lived plant species. Several subcommunities were present on the site. In addition to these subcommunities, about 34% of the landfill was barren.

The first subcommunity is typified by station E1, located near the entrance to the site in close proximity to SWD-5. This station was wetter than the other sites. It was dominated by grass and a composite. The composite was represented in only one of the quadrat samples, but was generally distributed over the location. Watercress occurred on this site, which is an obligate wetland indicator. This subcommunity is present on the southeast portion of the site and covers about 5% of the site property.

The second subcommunity is typified by sample E2, located on the eastern portion of the landfill, east of RIW-7. This area is a dry site which had apparently been disturbed within the last two years and had been seeded with grass. Grass was dominant on the site, with moss and hop clover also present. This subcommunity covers about 5% of the landfill.

The third subcommunity is typified by sample E3 and is located to the west of the shed northeast of SWD-4. This is a dry site that is dominated by grass and an unknown composite, which differed from the composite as at station E1. There was a very small herbaceous seedling distributed over this subcommunity, and corn speedwell and a mustard were also present. Evidently this are had been disturbed 2 or 3 years ago, but was not seeded. This subcommunity covers about 8% of the site.

The fourth subcommunity is typified by E4, located in the southern portion of the solid waste disposal area. This subcommunity is dominated by broomsedge. A second, unidentified grass was also common. See the vegetation description for station E4 for a list of the other plant species at this site. This community is a type that has been left undisturbed for a longer period of time than the second or third subcommunity. The broomsedge subcommunity covers about 8% of the site and forms a continuum with the fifth subcommunity.

The fifth subcommunity is the only subcommunity on the disturbed portion of the landfill with a shrub layer. Sample station E5 is in a location that is ecologically intermediate between the fourth and fifth subcommunity. This area has been left undisturbed long enough to permit woody vegetation to grow and has succeeded into a young pine (pitch, Virginia, and table-mountain) stand that covers about 10% of the site on the southwestern part of the site, roughly from SWD-1 east to SWD-2 and nearly as far north as RIW-1. This subcommunity could be described as a southern variant of the pitch pine forest cover type where the stocking is a mix of pitch, Virginia and table-mountain pine (Eyre, 1980). This type is an intermediate successional step that, in the absence of disturbance, will succeed back into an oak-pine cover type that was the original vegetation of the landfill.

The terrestrial vegetation in the landfill is undergoing early successional growth typical of that region. There is poor surface soil present at many areas on the landfill resulting xeric conditions and relatively sparse vegetative growth. Xeric conditions and poor soil quality may be responsible for the stunted growth of some shrubs up on the ridge. Given time, the vegetation will eventually return to woodlands similar to those which surround the landfill.

The original oak-pine forest still covers about 30% of the landfill where there has been little ecological disturbance. This extends over most of the northern part of the landfill. The forest is a Chestnut Oak-Pitch pine cover type, a variant of the Chestnut Oak forest cover type (Eyre, 1980). Important associated tree species include scarlet and white oak, red oak, and black tupelo. This is a subclimax or climax forest type that occurs in dry areas, particularly on rocky outcrops, ridge-tops and southern slopes. This cover type occurs primarily in the Appalachians at elevations of 450 to 1,400 meters, but also occurs intermittently in southern New England, the Piedmont, the Catskills of New York, and the New Jersey sand plains (Eyre, 1980). The off-site forest was mature, or nearly mature, secondary or tertiary growth, but lacked the large overmature trees and the windthrown trees characteristic of a true climax forest.

Although the typical forest cover type of the area is Chestnut Oak-Pitch Pine, sites adjacent to the streams are more mesic and will locally harbor a different composition of plant species, both trees and herbaceous plants. Therefore the xeric forest stations will have a different plant composition than the stream stations that are located in the forest.

Wildlife - Wildlife found on the landfill is typical of that found in the habitats described. The birds observed have habitat preferences that range from open (i.e., bluebirds) to forested (i.e., pileated woodpecker). Birds observed are typical of those found in the habitat described and season of the visit. Populations of small mammals and game species, such as deer, were present. The wildlife population utilizing the landfill will change with time as the vegetation succeeds back into forest.

Summary of Aquatic Investigation

Benthic Macroinvertebrate Investigation - The aquatic investigation indicated a good overall aquatic community and habitat. The reference station stream characteristics and community appeared to be representative of the area. Sensitive organisms were usually dominant in the benthic collections. Diversity was good, and the numbers of organisms collected was generally good. The exceptions were at SE-1 and SB-6 where ecological stress was evident. SB-6 appears to have significant impairment, while SE-1 appears to be under moderate stress. It should be noted that the habitat, as well as potential site impacts, may contribute to the impairment at SB-6.

Summary of Bioassays - Significant toxicity was reported during each bioassay involving surface water and sediments taken from SB-7. The chronic bioassay using *C. dubia* indicated toxicity from surface water taken from all sample locations, however, these results are in question. Aside from the bioassay involving SB-7, no toxicity was reported during the 7 day chronic bioassay using *P. promelas* or the 10 day chronic bioassay using *H. azteca*. The only exception was a statistically insignificant decrease in survival of *H. azteca* using sediments taken from SA-5.

Stream Sampling Data Sheets

STREAM SAMPLING DATA SHEET

Site Name: Dixie Caverns

Township: Salem

County: Roanoke

State: Va

Sample Station (DC-EA-)	SG1	SF1	SA5	SE1	SB6	SD1
Date	3/25/91	3/25/91	3/25/91	3/26/91	3/26/91	3/26/91
Time	13:00	15:00	16:30	8:30	10:00	11:00
Surrounding Land Use (%)						
Forest	100	0	0	100	100	100
Field/Pasture	0	100	30	0	0	0
Agriculture	0	0	0	0	0	0
Residential/Maintained	0	0	60	0	0	0
Commercial	0	0	0	0	0	0
Industrial	0	0	0	0	0	0
Other: ROAD	0	0	10	0	0	0
Watershed Erosion	NONE	MOD.	NONE	NONE	NONE	NONE
Estimated Stream Width (ft)	8	12	6	4	2	2.5
Estimated Stream Depth (ft)	0.5	1.2	0.25	0.5	0.25	0.45
% Riffle	20	20	50	30	40	45
% Run	70	55	25	30	40	35
% Pool	10	25	25	40	20	20
Estimated Stream Velocity (ft/s)	2	1.6	3	1.2	2.3	2
Estimated Stream Flow (ft^3/s)	8	23	4.5	3.4	1.15	2.25
High Water Mark (ft)	2	3	2	1.5	1.5	1.5
Man-Made Modifications	none	Bridge, Park. lot	road	none	none	none
Canopy Cover (%)	75	0	0	55	50	60
Sediment/Substrate						
Odor	none	none	none	none	none	none
Oil	none	none	none	none	none	none
Deposits	none	none	none	none	unk. floc	none

STREAM SAMPLING DATA SHEET (cont'd)

Sample Station (DC-EA-)	SG1	SF1	SA5	SE1	SB6	SD1
Dominant Substrate Type (Inorganic)	Cobble	Cobble	Bedrock/ Cobble	Cobble	Sand/Silt	Cobble
% Bedrock	0	0	30	20	0	25
% Boulder (>0.25m)	5	25	10	10	0	15
% Cobble (0.065 - 0.25m)	75	45	30	35	20	35
% Gravel (0.002 - 0.065m)	15	15	20	15	20	10
% Sand (gritty)	5	10	5	5	30	10
% Silt (fine)	0	5	5	10	30	5
% Clay (slick)	0	0	0	5	0	0
Dominant Substrate Type (Organic)	Detritus	Detritus	Detritus	Detritus	Detritus	Detritus
% Detritus	100	90	90	70	65	90
% Muck/Mud	0	10	10	25	35	10
% Marl	0	0	0	5	0	0
Stream Odor	0	0	0	0	0	0
Stream Oils	0	0	0	0	0	0
Stream Turbidity	mostly clear	noticable	clear	clear	clear	clear

Weather Conditions

68°F clear

Photographs/Numbers

SG-1	SF-1	SA-5	SE-1	SB-6	SD-1
1N	5N	10N	14N	18N	22N
2S	6S	11S	15S	19S	1S
3E	7E	12E	16E	20E	2E
4W	8W	13W	17W	21W	3W
	9BC			4FL	

AR300542

STREAM SAMPLING DATA SHEET (cont'd)

Conditions - Parameters

Sample Stations (DC-EA-)	SG1	SF1	SA5	SE1	S86	SD1

Primary - Substrate & Instream Cover

1. Bottom substrate and available cover	16	16	11	15	5	15
2. Embeddedness	16	15	15	16	11	16
3. Flow	17	17	12	16	11	16

Secondary - Channel Morphology

4. Channel alteration	14	12	7	12	8	14
5. Bottom scouring and deposition	12	12	10	12	4	12
6. Pool/riffle, run/bend ratio	13	14	14	11	5	13

Tertiary - Riparian & Bank Structure

7. Bank Stability	10	7	7	8	7	10
8. Bank Vegetation	6	5	7	3	3	6
9. Stream Side Cover	7	4	10	6	3	7

Comparisons

Total Score	108	102	93	99	57	107
Percent of Comparability to Reference	98	94	85	91	52	98
Station Assessment Compared to Reference	Comparable	Comparable	Supporting	Comparable	Non-supporting	Comparable

Conditions	Excellent	Good	Fair	Poor
Primary	16-20	11-15	6-10	0-5
Secondary	12-15	8-11	4-7	0-3
Tertiary	9-10	6-8	3-5	0-2

Assessment Category	Percent of Comparability
Comparable to Reference	>89%
Supporting	75-88%
Partially Supporting	60-73%
Non Supporting	<59%

STREAM SAMPLING DATA SHEET (cont'd)

Benthic Collection

Sample Station (DC-EA-)	SG1	SF1	SA5	SE1	SB5	SD1

Observed Relative Abundance of Aquatic Biota

Periphyton	2	1	1	1	0	2
Slime	0	0	0	0	4	1
Filamentous Algae	0	2	1	2	0	0
Macroinvertebrate	4	4	3	2	2	4
Macrophytes	0	0	0	2	0	1
Fish	0	2	0	1	0	1

0 = Absent/Not Observed 1 = Rare 2 = Common 3 = Abundant 4 = Dominant

Sample Type

Riffle/Run	Surber						
	Driftnet		X				
	D-Frame	X		X	X	X	X
CPOM	D-Frame	X	X	X	X	X	X
	Hand	X		X	X	X	X
Collectors	1.	DJ	DJ	DJ	DJ	DJ	DJ
	2.	CRB	CRB	CRB	CRB	CRB	CRB
Preservatives	1.	ETOH	ETOH	H_20	H_20	H_20	H_20
	2.	H_20	H_20	ETOH	ETOH	ETOH	ETOH

Additional Comments

AR300544

Benthic Sample Organisms Data Sheets

BENTHIC SAMPLE ORGANISMS

Site Name: Dixie Caverns
Location: Salem
Township: Salem
State: VA

Sample ID: SA5 RR
Date: June 3, 1991
County: Roanoke Co.

TN	Taxon	#	Source[1]	Couplet Sequence	Det.
1	Tipulidae	4	1	Sight ID	CRB
2	Oligochaeta	4	5	Sight ID	CRB
3	Heptageniidae	49	7	Pg. 97: 1',2',7',8',11',12	CRB
4	Siphlonuridae	20	7	Pg. 97: 1',2',7',8',11',12' 13',15',16'	CRB
5	Perlodidae	1	4,7	Sight ID	CRB
6	Chironomidae	1	1	Sight ID	CRB
7	Ephemerellidae	3	4,7	Sight ID	CRB
8	Baetidae	1	7	Pg. 97: 1',2',7',8',11',12' 13',15',16	CRB
9	Leptophlebiidae	1	4,7	Sight ID	CRB
10	Taeniopterygidae	1	7	Pg. 184: 1',2',3,4	CRB
11	Nemouridae	4	7	Pg. 184: 1',2',3,4',5	CRB

Comments:

[1] References listed on last page of appendix.

AR300546

BENTHIC SAMPLE ORGANISMS

Site Name: Dixie Caverns
Location: Salem
Township: Salem
State: VA

Sample ID: SA5 CPOM
Date: June 3, 1991
County: Roanoke Co.

TN	Taxon	#	Source[1]	Couplet Sequence	Det.
1	Tipulidae	25	1	Sight ID	CRB
2	Oligochaeta	13	5	Sight ID	CRB
3	Chironomidae	1	1	Sight ID	CRB
4	Siphlonuridae	3	4,7	Sight ID	CRB
5	Heptageniidae	3	4,7	Sight ID	CRB
6	Ephemerellidae	6	4,7	Sight ID	CRB
7	Nemouridae	6	4,7	Sight ID	CRB
8	Perlodidae	3	4,7	Sight ID	CRB
9	Dytiscidae	1	3	Sight ID	CRB
10	Hydrophilidae	1	3	Sight ID	CRB
11	Diplopoda	1	3	Sight ID	CRB
12	Araneae	1	3	Sight ID	CRB

Comments: Tipulids were put in two vials (1A,1B). Spider and Millipede terrestrial.

[1] References listed on last page of appendix.

ORIGINAL
(Red)

BENTHIC SAMPLE ORGANISMS

Site Name: Dixie Caverns
Location: Salem
Township: Salem
State: VA

Sample ID: SB6 RR
Date: June 3, 1991
County: Roanoke Co.

TN	Taxon	#	Source[1]	Couplet Sequence	Det.
1	Gerridae	1	3	Sight ID	CRB
2	Dytiscidae	1	3	Sight ID	CRB
3	Siphlonuridae	2	4,7	Sight ID	CRB
4	Heptageniidae	1	4,7	Sight ID	CRB
5	Ephemerellidae	1	4,7	Sight ID	CRB
6	Chironomidae	1	1	Sight ID	CRB
7	Nemouridae	3	4,7	Sight ID	CRB
8	Limnephilidae	1	4,7	Sight ID	CRB

Comments: Dytiscid (TN #2) is an adult.

[1] References listed on last page of appendix.

AR300548

BENTHIC SAMPLE ORGANISMS

Site Name: Dixie Caverns
Location: Salem
Township: Salem
State: VA

Sample ID: SB6-CPOM
Date: June 3, 1991
County: Roanoke Co.

TN	Taxon	#	Source[1]	Couplet Sequence	Det.
1	Chironomidae	6	1	Sight ID	CRB
2	Simuliidae	3	1	Sight ID	CRB
3	Corydalidae	1	7	Sight ID	CRB
4	Siphlonuridae	2	4,7	Sight ID	CRB
5	Leptophlebiidae	1	4,7	Sight ID	CRB
6	Perlodidae	1	4,7	Sight ID	CRB
7	Nemouridae	4	4,7	Sight ID	CRB
8	Limnephilidae	1	4,7	Sight ID	CRB
9	Araneae	1	3	Sight ID	CRB

Comments: Spider probably terrestrial.

[1] References listed on last page of appendix.

BENTHIC SAMPLE ORGANISMS

Site Name: Dixie Caverns
Location: Salem
Township: Salem
State: VA

Sample ID: SD1 RR
Date: June 3, 1991
County: Roanoke Co.

TN	Taxon	#	Source[1]	Couplet Sequence	Det.
1	Corydalidae	1	7	Sight ID	CRB
2	Siphlonuridae	4	4,7	Sight ID	CRB
3	Leptophlebiidae	5	4,7	Sight ID	CRB
4	Ephemerellidae	2	4,7	Sight ID	CRB
5	Heptageniidae	26	4,7	Sight ID	CRB
6	Nemouridae	1	4,7	Sight ID	CRB
7	Chloroperlidae	2	4,7	Sight ID	CRB
8	Hydropsychidae	2	4,7	Sight ID	CRB
9	Rhyacophilidae	1	4,7	Sight ID	CRB
10	Lepidostomatidae	2	4,7	Sight ID	CRB

Comments:

[1] References listed on last page of appendix.

BENTHIC SAMPLE ORGANISMS

Site Name: Dixie Caverns
Location: Salem
Township: Salem
State: VA

Sample ID:SD1 CPOM
Date: June 3, 1991
County: Roanoke Co.

TN	Taxon	#	Source[1]	Couplet Sequence	Det.
1	Decapoda	2	5	Sight ID	CRB
2	Chironomidae	1	1	Sight ID	CRB
3	Empididae	1	3	Pg. 509: 1,2',3',30',43',45', 46',47,48',50',51',52',53' CRB	
4	Heptageniidae	2	4,7	Sight ID	CRB
5	Siphlonuridae	8	4,7	Sight ID	CRB
6	Leptophlebiidae	17	4,7	Sight ID	CRB
7	Perlodidae	2	4,7	Sight ID	CRB
8	Leuctridae	1	4,7	Sight ID	CRB
9	Limnephilidae	4	4,7	Sight ID	CRB
10	Hydropsychidae	1	4,7	Sight ID	CRB
11	Rhyacophilidae	1	4,7	Sight ID	CRB
12	Lepidostomatidae	14	4,7	Sight ID	CRB
13	Desmognathus sp.	1	8	Sight ID	DJ

Comments: The Empidid is an adult.

[1] References listed on last page of appendix.

BENTHIC SAMPLE ORGANISMS

Site Name: Dixie Caverns
Location: Salem
Township: Salem
State: VA

Sample ID: SE1 RR
Date: June 3, 1991
County: Roanoke Co.

TN	Taxon	#	Source[1]	Couplet Sequence	Det.
1	Gerridae	3	3	Sight ID	CRB
2	Tipulidae	2	1	Sight ID	CRB
3	Simuliidae	17	1	Sight ID	CRB
4	Heptageniidae	46	4,7	Sight ID	CRB
5	Ephemerellidae	10	4,7	Sight ID	CRB
6	Siphlonuridae	20	4,7	Sight ID	CRB
7	Hydropsychidae	1	4,7	Sight ID	CRB
8	Rhyacophilidae	1	4	Pg. 259: 1′,2′,4′,5,6,7′,8′,9′	CRB
9	Chloroperlidae	3	7	Pg. 184: 1′,2′,3′,7′,8	CRB
10	Chironomidae	2	1	Sight ID	CRB

Comments:

[1] References listed on last page of appendix.

BENTHIC SAMPLE ORGANISMS

Site Name: Dixie Caverns
Location: Salem
Township: Salem
State: VA

Sample ID: SE1 CPOM
Date: June 3, 1991
County: Roanoke Co.

TN	Taxon	#	Source[1]	Couplet Sequence	Det.
1	Tipulidae	3	1	Sight ID	CRB
2	Chironomidae	1	1	Sight ID	CRB
3	Simuliidae	1	1	Sight ID	CRB
4	Heptageniidae	7	4,7	Sight ID	CRB
5	Leptophlebiidae	5	4,7	Sight ID	CRB
6	Ephemerellidae	1	4,7	Sight ID	CRB
7	Siphlonuridae	45	4,7	Sight ID	CRB
8	Nemouridae	1	4,7	Sight ID	CRB
9	Chloroperlidae	4	4,7	Sight ID	CRB
10	Perlodidae	2	4,7	Sight ID	CRB
11	Hydropsychidae	1	4,7	Sight ID	CRB
12	Hydropsychidae	1	3	Pg. 581: 1',2',10,11,12'	CRB
13	Rhyacophilidae	1	4,7	Sight ID	CRB
14	Limnephilidae	1	4,7	Sight ID	CRB
15	Lepidostomatidae	6	4,7	Sight ID	CRB
16	Corixidae	4	3	Sight ID	CRB
17	Entomobryidae	1	3	Sight ID	CRB

Comments: Hydropsychidae TN #11 is a larva, TN #12 is an adult.

[1] References listed on last page of appendix.

BENTHIC SAMPLE ORGANISMS

Site Name: Dixie Caverns — Sample ID: SF1 RR
Location: Salem — Date: June 3, 1991
Township: Salem — County: Roanoke Co.
State: VA

TN	Taxon	#	Source[1]	Couplet Sequence	Det.
1	Tipulidae	5	1	Sight ID	CRB
2	Oligochaeta	4	5	Sight ID	CRB
3	Perlodidae	33	4,7	Sight ID	CRB
4	Empididae	1	1	Sight ID	CRB
5	Simuliidae	6	1	Sight ID	CRB
6	Chironomidae	29	1	Sight ID	CRB
7	Gomphidae	1	4,7	Sight ID	CRB
8	Nemouridae	72	4,7	Sight ID	CRB
9	Chloroperlidae	1	4,7	Sight ID	CRB
10	Philopotamidae	1	4,7	Sight ID	CRB
11	Ephemerellidae	1	4,7	Sight ID	CRB
12	Heptageniidae	3	4,7	Sight ID	CRB
13	Siphlonuridae	11	7	Sight ID	CRB
14	Planorbidae	1	5	Pg. 557: 1,51,54,67	CRB
15	Acari	1	5	Sight ID	CRB
16	Diplopoda	2	3	Sight ID	CRB
17	Formicidae	3	3	Sight ID	CRB
18	Isopoda	1	3	Sight ID	CRB
19	Noctuidae	1	4	Sight ID	CRB
20	Gastropoda	1		Sight ID	CRB
21	Eggs	5			CRB
22	Sminthuridae	1	3	Sight ID	CRB

Comments: The Gastropod is a terrestrial slug. Taxa numbers 16-20 and 22 are all probably terrestrial.

[1] References listed on last page of appendix.

BENTHIC SAMPLE ORGANISMS

Site Name: Dixie Caverns
Location: Salem
Township: Salem
State: VA

Sample ID: SF1 CPOM
Date: June 5, 1991
County: Roanoke Co.

TN	Taxon	#	Source[1]	Couplet Sequence	Det.
1	Tipulidae	5	1	Sight ID	CRB
2	Oligochaeta	15	5	Sight ID	CRB
3	Nemouridae	77	4,7	Sight ID	CRB
4	Simuliidae	6	1	Sight ID	CRB
5	Chironomidae	4	1	Sight ID	CRB
6	Siphlonuridae	54	4,7	Sight ID	CRB
7	Ephemerellidae	1	4,7	Sight ID	CRB
8	Baetidae	1	4,7	Sight ID	CRB
9	Heptageniidae	1	4,7	Sight ID	CRB
10	Leptophlebiidae	17	4,7	Sight ID	CRB
11	Limnephilidae	2	4,7	Sight ID	CRB
12	Staphylinidae	1	3	Sight ID	CRB
13	Dytiscidae	4	3	Sight ID	CRB
14	Chloroperlidae	1	4,7	Sight ID	CRB
15	Nemouridae	1	3	Pg. 1,2',4',5,6	CRB
16	Philopotamidae	1	4,7	Sight ID	CRB
17	Rhyacophilidae	2	4,7	Sight ID	CRB
18	Formicidae	2	3	Sight ID	CRB
19	Isopoda	1	3	Sight ID	CRB
20	Perlodidae	12	4,7	Sight ID	CRB

Comments: The Nemourid (TN #15) is an adult. Taxa numbers 12,18 and 19 are terrestrial.

[1] References listed on last page of appendix.

BENTHIC SAMPLE ORGANISMS

Site Name: Dixie Caverns
Location: Salem
Township: Salem
State: VA

Sample ID: SG1 RR
Date: June 3, 1991
County: Roanoke Co.

TN	Taxon	#	Source[1]	Couplet Sequence	Det.
1	Tipulidae	1	1	Sight ID	CRB
2	Blephariceridae	1	1	Sight ID	CRB
3	Simuliidae	23	1	Sight ID	CRB
4	Ephemerellidae	6	4,7	Sight ID	CRB
5	Heptageniidae	101	4,7	Sight ID	CRB
6	Chironomidae	1	1	Sight ID	CRB
7	Siphlonuridae	7	4,7	Sight ID	CRB
8	Heptageniidae	1	3	Pg. 179: 1',2',3',8',10', 14,15',16	CRB
9	Nemouridae	1	4,7	Sight ID	CRB
10	Chloroperlidae	2	4,7	Sight ID	CRB
11	Perlodidae	4	4,7	Sight ID	CRB
12	Hydropsychidae	1	4,7	Sight ID	CRB
13	Limnephilidae	10	4,7	Sight ID	CRB
14	Lepidostomatidae	1	4	Pg. 259: 1',2',4',5',13', 14',15',16',17',19	CRB
15	Isopoda	1	3	Sight ID	CRB
16	Desmognathus sp.	1	8	Sight ID	DJ

Comments: The Heptageniid (TN #8) is a subimago. The Isopod is terrestrial.

[1] References listed on last page of appendix.

BENTHIC SAMPLE ORGANISMS

Site Name: Dixie Caverns
Location: Salem
Township: Salem
State: VA

Sample ID: SG1 CPOM
Date: June 5, 1991
County: Roanoke Co.

TN	Taxon	#	Source[1]	Couplet Sequence	Det.
1	Pteronarcyidae	1	4,7	Sight ID	CRB
2	Corydalidae	1	7	Sight ID	CRB
3	Oligochaeta	3	5	Sight ID	CRB
4	Tipulidae	5	1	Sight ID	CRB
5	Chironomidae	1	1	Sight ID	CRB
6	Simuliidae	9	1	Sight ID	CRB
7	Siphlonuridae	25	4,7	Sight ID	CRB
8	Baetidae	1	4,7	Sight ID	CRB
9	Leptophlebiidae	1	4,7	Sight ID	CRB
10	Nemouridae	9	4,7	Sight ID	CRB
11	Heptageniidae	6	4,7	Sight ID	CRB
12	Perlodidae	24	4,7	Sight ID	CRB
13	Chloroperlidae	2	4,7	Sight ID	CRB
14	Ephemerellidae	23	4,7	Sight ID	CRB
15a	Hydropsychidae	1	4,7	Sight ID	CRB
b	Hydropsychidae	1	3	Sight ID	CRB
16	Rhyacophilidae	4	4,7	Sight ID	CRB
17	Hydrophilidae	1	4,7	Sight ID	CRB
18	Chrysomelidae	1	3	Sight ID	CRB
19	Entomobryidae	1	3	Sight ID	CRB
20	Diplopoda	2	3	Sight ID	CRB

Comments: Taxa numbers 18-20 are terrestrial. Taxa number 15a and 15b are in the same vial, 15b is an adult.

[1] References listed on last page of appendix.

References Cited

1. MacAlpine, J.F., B.V. Peterson, G.E. Shewell, H.J. Teskey, J.R. Vockeroth, and D.M. Wood. 1981 - 1987. Manual of Nearctic Diptera, Vol. I. Monographs No. 27. Research Branch, Agricultural Canada, 674 pp. (1981). Vol. II, Monograph No, 28. Research Branch, Agricultural Canada, pp. 675 - 1332 (1987).

2. Peterson, A. 1960. Larvae of Insects, part II. Ohio State University, Columbus, Ohio. 416 pp.

3. Borror, D.J., C.A. Triplehorn, and N.F. Johnson. 1989. Introduction to the study of insects. sixth edition. Saunders College Publishing, Philadelphia. 875 pp.

4. Stehr, F.W. 1987. Immature Insects, Vol. I. Kendall Hunt, Dubuque, Iowa. 754 pp.

5. Pennak, R.W. 1989. Fresh Water Invertebrates of the United States. John Wiley and Sons, New York. 628 pp.

6. Eddy, S. and A.C. Hodson. 1982. Taxonomic Keys of the Common Animals of the North Central States. Burgess Publishing Company, Minneapolis, Minn. 205 pp.

7. Merritt, R.W. and K.W. Cummins. 1984. An introduction to the Aquatic insects of North America. Kendall-Hunt Publishing Company, Dubuque, IA. 722 pp.

8. Conant, R. 1975. A field Guide to Reptiles and Amphibians. Houghton Mifflin Company, Boston, MA. 429 pp.

9. Emerson, W.K. and M.K. Jacobson. 1976. American Museum of Natural History Guide to Shells. Alfred A. Knopf, Inc. New York.

Benthic Sample Organisms QA/QC Sheets

QA/QC SHEET FOR MACROINVERTEBRATE SAMPLES

Site Name: Dixie Caverns   Date: June 5, 1991
Location: Salem, VA   Determiner: DJ

	Vial #	Source[1]	Taxon	Verify
1.	SG1-CPOM-08	7	Baetidae	Y
2.	SD1-CPOM-11	7	Rhyacophilidae	Y
3.	SF1-RR-07	7	Gomphidae	Y
4.	SG1-CPOM-15	7	Hydropsychidae	Y
5.	SF1-CPOM-03	7	Nemouridae	Y
6.	SB6-CPOM-07	Sight	Corydalidae	Y
7.	SG1-RR-14	7	Lepidostomatidae	Y
8.	SG1-RR-01	Sight	Tipulidae	Y
9.	SF1-CPOM-08	Sight	Baetidae	Y
10.	SE1-CPOM-13	Sight	Lepidostomatidae	Y
11.	SA5-RR-02	Sight	Oligochaeta	Y
12.	SG1-RR-13	7	Limnephilidae	Y
13.	SE1-CPOM-13	7	Entomobryidae	Y
14.	SA5-CPOM-04	7	Siphlonuridae	Y
15.	SA5-RR-05	7	Perlodidae	Y
16.	SD1-RR-05	7	Heptageniidae	Y
17.	SA1-RR-09	7	Leptophlebiidae	Y
18.				

Comments: The Leptophlebiid specimen is in bad condition.

[1]Sources are listed at the end of the Benthic Sample Organisms appendix (Appendix XX).

TCN 4208
RI REPORT
REV. #1
09/JAN/92

Forest Vegetation Data Sheets

FOREST VEGETATION DATA SHEET

Site Name: Dixie Caverns
Township: Salem
County: Roanoke
State: VA

Sample Location: F1B
Date: March 27, 1991
Time: 10:00
Recorders: DJ/CRB

Herbs & Bryophytes

#	Common Name	Scientific Name	Indicator Status	40" X 40" Quad					R
				Q1	Q2	Q3	Q4	X	
1	Blueberry	Vaccinium spp.		70	100	70	60	75	1
2	Black Tupelo	Nyssa sylvatica	FAC	30			40	17.5	2
3	Oak	Quercus spp.				30		7.5	3

Total of Average (ΣX) 100
Dominance Threshold Number Equals 50% X Total of Average (ΣX) 50

Shrub Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Mountain Laurel	Kalmia latifolia	FAC	20	3	20.5	2
2	Blueberry	Vaccinium spp.		40	4	38.0	1

Sum of Midpoints 58.5
Dominance Threshold Number Equals 50% X Sum of Midpoints 29.25

Woody Vine Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class[1]	R
1	Greenbrier	Smilex spp.		5	1	3.0	1

Sum of Midpoints 3.0
Dominance Threshold Number Equals 50% X Sum of Midpoints 1.5

Sapling Species[2]

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Black Tupelo	Nyssa sylvatica	FAC	40	4	38.0	
2	Pitch Pine	Pinus rigida	FACU	25	3	20.5	
3	Scarlet Oak	Quercus coccinea	UPL	15	2	10.5	
4	Chestnut Oak	Quercus prinus	UPL	15	2	10.5	

Sum of Midpoints 79.5
Dominance Threshold Number Equals 50% X Sum of Midpoints 39.75

Tree Species[3]

#	Common Name	Scientific Name	Indicator Status	DBH (in)	BA/ Tree (ft^2)	BA/ Sp. (ft^2)	R
1	Pitch Pine	Pinus rigida	FACU	9.4	0.48	2.40	1
2	Chestnut Oak	Quercus prinus	UPL	5	0.14	0.14	3
3	Scarlet Oak	Quercus coccinea	UPL	7.33	0.29	0.87	2

Total Basal Area of All Species Combined 3.41

Dominance Threshold Number Equals 50% X Total Basal Area 1.71

FOREST VEGETATION DATA SHEET

Site Name: Dixie Caverns Sample Location: F2B
Township: Salem Date: March 27, 1991
County: Roanoke Time: 8:50
State: VA Recorders: DJ/CRB

Herbs & Bryophytes

#	Common Name	Scientific Name	Indicator Status	40" X 40" Quad					R
				Q1	Q2	Q3	Q4	X	
1	Moss	Bryophyta		10	10		30	12.5	3
2	Lichen	Bryophyta		15	10	10	20	13.8	2
3	Mayflower	Epigaea repens	UPL			10	30	10	4
4	Red Maple	Acer rubrum	FAC				20	5	6
5	Greenbrier	Smilex spp.		15				3.8	7
6	Mountain Laurel	Kalmia latifolia	FAC	25	15			10	5
7	Blueberry	Vaccinium spp.		25	60	70		38.8	1
8	Striped Wintergreen	Chimaphila maculata	UPL	10				2.5	8.5
9	Iris	Iris spp.			5			1.3	10
10	Black Tupelo	Nyssa sylvatica	FAC			10		2.5	8.5

Total of Average (ΣX) _100.2_
Dominance Threshold Number Equals 50% X Total of Average (ΣX) __50.1_

Shrub Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Mountain Laurel	Kalmia latifolia	FAC	50	4	38.0	1.5
2	Blueberry	Vaccinium spp.		40	4	38.0	1.5

Sum of Midpoints _76.0__
Dominance Threshold Number Equals 50% X Sum of Midpoints _38.0__

Woody Vine Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Greenbrier	Smilex spp.		10	2	10.5	1

Sum of Midpoints _10.5__
Dominance Threshold Number Equals 50% X Sum of Midpoints __5.25_

Sapling Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Black Tupelo	Nyssa sylvatica	FAC	15	2	10.5	7.5
2	Sassafras	Sassafras albidum	FACU	15	2	10.5	2.5
3	Chestnut Oak	Quercus prinus	UPL	20	3	20.5	1

Sum of Midpoints _41.5__

Dominance Threshold Number Equals 50% X Sum of Midpoints _20.75_

Tree Species

#	Common Name	Scientific Name	Indicator Status	DBH (in)	BA/ Tree (ft^2)	BA/ Sp. (ft^2)	R
1	Scarlet Oak	Quercus coccinea	UPL	6.38	0.22	0.88	1
2	Chestnut Oak	Quercus prinus	UPL	5.38	0.16	0.64	3
3	Pitch Pine	Pinus rigida	FACU	12.25	0.82	0.82	2

Total Basal Area of All Species Combined _2.34__

Dominance Threshold Number Equals 50% X Total Basal Area _1.17__

FOREST VEGETATION DATA SHEET

Site Name: Dixie Caverns
Township: Salem
County: Roanoke
State: VA

Sample Location: F3B
Date: March 26, 1991
Time: 14:40
Recorders: DJ/CRB

Herbs & Bryophytes

#	Common Name	Scientific Name	Indicator Status	40" X 40" Quad					R
				Q1	Q2	Q3	Q4	X	
1	Moss	Bryophyta		20	35	15		17.5	1
2	Blueberry	Vaccinium spp.		80	60	80	80	75	2
3	Strawberry	Fragaria virginiana	FACU		5			1.3	5.5
4	Lichen	Bryophyta				5		1.3	5.5
5	Mountain Laurel	Kalmia latifolia	FAC				10	2.5	3.5
6	Red Maple	Acer rubrum	FAC				10	2.5	3.5

Total of Average (ΣX) 100.1
Dominance Threshold Number Equals 50% X Total of Average (ΣX) 50.05

Shrub Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Blueberry	Vaccinium spp.		55	5	63	1
2	Mountain Laurel	Kalmia latifolia	FAC	25	3	38	2

Sum of Midpoints 101
Dominance Threshold Number Equals 50% X Sum of Midpoints 50.5

Woody Vine Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	NIL						

Sum of Midpoints ______
Dominance Threshold Number Equals 50% X Sum of Midpoints ______

Sapling Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Red Maple	Acer rubrum	FAC	10	2	10.5	3.5
2	Oak	Quercus spp.		25	3	20.5	1
3	Black Tupelo	Nyssa sylvatica	FAC	10	2	10.5	3.5
4	Sassafras	Sassafras albidum	FACU	10	2	10.5	3.5
5	Dogwood	Cornus spp.	FACU	5	1	3.0	6
6	Virginia Pine	Pinus virginiana	UPL	10	2	10.5	3.5

Sum of Midpoints 65.5

Dominance Threshold Number Equals 50% X Sum of Midpoints 32.75

Tree Species

#	Common Name	Scientific Name	Indicator Status	DBH (in)	BA/ Tree (ft^2)	BA/ Sp. (ft^2)	R
1	Chestnut Oak	Quercus prinus	UPL	8	0.35	0.35	2
2	Red Oak	Quercus rubra	FACU	8.75	0.42	2.10	1

Total Basal Area of All Species Combined 2.45

Dominance Threshold Number Equals 50% X Total Basal Area 1.23

FOREST VEGETATION DATA SHEET

Site Name: Dixie Caverns Sample Location: F1
Township: Salem Date: March 27, 1991
County: Roanoke Time: 10:40
State: VA Recorders: DJ/CRB

Herbs & Bryophytes

#	Common Name	Scientific Name	Indicator Status	40" X 40" Quad					R
				Q1	Q2	Q3	Q4	X	
1	unknown	Ericaceae			33			8.3	5.5
2	Grass	Poaceae			33			8.3	5.5
3	unknown	undetermined		30	33			15.8	3
4	Lichen	Bryophyta				60	80	35	1
5	Striped Wintergreen	Chimaphila maculata	UPL			40	20	15	4
6	Pitch Pine	Pinus rigida	FACU	70				17.5	2

Total of Average (ΣX) 99.9
Dominance Threshold Number Equals 50% X Total of Average (ΣX) 49.95

Shrub Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Mountain Laurel	Kalmia latifolia	FAC	15	2	10.5	1.5
2	Blueberry	Vaccinium spp.		15	2	10.5	1.5

Sum of Midpoints 21
Dominance Threshold Number Equals 50% X Sum of Midpoints 10.5

Woody Vine Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Greenbrier	Smilex spp.		5	1	3.0	1

Sum of Midpoints 3.0
Dominance Threshold Number Equals 50% X Sum of Midpoints 1.5

Sapling Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Pitch Pine	Pinus rigida	FAC	20	3	20.5	1
2	Red Maple	Acer rubra	FAC	10	2	10.5	4
3	unknown	undetermined		5	1	3.0	8
4	Black Tupelo	Nyssa sylvatica	FAC	15	2	10.5	4
5	Flowering Dogwood	Cornus florida	FAC	5	1	3.0	8
6	Red Oak	Quercus rubra	FACU	10	2	10.5	4
7	*Sassafras*	*Sassafras albidum*	FACU	10	2	10.5	4
8	Carolina Hemlock	Tsuga caroliniana	UPL	5	1	30	8
9	Tulip-tree	Liriodendron tulipifera	FACU	15	2	10.5	4

Sum of Midpoints _82____

Dominance Threshold Number Equals 50% X Sum of Midpoints _41____

Tree Species

#	Common Name	Scientific Name	Indicator Status	DBH (in)	BA/ Tree (ft^2)	BA/ Sp. (ft^2)	R
1	Pitch Pine	Pinus rigida	FACU	5	0.14	0.14	2
2	White Oak	Quercus alba	FACU	7	0.27	0.27	1

Total Basal Area of All Species Combined __41__

Dominance Threshold Number Equals 50% X Total Basal Area __20.5_

FOREST VEGETATION DATA SHEET

Site Name: Dixie Caverns
Township: Salem
County: Roanoke
State: VA

Sample Location: F2
Date: March 26, 1991
Time: 15:15
Recorders: DJ/CRB

Herbs & Bryophytes

#	Common Name	Scientific Name	Indicator Status	40" X 40" Quad					R
				Q1	Q2	Q3	Q4	X	
1	Blueberry	Vaccinium spp.		30	70	30	60	47.5	1
2	Moss	Bryophyta					20	5	5.5
3	Lichen	Bryophyta		10		10	20	10	3
4	Mountain Laurel	Kalmia latifolia	FAC	50		50		25	2
5	Striped Wintergreen	Chimaphila maculata	UPL	10		10		5	5.5
6	Sassafras	Sassafras albidum	FACU		30			7.5	4

Total of Average (ΣX) 100

Dominance Threshold Number Equals 50% X Total of Average (ΣX) 50

Shrub Species

Sample Location

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Blueberry	Vaccinium spp.		30	4	38.0	1.5
2	Mountain Laurel	Kalmia latifolia	FAC	40	4	38.0	1.5

Sum of Midpoints 76

Dominance Threshold Number Equals 50% X Sum of Midpoints 38

Woody Vine Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	NIL						

Sum of Midpoints ______

Dominance Threshold Number Equals 50% X Sum of Midpoints ______

Sapling Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Sassafras	Sassafras albidum	FACU	15	2	10.5	2.5
2	Virginia Pine	Pinus virginiana	UPL	15	2	10.5	2.5
3	Black Tupelo	Nyssa sylvatica	FAC	15	2	10.5	2.5
4	Oak	Quercus spp.		15	2	10.5	2.5

Sum of Midpoints 42

Dominance Threshold Number Equals 50% X Sum of Midpoints 21

Tree Species (over 5.0 in. dbh + > 20 ft. tall)

#	Common Name	Scientific Name	Indicator Status	DBH (in)	BA/ Tree (ft^2)	BA/ Sp. (ft^2)	R
1	White Oak	Quercus alba	FACU	6	0.20	0.20	4
2	Pitch Pine	Pinus rigida	FACU	7	0.27	0.27	3
3	Chestnut Oak	Quercus prinus	UPL	7	0.27	0.54	1
4	Blackjack Oak	Quercus marilandica	UPL	5.5	0.16	0.32	2

Total Basal Area of All Species Combined 1.33

Dominance Threshold Number Equals 50% X Total Basal Area 0.67

FOREST VEGETATION DATA SHEET

Site Name: Dixie Caverns Sample Location: F3
Township: Salem Date: March 26, 1991
County: Roanoke Time: 14:15
State: VA Recorders: DJ/CRB

Herbs & Bryophytes

#	Common Name	Scientific Name	Indicator Status	40" X 40" Quad					R
				Q1	Q2	Q3	Q4	X	
1	Blueberry	Vaccinia spp.		100	50		60	52.5	1
2	Mountain Laurel	Kalmia latifolia	FAC		50		40	22.5	2

Total of Average (ΣX) _75__
Dominance Threshold Number Equals 50% X Total of Average (ΣX) _37.5_

Shrub Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Blueberry	Vaccinium spp.		40	4	38.0	2
2	Mountain Laurel	Kalmia latifolia	FAC	30	4	38.0	2
3	Sassafras	Sassafras albidum	FACU	10	2	10.5	4.5
4	Witch Hazel	Hamamelis virginiana	FACU	10	2	10.5	4.5
5	Unknown	Undetermined		30	4	38.0	2

Sum of Midpoints __138__
Dominance Threshold Number Equals 50% X Sum of Midpoints ___64__

Woody Vine Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	NIL						

Sum of Midpoints _______
Dominance Threshold Number Equals 50% X Sum of Midpoints _______

Sapling Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Serviceberry	Amelanchier spp.		15	2	10.5	2.5
2	Black Tupelo	Nyssa sylvatica	FAC	20	3	20.5	1
3	Pitch Pine	Pinus rigida	FACU	15	2	10.5	2.5

Sum of Midpoints __41.5_
Dominance Threshold Number Equals 50% X Sum of Midpoints __20.75

Tree Species

#	Common Name	Scientific Name	Indicator Status	DBH (in)	BA/ Tree (ft^2)	BA/ Sp. (ft^2)	R
1	Pitch Pine	Pinus rigida	FACU	6.5	0.23	0.46	1
2	Chestnut Oak	Quercus prinus	UPL	6	0.20	0.40	2

Total Basal Area of All Species Combined __0.86_
Dominance Threshold Number Equals 50% X Total Basal Area __0.43_

FOREST VEGETATION DATA SHEET

Site Name: Dixie Caverns Sample Location: F4
Township: Salem Date: March 26, 1991
County: Roanoke Time: 13:30
State: VA Recorders: DJ/CRB

Herbs & Bryophytes

#	Common Name	Scientific Name	Indicator Status	40" X 40" Quad					R
				Q1	Q2	Q3	Q4	X	
1	Mountain Laurel	Kalmia latifolia	FAC	20	60		30	27.5	2
2	Blueberry	Vaccinium spp.		60	20	100	50	57.5	1
3	Striped Wintergreen	Chimaphila maculata	UPL		20			5	4
4	Greenbrier	Smilex spp.		20			20	10	3

Total of Average (ΣX) _100__
Dominance Threshold Number Equals 50% X Total of Average (ΣX) __50__

Shrub Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Witch Hazel	Hamamelis virginiana	FAC	20	3	20.5	2
2	Blueberry	Vaccinium spp.		30	4	38.0	1
3	Mountain Laurel	Kalmia latifolia	FAC	15	2	16.5	3

Sum of Midpoints __69__
Dominance Threshold Number Equals 50% X Sum of Midpoints __34.5_

Woody Vine Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Greenbrier	Smilex spp.		10	2	10.5	1

Sum of Midpoints _10.5_
Dominance Threshold Number Equals 50% X Sum of Midpoints __5.25_

Sapling Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Serviceberry	Amelanchier spp.		25	3	20.5	2
2	Red Maple	Acer rubrum	FAC	20	3	20.5	2
3	Oak	Quercus spp.		20	3	20.5	2
4	Dogwood	Cornus florida	FACU	15	2	10.5	4

Sum of Midpoints __72__
Dominance Threshold Number Equals 50% X Sum of Midpoints __36__

Tree Species

#	Common Name	Scientific Name	Indicator Status	DBH (in)	BA/ Tree (ft^2)	BA/ Sp. (ft^2)	R
1	Red Oak	Quercus rubra	FACU	5	0.14	0.14	4
2	Chestnut Oak	Quercus prinus	UPL	6	0.20	0.40	1
3	Red Maple	Acer Rubrum	FAC	8	0.35	0.35	2
4	White Oak	Quercus alba	FACU	7	0.27	0.27	3

Total Basal Area of All Species Combined __1.16_

Dominance Threshold Number Equals 50% X Total Basal Area __0.58_

L

FOREST VEGETATION DATA SHEET

Site Name: Dixie Caverns   Sample Location: F5
Township: Salem   Date: March 27, 1991
County: Roanoke   Time: 10:55
State: VA   Recorders: DJ/CRB

Herbs & Bryophytes

#	Common Name	Scientific Name	Indicator Status	40" X 40" Quad Q1	Q2	Q3	Q4	X	R
1	Mountain Laurel	Kalmia latifolia	FAC			70		17.5	2
2	Blueberry	Vaccinium spp.		100	90	30	90	77.5	1
3	Greenbrier	Smilex spp.			10		10	5	3

Total of Average (ΣX) 110
Dominance Threshold Number Equals 50% X Total of Average (ΣX) 55

Shrub Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Mountain Laurel	Kalmia latifolia	FAC	15	2	10.5	2
2	Blueberry	Vaccinium spp.		60	5	63.0	1

Sum of Midpoints 73.5
Dominance Threshold Number Equals 50% X Sum of Midpoints 36.75

Woody Vine Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Greenbrier	Smilex spp.		10	2	10.5	1

Sum of Midpoints 10.5
Dominance Threshold Number Equals 50% X Sum of Midpoints 5.25

Sapling Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Black Tupelo	Nyssa sylvatica	FAC	30	4	38.0	1
2	Sassafras	Sassafras albidum	FACU	15	2	10.5	3.5
3	Red Maple	Acer rubrum	FAC	10	2	10.5	3.5
4	Hickory	Carya spp.		10	2	10.5	3.5
5	Flowering Dogwood	Cornus florida	FACU	10	2	10.5	3.5

Sum of Midpoints 80
Dominance Threshold Number Equals 50% X Sum of Midpoints 40

Tree Species

#	Common Name	Scientific Name	Indicator Status	DBH (in)	BA/ Tree (ft^2)	BA/ Sp. (ft^2)	R
1	Pitch Pine	Pinus rigida	FACU	8.2	0.37	1.85	1
2	Scarlet Oak	Quercus coccinea	UPL	6	0.20	0.20	3
3	White Oak	Quercus alba	FACU	8.3	0.38	0.76	2

Total Basal Area of All Species Combined __2.81_
Dominance Threshold Number Equals 50% X Total Basal Area __1.41_

1. Cover Class (midpoint): T < 1% (none); 1 = 1-5% (3.0); 2 = 6-15% (10.5); 3 = 16-25% (20.5); 4 = 26-50% (38.0); 5 = 51-75% (63.0); 6 = 76-95% (85.5); 7 = 96-100% (98.0).

2. Saplings are defined as being 0.4 - 5.0 in. DBH and less than 20 ft. tall.

3. Trees are defined as being over 5.0 in. DBH, and/or over 20 ft. tall.

Emergent Vegetation Data Sheets

EMERGENT VEGETATION DATA SHEET

Site Name: Dixie Caverns　Sample Location: E1
Township: Salem　Date: March 27, 1991
County: Roanoke　Time: 13:40
State: VA　Recorders: DJ/CRB

Herbs & Bryophytes

#	Common Name	Scientific Name	Indicator Status	40" X 40" Quad					R
				Q1	Q2	Q3	Q4	X	
1	Vetch	Vicia spp.		25	5	10	10	12.5	3.5
2	Watercress	Nasturtium officinale	OBL	10		20	20	12.5	3.5
3	Grass	Poaceae		60	95	5	50	52.5	1
4	Moss	Bryophyta		5			10	3.8	5
5	unknown	Composite				55		13.8	2
6	Bedstraw	Gallium spp.				10		2.5	6.5
7	Corn Speedwell	Veronica arvensis	FACU				10	2.5	6.5

Total of Average (ΣX) 100.1
Dominance Threshold Number Equals 50% X Total of Average (ΣX) 50.05

Shrub Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class[1]	R
1	NIL						

Sum of Midpoints ______
Dominance Threshold Number Equals 50% X Sum of Midpoints ______

Woody Vine Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	NIL						

Sum of Midpoints ______
Dominance Threshold Number Equals 50% X Sum of Midpoints ______

Sapling Species[2]

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	NIL						

Sum of Midpoints ______
Dominance Threshold Number Equals 50% X Sum of Midpoints ______

Tree Species[3]

#	Common Name	Scientific Name	Indicator Status	DBH (in)	BA/ Tree (ft^2)	BA/ Sp. (ft^2)	R
1	NIL						

Total Basal Area of All Species Combined _______

Dominance Threshold Number Equals 50% X Total Basal Area _______

EMERGENT VEGETATION DATA SHEET

Site Name: Dixie Caverns
Township: Salem
County: Roanoke
State: VA

Sample Location: E2
Date: March 27, 1991
Time: 14:00
Recorders: DJ/CRB

Herbs & Bryophytes

#	Common Name	Scientific Name	Indicator Status	40" X 40" Quad Q1	Q2	Q3	Q4	X	R
1	Broomsedge	Andropogon spp.		80	75	90	85	82.5	1
2	Moss	Bryophyta		20	20	10	10	15	2
3	Hop Clover	Trifolium agrarium	UPL		5			1.3	3.5
4	Unknown	undetermined					5	1.3	3.5

Total of Average (ΣX) 101.1
Dominance Threshold Number Equals 50% X Total of Average (ΣX) 50.55

Shrub Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	NIL						

Sum of Midpoints ______
Dominance Threshold Number Equals 50% X Sum of Midpoints ______

Woody Vine Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	NIL						

Sum of Midpoints ______
Dominance Threshold Number Equals 50% X Sum of Midpoints ______

Sapling Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	NIL						

Sum of Midpoints ______
Dominance Threshold Number Equals 50% X Sum of Midpoints ______

Tree Species

#	Common Name	Scientific Name	Indicator Status	DBH (in)	BA/ Tree (ft^2)	BA/ Sp. (ft^2)	R
1	NIL						

Total Basal Area of All Species Combined ______

Dominance Threshold Number Equals 50% X Total Basal Area ______

EMERGENT VEGETATION DATA SHEET

Site Name: Dixie Caverns Sample Location: E3
Township: Salem Date: March 27, 1991
County: Roanoke Time: 15:00
State: VA Recorders: DJ/CRB

Herbs & Bryophytes

#	Common Name	Scientific Name	Indicator Status	40" X 40" Quad					R
				Q1	Q2	Q3	Q4	X	
1	Cress	Cruciferae		10			5	3.8	5
2	unknown composite	Compositae		25	50	80	55	52.5	1
3	Grass	Poaceae		50	20		5	18.8	2
4	unknown	undetermined		10	15	10	20	13.8	3
5	Corn Speedwell	Veronica arvensis	FACU	5	15	10	10	10	4
6	Moss	Bryophyta					5	1.3	6

Total of Average (ΣX) 100.2
Dominance Threshold Number Equals 50% X Total of Average (ΣX) 50.1

Shrub Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	NIL						

Sum of Midpoints ______
Dominance Threshold Number Equals 50% X Sum of Midpoints ______

Woody Vine Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	NIL						

Sum of Midpoints ______
Dominance Threshold Number Equals 50% X Sum of Midpoints ______

Sapling Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	NIL						

Sum of Midpoints ______
Dominance Threshold Number Equals 50% X Sum of Midpoints ______

Tree Species

#	Common Name	Scientific Name	Indicator Status	DBH (in)	BA/ Tree (ft²)	BA/ Sp. (ft²)	R
1	NIL						

Total Basal Area of All Species Combined ________

Dominance Threshold Number Equals 50% X Total Basal Area ________

EMERGENT VEGETATION DATA SHEET

Site Name: Dixie Caverns Sample Location: E4
Township: Salem Date: March 27, 1991
County: Roanoke Time: 14:30
State: VA Recorders: DJ/CRB

Herbs & Bryophytes

#	Common Name	Scientific Name	Indicator Status	40" X 40" Quad Q1	Q2	Q3	Q4	X	R
1	Lichen	Bryophyta		20	10		5	8.8	3.5
2	Broomsedge	Andropogon spp.		65	60	40	45	52.5	1
3	Green Grass	Poaceae		5				1.3	9
4	unknown	undetermined		10	10	5	10	8.8	3.5
5	unknown composite #1	Compositae			15		10	6.3	5
6	Moss	Bryophyta			5		10	3.8	6
7	Brown Grass #2	Poaceae				40	15	13.8	2
8	Wood Sorrel	Oxalis stricta	UPL			5	5	2.5	7
9	Bittercress	Cardamine pensylvanica	OBL			5		1.3	9
10	unknown composite #2	Compositae				5		1.3	9

Total of Average (ΣX) 100.4
Dominance Threshold Number Equals 50% X Total of Average (ΣX) 50.2

Shrub Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	NIL						

Sum of Midpoints ______
Dominance Threshold Number Equals 50% X Sum of Midpoints ______

Woody Vine Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	NIL						

Sum of Midpoints ______
Dominance Threshold Number Equals 50% X Sum of Midpoints ______

Sapling Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	NIL						

Sum of Midpoints ______

Dominance Threshold Number Equals 50% X Sum of Midpoints ______

Tree Species

#	Common Name	Scientific Name	Indicator Status	DBH (in)	BA/ Tree (ft^2)	BA/ Sp. (ft^2)	R
1	NIL						

Total Basal Area of All Species Combined ______

Dominance Threshold Number Equals 50% X Total Basal Area ______

EMERGENT VEGETATION DATA SHEET

Site Name: Dixie Caverns Sample Location: E5
Township: Salem Date: March 27, 1991
County: Roanoke Time: 15:30
State: VA Recorders: DJ/CRB

Herbs & Bryophytes

#	Common Name	Scientific Name	Indicator Status	40" X 40" Quad					R
				Q1	Q2	Q3	Q4	X	
1	unknown composite	Compositae		70	10	5	40	31.3	1
2	Bedstraw	Gallium spp.		5				1.3	7.5
3	unknown mustard	Cruciferae		5		5	10	5	6
4	unknown	undetermined		15		5	10	7.5	5
5	moss	Bryophyta		5	30	15		12.5	4
6	lichen	Bryophyta			60	15		19.8	3
7	Brown Grass	Poaceae				50	40	22.5	2
8	Bittercress	Cardamine pensylvanica	OBL			5		1.3	7.5

Total of Average (ΣX) _100.2

Dominance Threshold Number Equals 50% X Total of Average (ΣX) __50.1_

Shrub Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	NIL						

Sum of Midpoints _______

Dominance Threshold Number Equals 50% X Sum of Midpoints _______

Woody Vine Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	NIL						

Sum of Midpoints _______

Dominance Threshold Number Equals 50% X Sum of Midpoints _______

Sapling Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Pitch Pine	Pinus rigida	UPL	30	4	38.0	1.5
2	Virginia Pine	Pinus virginiana	UPL	30	4	38.0	1.5
3	Red Maple	Acer rubrum	FAC	10	2	10.5	3

Sum of Midpoints _86.5__

Dominance Threshold Number Equals 50% X Sum of Midpoints _43.25_

Tree Species

#	Common Name	Scientific Name	Indicator Status	DBH (in)	BA/ Tree (ft^2)	BA/ Sp. (ft^2)	R
1	Table Mountain Pine	Pinus pungens	UPL	6.5	0.23	0.92	1
2	Virginia Pine	Pinus virginiana	UPL	6	0.2	0.20	3
3	Pitch Pine	Pinus rigida	UPL	7	0.27	0.27	2

Total Basal Area of All Species Combined _1.39__

Dominance Threshold Number Equals 50% X Total Basal Area _0.69__

1. Cover Class (midpoint): T < 1% (none); 1 = 1-5% (3.0); 2 = 6-15% (10.5); 3 = 16-25% (20.5); 4 = 26-50% (38.0); 5 = 51-75% (63.0); 6 = 76-95% (85.5); 7 = 96-100% (98.0).

2. Saplings are defined as being 0.4 - 5.0 in. DBH, and less than 20 ft. tall.

3. Trees are defined as being greater than 5.0 in. DBH and/or greater than 20 ft. tall.

Streamside Vegetation Data Sheets

STREAMSIDE VEGETATION DATA SHEET

Site Name: Dixie Caverns Sample Location: S1B
Township: Salem Date: March 27, 1991
County: Roanoke Time: 12:50
State: VA Recorders: DJ/CRB

Herbs and Bryophytes

#	Common Name	Scientific Name	Indicator Status	40" X 40" Quad Q1	Q2	Q3	Q4	X	R
1	Moss	Bryophyta		40	30	50		30	1
2	Galax	Galax aphylla	UPL	60				15	4
3	Witch Hazel	Hamamelis virginiana	FACU				100	25	2
4	Unknown	undetermined				50		12.5	5
5	Round-leaf Violet	Viola rotundifolia	FAC		70			17.5	3

Total of Average (ΣX) 100
Dominance Threshold Number Equals 50% X Total of Average (ΣX) 50

Shrub Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class[1]	R
1	Witch Hazel	Hamamelis virginiana	FACU	20	3	20.5	1
2	Alternate-leaf Dogwood	Cornus alternifolia	UPL	15	2	10.5	2
3	Mountain Laurel	Kalmia latifolia	FAC	5	1	3.0	3

Sum of Midpoints 34.4
Dominance Threshold Number Equals 50% X Sum of Midpoints 17.0

Woody Vine Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Grape	Vitis spp.		5	1	3.0	1.5
2	Greenbrier	Smilex spp.		5	1	3.0	1.5

Sum of Midpoints 6.0
Dominance Threshold Number Equals 50% X Sum of Midpoints 3.0

Sapling Species[2]

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Red Maple	Acer rubrum	FAC	10	2	10.5	2.5
2	Oak	Quercus sp.		15	2	10.5	2.5
3	Serviceberry	Amelanchier sp.		10	2	10.5	2.5
4	Hickory	Carya sp.		10	2	10.5	2.5

Sum of Midpoints 42

Dominance Threshold Number Equals 50% X Sum of Midpoints 21

Tree Species[3]

#	Common Name	Scientific Name	Indicator Status	DBH (in)	BA/ Tree (ft^2)	BA/ Sp. (ft^2)	R
1	Black Birch	Betula lenta	FACU	8	0.35	0.35	3
2	Chestnut Oak	Quercus prinus	UPL	9.88	0.53	2.12	1
3	Sycamore	Platanus occidentalis	FACW	5	0.14	0.14	5
4	Tulip-Tree	Liriodendron tulipifera	FACU	11.75	0.75	0.75	2
5	Serviceberry	Amelanchier spp.		6	0.20	0.20	4

Total Basal Area of All Species Combined 3.56

Dominance Threshold Number Equals 50% X Total Basal Area 1.78

STREAMSIDE VEGETATION DATA SHEET

Site Name: Dixie Caverns Sample Location: SF1
Township: Salem Date: March 25, 1991
County: Roanoke Time: 15:00
State: VA Recorders: DJ/CRB

Herbs & Bryophytes

#	Common Name	Scientific Name	Indicator Status	40" X 40" Quad Q1	Q2	Q3	Q4	X	R
1	Wild Hops	Humulus lupulus	FACU	90	85	100	100	93.8	1
2	Field Garlic	Allium vineale	FACU	10	7			4.3	2
3	Wild Onion	Allium canadense	FACU		8			2.0	3

Total of Average (ΣX) 105.1
Dominance Threshold Number Equals 50% X Total of Average (ΣX) 52.55

Shrub Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	NIL						

Sum of Midpoints ______
Dominance Threshold Number Equals 50% X Sum of Midpoints ______

Woody Vine Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	NIL						

Sum of Midpoints ______
Dominance Threshold Number Equals 50% X Sum of Midpoints ______

Sapling Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	NIL						

Sum of Midpoints ______
Dominance Threshold Number Equals 50% X Sum of Midpoints ______

Tree Species

#	Common Name	Scientific Name	Indicator Status	DBH (in)	BA/ Tree (ft^2)	BA/ Sp. (ft^2)	R
1	NIL						

Total Basal Area of All Species Combined ______

Dominance Threshold Number Equals 50% X Total Basal Area ______

STREAMSIDE VEGETATION DATA SHEET

Site Name: Dixie Caverns
Township: Salem
County: Roanoke
State: VA

Sample Location: SA5
Date: March 25, 1991
Time: 16:30
Recorders: DJ/CRB

Herbs & Bryophytes

#	Common Name	Scientific Name	Indicator Status	40" X 40" Quad Q1	Q2	Q3	Q4	X	R
1	Red Raspberry	Rubus occidentalis	UPL			5		1.3	11
2	Chickweed	Stellaria spp.				70	60	32.5	1
3	Common Dandelion	Taraxacum officinale	FACU			3	5	2	7.5
4	Lily	Liliaceae				5		1.3	11
5	Wild Onion	Allium canadense	FACU			3	5	2	7.5
6	Grass	Poaceae				4		1	14
7	Bittercress	Cardamine pensylvanica	OBL			5		1.3	11
8	Japanese Honeysuckle	Lonicera japonica	FACU	70	40	5	10	31.3	2
9	Black Walnut	Juglans nigra	FACU		20		10	7.5	4
10	Green Ash	Fraxinus pennsylvanica	FACW				5	1.3	11
11	Wild Garlic	Allium vineale	FACU				5	1.3	11
12	Moss	Bryophyta		20				5	5
13	Poison Ivy	Toxicodendron radicans	FAC	10				2.5	6
14	Birdsfoot trefoil	Lotus corniculatus	FACU		40			10	3

Total of Average (ΣX) 100.3
Dominance Threshold Number Equals 50% X Total of Average (ΣX) 50.15

Shrub Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	NIL						

Sum of Midpoints ______
Dominance Threshold Number Equals 50% X Sum of Midpoints ______

Woody Vine Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	NIL						

Sum of Midpoints ______
Dominance Threshold Number Equals 50% X Sum of Midpoints ______

Sapling Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	NIL						

Sum of Midpoints _______
Dominance Threshold Number Equals 50% X Sum of Midpoints _______

Tree Species

#	Common Name	Scientific Name	Indicator Status	DBH (in)	BA/ Tree (ft^2)	BA/ Sp. (ft^2)	R
1	NIL						

Total Basal Area of All Species Combined _______
Dominance Threshold Number Equals 50% X Total Basal Area _______

STREAMSIDE VEGETATION DATA SHEET

Site Name: Dixie Caverns Sample Location: SG1
Township: Salem Date: March 25, 1991
County: Roanoke Time: 13:00
State: VA Recorders: DJ/CRB

Herbs & Bryophytes

#	Common Name	Scientific Name	Indicator Status	40" X 40" Quad Q1	Q2	Q3	Q4	X	R
1	Moss	Bryophyta		5	15		3	5.8	2
2	Japanese Honeysuckle	Lonicera japonica	FACU	75	60	64	75	68.5	1
3	Strawberry	Fragaria virginiana	FACU		3			0.8	13.5
4	Bedstraw	Gallium spp.		5	3	6		3.5	4
5	Grass	Poaceae		5	15			5	3
6	Poison Ivy	Toxicodendron radicans	FAC		3	6		2.3	6.5
7	Gill-on-the-ground	Glecoma hederacea	FACU			6		1.5	9.5
8	Wild Onion	Allium canadense	FACU			6		1.5	9.5
9	Hemlock Parsley	Conioselinum chinense	FACW			6	3	1.5	9.5
10	Speedwell	Veronica spp.		5		6		2.8	5
11	Greenbrier	Smilex spp.					3	0.8	14.5
12	Witch Hazel	Hamamelis virginiana	FACU				10	2.3	6.5
13	Grape	Vitis spp.					6	1.5	9.5
14	Flowering Dogwood	Cornus florida	FACU	5				1.3	12

Total of Average (ΣX) 99.1
Dominance Threshold Number Equals 50% X Total of Average (ΣX) 49.55

Shrub Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Spicebush	Lindera benzoin	FACW	50	4	38.0	1
2	Witch Hazel	Hamamelis virginiana	FACU	15	2	10.5	2

Sum of Midpoints 48.5
Dominance Threshold Number Equals 50% X Sum of Midpoints 24.25

Woody Vine Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Grape	Vitis spp.		15	2	10.5	1
2	Poison Ivy	Toxicodendron radicans	FAC	5	1	3.0	2.5
3	Greenbrier	Smilex spp.		5	1	3.0	2.5

Sum of Midpoints _16.5__
Dominance Threshold Number Equals 50% X Sum of Midpoints __8.25_

Sapling Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Flowering Dogwood	Cornus florida	FACU	5	1	3.0	3.5
2	unknown	undetermined		20	3	20.5	1
3	Bitternut Hickory	Carya cordiformis	FACU	5	1	3.0	3.5
4	Sycamore	Platanus occidentalis	FACW	5	1	3.0	3.5
5	Eastern Redcedar	Juniperus virginiana	FACU	3	1	3.0	3.5

Sum of Midpoints _32.5__
Dominance Threshold Number Equals 50% X Sum of Midpoints _10.25_

Tree Species

#	Common Name	Scientific Name	Indicator Status	DBH (In)	BA/ Tree (ft^2)	BA/ Sp. (ft^2)	R
1	Sycamore	Platanus occidentalis	FACW	16.75	1.53	1.53	1
2	Green Ash	Fraxinus pennsylvanicus	FACW	9.5	0.49	0.49	3
3	Swamp White Oak	Quercus bicolor	FACW	12.75	0.91	0.91	2

Total Basal Area of All Species Combined _2.93__
Dominance Threshold Number Equals 50% X Total Basal Area _1.47__

STREAMSIDE VEGETATION DATA SHEET

Site Name: Dixie Caverns Sample Location: S3B
Township: Salem Date: March 27, 1991
County: Roanoke Time: 8:45
State: VA Recorders: DJ/CRB

Herbs & Bryophytes

#	Common Name	Scientific Name	Indicator Status	40" X 40" Quad Q1	Q2	Q3	Q4	X	R
1	Galax	Galax aphylla	UPL	12		40	40	23.3	1.5
2	Oak	Quercus spp.					20	5	8.5
3	Christmas fern	Polystichum acrostichoides	FACU	22				5.5	7
4	Greenbrier	Smilex spp.				50	40	22.5	1.5
5	Moss	Bryophyta		13	20	10		10.8	3
6	Striped Wintergreen	Chimaphila maculata	UPL	13	20			8.3	5
7	unknown	undetermined			20			5	8.5
8	Grass	Poaceae		13	20			8.3	5
9	Lichen	Bryophyta		13	20			8.3	5
10	Forget-me-not	Myosotis scorpioides	OBL	13				3.3	10

Total of Average (ΣX) 100.3
Dominance Threshold Number Equals 50% X Total of Average (ΣX) 50.15

Shrub Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Spicebush	Lindera benzoin	FACW	15	2	10.5	3
2	Witch Hazel	Hamamelis virginiana	FACU	20	3	20.5	1
3	Dogwood	Cornus spp.		15	2	10.5	3
4	Blueberry	Vaccinium spp.		10	2	10.5	3
5	Mountain Laurel	Kalmia latifolia	FAC	5	1	3.0	5.5
6	Unknown	Undetermined		5	1	3.0	5.5

Sum of Midpoints 58
Dominance Threshold Number Equals 50% X Sum of Midpoints 29

Woody Vine Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Greenbrier	Smilex spp.		10	2	10.5	1

Sum of Midpoints 10.5
Dominance Threshold Number Equals 50% X Sum of Midpoints 5.25

Sapling Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Serviceberry	Amelanchier spp.		10	2	10.5	2
2	Oak	Quercus spp.		10	2	10.5	2
3	Hickory	Carya spp.		5	1	3.0	4
4	Red Maple	Acer rubrum	FAC	15	2	10.5	2

Sum of Midpoints _34.5__

Dominance Threshold Number Equals 50% X Sum of Midpoints _17.25_

Tree Species

#	Common Name	Scientific Name	Indicator Status	DBH (in)	BA/ Tree (ft^2)	BA/ Sp. (ft^2)	R
1	Hickory	Carya spp.		6	0.2	0.2	3
2	Chestnut Oak	Quercus prinus	UPL	10.75	0.90	1.8	1
3	Black Oak	Quercus velutina	UPL	15.5	1.31	1.31	2

Total Basal Area of All Species Combined _3.31__

Dominance Threshold Number Equals 50% X Total Basal Area _1.65__

STREAMSIDE VEGETATION DATA SHEET

Site Name: Dixie Caverns Sample Location: SB6
Township: Salem Date: March 26, 1991
County: Roanoke Time: 10:00
State: VA Recorders: DJ/CRB

Herbs & Bryophytes

#	Common Name	Scientific Name	Indicator Status	40" X 40" Quad					R
				Q1	Q2	Q3	Q4	X	
1	Moss	Bryophyta			10	60		17.5	1
2	Red Maple	Acer rubrum	FACU		10	10		5	9.5
3	Grass	Poaceae				10		2.5	12.5
4	Lily #1	Liliaceae				20		5	9.5
5	Flowering Dogwood	Cornus florida	FACU				40	10	4
6	Greenbrier	Smilex spp.					30	7.5	8
7	Witch Hazel	Hamamelis virginiana	FACU		10		15	8.8	7
8	Bitternut Hickory	Carya cordiformis	FACU				15	3.8	11
9	Lichen	Bryophyta		30	10			10	4
10	Oak	Quercus spp.		30	10			10	4
11	Azalea	Rhododendron spp.		40				10	4
12	Mountain Laurel	Kalmia latifolia	FAC		40			10	4
13	Lily #2	Liliaceae			10			2.5	12.5

Total of Average (ΣX) 102.6
Dominance Threshold Number Equals 50% X Total of Average (ΣX) 51.3

Shrub Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Witch Hazel	Hamamelis virginiana	FACU	20	3	20.5	1
2	unknown	undetermined		10	2	10.5	2.5
3	unknown Heath	Ericaceae		15	2	10.5	2.5
4	Blueberry	Vaccinium spp.		5	1	3.0	4

Sum of Midpoints 44.5
Dominance Threshold Number Equals 50% X Sum of Midpoints 22.25

Woody Vine Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Greenbrier	Smilex spp.		20	3	20.5	1

Sum of Midpoints _30.5__
Dominance Threshold Number Equals 50% X Sum of Midpoints _10.25_

Sapling Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Red Maple	Acer rubrum	FAC	30	4	38	2
2	Tulip-tree	Liriodendron tulipifera	FACU	35	4	38	2
3	Flowering Dogwood	Cornus florida	FACU	20	3	20.5	2
4	Oak	Quercus spp.		10	2	10.5	4

Sum of Midpoints _107__
Dominance Threshold Number Equals 50% X Sum of Midpoints __53.5_

Tree Species

#	Common Name	Scientific Name	Indicator Status	DBH (in)	BA/ Tree (ft^2)	BA/ Sp. (ft^2)	R
1	Tulip-tree	Liriodendron radicans	FACU	8	0.35	0.70	3
2	Red Oak	Quercus rubra	FACU	16	1.40	1.40	1
3	Chestnut Oak	Quercus prinus	UPL	8.5	0.39	0.78	2
4	White Oak	Quercus alba	FACU	9	0.44	0.44	4

Total Basal Area of All Species Combined _3.32__
Dominance Threshold Number Equals 50% X Total Basal Area _1.66__

1

STREAMSIDE VEGETATION DATA SHEET

Site Name: Dixie Caverns Sample Location: S3
Township: Salem Date: March 27, 1991
County: Roanoke Time: 15:45
State: VA Recorders: DJ/CRB

Herbs & Bryophytes

#	Common Name	Scientific Name	Indicator Status	40" X 40" Quad Q1	Q2	Q3	Q4	X	R
1	Greenbrier	Smilex spp.		100	90			47.5	1
2	Red Maple	Acer rubrum	FAC		10			2.5	6
3	Christmas Fern	Polystichum acrostichoides	FACU			20	100	30	2
4	unknown fern	Polypodiaceae						10	4
5	unknown mint	Labiatae				10		2.5	6
6	Grass	Poaceae				10		2.5	6
7	Moss	Bryophyta				60		15	3

Total of Average (ΣX) _110__
Dominance Threshold Number Equals 50% X Total of Average (ΣX) __55__

Shrub Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Witch Hazel	Hamamelis virginiana	FACU	15	2	10.5	1

Sum of Midpoints _10.5_
Dominance Threshold Number Equals 50% X Sum of Midpoints __5.25_

Woody Vine Species

#	Common Name	Scientific Name	Indicator Status	% Areal Cover	Cover Class	Mdpt. Cover Class	R
1	Greenbrier	Smilex spp.		20	3	20.5	1

Sum of Midpoints _20.5_
Dominance Threshold Number Equals 50% X Sum of Midpoints _10.25_