Delivery Order No. 0013
Environmental Services
Program Support
DACA31-94-D-0064

Team Radford

RADFORD ARMY AMMUNITION PLANT, VIRGINIA

Screening Ecological Risk Assessment

DRAFT DOCUMENT

September 1999

ALLIANT TECHSYSTEMS

Alliant Techsystems Inc.
Radford Army Ammunition Plant
Route 114
P.O. Box 1
Radford, VA 24141-0100

January 31, 2000

Robert Thomson
U. S. Environmental Protection Agency
Region III
1650 Arch Street
Philadelphia, PA 19103-2029

Subject: EPA letter November 30, 1999, Review of Draft Screening Ecological Risk Assessment
Radford Army Ammunition Plant, Radford VA
EPA ID# VA1 210020730

Dear Mr. Thomson:

The subject letter provided comments to RFAAP's Screening Ecological Risk Assessment (SERA). Attachment 1 provides our detailed responses to your comments contained in the subject letter. Section I of this attachment discusses in detail the actions and items that need further discussion between RFAAP and EPA. Section II of this attachment provides a response to each of your comments. Briefly we want to outline some of our concerns with comments from the subject letter.

First, note that completion of the SERA is dependent on completing the inorganic background study. The background study is incomplete primarily due to the fact that sample coordinates do not exist. Thus it was mutually agreed during your visit to RFAAP on November 4, 1999 that a new effort needed to be undertaken to replace the inorganic background data. Since November 4, the Army is performing procurement actions and has further consulted with Region III on the statement of work, a crucial part of this process. At this time it can not be accurately estimated when this process will be completed as funds for this project are not expected until the second quarter of FY 2000 (January to March 2000). Our projection is that the work plan development, review and data collection could result in the completion of the draft inorganic background study report by the end of the calendar year 2000.

Our second concern is the ability to revise the draft SERA to reflect the Final Site Screening Process for the Nansemond Ordnance Depot (SSP). From the November 4, 1999 meeting, you suggested that RFAAP review the final document and assess whether to incorporate the entire document or relevant portions as the strategy for completing the site screening process. This suggestion was further reinforced in EPA's letter dated November 17, 1999 to RFAAP from Maria Vickers. RFAAP would require approximately 30 days to review the document prior to determining the best strategy to ensure RFAAP's ecological risk assessments are adequately addressed. To date RFAAP does not have a copy of the final document and cannot determine at

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this time the specific impact on the deliverable due date for the SERA revision. If RFAAP receives the document during the background study effort, it is possible that a revised SERA could be submitted in March 2001.

Third, there are differences in the technical approach in what EPA is requesting now versus what EPA directed RFAAP to perform during a November 9 and 10, 1998 site visit by the Region III Biological Technical Assistance Group (BTAG). Primarily the differences relate to whether or not to group the site data and to use an accumulation factor of one. This was discussed in detail in the October 1998 RFAAP Ecological Risk Assessment Approach document which was forwarded to EPA on October 16, 1998. RFAAP further discussed this approach during the November 1998 BTAG visit and grouped the data and used an accumulation factor of one. Additional Region III comments were received via email from Barbara Okorn, BTAG leader on January 19, 1999 but were not related to these issues and did not require the October 1998 document to be revised. Again, if these issues are resolved during the background study effort, it is possible that a revised SERA could be submitted in March 2001.

The fourth item of concern is in regard to response turn around. We were given 10 days from receipt of the subject letter instead of the 15 days allowed in the permit. Due to RFAAP's certification process, we typically need the full 15 days or more to adequately respond. Our understanding is that certification is required when submitting reports, not general correspondence or response to comments. Please let us know your criteria for certification.

Fifth, we suggest that it would be constructive that prior to RFAAP submitting a Work Plan for review, a project team meeting (or conference call) be held to discuss EPA concerns. A similar meeting could be held prior to submitting a report.

To conclude and for the reasons discussed above, at this time we are projecting March 2001 as the date for the revised SERA. Please note that the schedules for other reports that deal with risk issues and their associated follow-on work (i.e. CMS) will be similarly impacted by the SSP, completion of the inorganic background study and the SERA. We have shown this on the project schedule (Attachment 2).

If you have any questions or comments please contact either Jerry Redder of my staff (540) 639-7536 or Jim McKenna, ACO Staff (540) 639-8641.

Sincerely,

C. A. Jake

C. A. Jake, Manager
Environmental Affairs
Alliant Ammunition and Powder Company, LLC

Enclosure

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JJRedder

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c: Russell Fish, P.E., EPA Region III
1650 Arch Street
Philadelphia, PA 19103-2029

Leslie Romanchik
Virginia Department of Environmental Quality
Waste Division
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Richmond, VA 23240-0009

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bc: Administrative File
J. McKenna, ACO Staff
S. J. Barker-ACO Staff
Rob Davie-ACO Staff
C. A. Jake
J. J. Redder
Env. File

Coordination: J. McKenna
J. McKenna

00-315-17
JJRedder

ATTACHMENT 1

:al of the revisions requested by EPA Region III to address comments on the Screening Ecological Risk Assessment (SERA) directly impacts the Army's ability to provide an accurate deliverable due date either because of an issue dispute or scheduling considerations. Comments that either impact the revision schedule and/or items in dispute are associated with three main elements, including:

(1) additional level of effort associated with the planning, performance, evaluation, and final inorganic background study report;
(2) evaluation of the final site screening process document to determine whether the installation should incorporate the document fully or incorporate applicable portions relevant to RFAAP; and
(3) SERA technical approach differences between what EPA Region III is currently requesting and the strategy the Army was initially directed by Region III to perform.

Revision comments that are either currently in dispute or have associated schedule considerations that impact the Army's ability to accurately predict the SERA deliverable due date are included in Section I. Responses to all comments are provided in Section 2 and are listed in the order of presentation.

SECTION 1

A. Inorganic Background Study

· pecified by EPA Region III, screening contaminants based upon the comparison of the contaminant entration to naturally occurring inorganic background concentration will not be valid at RFAAP at this time due to the Permittee's withdrawal of the Statistical Inorganic Background Report of November 10, 1999. This report is incomplete primarily due to the fact that sample coordinates do not exist. Thus it was mutually agreed in a meeting held November 4, 1999 that a new effort needed to be undertaken to replace the background data. Since November 4, the Army is performing procurement actions and has further consulted with Region III on the statement of work, a crucial part of this process. At this time it can not be accurately estimated when this process will be completed as funds for this project are not expected until the second quarter of FY 2000 (Jan to Mar 2000). Our projection is that the work plan development and review could result in the completion of the draft inorganic background study report by the end of the calendar year 2000. Note that completion of the SERA is dependent on first completing the inorganic background study.

B. Site Screening Process

During the November 4, 1999 meeting with EPA, it was suggested by EPA that RFAAP review the *Final Site Screening Process For the Former Nansemond Ordnance Depot*, and assess whether to incorporate the entire document or relevant portions as the strategy for completing the site screening process (SSP). This suggestion was also specified in the November 17, 1999, Continuance of RCRA Corrective Action Permit Radford Army Ammunition Plant, EPA ID No. VA1210020730 letter received from Maria Parisi Vickers, Associate Director for RCRA, Waste and Chemicals Management Division.

The Army would require approximately 30 days to review the document prior to determining the best strategy sure RFAAP ecological risk assessments are adequately addressed. To date RFAAP does not have a copy

of the final document and can not determine at this time the specific impact on the deliverable due date for
'RA revision.

C. SERA Approach

The SERA approach was documented in the RFAAP, Ecological Risk Assessment Approach, Main Manufacturing Area and New River Unit, October 1998. Several areas that were agreed upon by the EPA Region III BTAG during the time of development that are currently provided as revision comments include:

- Grouping data together for evaluation in the SERA as opposed to leaving sites separate by SWMU was discussed and agreed to during the site visit with the Region III BTAG on 11/9-10/98. The decision to group data for the screening ERA was made for the following reasons:

  - Maximum concentrations were used in the screening ERA, which ensures that risks are not underestimated by grouping data. The risk management considered in greater detail the pattern of contamination to identify site-specific characteristics.
  - All sites in the Main Manufacturing Area fall within the same New River watershed.
  - Similar chemicals were detected in most of the sites.
  - Many of the higher trophic-level receptors could be exposed at multiple sites.
  - Although there is variation in habitat type within and between SWMUs, each was determined to be capable of supporting the associated receptors evaluated for the area.

  Region III BTAG guidance at the time the risk assessment was completed was to use an accumulation factor of one in conjunction with the maximum detected concentration. It was our understanding that BTAG considered this approach as a conservative indicator of exposure concentration. Consistent with USEPA guidance and direction, the use of an accumulation factor of one is also documented in the Radford Army Ammunition Plant screening ERA approach document (USAEC 1998).

- The primary objective of the site visit conducted with the USEPA Region III BTAG on November 9-10, 1998 was to confirm that the available sample data was adequate to conduct the SERA. BTAG stated the currently available data was sufficient for conducting the SERA.

SECTION 2

A. General Comments

Paragraphs 1 and 2

Preliminary conceptual site models and associated sampling location data have been developed for all solid waste management units discussed in the SERA. This information will be included as an appendix to the document to ensure appropriate migration and exposure pathways have been sampled. Each area evaluated will include detailed information on the site history, previous operational history, and associated chemicals of
ncern. Detailed fate and transport mechanisms will be included, as appropriate. Toxicity screening
iducted during the SERA focuses primarily on survival and reproduction, both of which are ecologically

relevant effects. A more detailed evaluation of toxicity modes will be performed later in the ERA.

Paragraph 3

An evaluation of the habitats within each SWMU was performed during the SERA for the selection of ecological receptors. Although this information was not included in the SERA text, a description of habitats on and surrounding each SWMU and the potential receptors occurring within each of these areas can be added.

Paragraph 4

Grouping data together for evaluation in the SERA as opposed to leaving sites separate by SWMU was discussed and agreed to during the site visit with the Region III BTAG on 11/9-10/98. The decision to group data for the screening ERA was made for the following reasons:

- Maximum concentrations were used in the screening ERA, which ensures that risks are not underestimated by grouping data. The risk management considered in greater detail the patterns of contamination to identify site-specific characteristics.
- All sites in the Main Manufacturing Area fall within the same New River watershed.
- Similar chemicals were detected in most of the sites.
- Many of the higher trophic-level receptors could be exposed at multiple sites.
- Although there is variation in habitat type within and between SWMUs, each was determined to be capable of supporting the associated receptors evaluated for the area.

B. Specific Comments

Paragraph 1

We concur that sediment samples are needed to characterize risks in SWMU 31. Sediment samples will be collected in each of the lagoons upon approval of Workplan Addendum 9, unless directed otherwise.

Paragraph 2

We concur that an accumulation factor of one could underestimate exposure for some highly bioaccumulative chemicals, while it is likely to overestimate exposure for most other chemicals. However, Region III BTAG guidance at the time the risk assessment was completed was to use an accumulation factor of one in conjunction with the maximum detected concentration. It was our understanding that BTAG considered this approach as a conservative indicator of exposure concentration. Consistent with USEPA guidance and direction, the use of an accumulation factor of one was documented in the Radford Army Ammunition Plant screening ERA approach document (USAEC 1998).

Paragraph 3

Additional considerations (e.g., chemical distribution, bioavailability) will be provided before eliminating se chemicals from further evaluation. For example, withdrawal of the statistical inorganic background report will require reevaluation of SERA Section 2.

agraph 4

All surface soil samples from SWMU 31 were considered in the SERA for a worst-case estimation of risk. Based on the risk observed, sample locations driving these risks were evaluated in more detail. The area from which the samples were collected represents a transitional zone between sediment and surface soil and would not support terrestrial plant life. These samples can be eliminated from this pathway in the revised SERA as directed by BTAG.

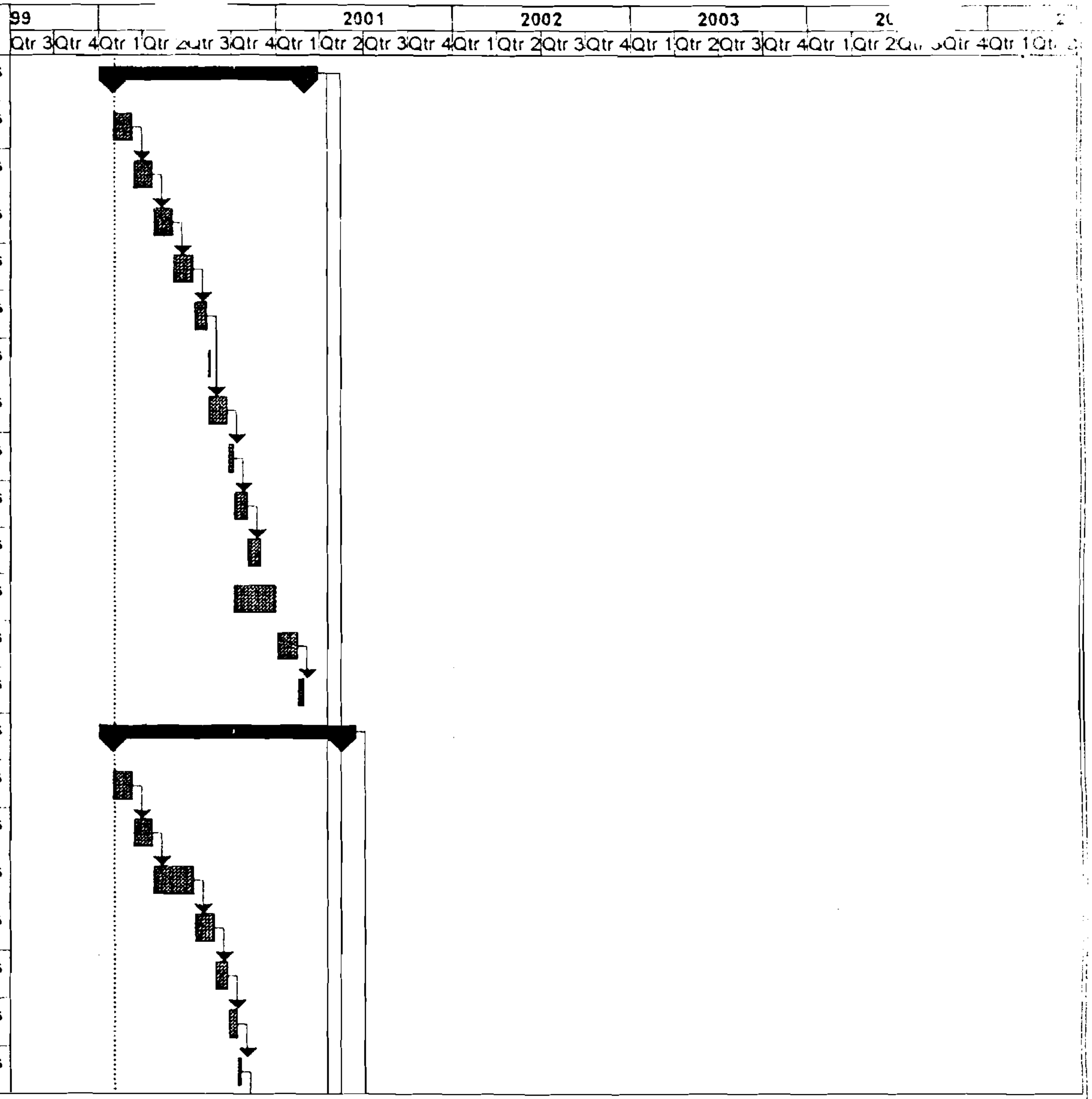
Paragraph 5

Please see response to comment for Paragraph 3.

Paragraph 6

As discussed in the general comments, additional text will be added describing the habitats and potential ecological receptors occurring within each of the SWMUs and site conceptual models will be included as an appendix. As stated in Section 1, one of the primary objectives of the site visit conducted with the USEPA Region III BTAG on November 9-10, 1998 was to confirm that the available sample data was adequate to conduct the SERA. BTAG stated the currently available data was sufficient for conducting the SERA.

ID	Task Name	Duration
1	**Facility Wide Background Study**	**283 days**
2	Procurement	30 days
3	Award	30 days
4	WP Addendum - Draft WPA	30 days
5	EPA Review - Draft WPA	30 days
6	WPA - Draft Final (DF)	20 days
7	Sample Collection	5 days
8	EPA Review-Draft Final WPA	30 days
9	Final WPA	10 days
10	EPA Review-Final WPA	20 days
11	Final WPA	20 days
12	Draft Background Study Report	60 days
13	EPA Review-Report	30 days
14	Final Background Study Report	10 days
15	**Quantitative HHRA 39, 48, 54**	**338 days**
16	Procurement	30 days
17	Award	30 days
18	Scoping Document	60 days
19	EPA Review	30 days
20	Final Scoping Document	20 days
21	ID of Chemical of Concern	15 days
22	Cumulative Risk Screening	5 days

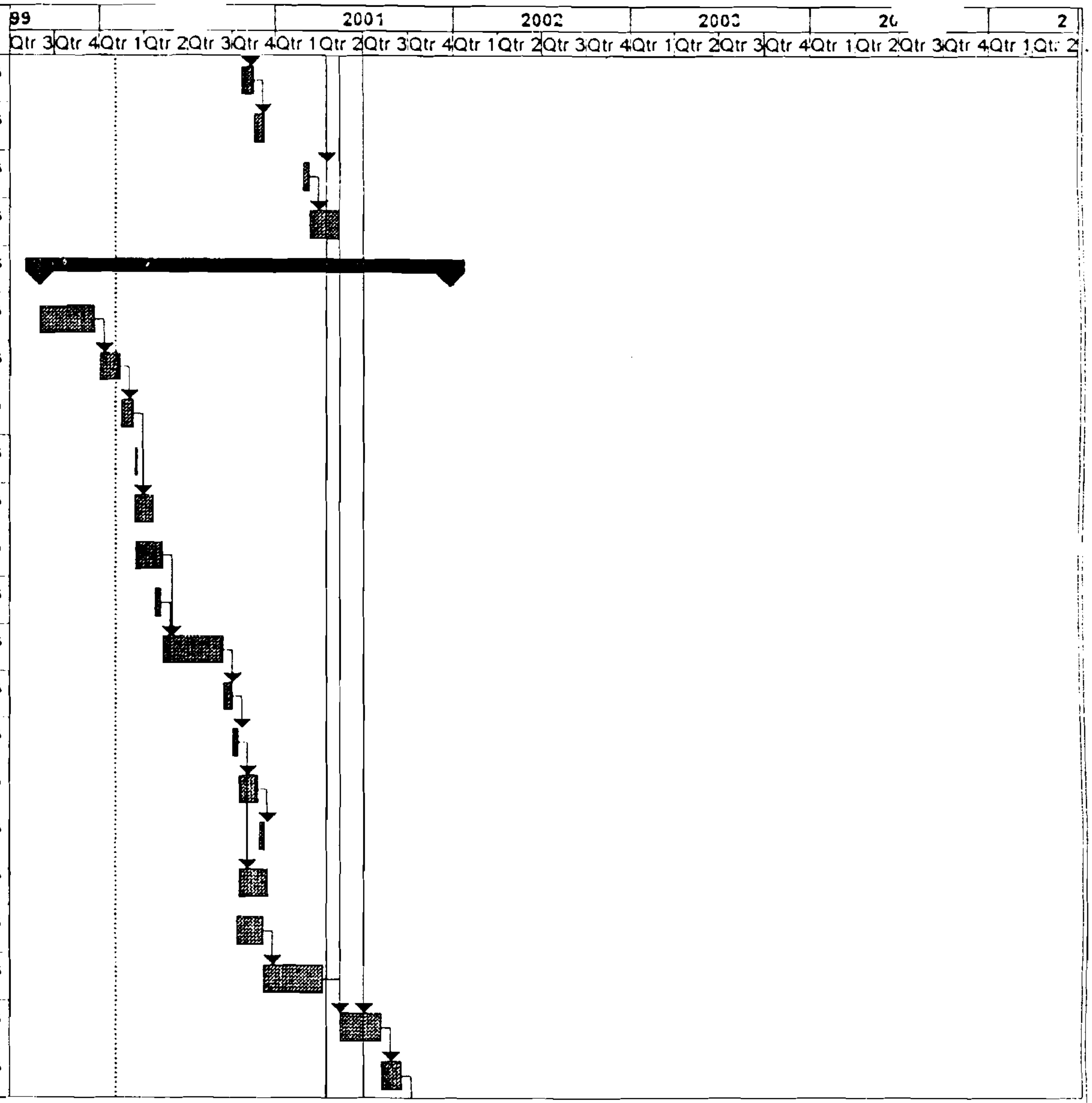


RFAAP Draft Project Schedule
Date: [illegible]

Task
Progress
Milestone
Summary
Rolled Up Task
Rolled Up Milestone
Rolled Up Progress
External Tasks
Project Summary
Split
Rolled Up Split

[redacted]

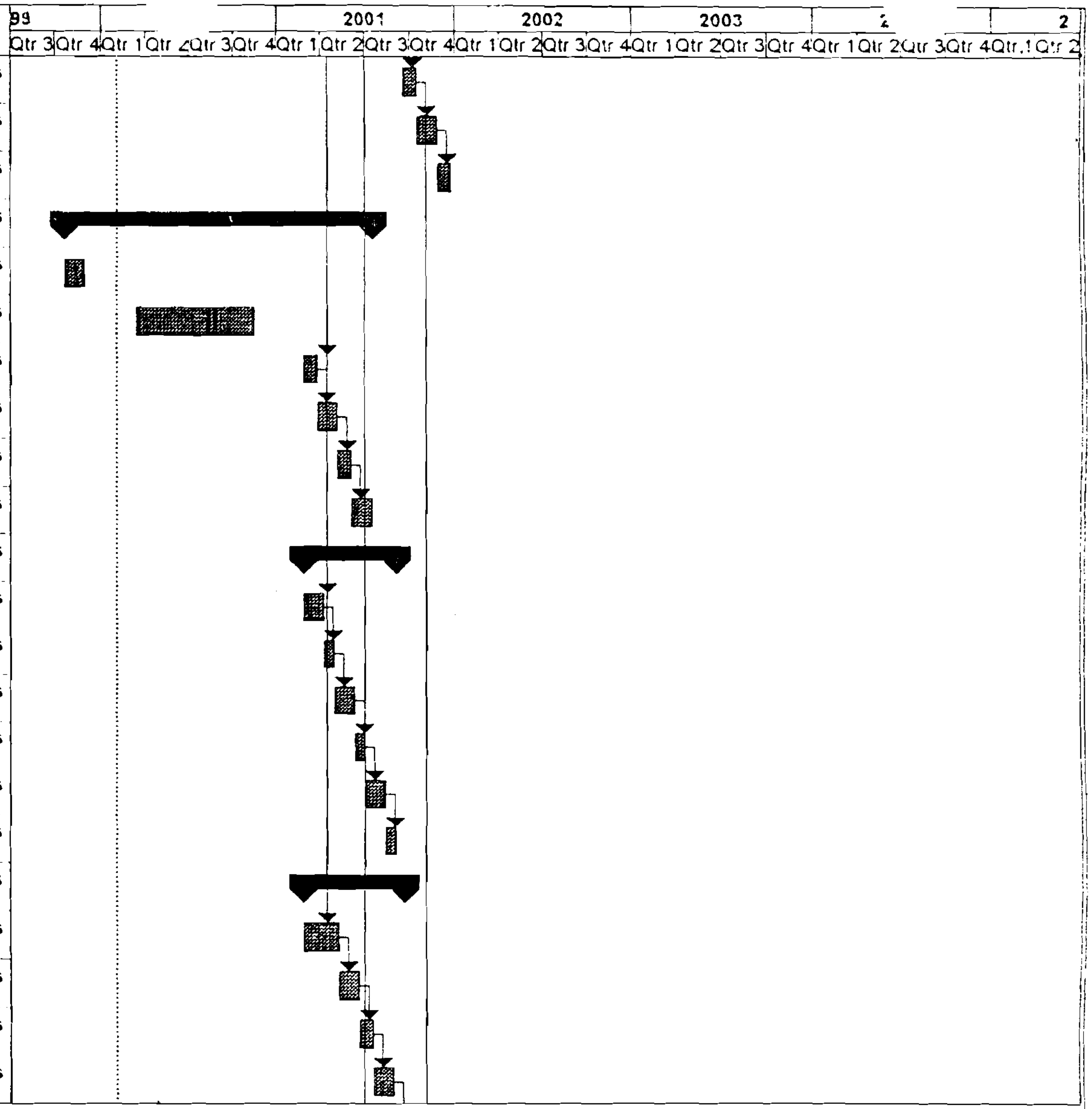
ID		Task Name	Duration
23		Exposure Point	20 days
24		Human Risk Characterization	15 days
25		Background Comparison	10 days
26		Report Development	45 days
27		**31, 39, 48, 49, and 58**	**606 days**
28		Draft WP Addendum (WPA) 9	80 days
29		EPA Review - Draft WPA 9	30 days
30		WPA 9 - Draft Final (DF)	20 days
31		GW/SW/sediment sampling- 31	5 days
32		EPA Review - DF WPA 9	30 days
33		Dye Trace - High Flow	40 days
34		WPA 9 - Final	10 days
35		High Flow Results	90 days
36		Monitoring Well Install. - 48/49	14 days
37		Groundwater Sampling - 48/49	10 days
38		EPA Review - Final WPA 9	30 days
39		Final WPA 9	10 days
40		Data Validation - 31,48/49	45 days
41		Dye Trace - Low Flow	40 days
42		Low Flow Results	90 days
43		Revised RFI	60 days
44		EPA RFI Review	30 days



RFAAP Draft Project Schedule
Date [illegible]

Task | Rolled Up Task | Project Summary
Progress | Rolled Up Milestone | Split
Milestone | Rolled Up Progress | Rolled Up Split
Summary | External Tasks

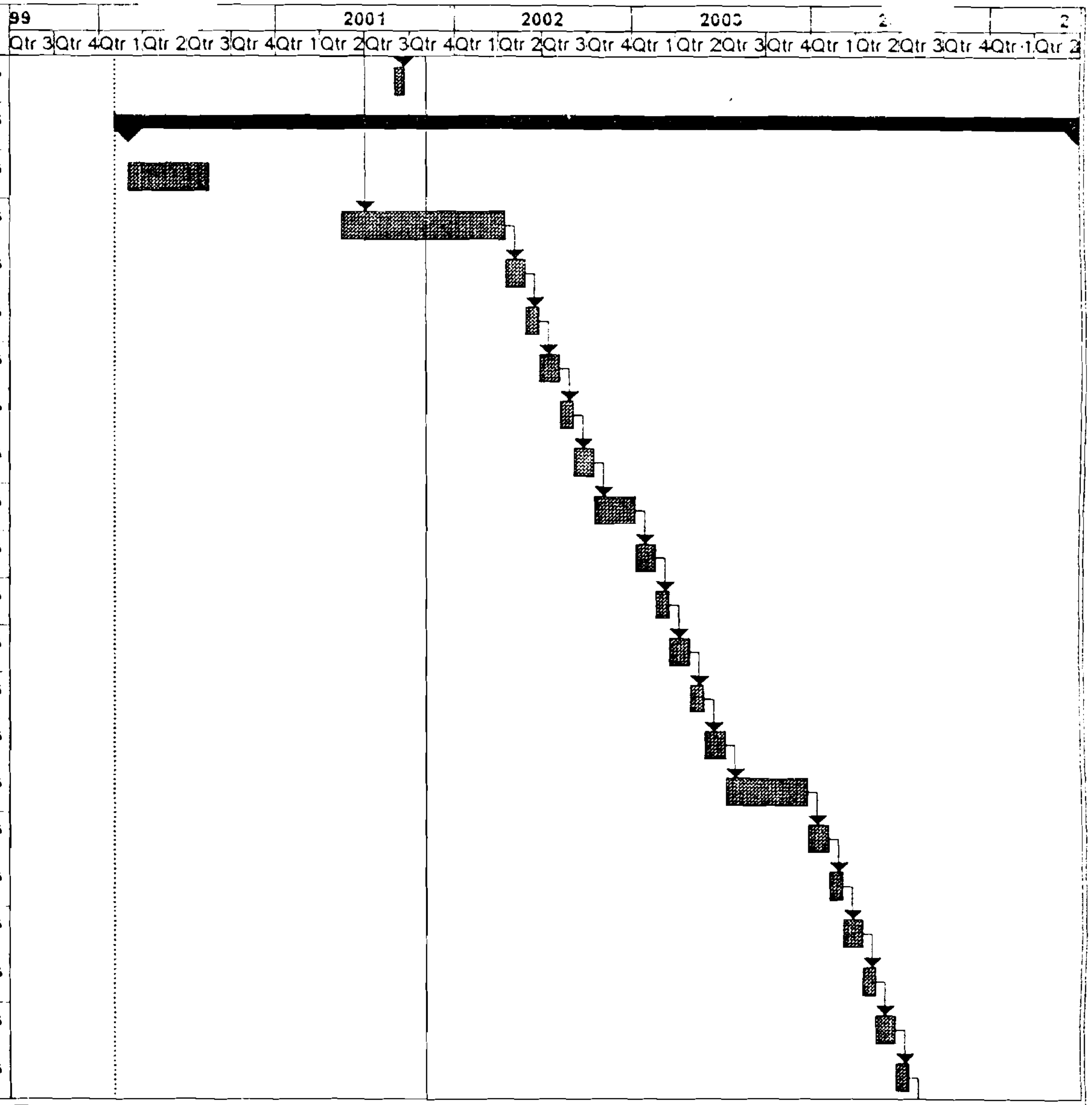
ID	Task Name	Duration
45	Draft Final RFI	20 days
46	EPA RFI Review	30 days
47	Final RFI	20 days
48	**Screening Eco. Risk Assessment**	**456 days**
49	EPA Review-Draft Screening ERA	30 days
50	Data Gap Completion	180 days
51	Draft Final Screening ERA	20 days
52	EPA Review - Draft Final ERA	30 days
53	Final Screening ERA	20 days
54	EPA Review-Final ERA	30 days
55	**Former Lead Furnace Area**	**135 days**
56	EPA Review-Draft RFI	30 days
57	Draft Final RFI Report	15 days
58	EPA Review-Draft Final	30 days
59	Final RFI Report	15 days
60	EPA Review-Final RFI Report	30 days
61	Final Report	15 days
62	**RI - Building 4343**	**148 days**
63	Draft RI Report	53 days
64	EPA Review - Draft RI Report	30 days
65	Draft Final RI Report	20 days
66	EPA Review-Draft Final RI Report	30 days



RFAAP Draft Project Schedule
Date: 1/13/00

Task | Rolled Up Task | Project Summary
Progress | Rolled Up Milestone | Split
Milestone | Rolled Up Progress | Rolled Up Split
Summary | External Tasks

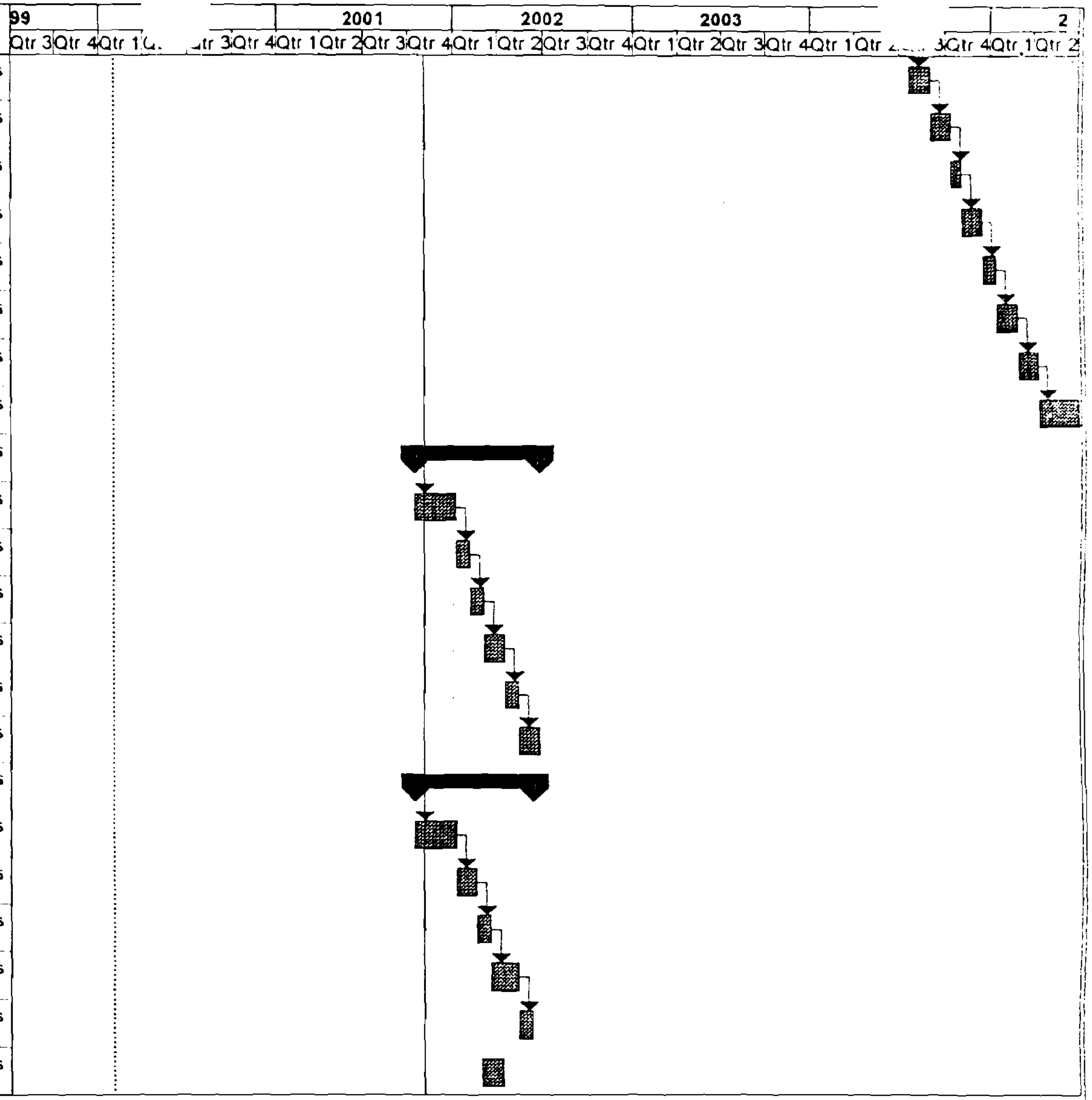
ID	Task Name	Duration
67	Final Report	15 days
68	**New River Unit**	**1391 days**
69	Draft Baseline Risk Assessment	120 days
70	Draft RI Report	240 days
71	EPA Review - Draft RI	30 days
72	Draft Final RI	20 days
73	EPA Review - Draft Final RI	30 days
74	Final RI Report	20 days
75	EPA Review - Final RI	30 days
76	Draft Closure Report - WBG	60 days
77	EPA Review-Closure Report	30 days
78	Draft Final Closure Report	20 days
79	EPA Review - Draft Final Report	30 days
80	Final Closure Report - WBG	20 days
81	EPA Review-Final Closure - WBG	30 days
82	Feasibility Study (FS)	120 days
83	EPA Review - Draft FS	30 days
84	Draft Final FS	20 days
85	EPA Review - Draft Final FS	30 days
86	Final FS	20 days
87	EPA Review - Final FS	30 days
88	Final FS	20 days



RFAAP Draft Project Schedule
Date:

Task · Progress · Milestone · Summary · Rolled Up Task · Rolled Up Milestone · Rolled Up Progress · External Tasks · Project Summary · Split · Rolled Up Split

ID	Task Name	Duration
89	Draft Proposed Plan - NBG	30 days
90	EPA Review - Proposed Plan NBG	30 days
91	Draft Final Proposed Plan NBG	15 days
92	Public Comment	30 days
93	Final Proposed Plan	20 days
94	Draft ROD - NBG	30 days
95	EPA Review	30 days
96	Final ROD	60 days
97	**CMS SWMU 39**	**180 days**
98	Draft CMS	60 days
99	EPA Review - Draft CMS	20 days
100	Draft Final -CMS	20 days
101	EPA Review - Draft Final CMS	30 days
102	Final CMS	20 days
103	EPA Review - Final CMS	30 days
104	**CMS at SWMU 48**	**170 days**
105	Draft CMS	60 days
106	EPA Review -Draft CMS	30 days
107	Draft Final	20 days
108	EPA Review - Draft Final CMS	40 days
109	Final CMS	20 days
110	EPA Review - Final CMS	30 days



RFAAP Draft Project Schedule
Date: 1/18/00

Task		Rolled Up Task		Project Summary	
Progress		Rolled Up Milestone		Split	
Milestone		Rolled Up Progress		Rolled Up Split	
Summary		External Tasks			

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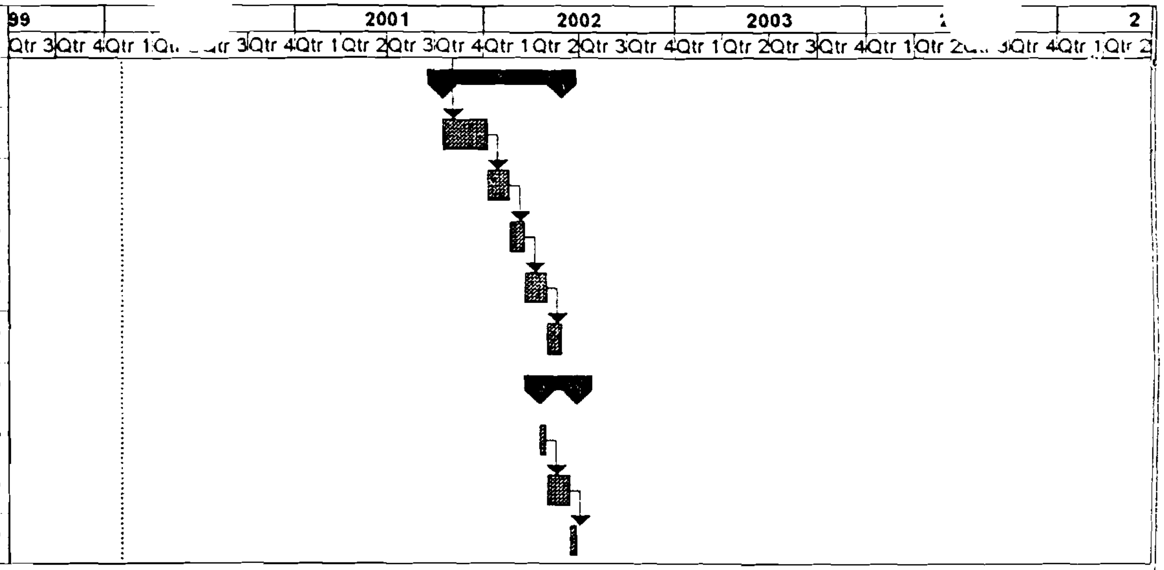
ID	Task Name	Duration
111	**IRM Report option at SWMU 48**	**160 days**
112	Draft	60 days
113	EPA Review	30 days
114	Draft Final	20 days
115	EPA Review	30 days
116	Final	20 days
117	**Decision Document - SWMU 48**	**81 days**
118	Draft	10 days
119	EPA Review	30 days
120	Final	10 days



RFAAP Draft Project Schedule
Date 1/13/00

Task		Rolled Up Task		Project Summary	
Progress		Rolled Up Milestone		Split	
Milestone		Rolled Up Progress		Rolled Up Split	
Summary		External Tasks			

[redacted]

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McKenna, Jim

m:	Redder, Jerome
t:	Monday, January 31, 2000 5:34 PM
	'Rob Thomson, EPA Region III'
Cc:	Jake, Carolyn; Davie, Robert; McKenna, Jim
Subject:	Response to Nov. 30, 1999 letter

Attached is the draft letter in response to your Nov. 30, 1999 letter. I had difficulties obtaining signatures to get it out FedEx today. it will be in FedEx Feb. 1, 2000. The schedule is MS Project version 5.0. We will print a copy to with the letter.

REPLYEPASERA2.doc

2002rev4h.MPP

15

McKenna, Jim

From: McKenna, Jim
: Wednesday, January 26, 2000 9:19 AM
Redder, Jerome
Cc: Davie, Robert; Barker, Shelley
Subject: Response to EPA's letter of 11/30/99

REPLYEPASERA2.doc   2002rev4h.MPP

Jerry,

Been looking over my earlier draft response and incorporated our updated project schedule information and did a little word smithing. Please look it over. I recommend that we attach the project schedule (in the file below) that we recently updated and is to be on our web site. I'll be out Jan 31, 2000 and my understanding is that our response needs to be out on or before Jan 31.

Thanks,
Jim

Rec'd 12-9-99 99-147

Jake
Redder
McKenna
file

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

November 30, 1999

Deadline - 12/15

In reply
Refer to 3HS13

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

Commander,
Radford Army Ammunition Plant
Attn: SIORF-SE-EQ (Jim McKenna)
P.O. Box 2
Radford, VA 24141-0099

C.A. Jake
Environmental Manager
Alliant Techsystems, Inc.
Radford Army Ammunition Plant
P.O. Box 1
Radford, VA 24141-0100

Re: Radford Army Ammunition Plant
EPA ID# VA 1210020730
Review of draft Screening Ecological Risk Assessment

Dear Mr. McKenna and Ms. Jake:

The U.S. Environmental Protection Agency (EPA) has reviewed the Army's draft Screening Ecological Risk Assessment, dated September, 1999, for the Radford Army Ammunition Plant (RFAAP), and we offer the following comments and concerns as outlined below:

The draft Screening Ecological Risk Assessment (SERA) report includes an evaluation of solid waste management units (SWMU) 71, 17, 54, 31, 39, Former Lead Furnace Area, and the New River. The SERA generally follows Steps 1 and 2 of the EPA guidance, but several important parts are missing as outlined below. It also important to note that any screening of contaminants based upon the comparison of the contaminant concentration to naturally occurring inorganic background concentrations is not valid, based upon the Permittee's withdrawal of the Statistical Inorganic Background Report as of November 10, 1999.

General Comments

There are several things not included in the draft report that need to be presented. All of this information stated below should be used to develop a preliminary site conceptual model. The preliminary conceptual model would then be used to determine which receptors should be evaluated in the SERA. The final report needs the following additional information to develop individual site conceptual models:

- Detailed site maps for individual SWMUs showing the sampling locations for data used in the SERA. These maps should also include surface contours and any obvious drainage features present at the site. These maps along with the preliminary site conceptual model should be used to determine if all migration and exposure pathways have been sampled and if there are data gaps.

- Detailed information on the history of the individual SWMUs, including when the site was used and what it was used for, and chemicals and materials suspected of being used. There should also be a detailed description of fate and transport mechanisms, and modes of toxicity for these suspected contaminants. In addition, this will provide justification for analyzing for a limited number of contaminants.

- Detailed description of the ecological habitat present at the site (i.e., forested, field, paved etc.), distance to nearest water body (i.e., New River), and the ecological receptors that would be expected to be present at the site. This information will be used to determine which receptors should be evaluated in the SERA. The report currently only contains a detailed description of the ecological habitat for the entire facility.

The EPA BTAG generally supports the consolidation of many small sites located in close proximity to each other into a single risk assessment, particularly when evaluating risk to far ranging wildlife species. However, the reason for the consolidation of sites in the current document is unclear. Given that none of the sites are in close proximity to each other (i.e., greater than a mile apart), this consolidation is inappropriate and creates unnecessary confusion. Therefore, separate site conceptual models and SERA should be performed for the individual SWMUs. This will create much less confusion, particularly in Section 2.

Specific comments

Table 1-6 on page 1-15 presents a summary of sediment sampling that has occurred at all of the SWMUs. It appears that only surface water was collected from the lagoons at SWMU 31, and that no sediment has been collected. Given that many contaminants will accumulate in sediments, sampling of these sediments would be warranted. Once site conceptual models are developed for each SWMU, other data gaps may become apparent, where exposure to ecological receptors has not been adequately characterized.

Section 1.1.3.3 on page 1-19 states that accumulation factors of one will be used for all chemicals in prey. An accumulation factor of one may not be appropriate for chemicals known to bioaccumulate to factors greater than one. If certain chemicals are known to bioccumulate, more appropriate bioaccumulation factors should be used to more realistically evaluate food chain effects.

There are several references in Section 2 to the magnitude of the exceedance of the environmental effects quotients (EEQ). Many areas are recommended for no further action based on low EEQs. Based on the high level of uncertainty at this screening phase, it would be premature to eliminate areas, chemicals and SWMUs from further consideration based on slight exceedances of screening values, particularly when concentrations exceed background concentrations.

Section 2.6.3 on page 2-5 states that aluminum should not be considered further, since the lagoons would not support terrestrial vegetation, and thus the pathway to the meadow vole is incomplete. It is unclear why this pathway was evaluated, if no exposure pathway exists. Individual site conceptual models should identify other pathways that are incomplete, and that do not need to be evaluated in the SERA. There are several additional references to this throughout Section 2.

There are several references throughout Section 2 for compounds eliminated from further consideration, since soil concentrations only slightly exceeded background. The definition of slightly exceeded background should be provided. In addition, if mean media concentrations are above screening values and exceed background concentrations, this may not be enough justification to eliminate from future consideration. Additional information that can be used would be site history (i.e., chemicals used at the site), and the spatial distribution of the exceedances.

In general, the SERA for these SWMUs is not adequate to evaluate ecological risk. Site conceptual models will need to be developed that consider additional information as stated above. The development of a site conceptual model will ensure that sampling is adequate and data gaps do not exist, and that the appropriate ecological receptors have been evaluated in the SERA.

This concludes EPA's review of the Army's draft Screening Ecological Risk Assessment, dated September, 1999, for the RFAAP. The referenced draft Screening Ecological Risk Assessment is disapproved by EPA in its current form, and must be revised to reflect the comments above. Should you disagree with any condition of this disapproval, you must notify EPA within ten (10) days of receipt of this letter and include the specific condition(s) in dispute, the position you believe should be adopted, the basis for your position, and any other relevant information. Otherwise, the revisions requested above shall be incorporated into a revised draft Screening Ecological Risk Assessment document. Within thirty (30) calendar days of receipt of this letter, the Permittees shall propose a deliverable due date for the above referenced revised draft Screening Ecological Risk Assessment document to EPA.

If you have any questions, please call me at 215-814-3357.

Sincerely,

Robert Thomson, PE
Federal Facilities Branch

cc: Russell Fish, EPA
John McCloskey, BTAG-FWS
Leslie Romanchik, VDEQ-RCRA
Devlin M. Harris, VDEQ-CERCLA

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October 25, 1999

Alliant Techsystems Inc.
Radford Army Ammunition Plant
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P.O. Box 1
Radford, VA 24141-0100

U. S. Environmental Protection Agency
Region III
1650 Arch Street
Philadelphia, PA 19103-2029

Attention: Robert Thomson

Subject: Draft Screening Ecological Risk Assessment, Radford Army Ammunition Plant
Radford Army Ammunition Plant, Radford VA
EPA ID# VA1 210020730

Dear Mr. Thomson:

Enclosed is a certified copy of the "Draft Screening Ecological Risk Assessment, Radford Army Ammunition Plant, September 1999" (ERA). Your six additional copies, Mr. Harris' and Ms. Romanchik's copies will be sent under separate cover.

Please note this ERA follows the procedures contained in the "Ecological Risk Assessment Approach", October 1998 that was sent to your office October 16, 1998 as well as the discussions held with you and Ms. Barbara Okorn during the November 9 and 10, 1998 site visit at Radford.

Please coordinate with and provide any questions or comments to myself at (540) 639-8266, Jerry Redder of my staff (540) 639-7536 or Jim McKenna, ACO Staff (540) 639-8641.

Sincerely,

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Concerning Draft Screening Ecological Risk Assessment, Radford Army Ammunition Plant

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

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Team Radford

Delivery Order No. 0013
Environmental Services
Program Support
DACA31-94-D-0064

RADFORD ARMY AMMUNITION PLANT, VIRGINIA

Screening Ecological Risk Assessment

DRAFT DOCUMENT

September 1999

24

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	September 1999	Screening Ecological Risk Assessment, 1999

4. TITLE AND SUBTITLE

Radford Army Ammunition Plant, Screening Ecological Risk Assessment

5. FUNDING NUMBERS

U.S. Army Environmental Center
Contract No.DACA31-94-D-0064
Delivery Order 0013

6. AUTHOR(S)

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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

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8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

U.S. Army Environmental Center
Aberdeen Proving Ground, MD 21010

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

This screening -level Ecological Risk Assessment (ERA) presents an evaluation of the potential adverse effects to non-human receptors resulting from exposure to chemicals of concern at the Radford Army Ammunition Plant Main Manufacturing Area. The ERA was developed in accordance with relevant Army guidance and national and regional USEPA guidance for evaluating ecological risks at hazardous waste sites. The approach that received concurrence for use by the EPA Region III Biological Assistance Team is documented in, Ecological Risk Assessment Approach, Main Manufacturing Area and New River Unit, October 1998. Primary screening-level activities include the following: data evaluation, summary, and screening; preliminary identification of assessment endpoints; development of preliminary conceptual model; identification of indicator species, screening model, and model input parameters; evaluatation of screening ERA outcomes and problem formulation; bioassessment investigation; and risk characterization and management.

14. SUBJECT TERMS

15. NUMBER OF PAGES

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	None

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EXECUTIVE SUMMARY

Solid waste management units and areas of concern selected for ecological risk assessment screening in accordance with the USEPA Biological Technical Assistance Team approach specifications included the following:

- SWMU 71—Flash Burn Parts Area
- SWMU 17—Air Curtain Destructor and Open Burning Grounds
- SWMU 54—Propellant Burning Ash Disposal Area
- SWMU 31—Coal Ash Settling Lagoon
- SWMU 39—Incinerator Wastewater Settling Lagoons
- FLFA—Former Lead Furnace Area
- New River

Exposure pathways and potential receptor species were determined based on (1) ecological habitat/receptors; (2) nature and extent of chemical contamination; (3) contamination source; (4) chemical transport media; (5) receptor organism contact potential; and (6) contact route of exposure. Indicator species selection was based on the likelihood of a species interaction with the site and immediate surrounding areas, feeding habits and life history of the organism/guild, and the availability of toxicity data. Results of the screening-level ERA for the indicator species/exposure pathways selected for evaluation are as follows:

- **Terrestrial Plants.** Available toxicity information suggests that organic chemicals of potential concern (COPCs) are unlikely to impose adverse affects. Lead concentrations exceeded terrestrial plant threshold (TRV) at many locations within SWMU 17 and will be carried through the ERA. The FLFA does not warrant any further consideration because the elevated soil concentrations have been removed. Mercury exceeded the terrestrial plant toxicity reference value at on location associated with SWMU 71, which represents a potential source area and will be carried through the ERA.
- **Terrestrial Invertebrates.** Available toxicity information suggests that organic COPCs are unlikely to impose adverse affects. Copper (SWMUs 17 and 39), lead (SWMU 17), and mercury (SWMU 71) and will be carried through the ERA.
- **Terrestrial Wildlife.**
  - ***Herbivorous Mammals.*** Inorganic and organic COPCs are unlikely to adversely impact and are not recommended for further evaluation.
  - ***Vermivorous Bird.*** Available toxicity information suggests that organic COPCs are unlikely to impose adverse affects. Chemicals that will be carried through the ERA include lead (SWMUs 17 and 39) and methylmercury (SWMU 71).
  - ***Vermivorous Small Mammals.*** Available toxicity information suggests that organic COPCs are unlikely to impose adverse affects. Methylmercury will be carried through the ERA (SWMU 17).
  - ***Predatory Birds.*** Available toxicity information suggests that organic COPCs are unlikely to impose adverse affects. Methylmercury will be carried through the ERA (SWMU 17).
  - ***Predatory Mammals.*** Available toxicity information suggests that organic COPCs are unlikely to impose adverse affects. Methylmercury will be carried through the ERA (SWMU 17).
  - ***Piscivorous Birds.*** Available toxicity information suggests that organic COPCs are unlikely to impose adverse affects. Lead will be carried through the ERA (New River).
- **Aquatic Organisms.** Lead will be carried through the ERA (New River).
- **Benthic Organisms.** Lead will be carried through the ERA (New River).

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1.0 SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT

The purpose of the screening-level Ecological Risk Assessment (ERA) is to assess the potential for adverse effects to non-human receptors resulting from exposure to chemicals at the Main Section of the Radford Army Ammunition Plant (RFAAP). This ERA was conducted in accordance with national and regional USEPA guidance for evaluating ecological risks at hazardous waste sites (USEPA, 1989a,b, 1992, and 1997) and in accordance with relevant Army guidance (Wentsel et al. 1994). Figure 1–1 (USEPA 1997) presents the overall ERA process that will be used for RFAAP consistent with USEPA (1997) and the approach outlined in the RFAAP Ecological Risk Assessment Approach (October 1998). The screening-level ERA encompasses Steps 1 and 2 of the eight-step process for conducting ERAs as presented in USEPA (1997). The screening-level ERA is intended to allow rapid determination that either RFAAP poses negligible ecological risk or that specific contaminants and exposure pathways require further evaluation. The following sections are included in the screening ERA:

- **Problem Formulation**—A preliminary conceptual model is developed for RFAAP which addresses the environmental setting and identifies chemicals of potential concern (COPCs), exposure pathways and receptors for analysis, and assessment and measurement endpoints.
- **Exposure Assessment**—The preliminary concentrations and/or doses of COPCs to which ecological receptors selected for evaluation could be exposed are estimated.
- **Ecological Effects Assessment**—Contaminant exposure levels that represent conservative thresholds for adverse ecological effects are selected for each exposure pathway and COPC.
- **Risk Characterization**—Estimated COPC exposure concentrations/doses are compared to conservative toxicity reference values to determine if there are potential risks to RFAAP ecological receptors.
- **Uncertainties**—The uncertainties associated with the screening ERA are determined.

The results of this screening ERA and its evaluation will be discussed with the USEPA as part of a Scientific Management Decision Point (SMDP). The SMDP will determine if the eight-step ERA process for RFAAP can be terminated at this screening phase or if there is need for additional site investigation (Steps 3 through 8 of the process).

1.1 PROBLEM FORMULATION

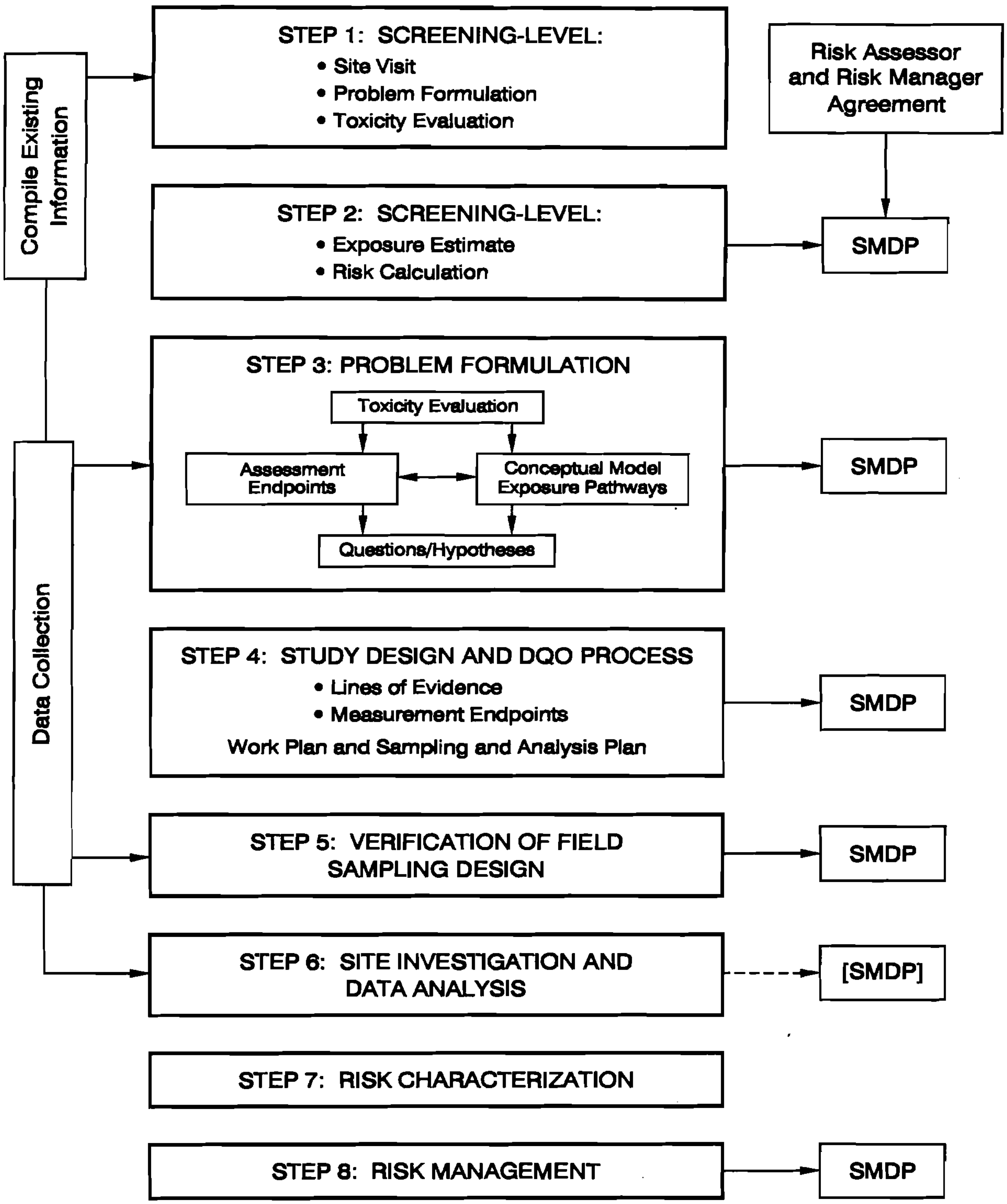
The purpose of the problem formulation section is to identify RFAAP chemicals of concern and the ecological receptors and exposure pathways for evaluation. Available information is evaluated regarding site history and past and present land use activities, habitat and wildlife, and COPCs associated with the site in order to identify the pathways by which ecological receptors could be exposed to chemicals and the assessment endpoints for the screening ERA.

1.1.1 Site Description

The installation is approximately 6,900 acres in size and is located within Pulaski and Montgomery Counties in the mountains of southwest Virginia. It is situated along the New River in the northeast corner of a narrow valley of the Appalachian Mountains. The Main Section, which is the focus of this ERA, is located 10 miles west of Blacksburg and 47 miles southwest of Roanoke. The New River provides drainage for the entire area and divides the Main Section of RFAAP into the Main Manufacturing and Horseshoe Areas (see Figure 1–2). The Horseshoe Area is located within the meander of the New River and the Main Manufacturing Area is south of the New River. The largest tributary of the New River, Stroubles Creek, flows through the southeastern portion of the Main Manufacturing Area. Other small streams and manmade water bodies also occur in the Main Manufacturing Area and many discharge to the New River.

FIGURE 1-1

Eight-step Ecological Risk Assessment Process for Superfund



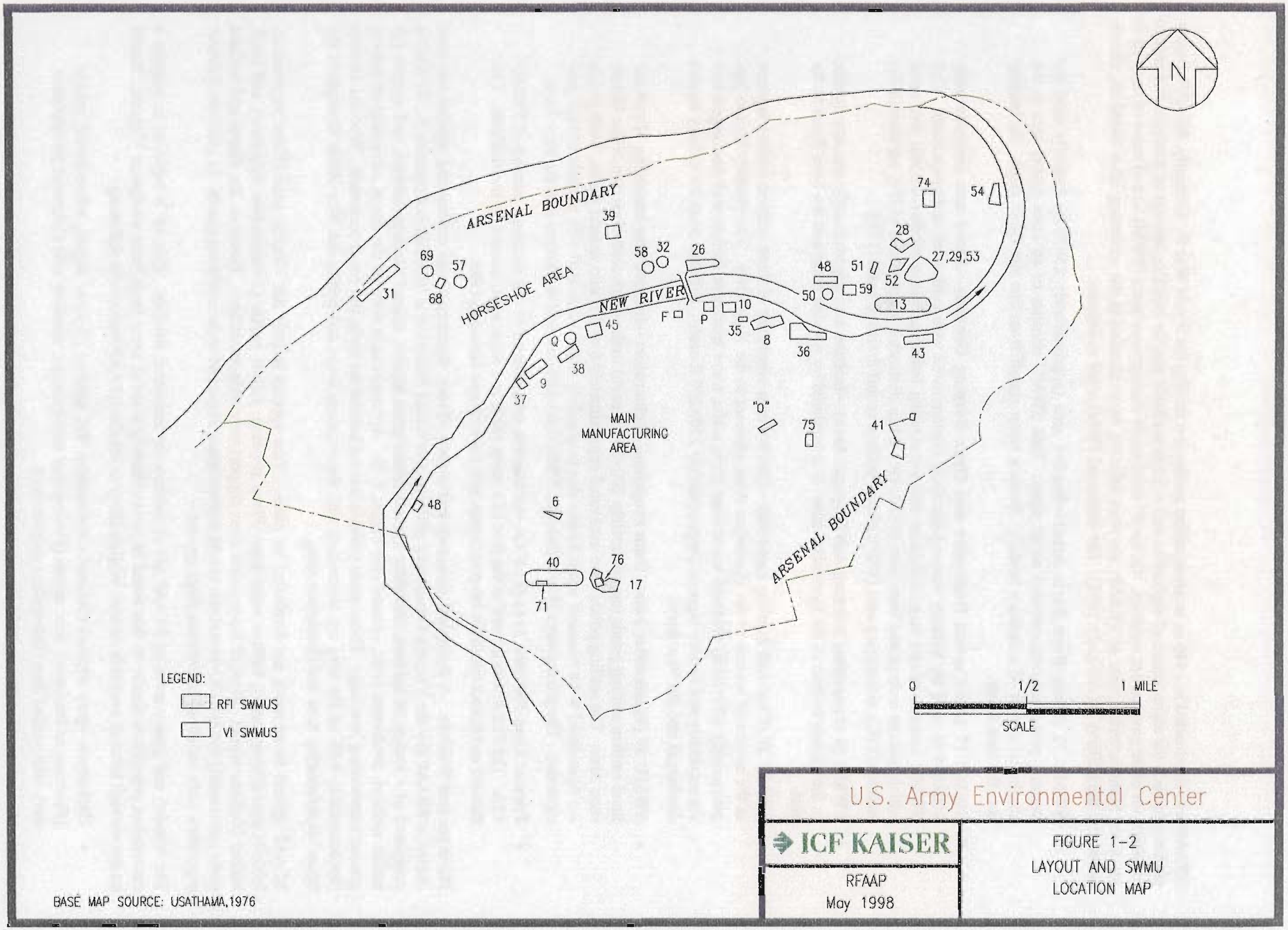
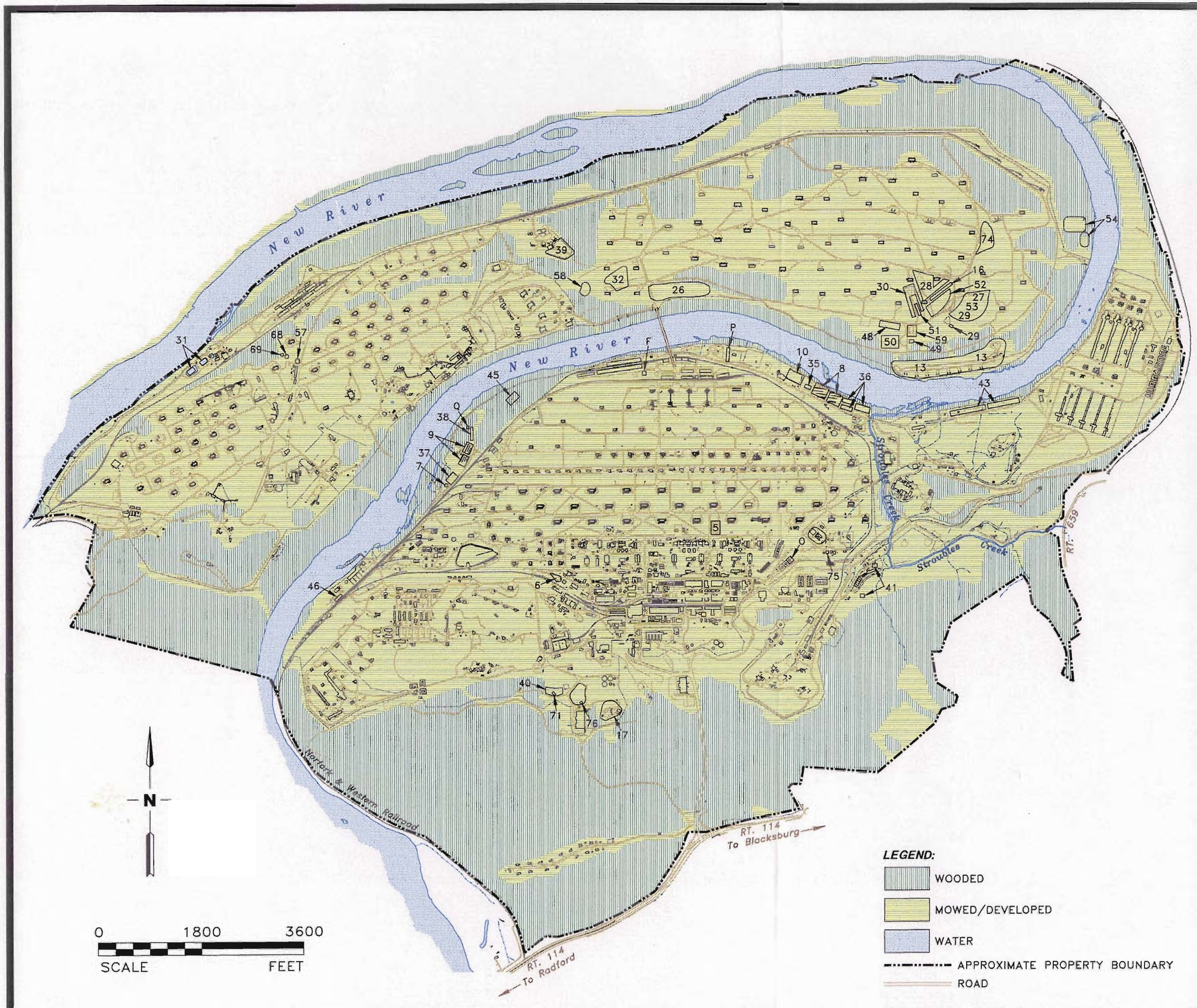


FIGURE 1-2
LAYOUT AND SWMU
LOCATION MAP



HWMU No. *	SWMU No. **	AOC No. ***	Name
4			ACIDIC WASTEWATER EQULAZATION LAGOON
5			ACIDIC WASTEWATER EQULAZATION LAGOON
7			OLUM PLANT WASTEWATER TREATMENT LAGOON
16			HAZARDOUS WASTE LANDFILL
	6		ACIDIC WASTEWATER LAGOON
	8		CALCIUM SULFATE SETTLING LAGOON (A-B)
	9		CALCIUM SULFATE SETTLING LAGOON (C)
	10		BIO-PLANT AND EQUALIZATION BASIN
	13		PROPELLANT OPEN BURNING GROUND
	17		CONTAMINATED WASTE INCINERATOR & BURNING GROUND
	26		FLYASH LANDFILL No.1
	27		CALCIUM SULFATE LANDFILL
	28		SANITARY LANDFILL
	29		FLYASH LANDFILL No.2
	31		BOTTOM ASH SETTLING LAGOONS
	32		INERT WASTE LANDFILL No.1
	35		CALCIUM SULFATE DRYING BEDS (A-B)
	36		CALCIUM SULFATE DRYING BEDS (A-B)
	37		CALCIUM SULFATE DRYING BEDS (C)
	38		CALCIUM SULFATE DRYING BEDS (C)
	39		INCINERATOR WASTEWATER SETTLING LAGOONS
	40		SANITARY LANDFILL
	41		RED WATER ASH LANDFILL
	43		SANITARY LANDFILL
	45		SANITARY LANDFILL
	46		WASTE PROPELLANT DISPOSAL (18A1)
	48		OIL WATER DISPOSAL TRENCH
	49		RED WATER ASH DISPOSAL AREA
	50		CALCIUM SULFATE LANDFILL
	51		TNT NEUTRALIZATION SLUDGE
	52		SANITARY LANDFILL
	53		ACTIVATED CARBON DISPOSAL AREA
	54		POND BY BUILDING No. 4931
	57		PROPELLANT ASH DISPOSAL AREA
	58		RUBBLE PILE
	59		BOTTOM ASH PILE
	61		MOBIL WASTE OIL TANKS
	68		CHROMIC ACID TREATMENT TANKS
	69		POND BY CHROMIC ACID TREATMENT TANKS
	71		FLASH BURN PARTS AREA
	74		INERT LANDFILL No.3
	75		WASTE OIL UNDERGROUND STORAGE TANK
	76		WASTE OIL UNDERGROUND STORAGE TANK
		F	DRUM STORAGE AREA (BUILDING No. 9387-2)
		O	UNDER GROUND FUEL OIL SPILL
		P	SCRAP METAL SALVAGE YARD
		Q	ALLEGED ABANDONED LAGOON

* HAZARDOUS WASTE MANAGEMENT UNIT

** SOLID WASTE MANAGEMENT UNIT

*** AREA OF CONCERN

DEPARTMENT OF THE ARMY

U.S. Army Environmental Center

the IT group

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HABITAT LOCATIONS AT RFAAP

TASK NO.: 70403	SITE: RADFORD ARMY AMMUNITION PLANT VIRGINIA	FIGURE NO.: 1-3

- Omnivores—opossum (*Didelphis virginiana*), raccoon (*Procyon lotor*), mink (*Mustela vison*), turkey vulture (*Cathartes aura*), black vulture (*Coragyps atratus*);
- Vermivores—masked shrew (*Sorex cinereus*), short-tailed shrew (*Blarina brevicauda*), bobwhite quail (*Colinus virginianus*), wild turkey (*Meagris gallopavo*), woodcock (*Scolopax minor*), red-winged blackbird (*Agelaius phoeniceus*), red-eyed vireo (*Vireo olivaceus*), Carolina chickadee (*Parus carolinensis*), eastern wood peewee (*Contopus virens*), brown thrasher (*Toxostoma rufum*); and
- Predators—red-tailed hawk (*Buteo jamaicensis*), American kestrel (*Falco sparverius*).

The grassy areas of RFAAP are likely to support a variety of wildlife, including the following:

- Herbivores—woodchuck (*Marmota monax*), common yellowthroat (*Geothlypis trichas*), eastern meadowlark (*Sturnella magna*), eastern cottontail (*Sylvilagus floridanus*);
- Vermivores—eastern mole (*Scalopus aquaticus*), American robin (*Turdus migratorius*); and
- Predators—red fox (*Vulpes vulpes*).

There are three types of aquatic habitats observed at RFAAP: the New River, Stroubles Creek, and several manmade water bodies (lagoons, settling basins). The aquatic habitats evaluated in this ERA are the New River and the three lagoons associated with SWMU 31. The water and sediment quality parameters of these water bodies are summarized in Table 1–1.

The New River supports a diversity of aquatic species, including the following:

- Fish—Appalachia darter (*Percina gymnocephala*), largemouth bass (*Micropterus salmoides*), mottled sculpin (*Cottus bairdi*), river chub (*Nocomis micropogon*), whitetail shiner (*Cyprinella galactura*), common carp (*Cyprinus carpio*), smallmouth bass (*Micropterus dolomieui*), flathead catfish (*Pylodictis olivaris*);
- Aquatic invertebrates—amphipods, decapods, gastropods, chironomids, oligochaetes, bivalves, aquatic insect larvae (including ephemeropterans, plecopterans, and trichopterans);
- Amphibians and reptiles—American toad (*Bufo americanus*), bullfrog (*Rana catesbeiana*), eastern painted turtle (*Chrysemys p. picta*); and
- Piscivorous birds—double-crested cormorant (*Phalacrocorax auritus*), wood duck (*Aix sponsa*), mallard (*Anas platyrhyncos*), American black duck (*Anas rubripes*), great blue heron (*Ardea herodias*), green heron (*Butorides striatus*).

Aquatic species inhabiting the SWMU 31 lagoons include fish and aquatic invertebrates. Lagoon 1 is unlikely to support fish based on observations of the water body, while Lagoons 2 and 3 likely contain a limited number of fish species including bluegill (*Lepomis macrochirus*) and minnow (*Pimephales* spp.). All of these water bodies are expected to support a variety of aquatic invertebrates and aquatic insect larvae similar to that of the New River.

Threatened and Endangered Species. The findings listed in the biological inventory (Appendix A) indicate that no endangered plants or animals have been observed on RFAAP. The state-listed rare plants observed on site include *Clematis coactilis, Cystopteris tennesseensis, Hasteola suaveolens, Sagittaria rigida, Eleocharis intermedia*. State threatened animals located at RFAAP include the invertebrate *Speyeria idalia* and the birds *Ammodramus henslowii* and *Lanius ludovicianus*.

1.1.2 Chemicals of Potential Concern

1.1.2.1 Preparation of Chemical Data. The methodologies used to screen and summarize the chemical data in order to select COPCs are in accordance with USEPA (1989a,b) guidance and included the following:

- Data collected during the last five calendar years were used for quantitative evaluations.
- Fully validated data in accordance with the M3 validation level from USEPA (1995c).

Table 1-1
Water and Sediment Quality Parameters for Aquatic Habitats at RFAAP

Habitat	Water Parameter										Sediment Parameter	
	Temperature (°C)	DO (ppm)	Conductivity (μmho/cm)	pH	Redox Potential (mV)	Turbidity (NTU)	Hardness (mg/L $CaCO_3$)		TOC (mg/L)		TOC (%)	
							range	mean	range	mean	range	mean
Lagoon 1 (SWMU 31)	15.89	9.79	113	7.31	671	2.92	NA	NA	NA	NA	NA	NA
Lagoon 2 (SWMU 31)	19.99	9.63	127	7.3	502	2.64	NA	NA	NA	NA	NA	NA
Lagoon 3 (SWMU 31)	20.51	10.69	124	7.59	485	3.36	NA	NA	NA	NA	NA	NA
New River	NA	NA	NA	NA	NA	NA	42.7–51.3	45.4	1.2–2.32	1.97	0.98–9.2	3.6

NA = no data available.

- Discrete samples were used and composite samples were not included.
- Data collected from areas that are not accessible to ecological receptors were not considered. For example, soil data collected at depths greater than one foot were not evaluated.
- Soil and sediment data collected within one foot below ground surface were used for the quantitative evaluation.
- The samples were divided into data groupings by environmental media and exposure areas. to characterize environmental conditions relevant to exposure areas and determine exposure concentrations for target populations. Data groupings were developed for surface soil (2), sediment (1), and surface water (4) samples. One surface soil grouping included samples from the entire evaluated area. The second surface soil grouping included samples to establish background concentrations. The sediment grouping included samples collected from the New River and a natural spring. Four surface water groupings were developed for samples from the New River and three lagoons.
- Sample data were evaluated against blank (laboratory, equipment rinse, field, and trip) data. When the chemical concentration detected in a site-related sample was less than 10 times (common laboratory chemicals) or five times (all other compounds) the concentration detected in the corresponding blank sample, the result was excluded from screening.
- The maximum concentration of a duplicate pair was used to represent the concentration for that location.
- The arithmetic mean concentration of a chemical within a given sample data grouping was calculated by averaging detected concentrations with one-half the maximum detection limit of the non-detected results, as applicable. (Note: When one-half the maximum detection limit exceeded the maximum detected concentration in a sample grouping, the arithmetic mean could exceed the maximum detected concentration.)
- Data that were rejected during the validation (R-qualified) were not used.
- Frequency of detection was calculated as the number of samples in which the chemical was detected over the total number of samples analyzed.

1.1.2.2 Identification of COPCs. Chemicals were selected as COPCs when maximum detected concentrations exceeded the screening level concentrations for ecological receptors provided by the USEPA Region III Biological Technical Assistance Group (BTAG) (USEPA 1995b). USEPA Region III BTAG Screening Levels are based on chemical concentrations considered to be protective of the most sensitive organism in a medium. Screening levels for some chemicals were available for both flora and fauna, in which case the lower of the two values was used. Chemicals with maximum concentrations below the screening levels were eliminated from further consideration. All other chemicals were maintained as COPCs, including those without an associated USEPA Region III BTAG Screening Level.

Tables 1–2 through 1–4 present summaries of the detected chemicals in surface soil, sediment, and surface water and include minimum and maximum detected concentrations, location of the maximum detected concentration, arithmetic mean and 95% UCL of the mean detected concentration, range of detection limits, maximum detected background concentrations (for surface soil only), and screening level comparisons.

Chemicals that were not detected in any samples in either surface soil, sediment, or surface water were compared to USEPA Region III BTAG Screening Levels to evaluate the adequacy of detection limits for each of these media. The results of these comparisons are presented in Appendix B.

1.1.2.2.1 ***Surface Soil.*** A total of 27 surface soil samples (excluding background) were evaluated. Table 1–5 presents the sample grouping characteristics, including associated sampling date, contractor, and chemical analytes.

Table 1–2
Occurrence, Distribution, and Selection of Chemicals of Concern, Surface Soil

CAS Number	Chemical	Minimum (1) Concentration	Maximum (1) Concentration	Location of Maximum Concentration	Mean Concentration	95 % UCL of the Mean (2)	Range of Detection Limits	Background Concentration (3)	Screening Toxicty Value	Screening Toxicity Value Source (4)	HQ Value (5)	COC Flag (Y or N)
Organics (μg/kg)												
83-32-9	Acenaphthene	210	280	31SL2-2	180	580	120 - 220	ND	100	Region III BTAG	3	Y
56-55-3	Benz[*a*]anthracene	28.0	770	17ASB105	110	1,040	12.0 - 41.0	ND	100	Region III BTAG	8	Y
50-32-8	Benzo[*a*]pyrene	40.0	68.0	31SL3-2	242	42,600	12.0 - 1,200	ND	100	Region III BTAG	0.7	N
205-99-2	Benzo[*b*]fluoranthene	41.0	1,500	17ASB105	245	3,980	23.0 - 310	ND	100	Region III BTAG	15	Y
191-24-2	Benzo[*g,h,i*]perylene	37.0	960	17ASB105	160	1,230	23.0 - 180	ND	100	Region III BTAG	10	Y
207-08-9	Benzo[*k*]fluoranthene	21.0	440	17ASB105	84.6	699	12.0 - 130	ND	100	Region III BTAG	4.4	Y
84-74-2	Di-n-butylphthalate	NA	820	39SB1A	978	2,560	450 - 4,400	ND	NSL	Region III BTAG	--	Y
218-01-9	Chrysene	21.0	810	17ASB105	114	5,070	2.00 - 32.0	ND	100	Region III BTAG	8	Y
53-70-3	Dibenz[*a,h*]anthracene	37.0	41.0	31SL1-2	75.4	315	23.0 - 310	ND	100	Region III BTAG	0.4	N
84-66-2	Diethylphthalate	NA	68.0	39SB1A	832	14,400	240 - 4,400	ND	NSL	Region III BTAG	—	Y
117-81-7	Bis(2-ethylhexyl)phthalate	2,300	7,900	17ASB105	2,670	27,800	450 - 4,400	ND	NSL	Region III BTAG	—	Y
206-44-0	Fluoranthene	34.0	630	17ASB105	117	1,050	23.0 - 43.0	ND	100	Region III BTAG	6	Y
86-73-7	Fluorene	NA	37.0	31SL3-2	23.6	43.7	23.0 - 55.0	ND	100	Region III BTAG	0.4	N
193-39-5	Indeno(1,2,3-c,d)pyrene	23.0	24.0	31SL2-2	460	1,570,000	6.90 - 2,400	ND	100	Region III BTAG	0.2	N
91-20-3	Naphthalene	190	210	31SL1-2	228	465	120 - 740	ND	100	Region III BTAG	2	Y
85-01-8	Phenanthrene	48.0	1,300	17ASB105	190	5,600	12.0 - 32.0	ND	100	Region III BTAG	13	Y
129-00-0	Pyrene	36.0	1,200	17ASB105	187	97,900	1.00 - 83.0	ND	100	Region III BTAG	12	Y
Inorganics (mg/kg)												
7429-90-5	Aluminum	13,600	110,000	31SL3-2	42,500	72,800	NA	19,100	1	Region III BTAG	110,000	Y
7440-36-0	Antimony	1.50	60.8	17ASB105	8.67	15.4	0.660 - 19.6	7.14	0.48	Region III BTAG	127	Y
7440-38-2	Arsenic	4.20	88.0	17BSS1	17.2	33.4	2.50 - 7.90	7.32	328	Region III BTAG, TOTAL ARSENIC	0.3	N
7440-39-3	Barium	23.9	4,000	17ASB105	320	439	NA	103	440	Region III BTAG	9	Y
7440-41-7	Beryllium	0.813	3.89	17BSS2	1.56	1.86	1.30	0.922	0.02	Region III BTAG	195	Y
7440-43-9	Cadmium	1.50	10.7	17ASB105	1.31	2.48	0.130 - 1.30	0.700	2.5	Region III BTAG	4	Y
7440-70-2	Calcium	528	42,800	RDSX*31	8,000	22,000	NA	100,000	NSL	Region III BTAG	—	Y
7440-47-3	Chromium	23.4	1,600	17ASB105	120	122	NA	39.8	0.0075	Region III BTAG, TOTAL CHROMIUM	213,333	Y
7440-48-4	Cobalt	5.68	18.5	RDSX*35	12.1	15.6	NA	22.1	100	Region III BTAG	0.2	N
7440-50-8	Copper	15.6	336	39SB1A	90.2	361	NA	23.4	15	Region III BTAG	22	Y
7439-89-6	Iron	19,400	44,500	39SB3A	30,000	34,500	NA	31,300	12	Region III BTAG	3,708	Y
7439-92-1	Lead	9.80	7,070	39SB1A	640	1,550	10.5	255	0.01	Region III BTAG	707,000	Y
7439-95-4	Magnesium	2,080	27,000	RDSX*35	8,680	16,200	NA	41,200	NSL	Region III BTAG	—	Y
7439-96-5	Manganese	144	1,330	RDSX*35	583	1,060	NA	892	330	Region III BTAG	4.0	Y
7439-97-6	Mercury	0.0682	17.0	RDSX*39	0.940	1.37	0.0500 - 1.30	0.0500	0.058	Region III BTAG	293	Y
7440-02-0	Nickel	9.08	704	17ASB105	68.0	84	NA	27.4	2	Region III BTAG	352	Y
7440-09-7	Potassium	1,020	3,080	39SB3A	1,820	2,260	NA	3,160	NSL	Region III BTAG	—	Y
7782-49-2	Selenium	0.587	0.890	39SB1A	0.540	0.81	0.250 - 5.30	0.250	1.8	Region III BTAG	0.5	N
7440-22-4	Silver	0.0212	33.0	17ASB105	1.95	28.4	0.0124 - 2.60	1.57	0.0000098	Region III BTAG	3,367,347	Y
7440-23-5	Sodium	184	805	RDSX*38	500	748	NA	299	NSL	Region III BTAG	—	Y
7440-62-2	Vanadium	41.1	89.9	39SB3A	62.9	72.3	NA	60.4	0.5	Region III BTAG	180	Y
7440-66-6	Zinc	34.2	214	31SL3-2	107	153	NA	345	10	Region III BTAG	21	Y

Refer to Table 1–4 for footnote references.

Table 1–3
Occurrence, Distribution, and Selection of Chemicals of Concern, Sediment, New River

CAS Number	Chemical	Minimum (1) Concentration	Maximum (1) Concentration	Location of Maximum Concentration	Mean Concentration	95 % UCL of the Mean (2)	Range of Detection Limits	Screening Toxicity Value	Screening Toxicity Value Source (4)	HQ Value (5)	COC Flag (Y or N)
					Organics (µg/kg)						
56-55-3	Benz[*a*]anthracene	NA	120	NRSE5	53.7	9.30E+05	41.0	261	Region III BTAG	0.5	N
84-74-2	Di-n-butylphthalate	NA	10,000	NRSE4-2	3,770	5.47E+13	1,300	1,400	Region III BTAG	**7.1**	Y
218-01-9	Chrysene	NA	140	NRSE5	57.3	1.43E+08	32.0	384	Region III BTAG	0.4	N
84-66-2	Diethylphthalate	NA	4,800	NRSE4-2	1,680	6.62E+21	240	200	Region III BTAG	**24**	Y
131-11-3	Dimethylphthalate	NA	6,400	NRSE4-2	2,150	1.41E+42	63.0	71	Region III BTAG	**90**	Y
117-81-7	Bis(2-ethylhexyl)phthalate	NA	5,100	NRSE4-2	1,860	9.99E+15	480	1,300	Region III BTAG	**3.9**	Y
206-44-0	Fluoranthene	0.0600	160	NRSE5	78.7	2.37E+07	32.0	600	Region III BTAG	0.3	N
86-30-6	n-Nitrosodiphenylamine	NA	2,000	NRSE4-2	763	1.81E+12	290	28	Region III BTAG	**71**	Y
85-01-8	Phenanthrene	NA	160	NRSE5	64.0	1.03E+09	32.0	240	Region III BTAG	0.7	N
129-00-0	Pyrene	NA	210	NRSE5	97.7	3.58E+05	83.0	665	Region III BTAG	0.3	N
118-96-7	2,4,6-Trinitrotoluene,	NA	21,000	NRSE5	7,670	3.25E+16	2,000	NSL	Region III BTAG	—	Y
					Inorganics (mg/kg)						
7440-38-2	Arsenic	5.73	11.1	SPG3SE1	4.56	1.16E+07	0.300 - 2.50	0.57	Region III BTAG, TOTAL ARSENIC	**19**	Y
7440-39-3	Barium	74.8	447	SPG3SE1	261	804	NA			—	Y
7440-41-7	Beryllium	0.764	2.70	SPG3SE1	1.41	204	NA			—	Y
7440-47-3	Chromium	28.9	40.0	SPG3SE1	34.5	50.7	NA			**8,000**	Y
7439-92-1	Lead	350	3,400	NRSE4, NRSE4-2	2,383	6.33E+03	NA			**73**	Y
7439-97-6	Mercury	0.0813	0.125	NRSE4, NRSE4-2	0.0891	0.97	0.0500	0.15	Region III BTAG	0.8	N
7440-02-0	Nickel	10.2	33.8	SPG3SE1	18.1	1.58E+03	NA			**1.6**	Y
7440-22-4	Silver	0.0726	0.139	SPG3SE1	0.572	8.22E+03	4.00	1	Region III BTAG	0.1	N

Refer to Table 1–4 for footnote references.

Table 1–4
Occurrence, Distribution, and Selection of Chemicals of Concern, Surface Water

PART A. NEW RIVER

CAS Number	Chemical	Minimum (1) Concentration	Maximum (1) Concentration	Location of Maximum Concentration	Mean Concentration	95 % UCL of the Mean (2)	Range of Detection Limits	Screening Toxicity Value	Screening Toxicity Value Source (4)	HQ Value (5)	COC Flag (Y or N)
Inorganics (µg/L)											
7440-39-	Barium	21.1	26.6	SPG3SW1	25.1	29.1	NA			<0.1	N
7439-92-1	Lead	9.80	25.2	SPG3SW1	11.8	670	4.47	3.2	Region III BTAG	7.9	Y

PART B. LAGOON 1

CAS Number	Chemical	Minimum (1) Concentration	Maximum (1) Concentration	Location of Maximum Concentration	Mean Concentration	95 % UCL of the Mean (2)	Range of Detection Limits	Screening Toxicity Value	Screening Toxicity Value Source (4)	HQ Value (5)	COC Flag (Y or N)
Organics (µg/L)											
84-74-2	Di-n-butylphthalate	NA	1.00	31SW1	1.00	NC	NA	0.3	Region III BTAG	3.3	Y
84-66-2	Diethylphthalate	NA	2.00	31SW1	2.00	NC	NA	3	Region III BTAG	0.7	N
Inorganics (µg/L)											
7429-90-5	Aluminum	NA	738	31SW1	738	NC	NA	25	Region III BTAG	30	Y
7440-39-3	Barium	NA	20.2	31SW1	20.2	NC	NA	10,000	Region III BTAG	<0.1	N
7440-70-2	Calcium	NA	11,400	31SW1	11,400	NC	NA	NSL	Region III BTAG	—	Y
7439-95-4	Magnesium	NA	4,350	31SW1	4,350	NC	NA	NSL	Region III BTAG	—	Y
7440-09-7	Potassium	NA	1,150	31SW1	1,150	NC	NA	NSL	Region III BTAG	—	Y
7440-23-5	Sodium	NA	5,700	31SW1	5,700	NC	NA	NSL	Region III BTAG	—	Y
7440-66-6	Zinc	NA	5.20	31SW1	5.20	NC	NA	19	Region III BTAG	0.3	N

PART C. LAGOON 2

CAS Number	Chemical	Minimum (1) Concentration	Maximum (1) Concentration	Location of Maximum Concentration	Mean Concentration	95 % UCL of the Mean (2)	Range of Detection Limits	Screening Toxicity Value	Screening Toxicity Value Source (4)	HQ Value (5)	COC Flag (Y or N)
Organics (µg/L)											
84-66-2	Diethylphthalate	NA	3.00	31SW2	3.00	NC	NA	3	Region III BTAG	1.0	Y
Inorganics (µg/L)											
7429-90-5	Aluminum	NA	297	31SW2	297	NC	NA	25	Region III BTAG	12	Y
7440-39-3	Barium	NA	17.5	31SW2	17.5	NC	NA	10,000	Region III BTAG	<0.1	N
7440-70-2	Calcium	NA	10,500	31SW2	10,500	NC	NA	NSL	Region III BTAG	—	Y
7439-95-4	Magnesium	NA	4,040	31SW2	4,040	NC	NA	NSL	Region III BTAG	—	Y
7440-09-7	Potassium	NA	1,210	31SW2	1,210	NC	NA	NSL	Region III BTAG	—	Y
7440-23-5	Sodium	NA	9,660	31SW2	9,660	NC	NA	NSL	Region III BTAG	—	Y
7440-66-6	Zinc	NA	3.00	31SW2	3.00	NC	NA	19	Region III BTAG	0.2	N

Table 1-4 (Continued)

PART D. LAGOON 3

CAS Number	Chemical	Minimum (1) Concentration	Maximum (1) Concentration	Location of Maximum Concentration	Mean Concentration	95 % UCL of the Mean (2)	Range of Detection Limits	Screening Toxicity Value	Screening Toxicity Value Source (3)	HQ Value (4)	COC Flag (Y or N)
					Organics (µg/L)						
84-66-2	Diethylphthalate	NA	8.00	31SW3	8.00	NC	NA	3	Region III BTAG	**2.7**	Y
					Inorganics (µg/L)						
7429-90-5	Aluminum	NA	585	31SW3	585	NC	NA	25	Region III BTAG	**23**	Y
7440-39-3	Barium	NA	17.5	31SW3	17.5	NC	NA	10,000	Region III BTAG	<0.1	N
7440-70-2	Calcium	NA	9,710	31SW3	9,710	NC	NA	NSL	Region III BTAG	—	Y
7439-95-4	Magnesium	NA	3,670	31SW3	3,670	NC	NA	NSL	Region III BTAG	—	Y
7439-96-5	Manganese	NA	21.1	31SW3	21.1	NC	NA	10	Region III BTAG	**2.1**	Y
7440-02-0	Nickel	NA	4.10	31SW3	4.10	NC	NA	8.3	Region III BTAG	0.5	N
7440-09-7	Potassium	NA	1,110	31SW3	1,110	NC	NA	NSL	Region III BTAG	—	Y
7440-23-5	Sodium	NA	8,480	31SW3	8,480	NC	NA	NSL	Region III BTAG	—	Y
7440-66-6	Zinc	NA	3.10	31SW3	3.10	NC	NA	19	Region III BTAG	0.2	N

(1) Minimum/maximum detected concentration above the sample quantitation limit (SQL).
(2) The 95 % Upper Confidence Limit (UCL) represents the RME concentration.
(3) Value is the maximum detected background surface soil concentration.
(4) Screening toxicity value source is from the U.S. Environmental Protection Agency (USEPA). 1995. Region III Biological Technical Advisory Group (BTAG) Screening Levels. Draft Document.
(5) Hazard quotient (HQ) is defined as Maximum Concentration/Screening Toxicity Value.
NA = not applicable; NSL = no screening level available; ND = not detected,; NC = not calculated.

Table 1–5
Surface Soil (0–1-foot) Sample Groupings

Grouping Name	Company/ Sampling Date	Samples		Analytes
Surface soil	Dames & Moore July 1993	*SWMU 71:*		
		RDSX*29 RDSX*31 RDSX*33 RDSX*35	RDSX*37 RDSX*38 RDSX*39	Total metals Total petroleum hydrocarbons
	ParsonsEngineering December 1994	*SWMU 17:*		
		17ASB105 17ASB205 17ASB305 17ASS3 17BSS1	17BSS2 17CSB105 17CSB205 17DSB105 17DSB205	Total metals, Explosives VOCs (17ASB105, 205, 305) SVOCs (17ASB105, 205, 305)
	ICF Kaiser April/May 1998	*Former Lead Furnace Area:*		
		LFSB1A LFSB8A LFSB9A	LFSB10A LFSB11A	Lead
		SWMU 39:		
		39SB1A	39SB3A	Total metals, PAHs, SVOCs
		SWMU 31:		
		31SL1-2 31SL2-2	31SL3-2	Total metals, PAHs, SVOCs
Background	Dames & Moore March 1992	RVFS*49 RVFS*65 RVFS*88	RVFS*90 RVFS*113	Total metals

Table 1–2 presents the occurrence, distribution, and selection of COPCs in surface soil. The maximum detected background concentrations are included in Table 1–2 for comparison to inorganic metal concentrations detected in the other surface soil samples. A total of 17 organic chemicals were detected including 14 polycyclic aromatic hydrocarbons (PAHs) and three (3) phthalate esters. Thirteen organic compounds were selected as COPCs based on detection at concentrations above Region III Screening Levels (10 compounds) or the lack of a corresponding BTAG Screening Level (3). The organic COPCs include the following:

- PAHs—acenaphthene, benz[*a*]anthracene, benzo[*b*]fluoranthene, benzo[*g,h,i*]perylene, chrysene, pyrene, fluoranthene, benzo[*k*]fluoranthene, naphthalene, and phenanthrene;
- Phthalate esters—di-n-butylphthalate, diethylphthalate, bis(2-ethylhexyl)phthalate.

The inorganic COPCs were selected based on detection at concentrations above Region III Screening Levels (15) or the lack of a corresponding BTAG Screening Level (4) and include the following:

- Metals—aluminum, antimony, barium, beryllium, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, silver, sodium, vanadium, zinc.

1.1.2.2.2 ***Sediment.*** The sampling characteristics for the four sediment samples evaluated are listed in Table 1–6.

Chemicals detected in sediment samples are presented in Table 1–3. A total of 11 organic chemicals were detected, consisting of five PAHs, four phthalate esters, and two explosives. Six organic chemicals were selected as COPCs based on detected concentrations above Region III BTAG Screening Levels (5 compounds) or the lack of a corresponding BTAG Screening Level (1), including the following:

Table 1–6
Sediment Sample Groupings

Grouping Name	Company/ Sampling Date	Samples	Analytes
New River Area	Parsons Engineering January 1995	*Associated with SWMU 17:* SPG3SE1	Total metals Explosives
	Parsons Engineering July 1995	*Near SWMU 13:* NRSE4, NRSE4–2 *Near SWMU 54:* NRSE5	Total metals Explosives VOCs SVOCs

- Phthalate esters—di-n-butylphthalate, diethylphthalate, dimethylphthalate, bis(2-ethylhexyl)phthalate; and
- Explosives–n-nitrosodiphenylamine, 2,4,6-trinitrotoluene.

Inorganic chemicals identified as COPCs based on detection at concentrations above Region III BTAG Screening Levels (4) or the lack of a corresponding BTAG Screening Level (2) include the following:

- Metals—arsenic, barium, beryllium, chromium, lead, nickel.

1.1.2.2.3 ***Surface Water.*** Surface water groupings are presented in Table 1–7.

Table 1–7
Surface Water Sample Groupings

Grouping Name	Company/ Sampling Date	Samples	Analytes
New River Area	Parsons Engineering January 1995	*Associated with SWMU 17:* SPG3SW1	Metals, PAHs, Explosives
	Parsons Engineering July 1995	*Near SWMU 13:* NRSW4, NRSW4–2 *Near SWMU 54:* NRSW5	Metals, PAHs, SVOCs, VOCs, Explosives
Lagoon 1	ICF Kaiser, May 1998	31SW1:	Metals, PAHs, SVOCs
Lagoon 2	ICF Kaiser, May 1998	31SW2:	Metals, PAHs, SVOCs
Lagoon 3	ICF Kaiser, May 1998	31SW3:	Metals, PAHs, SVOCs

The chemicals detected in the surface water samples are presented in Table 1–4. The COPCs for each of the data groupings include the following:

- **New River**. No organic chemicals were detected in the surface water samples collected from this area. The inorganic chemicals detected were barium and lead. Lead was identified as a COPC.
- **Lagoon 1**. Two organic chemicals, di-n-butylphthalate and diethylphthalate, were detected in the surface water sample taken from this area. Di-n-butylphthalate was identified as an organic COPC because the detected concentration was above the Region III Screening Level. A total of seven inorganic chemicals were detected in this surface water sample. The inorganic chemicals identified as COPCs were as follows:

  — Aluminum, calcium, magnesium, potassium, and sodium.

- **Lagoon 2.** Diethylphthalate was the only organic chemical detected in the surface water sample taken from this area and was identified as a COPC. A total of seven inorganic chemicals were detected in this sample. The inorganic chemicals identified as COPCs were as follows:
  - — Aluminum, calcium, magnesium, potassium, and sodium.
- **Lagoon 3.** The only organic chemical detected in the surface water sample taken from this area was diethylphthalate. This chemical was identified as a COPC because the detected concentration was above the Region III Screening Level. Of the nine inorganic chemicals detected, the six identified as COPCs were as follows:
  - — Aluminum, calcium, magnesium, manganese, potassium, and sodium.

1.1.3 Identification of Exposure Pathways and Receptors for Analysis

Exposure pathways and potential receptor species were identified based on the (1) likely presence of ecological habitat/receptors; (2) nature and extent of chemical contamination; (3) source of chemicals; (4) media associated with chemical transport; (5) point of potential contact by the receptor organism; and (6) route of exposure at the contact point.

Potential receptors at RFAAP could potentially be exposed to the identified COPCs via a number of exposure pathways. Table 1–8 identifies the exposure pathways by which potential ecological receptors could be exposed to COPCs and, in general terms, the pathways selected for evaluation in the ERA. Ecological receptors evaluated during the screening-level ERA include the terrestrial and aquatic plant, soil invertebrate, terrestrial wildlife, and aquatic communities. Potential risks to these communities are evaluated in Section 1.4, "Risk Characterization."

One of the main goals of this assessment is to determine whether the receptors that may use this site are at potential risk from in-situ contaminants. Because it is not feasible to evaluate all potential receptors for some exposure pathways at the site, a subset is selected that best represents potential exposure pathways and receptor species. These receptors, identified as "indicator species," are selected as representatives of a particular community, guild or trophic level. Accordingly, evaluation of an indicator species is intended to represent a group of species within a trophic level or guild and not simply the species identified for evaluation.

The selection of the indicator species was based on several factors: (1) likelihood of a species to use the site and the area immediately surrounding the site; (2) potential for exposure to site-related contaminants based on the feeding habits and life history of the organisms/guild represented by the indicator species; (3) availability of life history and exposure information for the selected indicator species; and (4) availability of toxicity information for the indicator species. To identify potentially impacted wildlife species groups or guilds, the feeding guilds of the mammals and birds known to occur at RFAAP were reviewed. Those identified as having the greatest potential to be adversely affected were selected for detailed evaluation in the ERA.

1.1.3.1 Terrestrial and Aquatic Plant Community. Terrestrial plants within the RFAAP study area may be exposed to COPCs in soil as a result of direct contact and subsequent uptake through roots or direct foliar uptake. Plants in the wetland areas and adjacent to springs, settling ponds or lagoons, and the New River may also be exposed to chemicals in sediment and/or mobilized in surface water. Very little information is available to evaluate plant exposure to contaminants through foliar uptake, contact with surface water, or root uptake from sediment. Therefore, only potential risks from direct contact with chemicals in surface soil via root uptake were evaluated in the ERA. Because of limitations in the available toxicity data no specific plant species were selected for evaluation, instead the assessment evaluated the potential for adverse effects to herbaceous plant communities.

1.1.3.2 Soil Invertebrate Community. Soil invertebrates may be exposed to chemicals in surface soil through dermal absorption and ingestion of contaminated soils. Earthworms were selected as the receptor species for evaluating the potential for adverse effects to soil invertebrates because of their direct contact with soil, sensitivity, and availability of toxicity data. Earthworms serve an important ecological role in the aeration of soils and cycling of nutrients and are an important food source for some carnivorous species (e.g., shrews).

Table 1–8
Potential Exposure Pathways for Ecological Receptors at RFAAP

Potential Receptors	Exposure Route	Pathway(s) Selected for Evaluation?	Comments
SURFACE SOIL			
Terrestrial plants	Direct contact (root uptake)	Yes	Pathway potentially complete; selected for quantitative evaluation.
	Direct contact (foliar uptake)	No	Not evaluated because applicable exposure and toxicity data could not be found in the scientific literature.
Terrestrial invertebrates (e.g., earthworms)	Ingestion and direct contact (dermal absorption)	Yes	Pathway potentially complete; selected for quantitative evaluation.
Terrestrial wildlife (e.g., mammals, birds)	Ingestion	Yes	Pathway potentially complete; selected for quantitative evaluation.
	Direct contact (dermal absorption)	No	Not evaluated because applicable exposure data could not be found in the scientific literature. In addition, pathway is most likely insignificant in comparison to the ingestion of contaminated food.
FOOD			
Terrestrial wildlife	Ingestion	Yes	Pathway potentially complete; selected for quantitative evaluation.
SURFACE WATER			
Terrestrial wildlife	Ingestion	Yes	Pathway potentially complete; selected for quantitative evaluation.
	Direct contact (dermal absorption)	No	Not evaluated because applicable exposure and toxicity data could not be found in the scientific literature; however, pathway is not likely to result in significant risks because exposure is likely to be limited.
Aquatic plants	Direct contact	No	Pathway not evaluated because applicable toxicity data could not be found in the scientific literature.
Aquatic life	Ingestion, respiration, direct contact	Yes	Pathway potentially complete; selected for quantitative evaluation.
SEDIMENT			
Aquatic plants	Direct contact	No	Pathway not evaluated because applicable exposure and toxicity data could not be found in the scientific literature.
Benthic aquatic life	Ingestion, respiration, direct contact	Yes	Pathway potentially complete; selected for quantitative evaluation.
Terrestrial wildlife	Ingestion	Yes	Pathway potentially complete; selected for quantitative and/or qualitative evaluation.
	Direct contact (absorption)	No	Not selected for evaluation because applicable exposure and toxicity data could not be found in the scientific literature; however, pathway is not likely to result in significant risks because exposure is likely to be limited.

1.1.3.3 Terrestrial Wildlife Community. RFAAP terrestrial wildlife may be exposed to COPCs by several pathways, including: (1) the ingestion of contaminated sediment, soil, surface water, or food while foraging; (2) dermal absorption of chemicals from soil, sediment, or surface water; and (3) inhalation of chemicals that have been wind-eroded from soil. Among these potential exposure pathways, the greatest potential for exposure to chemicals is likely to result from the ingestion of chemicals in food and surface water. The incidental ingestion of contaminated soil or sediment (while foraging) is a less important exposure route. The ingestion of food, soil, sediment, and surface water, however, are all viable exposure pathways and were considered further. Receptor-specific exposures via inhalation or dermal absorption were not selected for further evaluation because of a lack of appropriate exposure data and the expectation that these pathways would be insignificant in comparison to the other exposure pathways (ingestion of food, soil/sediment, surface water).

Because of multiple potential exposure routes, all chemicals identified as COPCs in soil, sediment, or surface water (abiotic media) were conservatively evaluated for their potential to adversely affect terrestrial wildlife via ingestion. It should be recognized, however, that the relative importance of the route by which a chemical is ingested will depend to a large extent on the chemical being evaluated. Chemicals having the potential to bioaccumulate, such as hydrophobic organic compounds (e.g., methylmercury), provide the greatest exposure to wildlife from the ingestion of prey. Chemicals having a limited potential to bioaccumulate provide the greatest exposure of wildlife through the direct ingestion of abiotic media. Although distinction between bioaccumulative properties is important when initially identifying pathways and receptors for evaluation in the ERA and when making risk management decisions, it does not have direct bearing on the screening-level risk assessment process outlined by the USEPA (1997), which directs that an accumulation factor of one (1) be assumed for all chemicals in prey.

Herbivorous Wildlife Exposure to Chemicals Through Ingestion of Terrestrial Plants, Surface Soil, and Surface Water. The ingestion of chemicals in terrestrial plant material was selected to evaluate the exposure of small mammalian herbivores to chemicals originating from surface soil. Plants were selected as a route of exposure for evaluation because they have intimate contact with soil, and thus, have the potential to uptake chemicals from the soil. Furthermore, plants serve as the only food source for herbivorous species, and thus, represent a potentially complete exposure pathway.

The meadow vole was selected as the receptor species for evaluating potential effects to herbivorous receptors. The meadow vole (*Microtus pennsylvanicus*) inhabits grassy areas (upland and wetland) and obtains a significant portion of its herbivorous diet from the site. It is also likely to have a relatively high rate of incidental ingestion of soil given that it is sometimes coprophagous (consumes its own feces for secondary nutrient adsorption) and builds runways and burrows in the soil. The meadow vole has a limited foraging range, increasing its potential to be exposed (directly or indirectly) to COPCs in the onsite surface soil. In addition to the ingestion of chemicals in plants, the ingestion of chemicals in surface water (from creeks or ponds) and surface soil was evaluated for this species.

Meadow vole.

Vermivorous Wildlife Exposure to Chemicals Through Ingestion of Soil Invertebrates, Surface Soil, and Surface Water. The ingestion of chemicals in earthworms was selected to evaluate the exposure of terrestrial wildlife to surface soil contaminants. The earthworm was selected because of its potential to uptake chemicals from soil, its function as an important food source for some carnivorous species, and the fact it represents a potentially complete exposure pathway. In addition to the ingestion of chemicals in earthworms, the inadvertent ingestion of chemicals in surface soil and surface water was evaluated for vermivorous wildlife receptors.

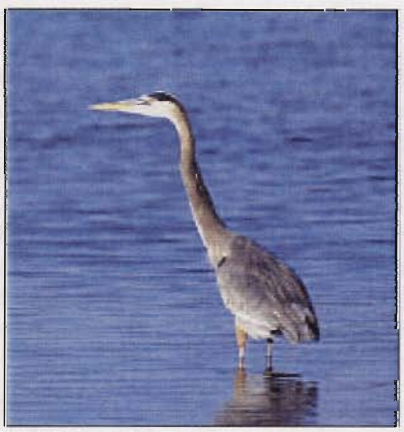
The short-tailed shrew (*Blarina brevicauda*) was selected as the vermivorous small mammal species because it feeds largely on soil invertebrates. It not only would be potentially exposed through prey items, but also would have a relatively high rate of incidental ingestion of soil while foraging. The short-tailed shrew has a small home range and could conceivably consume all of its diet from site-affected areas.

The American robin (*Turdus migratorius*) was selected as the vermivorous avian species for evaluation because a significant portion of its diet is comprised of earthworms. Robins are likely to forage throughout RFAAP and are present year-round at the site. The American robin also has a small home range, thus increasing the potential for exposure to a localized area of contamination.

Short-tailed shrew.

American robin.

Piscivorous/Aquatic Invertebrate-Eating Terrestrial Wildlife Exposure to Chemicals Through Ingestion of Aquatic Life, Sediment, and Surface Water. The aquatic habitats at RFAAP are known to support fish and amphibian populations. The exposure of piscivorous species to fish is a potentially complete exposure pathway, primarily for the New River which supports a diversity of fish populations. Lagoons 2 and 3 within SWMU 31 also support a limited diversity of fish. However, it is likely that all of these on-site water bodies support amphibians and larger aquatic invertebrates (e.g., crayfish) that could be a food source for some piscivorous species. The potential exposure of piscivorous species to fish and aquatic invertebrates in RFAAP aquatic habitats was selected for evaluation. It should be noted, however, amphibians and crayfish are expected to be a much less important food source for these species and the evaluation of this potential exposure pathway is expected to be highly conservative. In addition to the ingestion of chemicals in food items, the inadvertent ingestion of chemicals in sediment and surface water was evaluated for these receptors. Due to the physical and biological differences between the New River and the lagoons, these water bodies were evaluated separately for potential adverse effects to piscivorous/invertebrate-eating terrestrial wildlife.



Great blue heron.

The great blue heron (*Ardea herodias*) was selected as the avian receptor species for evaluating potential adverse effects to birds from the ingestion of fish and amphibians/aquatic invertebrates in all of the aquatic environments. Heron were selected for evaluation because a large proportion of their diet is comprised of fish (primarily), amphibians, and larger aquatic invertebrates and they are likely to forage in the water bodies on RFAAP.

The mink (*Mustela vison*) was selected as the small mammal receptor species for evaluating potential adverse effects to small mammals from the ingestion of fish and aquatic invertebrates from the on-site water bodies. Although not truly piscivorous, fish, amphibians, and crayfish often comprise an important food source for mink. Furthermore, mink are likely to frequent the aquatic habitats and adjacent wooded areas on the facility.

Mink.

Red-tailed hawk.

Predatory Bird and Mammal Exposure to Chemicals Through Ingestion of Small Mammals, Surface Soil, and Surface Water. The ingestion of chemicals in small mammals was selected to evaluate the exposure of small mammal-eating avian and mammalian predators to detected surface soil COPCs. The red-tailed hawk (*Buteo jamaicensis*) is common in the mixed landscapes typifying the region around RFAAP. The wooded habitats and riverside trees within RFAAP are considered ideal foraging and nesting habitats for red-tailed hawks. Small mammals are present at many locations on the facility and are likely to provide a plentiful food source, thus completing this potential exposure pathway. In addition to the ingestion of chemicals in food items, the ingestion of chemicals in surface water (from the New River) was further considered. Based on their foraging habits, soil ingestion is considered to be negligible; therefore, the ingestion of soil was not considered further for the ingestion pathway.

Red fox are carnivorous and feed primarily on small mammals and were selected for evaluation in the screening-level ERA as a representative small mammal predator. Red fox (*Vulpes vulpes*) occur in a wide range of different habitat types and could occur in many of the habitats present at RFAAP. They. Red fox consume a variety of food items in addition to small mammals and could be marginally exposed to chemicals through these additional food items, as well as through the ingestion of surface water and the incidental ingestion of soil while foraging.


Red fox.

1.1.3.4 Aquatic Life. Aquatic life could potentially be exposed to COPCs by direct contact with chemicals in surface water and sediment, respiration of chemicals in water and sediment, and ingestion of chemicals in sediment and food. No specific aquatic species were selected for evaluation and the assessment evaluated the potential for adverse effects to the overall aquatic community.

1.1.4 Identification of Assessment and Measurement Endpoints

The potential for adverse effects to ecological resources is dependent on the ecological receptor species and COPCs present on the site, and the pathways by which the ecological resources could be exposed to the COPCs. Assessment endpoints are defined as the ecological effects in the indicator species selected for evaluation. The evaluation of the potential for ecological effects to occur is one factor in the decision making process regarding the need for further investigation and/or remediation (Suter 1993). For example, the reproductive capability of a species and/or population may be an assessment endpoint selected for evaluation. Measurement endpoints are the outcomes of the methods or means by which the assessment endpoints are approximated or represented (Suter 1993). Measurement endpoints are generally surrogates for assessment endpoints and are necessary because, in most cases, assessment endpoints cannot be directly measured or observed. Typically, the measurement endpoints are the result of or outcome of the field and/or laboratory methods used to evaluate the assessment endpoints. For example, measurement endpoints for evaluation of potential adverse effects to organisms, populations, and/or communities may be the concentration of a chemical measured in an abiotic media to which the species could be exposed compared to an applicable toxicity value and/or may be the results of a fish population survey from the area of concern. General assessment endpoints have been selected during this phase, and more focused endpoints will be developed later in the process.

The assessment and measurement endpoints selected for evaluation are summarized in Table 1–9. In addition, Table 1–9 states formal testable hypotheses for each indicator species selected for evaluation. The objective of the screening-level ERA is to evaluate the potential for adverse effects to the population or community of the indicator species identified for evaluation, and not to determine the potential for adverse effects to individual organisms. However, few screening models are available that extrapolate from conclusions about the potential for adverse impacts to individuals to conclusions about the potential for adverse effects to a population or community. The ERA, therefore, focused on the evaluation of potential impacts to individual organisms and conservatively assumed similar conclusions for the population or community. When the ERA indicated individual organisms would not be adversely affected, it was concluded that the population or community of that organism would also not be adversely affected. Conversely, when the potential for adverse effects to individual organisms was indicated, it was assumed there is also the potential for adverse effects to the population or community. This latter assumption has the potential to overestimate the potential for adverse effects to ecological populations or communities.

1.2 EXPOSURE ASSESSMENT

The purpose of the exposure assessment is to identify the concentration and/or dose of the COPCs to which ecological receptors selected for evaluation in the ERA could be exposed. These estimated exposure doses/concentrations are then compared to toxicity reference values in Section 1.4, "Risk Characterization." Consistent with USEPA guidance (USEPA 1997), the maximum detected concentrations of COPCs in abiotic media were used to screen the potential for adverse effects to receptors.

Table 1–9
Assessment and Measurement Endpoints for Ecological Risk Assessment

Receptor of Concern	Exposure Pathway Evaluated	Assessment Endpoint	Testable Hypothesis	Measurement Endpoint	Available Site-Specific Data
Terrestrial plants	Root uptake of chemicals from surface soil	Protection of terrestrial plants from toxic effects of chemicals in surface soil to ensure chemicals do not have a negative impact on terrestrial plant communities	The concentration of chemicals in surface soil exceeds a level known to adversely affect terrestrial plant growth or yield	Compare chemical concentrations in surface soil at potentially impacted locations to toxicity benchmarks in literature	Surface soil
Herbivorous small mammals (voles)	Ingestion of chemicals in plants, surface soil, and surface water	Protection of herbivorous small mammals to ensure that ingestion of chemicals in plants, surface soil, and surface water does not have a negative impact on growth, survival, or reproduction	The concentration of chemicals in surface soil and surface water exceeds a level known to adversely affect meadow vole growth, survival, or reproduction	Compare estimated doses of chemicals from ingestion of plants, surface soil, and surface water to toxicity benchmarks in literature	Surface soil and surface water
Soil invertebrates (earthworms)	Ingestion and dermal absorption of chemicals from surface soil	Protection of soil invertebrates from toxic effects of chemicals in surface soil to ensure chemicals do not have a negative impact on soil invertebrate communities	The concentration of chemicals in surface soil exceeds a level known to adversely affect soil invertebrate survival or growth	Compare chemical concentrations in surface soil at potentially impacted locations to toxicity benchmarks in literature	Surface soil
Soil invertebrate-eating birds (robins)	Ingestion of chemicals in earthworms, surface soil, and surface water	Protection of worm-eating birds to ensure that ingestion of chemicals in earthworms, surface soil, and surface water does not have a negative impact on worm-eating bird populations	The ingestion of chemicals in earthworms, surface soil, and surface water exceeds a level known to adversely affect robin growth, survival, or reproduction	Compare estimated doses of chemicals from ingestion of earthworms, surface soil, and surface water to toxicity benchmarks in literature	Surface soil and surface water
Soil invertebrate-eating small mammals (shrews)	Ingestion of chemicals in earthworms, surface soil, and surface water	Protection of worm-eating mammals to ensure that ingestion of chemicals in earthworms, surface soil, and surface water does not have a negative impact on worm-eating mammal populations	The ingestion of chemicals in earthworms, surface soil, and surface water exceeds a level known to adversely affect shrew growth, survival, or reproduction	Compare estimated doses of chemicals from ingestion of earthworms, surface soil, and surface water to toxicity benchmarks in literature	Surface soil and surface water
Piscivorous birds (heron)	Ingestion of chemicals in food items (e.g., crayfish, amphibians, fish), sediment, and surface water	Protection of piscivorous birds to ensure that ingestion of chemicals in food items, sediment, and surface water does not have a negative impact on piscivorous bird populations	The ingestion of chemicals in food items, sediment, and surface water exceeds a level known to adversely affect heron growth, survival, or reproduction	Compare estimated doses of chemicals from ingestion of food items, sediment, and surface water to toxicity benchmarks in literature	Sediment and surface water
Piscivorous/aquatic invertebrate-eating small mammals (mink)	Ingestion of chemicals in aquatic food items (e.g., fish, aquatic invertebrates), sediment, and surface water	Protection of piscivorous mammals to ensure that ingestion of chemicals in food items, sediment, and surface water does not have a negative impact on piscivorous mammal populations	The ingestion of chemicals in aquatic food items, sediment, and surface water exceeds a level known to adversely affect mink growth, survival, or reproduction	Compare estimated doses of chemicals from ingestion of aquatic food items, sediment, and surface water to toxicity benchmarks in literature	Sediment and surface water
Predatory birds (red-tailed hawk)	Ingestion of chemicals in small mammals and surface water	Protection of small mammal-eating predatory birds to ensure that ingestion of chemicals in prey and surface water does not have a negative impact on small mammal-eating predatory bird populations	The ingestion of chemicals in small mammals and surface water exceeds a level known to adversely affect hawk growth, survival, or reproduction	Compare estimated doses of chemicals from ingestion of small mammals and surface water to toxicity benchmarks in literature	Surface soil and surface water
Predatory mammals (red fox)	Ingestion of chemicals in small mammals, surface soil, and surface water	Protection of small-mammal-eating predatory mammals to ensure that ingestion of chemicals in prey, surface soil, and surface water does not have a negative impact on predatory mammal populations	The ingestion of chemicals in small mammals, surface soil, and surface water exceeds a level known to adversely affect fox growth, survival, or reproduction	Compare estimated doses of chemicals from ingestion of small mammals, surface soil, and surface water to toxicity benchmarks in literature	Surface soil and surface water
Aquatic life	Ingestion, respiration, and dermal absorption of chemicals in surface water	Protection of aquatic life from toxic effects of chemicals in surface water to ensure chemicals do not have a negative impact on aquatic communities	The concentration of chemicals in surface water exceeds a level known to adversely affect aquatic life growth, survival, or reproduction	Compare chemical concentrations in surface water at potentially impacted locations to toxicity benchmarks in literature	Surface water
Benthic-dwelling aquatic life	Ingestion, respiration, and dermal absorption of chemicals in sediment	Protection of benthic organisms from toxic effects of chemicals in sediments to ensure chemicals do not have a negative impact on benthic communities	The concentration of chemicals in sediment exceeds a level known to adversely affect benthic community abundance and diversity	Compare chemical concentrations in sediment at potentially impacted locations to toxicity benchmarks in literature	Sediment

1.2.1 Terrestrial Life

1.2.1.1 Terrestrial Plants. Maximum surface soil chemical concentrations measured were used to evaluate the potential for adverse effects to terrestrial plants. This approach is a realistic initial measure of exposure based on the immobility of plants. When the maximum concentration exceeds the toxicity value, the overall proportion of sample locations where the toxicity value is exceeded is then considered to evaluate the potential for adverse effects at the community level in the risk management section (Section 2.0).

1.2.1.2 Soil Invertebrates. Maximum chemical concentrations measured in RFAAP surface soil were used to assess the potential for adverse effects to soil invertebrates (earthworms). As previously discussed, such an approach is a realistic initial measure of exposure because, based on the relative immobility of most soil invertebrates, exceedance of a toxicity value at a sample location indicates the potential for adverse effects at that location. When the maximum concentration exceeds the toxicity value, the overall proportion of sample locations where the toxicity value is exceeded is then considered, as appropriate, in the risk management section to evaluate the potential for adverse effects at the population level.

1.2.1.3 Terrestrial Wildlife. The potential for adverse effects to terrestrial wildlife was evaluated through estimated dose intake equations. The equations were derived from USEPA (1989a) and are consistent with USEPA (1997) guidance. The exposure parameters used in the equations have been reviewed and approved for use by the USEPA Region III BTAG.

The objective of the screening models is not to accurately quantify risks to indicator species, but to provide an upper bound risk estimate. Exposure assumptions used in the terrestrial wildlife models are presented in Table 1–10. Generally, actual risks are likely to be overestimated by the models. A more realistic scenario will be used as part of the risk management process, as appropriate, to further evaluate potential risks caused by chemicals.

Exposure Estimates for Meadow Vole from the Ingestion of Terrestrial Plants, Surface Soil, and Surface Water. Equation 1 was used to calculate the upper bound dose of chemicals that a vole could obtain from the ingestion of terrestrial plants:

$$Dose_{plant} = FI * C_{diet} \qquad (1)$$

where

$Dose_{plant}$ = amount of chemical ingested per da via the ingestion of plants (mg/kg bw-d);

FI = food ingestion rate (kg/kg bw-d); and

C_{diet} = estimated maximum chemical concentration in plants (mg/kg wet weight).

A food ingestion (FI) rate for meadow vole of 0.30 kg/kg bw-d reported by USEPA (1993) was used. The estimated chemical concentration in plants (C_{diet}), in Equation 1, was assumed to be the same as the maximum chemical concentration detected in the surface soil of RFAAP. This conservative assumption is expected to provide an upper bound estimate of chemical concentration in an herbivorous diet.

In addition to ingestion of chemicals in plants, voles may be exposed to chemicals through the inadvertent ingestion of surface soil while foraging. Equation 2 was used to calculate the upper bound dose of chemical that voles could obtain from the ingestion of soil:

$$Dose_{soil} = SI * C_{soil} \qquad (2)$$

where

$Dose_{soil}$ = amount of chemical ingested per day from soil (mg/kg bw-d);

SI = soil ingestion rate (kg/kg bw-d); and

C_{soil} = maximum chemical concentration in surface soil (mg/kg).

Meadow voles have a diet which is 2.4% soil (Sample and Suter 1994). This percent soil in the diet was multiplied by the FI presented earlier for this species to estimate soil ingestion rate (SI) for voles (0.0072 kg/kg bw-d). The maximum detected chemical concentration at the site was used for C_{soil}.

Table 1–10
Exposure Assumptions Used for Terrestrial Wildlife

Exposure Parameter	Value[a]		Notes
MEADOW VOLE			
Body weight	0.017	kg	
Food ingestion rate	0.30	kg/kg-day	
Incidental soil ingestion rate	2.4	% of total mass of diet	
Water ingestion rate	0.13	liters/kg-day	
AMERICAN ROBIN			
Body weight	0.077	kg	b
Food ingestion rate	0.89	kg/kg-day	
Incidental soil ingestion rate	1.9	% of total mass of diet	c,d
Water ingestion rate	0.14	liters/kg-day	
SHORT-TAILED SHREW			
Body weight	0.015	kg	e
Food ingestion rate	0.62	kg/kg-day	
Incidental soil ingestion rate	13	% of total mass of diet	d
Water ingestion rate	0.223	liters/kg-day	
GREAT BLUE HERON			
Body weight	2.229	kg	
Food ingestion rate	0.18	kg/kg-day	
Incidental soil ingestion rate	0	% of total mass of diet	
Water ingestion rate	0.045	liters/kg-day	
MINK			
Body weight	0.55	kg	
Food ingestion rate	0.22	kg/kg-day	
Incidental soil ingestion rate	0	% of total mass of diet	
Water ingestion rate	0.18	liters/kg-day	
RED-TAILED HAWK			
Body weight	1.2	kg	
Food ingestion rate	0.11	kg/kg-day	
Incidental soil ingestion rate	0	% of total mass of diet	
Water ingestion rate	0.057	liters/kg-day	
RED FOX			
Body weight	4.5	kg	e
Food ingestion rate	0.14	kg/kg-day	
Incidental soil ingestion rate	2.8	% of total mass of diet	f
Water ingestion rate	0.085	liters/kg-day	

[a]Values from USEPA (1993) unless othewise noted.
[b]Value from Dunning (1984).
[c]Value based on woodcock.
[d]Value from Sample and Suter (1994).
[e]Value from Sample et al. (1996).
[f]Value from Beyer et al. (1994).

In addition to the ingestion of chemicals from diet (plants) and surface soil, herbivorous wildlife may be exposed to chemicals via the ingestion of surface water. Equation 3 was used to calculate the dose of chemical that meadow voles could obtain from the ingestion of surface water:

$$Dose_{water} = WI * C_{water} \tag{3}$$

where

$Dose_{water}$ = amount of chemical ingested per day from surface water (mg/kg bw-d);

WI = water ingestion rate (L/kg bw-d); and

C_{water} = maximum chemical concentration in surface water (mg/L).

A water ingestion rate (WI) for voles of 0.13 L/kg-d from Sample and Suter (1994) was used. The maximum detected chemical concentration at the site was used for C_{water} as a conservative exposure estimate.

The total dietary exposure levels for voles to COPCs were determined using Equation 4:

$$Dose_{total} = Dose_{plant} + Dose_{soil} + Dose_{water} \tag{4}$$

The total dietary intakes were compared to dietary toxicity values in the Risk Characterization section of the ERA (Section 1.4) to determine if adverse effects are likely to occur to herbivorous mammals from the ingestion of COPCs in plants, surface soil, and surface water.

Exposure Estimates for Robin and Shrew from the Ingestion of Earthworms, Surface Soil, and Surface Water. Equation 5 was used to calculate the upper bound dose of chemicals that a robin or shrew could obtain from the ingestion of earthworms:

$$Dose_{worm} = FI * C_{diet} \tag{5}$$

where

$Dose_{worm}$ = amount of chemical ingested per day via the ingestion of worms (mg/kg bw-d);

FI = food ingestion rate (kg/kg bw-d); and

C_{diet} = estimated maximum chemical concentration in diet (mg/kg).

A food ingestion rate (FI) of 0.89 kg/kg-day and 0.62 kg/kg-day for robins and shrews, respectively, from the USEPA (1993) was used. The estimated chemical concentration in diet (C_{diet}), the other term in Equation 5, was assumed to be the same as the maximum chemical concentration detected in the surface soil of the evaluated areas of RFAAP. Use of this value assumes the wet weight concentration of chemicals in earthworms is the same as the maximum chemical concentration detected in the surface soil. Use of the maximum detected concentration for C_{soil} is conservative and provides an upper bound estimate of risk for the sampled areas because it assumes that wildlife are only exposed to contaminated areas, and that exposure will occur only at concentrations representative of the highest chemical concentrations detected in surface soil.

In addition to the ingestion of chemicals accumulated in earthworms, robins or shrews also may be exposed to chemicals through the inadvertent ingestion of surface soil while foraging. Equation 6 was used to calculate the upper bound dose of chemical that robins or shrews could obtain from the ingestion of soil:

$$Dose_{soil} = SI * C_{soil} \tag{6}$$

where

$Dose_{soil}$ = amount of chemical ingested per day from soil (mg/kg bw-d);

SI = soil ingestion rate (kg/kg bw-d); and

C_{soil} = maximum chemical concentration in surface soil (mg/kg).

Species-specific soil ingestion data were not available for robins. As a result, soil consumption for robins was assumed to be proportional to earthworm consumption based on the assumption that most soil is ingested by these species while foraging for earthworms (Sample and Suter 1994). Woodcock, a bird species that consumes virtually

100% earthworms, has a diet which is 10.4% soil (Beyer et al. 1994). Robins, which based on dietary information, are estimated to consume 18% of their diet in earthworms (USEPA 1993; Sample and Suter, 1994), would then be assumed to consume 1.9% of their total diet in soil. Based on percent dietary soil ingestion values presented by Sample and Suter (1994), a shrew's soil ingestion rate is equivalent to 13% of the total mass of its diet. The percent soil ingestion rates for robins and shrews were multiplied by the FIs presented earlier for these species to estimate soil ingestion rates (0.081 kg/kg bw-d for shrews and 0.017 kg/kg bw-d for robins). The maximum detected chemical concentration was used for C_{soil}.

In addition to the ingestion of chemicals from diet (earthworms) and surface soil, soil invertebrate-eating wildlife may be exposed to chemicals via the ingestion of surface water. Equation 7 was used to calculate the dose of chemical that robins and shrews could obtain from the ingestion of surface water:

$$Dose_{water} = WI * C_{water} \quad (7)$$

where

$Dose_{water}$ = amount of chemical ingested per day from surface water (mg/kg bw-d);

WI = water ingestion rate (L/kg bw-d); and

C_{water} = maximum chemical concentration in surface water (mg/L).

A water ingestion rate (WI) of 0.14 L/kg-d and 0.223 L/kg-day for robins and shrews, respectively, from USEPA (1993) was used. The maximum detected chemical concentration in surface water at the site was used for C_{water} as a conservative exposure estimate.

The total dietary exposure levels for robins or shrews to COPCs were determined using Equation 8:

$$Dose_{total} = Dose_{worm} + Dose_{soil} + Dose_{water} \quad (8)$$

The total dietary intakes are compared to dietary toxicity values in the Risk Characterization section of the ERA (Section 1.4) to determine if adverse effects are likely to occur to vermivorous birds and small mammals from the ingestion of COPCs in earthworms, surface soil, and surface water.

Exposure Estimates for Heron and Mink from the Ingestion of Aquatic Life, Sediment, and Surface Water. The ingestion of sediment was not evaluated for heron and mink because sediment ingestion by the heron and mink is negligible, as indicated by Sample and Suter (1994). Equation 9 was used to calculate the upper bound dose of chemicals that a heron or mink could obtain from the ingestion of aquatic food items at RFAAP:

$$Dose_{food} = FI * C_{diet} \quad (9)$$

where

$Dose_{food}$ = amount of chemical ingested per day via the ingestion of food (mg/kg bw-d);

FI = food ingestion rate (kg/kg bw-d); and

C_{diet} = estimated COPC concentration in diet (mg/kg).

A wet weight FI of 0.18 kg/kg bw-d reported by Kushlan (1978) was used for great blue heron. A wet weight FI of 0.22 kg/kg bw-d was estimated for mink using an equation from Nagy (1987) as reported by USEPA (1993).

The estimated chemical concentration in diet (C_{diet}), the other term in Equation 9, was assumed to be the same as the maximum chemical concentration detected in RFAAP sediment. Use of this value assumes the wet weight concentration of chemicals in prey items (e.g., fish, amphibians, aquatic invertebrates) is the same as the maximum chemical concentration detected in the sediment. This assumption is highly conservative for most chemicals and is expected to provide an absolute upper bound estimate of chemical concentration in diet for all except highly bioaccumulative chemicals.

In addition to the ingestion of chemicals from diet, heron and mink may be exposed to chemicals via the ingestion of surface water. Equation 10 was used to calculate the dose of chemical that heron and mink could obtain from the ingestion of surface water:

$$Dose_{water} = WI * C_{water} \quad (10)$$

where

$Dose_{water}$ = amount of chemical ingested per day from surface water (mg/kg bw-d);

WI = water ingestion rate (L/kg bw-d); and

C_{water} = maximum chemical concentration in surface water (mg/L).

A water ingestion rate (WI) of 0.045 L/kg-d for heron was estimated using an equation from Calder and Braun (1983) as cited in USEPA (1993). For mink, a water ingestion rate (WI) of 0.18 L/kg-d was calculated from Sample and Suter (1994) using a body weight of 0.55 kg from Mitchell (1961) as cited in USEPA (1993). The maximum detected chemical concentration in surface water at the site was used for C_{water} as a conservative exposure estimate.

The total dietary exposure levels for heron or mink to COPCs were determined using Equation 11:

$$Dose_{total} = Dose_{food} + Dose_{sediment} + Dose_{water} \quad (11)$$

The total dietary intakes are compared to dietary toxicity values in the Risk Characterization section of the ERA (Section 1.4) to determine if adverse effects are likely to occur to piscivorous/aquatic invertebrate-eating birds and small mammals from the ingestion of COPCs in aquatic prey, sediment, and surface water associated with the aquatic areas of concern at RFAAP.

Exposure Estimates for Red-Tailed Hawks and Red Foxes from the Ingestion of Terrestrial Prey, Surface Soil, and Surface Water. The ingestion of soil was not evaluated for red-tailed hawks because soil ingestion by the red-tailed hawk is negligible, as indicated by Sample and Suter (1994). Equation 12 was used to calculate the upper bound dose of chemicals that a red-tailed hawk and red fox could obtain from the ingestion of terrestrial prey:

$$Dose_{prey} = FI * C_{diet} \quad (12)$$

where

$Dose_{food}$ = amount of chemical ingested per day via the ingestion of food (mg/kg bw-d);

FI = food ingestion rate (kg/kg bw-d); and

C_{diet} = estimated COPC concentration in diet (mg/kg).

A wet weight FI of 0.11 kg/kg bw-d reported by Craighead and Craighead (1956) (as cited in USEPA 1993) for red-tailed hawk was used in the ERA. A wet weight FI of 0.14 kg/kg bw-d reported by the USEPA (1993) for red fox was used.

The estimated chemical concentration in diet (C_{diet}), the other term in Equation 12, was assumed to be the same as the maximum chemical concentration detected in RFAAP soil. Use of this value assumes the wet weight concentration of chemicals in prey items (e.g., small mammals) is the same as the maximum chemical concentration detected in the soil. This assumption is highly conservative for most chemicals and is expected to provide an absolute upper bound estimate of chemical concentration in diet for all except highly bioaccumulative chemicals.

In addition to the ingestion of chemicals accumulated in prey, foxes may also be exposed to chemicals through the inadvertent ingestion of surface soil while foraging. Equation 13 was used to calculate the upper bound dose of chemical that foxes could obtain from the ingestion of soil:

$$Dose_{soil} = SI * C_{soil} \quad (13)$$

where

$Dose_{soil}$ = amount of chemical ingested per day from soil (mg/kg bw-d);

si = soil ingestion rate (kg/kg bw-d); and

C_{soil} = maximum chemical concentration in surface soil (mg/kg).

Red foxes have a diet which is 2.8% soil (Beyer et al. 1994). This percent soil in the diet was multiplied by the FI presented earlier for this species to estimate soil ingestion rate (SI) for foxes (0.0039 kg/kg bw-d). The maximum detected chemical concentration at the site was used for C_{soil}. As discussed above, the ingestion of soil by red-tailed hawk was assumed to be negligible, thus the $Dose_{soil}$ is zero.

In addition to the ingestion of chemicals from diet and surface soil, predatory wildlife may be exposed to chemicals via the ingestion of surface water. Equation 14 was used to calculate the dose of chemical that hawks and foxes could obtain from the ingestion of surface water:

$$Dose_{water} = WI * C_{water} \tag{14}$$

where

$Dose_{water}$ = amount of chemical ingested per day from surface water (mg/kg bw-d);

WI = water ingestion rate (L/kg bw-d); and

C_{water} = maximum chemical concentration in surface water (mg/L).

A water ingestion rate (WI) of 0.057 L/kg-day and 0.085 L/kg-day for hawks and foxes, respectively, were estimated from equations by Calder and Braun (1983) as cited in USEPA (1993). The maximum detected chemical concentration in surface water at the site was used for C_{water} as a conservative exposure estimate.

The total dietary exposure levels for hawks and foxes to COPCs were determined using Equation 15:

$$Dose_{total} = Dose_{prey} + Dose_{soil} + Dose_{water} \tag{15}$$

The dietary intakes for red-tailed hawk and red fox are compared to dietary toxicity values in the Risk Characterization section of the ERA (Section 1.4) to determine if adverse effects are likely to occur to avian and mammalian small mammal predators from the ingestion of terrestrial prey, surface soil, and surface water.

1.2.2 Aquatic Life

1.2.2.1 Benthic Organisms. Maximum chemical concentrations detected in RFAAP sediment samples collected from the New River were used to evaluate the potential for adverse effects to benthic organisms. Data from these samples were compared to literature-based toxicity values. Based on the relative immobility of most aquatic invertebrates, chemical concentrations that exceed a toxicity value at one location have the potential to be associated with adverse effects to aquatic invertebrates at that location. If a chemical was not detected at concentrations exceeding the available toxicity value, it was concluded that the chemical is not likely to adversely affect benthic organisms in that area.

1.2.2.2 Aquatic Organisms. Chemical concentrations measured in surface water samples collected from RFAAP (in the New River and settling lagoons) were used to evaluate the potential for adverse effects to aquatic life. Data from each of the groupings were compared to literature-based toxicity values. The maximum detected surface water concentrations within each grouping were used to evaluate the potential for adverse effects to aquatic life from the presence of chemicals in surface water.

1.3 ECOLOGICAL EFFECTS ASSESSMENT

The purpose of the ecological effects assessment is to derive toxicity values for the indicator species selected for evaluation. The toxicity reference values (TRVs) represent concentrations of the COPCs that are acceptably protective of the ecological receptors being evaluated. TRVs were then compared to calculated exposure concentrations to evaluate each COPC's potential for adverse effects (Section 1.4). The majority of toxicity values presented in the following sections relate directly to the potential for adverse effects to the individual organism and not to the potential for adverse effects to a population or community. The potential for adverse effects to a population or community is the actual endpoint of concern being evaluated in the ERA.

1.3.1 Terrestrial Life

Toxicity criteria have not been developed by USEPA for terrestrial species. Consequently, toxicity data in the scientific literature were used to characterize the toxicity of the COPCs selected for evaluation.

1.3.1.1 Terrestrial Plants. TRVs protective of terrestrial plants were used to assess the potential for inorganic and organic chemicals to adversely affect terrestrial plants (Efroymson et al., 1997a). TRVs were established at a level associated with a 20% reduction in growth or other measured toxicological endpoint. This level is consistent with other screening level benchmarks for ecological risk assessment and the current regulatory approach. Because few toxicity values have been developed for organic chemicals, surrogate organic chemical TRVs were used for the evaluation of potential adverse effects to terrestrial plants, as applicable. Terrestrial plant TRVs were not available for antimony, calcium, iron, magnesium, potassium, and sodium.

There are limitations associated with the toxicity values available for terrestrial plants. The majority of the plant toxicity information available from the scientific literature is for inorganic chemicals and has been based on the evaluation of potential adverse effects to agricultural crops from the presence of inorganic chemicals in surface soil. Furthermore, phytotoxicity varies with the plant species and with the availability and form of a given chemical. If a chemical is more bioavailable to a plant for absorption or uptake, the phytotoxic potential of the chemical increases. Uncertainties associated with this will be discussed further in Section 1.5.

Terrestrial plant TRVs and toxicological endpoints from which the TRVs were derived are listed in Table 1–11.

1.3.1.2 Soil Invertebrates. TRVs reported by Efroymson et al. (1997b) to be protective of earthworm populations were used when available to assess the potential for chemicals to adversely affect earthworms. Efroymson et al. (1977b) established these TRVs at a level associated with 20% reduction in survival, growth, or reproduction, which is consistent with other screening level benchmarks for ecological risk assessment and with the current regulatory approach. In the absence of TRVs reported by Efroymson et al. (1997b), toxicity values reported in scientific literature were used to evaluate the potential for adverse effects to soil invertebrates. Note that fluorene is the only PAH for which Efroymson et al. present a soil invertebrate TRV, and thus, the value for fluorene was used as an indicator of risk for all other PAH COPCs. Uncertainties associated with this will be discussed further in Section 1.5. Soil invertebrate TRVs were not available for the inorganic chemicals aluminum, antimony, barium, beryllium, calcium, iron, magnesium, manganese, potassium, silver, sodium, and vanadium.

There are limitations associated with the toxicity values available for earthworms. First, the toxicity database is limited. In addition, toxicity varies with the species of earthworm and with the availability and form of a given chemical. For example, if a chemical is more bioavailable, the toxic potential of that chemical increases. Uncertainties associated with this will be discussed further in Section 1.5.

Earthworm TRVs and toxicological endpoints from which the TRVs were derived are listed in Table 1–11.

1.3.1.3 Terrestrial Wildlife. Risks to terrestrial wildlife from the ingestion of prey and surface water and from the inadvertent ingestion of abiotic media (e.g., soil, sediment) were selected for evaluation. Chemicals identified as having the potential to adversely affect terrestrial species were evaluated by employing dose-based toxicological benchmarks to evaluate the potential for adverse effects. Dose-based toxicological benchmarks (No Observed Adverse Effect Levels (NOAELs)) derived by Oak Ridge National Laboratory (ORNL 1996) were used to evaluate the potential for adverse effects to the receptors of concern. The ORNL TRVs were generally derived based upon measurements of survival, growth, or reproduction in the laboratory. For some of the terrestrial wildlife receptors, TRVs were not available for 2,4,6-TNT, n-nitrosodiphenylamine, and for the inorganic chemicals antimony, beryllium, calcium, iron, magnesium, potassium, silver and sodium.

Toxicity values from ORNL (1996) for both inorganic mercury and organic mercury were used to evaluate the range of possible mercury-related risks to wildlife because (1) organic mercury (e.g., methylmercury) is consistently more toxic than inorganic mercury; (2) the analysis of total mercury done at RFAAP does not differentiate between the different forms of mercury in surface soil; and (3) the transformation of mercury to methylmercury is largely a microbially-mediated process, and there is potential for the form of mercury in soil to change with altered environmental conditions (Eisler 1987b).

If a toxicological benchmark for a particular COPC was not available from ORNL (1996), the scientific literature was reviewed for oral toxicity data. TRVs were then derived with these data according to Equation 16:

Table 1–11
Summary of Terrestrial Plant and Earthworm Toxicity Reference Values
(Concentrations in μg/kg organics, mg/kg inorganics)

Chemical	Terrestrial Plant			Earthworms		
	TRV[A]	Endpoint	Chemical Form/Surrogate[B]	TRV[A]	Endpoint	Chemical Form/Surrogate[B]
PAHs:						
Acenaphthene	20,000	Growth	—	30,000	Survival	Fluorene
Benz[*a*]anthracene	20,000	Growth	Acenaphthene	30,000	Survival	Fluorene
Benzo[*b*]fluoranthene	20,000	Growth	Acenaphthene	30,000	Survival	Fluorene
Benzo[*g,h,i*]perylene	20,000	Growth	Acenaphthene	30,000	Survival	Fluorene
Benzo[*k*]fluoranthene	20,000	Growth	Acenaphthene	30,000	Survival	Fluorene
Chrysene	20,000	Growth	Acenaphthene	30,000	Survival	Fluorene
Fluoranthene	20,000	Growth	Acenaphthene	30,000	Survival	Fluorene
Naphthalene	20,000	Growth	Acenaphthene	30,000	Survival	Fluorene
Phenanthrene	20,000	Growth	Acenaphthene	30,000	Survival	Fluorene
Pyrene	20,000	Growth	Acenaphthene	30,000	Survival	Fluorene
Other Semivolatile Organics:						
Di-n-butylphthalate	200,000	Growth	—	200,000	Survival	Dimethylphthalate
Diethylphthalate	100,000	Growth	—	200,000	Survival	Dimethylphthalate
Bis(2-ethylhexyl)phthalate	100,000	Growth	Diethylphthalate	200,000	Survival	Dimethylphthalate
Inorganics:						
Aluminum	50	Seedling establishment	$Al_2(SO_4)_3$	NA	—	—
Antimony	NA	—	—	NA	—	—
Barium	500	Growth	$Ba(NO_3)_2$	NA	—	—
Beryllium	10	Unspecified toxic effects	Unspecified	NA	—	—
Cadmium	4	Growth	Multiple forms tested	20	Urease, Phosphatase, and Arylsulfatase Activity	Multiple forms tested
Calcium	NA	—	—	NA	—	—
Chromium	1	Growth	Chromium VI as $K_2Cr_2O_7$	0.4	Survival	$K_2Cr_2O_7$
Copper	100	Growth	$CuSO_4$	50	Survival, Growth, Cocoon production	$CuCl_2$
Iron	NA	—	—	NA	—	—
Lead	50	Growth	$PbCl_2$	500	Reproduction	—
Magnesium	NA	—	—	NA	—	—
Manganese	500	Growth	$MnSO_4$	NA	—	—
Mercury	0.3	Unspecified toxic effects	Unspecified	0.1	Survival, Cocoon production	$HgCl_2$
Nickel	30	Growth	$NiCl_2$, $NiSO_4$	200	Cocoon Production	$C_4H_6NiO_4$
Potassium	NA	—	—	NA	—	—
Silver	2	Unspecified toxic effects	Unspecified	NA	—	—
Sodium	NA	—	—	NA	—	—
Vanadium	2	Unspecified toxic effects	Unspecified	NA	—	—
Zinc	50	Growth	$ZnSO_4$	100	Cocoon and juvenile production	$Zn(NO_3)_2$

[A]TRV information is from Efroymson et al. 1997.
[B]For organic chemicals, this column indicates when toxicity data for a related chemical was used as a surrogate for the COPC. For inorganic chemicals, the chemical form used to derive the TRV is indicated.
NA = TRV not available.

$$TRV = d / UF \quad (16)$$

where

d = literature-based daily dose (mg/kg bw-d); and

UF = total uncertainty factor.

A dose (d) was conservatively selected from the available scientific literature for each COPC. The following criteria were used to select the dose values:

- Doses based on the indicator species selected for evaluation were used preferentially; however, if toxicity information was not available for these species, doses for animals within the same class as the indicator species were used.
- Data for reproductive or developmental effects were used preferentially; otherwise, the lowest dose (i.e., most conservative) for which a NOAEL or Lowest Observed Adverse Effect Level (LOAEL) was available was used.
- Chronic data were used in preference to subchronic or acute data, and NOAELs were used in preference to LOAELs and LD_{50}s.

The UFs used in Equation 16 were taken from Sample et al. (1996) and Wentsel et al. (1994). The magnitude of the uncertainty factor is dependent upon both the length of the toxicological study used (i.e., chronic, subchronic, acute) and the endpoint measured (i.e., NOAEL, LOAEL, LD_{50}).

Toxicity values for exposure of avian wildlife to PAHs are not reported in ORNL (1996), therefore TRVs were derived according to Equation 16 for all avian receptor species. Uncertainty factors reported in Sample et al. (1996) were applied to daily doses reported in Schafer et al. (1983) to derive TRVs.

If the available literature-based toxicological data were based on animals other than the selected indicator species, mammalian TRVs were extrapolated to account for size differences between the test species and the selected indicator species. The generic extrapolation equation, based on the relationship of body weight and surface area (Sample et al. 1996), is given below:

$$d_a = d_b * (bw_b/bw_a)^{1/4} \quad (17)$$

where

d_a = toxicity value (mg/kg bw-d) for species "a", species to be extrapolated to (e.g., fox);

d_b = toxicity values for species "b", test species to extrapolate from (e.g., rat);

bw_a = body weight of species a; and

bw_b = body weight of species b.

Toxicity values for exposure of terrestrial wildlife to silver are not reported in ORNL (1996), so TRVs were extrapolated from toxicity values available from ORNL (1996) for mammalian test species. Equation 17, as described above, was used to derive silver TRVs for shrews, voles, and foxes from LOAELs presented for mammalian test species. The following body weights were used for extrapolation: 0.35 kg for rat, 0.015 kg for shrew, 0.017 kg for vole, and 4.5 kg for fox (Sample et al. 1996; USEPA 1993).

The uncertainties associated with the extrapolation and derivation of TRVs using the methods presented here are discussed in Section 1.5. Table 1–12 presents endpoints, literature-based daily doses, total uncertainty factors, and derived TRVs for COPCs for which ORNL does not present TRVs.

TRVs could not be derived for certain COPCs due to a lack of available information in the scientific literature. The following is a list of COPCs for which terrestrial wildlife TRVs could not be derived: antimony, beryllium, and silver for robins or hawks; 2,4,6-TNT and n-nitrosodiphenylamine for mink; and 2,4,6-TNT, n-nitrosodiphenylamine, and beryllium for heron. Additionally, TRVs for calcium, iron, magnesium, potassium, and sodium were not available for any of the wildlife receptors.

5-3

A summary of all the wildlife TRVs and the toxicological endpoints used to derive the TRVs are presented in Tables 1–12 through Table 1–16.

1.3.2 Aquatic Life

1.3.2.1 Benthic Organisms. Several sources of toxicity data were used to identify the potential for chemicals in sediment to cause adverse effects to benthic communities. Effects range-low (ER-L) values reported in Long et al. (1995), and alternatively in Long and Morgan (1990), were employed as TRVs to determine if chemicals in the sediments are likely to impact aquatic communities. Effects range values were derived from the compilation of the available sediment toxicity data for a chemical. The ER-L value is equivalent to the lower 10th percentile of the available toxicity data, which is estimated to be the approximate concentration at which adverse effects are likely to occur in sensitive life stages and/or species.

Additionally, threshold effects levels (TELs) have recently been derived by MacDonald et al. (1996) using a weight-of-evidence approach based on numerous studies performed on coastal sediments. TEL values are defined as values which were rarely associated with adverse biological effects. In the absence of an ER-L value, the TEL value was employed as the TRV to determine if chemicals in the sediments in RFAAP are likely to impact benthic organisms.

When ER-Ls and TELs were not available, guidelines developed by the OMEE (1993) were used to screen the potential for adverse effects to benthic organisms. In the absence of the above TRVs, sediment quality benchmark (SQB) values were selected from Jones et al. (1997). The methodology used to generate the SQBs is the EqP approach, similar to the approach used to derive the USEPA SQC. SQBs are based on organic carbon content in sediment. Accordingly, SQBs were calculated based on the average total organic carbon content for the New River sediment data grouping.

Sediment TRVs were not available for dimethylphthalate, n-nitrosodiphenylamine, 2,4,6-trinitrotoluene, barium, and beryllium, and there is some uncertainty associated with the potential for these chemicals to adversely affect benthic organisms.

1.3.2.2 Aquatic Organisms. Federal Ambient Water Quality Criteria developed by USEPA (1995a) for the protection of aquatic life were used to assess potential impacts to aquatic species. Chronic freshwater AWQC were used to evaluate the potential for adverse effects to aquatic life from chemicals measured in the surface water bodies associated with RFAAP, because chronic freshwater AWQC are the most representative of longer-term exposure likely to occur in these water bodies. Hardness-dependent criteria were calculated according to equations given by USEPA (1995a) based on the average hardness measured for the New River surface water samples, the only area where hardness-dependent chemicals were identified as COPCs. The average hardness used in calculating hardness-dependent AWQC was 46.2 mg/l as $CaCO_3$ for the New River.

When a chronic AWQC was not available for a particular chemical, the Tier II chronic value from Suter and Tsao (1996) was used. TRVs were not available for calcium, magnesium, potassium, and sodium, and there is some uncertainty associated with the potential for these chemicals to adversely affect aquatic life.

1.4 RISK CHARACTERIZATION

The purpose of the risk characterization is to determine if there is potential for ecological receptors to be adversely affected by the presence of COPCs at RFAAP by comparing potential exposure concentrations to TRVs.

Consistent with USEPA (1997) and discussions with the USEPA Region III BTAG, the objective of this evaluation is to identify chemicals having the potential to adversely affect ecological resources while eliminating other COPCs from further consideration. Consistent with this approach, the highly conservative models used to evaluate the potential for adverse effects were designed to estimate an upper bound potential for adverse effects to the selected indicator species, such that risks are likely to be overestimated but are highly unlikely to be underestimated. Exceedance of a toxicity value indicates the *potential* for adverse effects but does not indicate an occurrence of an adverse effect. Consistent with current guidance, chemicals having estimated exposure concentrations exceeding TRVs have been evaluated further in the risk management section (Section 2.0) to determine the need for further evaluation or action.

Table 1–12
Derivation of Wildlife Toxicity Reference Values for Selected COPCs

Chemical	Test Animal	Test Animal Body Weight (kg)	Endpoint	Literature-Based Daily Dose (mg/kg bw-d)	Reference	Total Uncertainty Factor	Avian Toxicity Reference Value[A] (mg/kg bw-d)	Toxicity Reference Value for Shrew[B] (mg/kg bw-d)	Toxicity Reference Value for Vole[B] (mg/kg bw-d)	Toxicity Reference Value for Fox[B] (mg/kg bw-d)
Acenaphthene	Red-winged Blackbird	NA	Acute NOAEL	101	Schafer et al. (1983)	30	3.37	—	—	—
Fluorene	Red-winged Blackbird	NA	Acute NOAEL	101	Schafer et al. (1983)	30	3.37	—	—	—
Phenanthrene	Red-winged Blackbird	NA	Acute NOAEL	113	Schafer et al. (1983)	30	3.77	—	—	—
Silver	Rat	0.35	Subchronic LOAEL	222.2	Mattuk et al. (1981) as cited in ATSDR (1990)	20	—	24.4	23.7	5.87

[A]TRVs were derived by applying uncertainty factors to literature-based daily doses (Equation 16) as presented in Section 1.3.1 of the text. Avian TRVs presented are applicable to any avian receptor species (see Section 1.3.1 of the text).
[B]TRVs were derived by applying uncertainty factors to literature-based daily doses (Equation 16) and scaling for body weight (Equation 17) as presented in Section 1.3.1 of the text. The following body weights were used in the calculations: 0.015kg for shrew, 0.017kg for vole, and 4.5kg for fox.
— = TRV not needed for this receptor.

Table 1–13
Summary of Mammalian Toxicity Reference Values for Surface Water and Surface Soil COPCs

(Concentrations in mg/kg bw-d)

Chemical	Shrew TRV[A]	Vole TRV[A]	Fox TRV[A]	Endpoint	Chemical Form/Surrogate[B]
PAHs:					
Acenaphthene	1.19	0.91	0.29	Reproduction	Benzo[*a*]pyrene
Benz(a)anthracene	1.19	0.91	0.29	Reproduction	Benzo[*a*]pyrene
Benzo(b)fluoranthene	1.19	0.91	0.29	Reproduction	Benzo[*a*]pyrene
Benzo(g,h,i)perylene	1.19	0.91	0.29	Reproduction	Benzo[*a*]pyrene
Benzo(k)fluoranthene	1.19	0.91	0.29	Reproduction	Benzo[*a*]pyrene
Chrysene	1.19	0.91	0.29	Reproduction	Benzo[*a*]pyrene
Fluoranthene	1.19	0.91	0.29	Reproduction	Benzo[*a*]pyrene
Naphthalene	1.19	0.91	0.29	Reproduction	Benzo[*a*]pyrene
Phenanthrene	1.19	0.91	0.29	Reproduction	Benzo[*a*]pyrene
Pyrene	1.19	0.91	0.29	Reproduction	Benzo[*a*]pyrene
Other Semivolatile Organics:					
Di-n-butylphthalate	654	500	157	Reproduction	—
Diethylphthalate	5450	4165	1310	Reproduction	—
Bis(2-ethylhexyl)phthalate	21.8	16.6	5.2	Reproduction	—
Inorganics:					
Aluminum	2.295	1.754	0.551	Reproduction	$AlCl_3$
Antimony	0.149	0.114	0.036	Lifespan, Longevity	Antimony potassium tartrate
Barium	11.8	9	2.8	Growth, Hypertension	Barium chloride
Beryllium	1.45	1.11	0.35	Longevity, Weight loss	Beryllium sulfate
Cadmium	2.12	1.62	0.509	Reproduction	Cadmium chloride
Calcium	NA	NA	NA	—	—
Chromium	7.21	5.51	1.73	Body weight, Food consumption	Chromium VI
Copper	33.4	25.5	8	Reproduction	Copper sulfate
Iron	NA	NA	NA	—	—
Lead	17.58	13.44	4.22	Reproduction	Lead acetate
Magnesium	NA	NA	NA	—	—
Manganese	193	148	46	Reproduction	Mn_3O_4
Mercury	2.86	2.18	0.69	Reproduction	Mercuric chloride
Nickel	87.91	67.18	21.12	Reproduction	Nickel sulfate hexahydrate
Potassium	NA	NA	NA	—	—
Sodium	NA	NA	NA	—	—
Vanadium	0.428	0.327	0.103	Reproduction	Sodium metavanadate
Zinc	351.7	268.7	84.5	Reproduction	Zinc oxide

[A]TRVs from ORNL (1996), unless otherwise noted.
[B]For organic chemicals, this column indicates when toxicity data for a related chemical was used as a surrogate for the COPC. For inorganic chemicals, the chemical form used to derive the TRV is indicated.
NA = TRV not available.

Table 1–14
Summary of Mammalian Toxicity Reference Values for Surface Water and Sediment COPCs

(Concentrations in mg/kg bw-d)

Chemical	Mink TRV[A]	Endpoint	Chemical Form/Surrogate[B]
Lagoon			
Other Semivolatile Organics:			
Di-n-butylphthalate	229	Reproduction	—
Diethylphthalate	1907	Reproduction	—
Inorganics:			
Aluminum	0.803	Reproduction	$AlCl_3$
Calcium	NA	—	—
Magnesium	NA	—	—
Manganese	68	Reproduction	Mn_3O_4
Potassium	NA	—	—
Sodium	NA	—	—
New River			
Explosives:			
2,4,6-Trinitrotoluene	NA	—	—
Other Semivolatile Organics:			
Bis(2-ethylhexyl)phthalate	7.6	Reproduction	—
Di-n-butylphthalate	229	Reproduction	—
Diethylphthalate	1907	Reproduction	—
Dimethylphthalate	7.6	Reproduction	Bis(2-ethylhexyl)phthalate
n-Nitrosodiphenylamine	NA	—	
Inorganics:			
Arsenic	0.052	Reproduction	Arsenite
Barium	4.1	Growth, Hypertension	Barium chloride
Beryllium	0.51	Longevity, Weight loss	Beryllium sulfate
Chromium	2.52	Body weight, Food consumption	
Lead	6.15	Reproduction	Lead acetate
Nickel	30.77	Reproduction	Nickel sulfate hexahydrate

[A]TRVs from ORNL (1996), unless otherwise noted.

[B]For organic chemicals, this column indicates when toxicity data for a related chemical was used as a surrogate for the COPC. For inorganic chemicals, the chemical form used to derive the TRV is indicated.

NA = TRV not available.

Table 1–15
Summary of Avian Toxicity Reference Values for Surface Soil and Surface Water COPCs

(Concentrations in mg/kg bw-d)

Chemical	Robin/Hawk TRV[A]	Endpoint	Chemical Form/Surrogate[B]
PAHs:			
Acenaphthene	3.37 [C]	Mortality	—
Benz[*a*]anthracene	3.37 [C]	Mortality	Fluorene
Benzo[*b*]fluoranthene	3.37 [C]	Mortality	Fluorene
Benzo[*g,h,i*]perylene	3.37 [C]	Mortality	Fluorene
Benzo[*k*]fluoranthene	3.37 [C]	Mortality	Fluorene
Chrysene	3.37 [C]	Mortality	Fluorene
Fluoranthene	3.37 [C]	Mortality	Fluorene
Naphthalene	3.37 [C]	Mortality	Fluorene
Phenanthrene	3.77 [C]	Mortality	—
Pyrene	3.37 [C]	Mortality	Fluorene
Other Semivolatile Organics:			
Di-n-butylphthalate	0.11	Reproduction	—
Diethylphthalate	0.11	Reproduction	Di-n-butylphthalate
Bis(2-ethylhexyl)phthalate	1.1	Reproduction	—
Inorganics:			
Aluminum	109.7	Reproduction	$Al_2(SO_4)_2$
Antimony	NA	—	—
Barium	20.8	Mortality	Barium hydroxide
Beryllium	NA	—	—
Cadmium	1.45	Reproduction	Cadmium chloride
Calcium	NA	—	—
Chromium	1.0	Reproduction	Chromium III as $CrK(SO_4)_2$
Copper	47	Growth, Mortality	Copper oxide
Iron	NA	—	—
Lead	3.85	Reproduction	Metallic lead
Magnesium	NA	—	—
Manganese	997	Growth, Behavior	Mn_3O_4
Mercury	0.45	Reproduction	Mercuric chloride
Nickel	77.4	Mortality, Growth, Behavior	Nickel sulfate
Potassium	NA	—	—
Silver	NA	—	—
Vanadium	11.4	Mortality, Body weight, Blood chemistry	Vanadyl sulfate
Zinc	14.5	Reproduction	Zinc sulfate

[A]TRVs from ORNL (1996), unless otherwise noted.
[B]For organic chemicals, this column indicates when toxicity data for a related chemical was used as a surrogate for the COPC. For inorganic chemicals, the chemical form used to derive the TRV is indicated.
[C]Value is derived on Table 1–12.
NA = TRV not available.

Table 1–16
Summary of Avian Toxicity Reference Values for Surface Water and Sediment COPCs

(Concentrations in mg/kg bw-d)

Chemical	Heron TRV[A]	Endpoint	Chemical Form/Surrogate[B]
Lagoon			
Other Semivolatile Organics:			
Di-n-butylphthalate	0.11	Reproduction	—
Diethylphthalate	0.11	Reproduction	di-n-Butylphthalate
Inorganics:			
Aluminum	109.7	Reproduction	$Al_2(SO_4)_2$
Calcium	NA	—	—
Magnesium	NA	—	—
Manganese	997	Growth, Behavior	Mn_3O_4
Potassium	NA	—	—
Sodium	NA	—	—
New River			
Explosives:			
2,4,6-Trinitrotoluene	NA	—	—
Other Semivolatile Organics:			
Bis(2-ethylhexyl)phthalate	1.1	Reproduction	—
Di-n-butylphthalate	0.11	Reproduction	—
Diethylphthalate	0.11	Reproduction	di-n-Butylphthalate
Dimethylphthalate	0.11	Reproduction	di-n-Butylphthalate
n-Nitrosodiphenylamine	NA	—	
Inorganics:			
Arsenic	2.5	Mortality	Copper acetoarsenite
Barium	20.8	Mortality	Barium hydroxide
Beryllium	NA	—	—
Chromium	1	Reproduction	Chromium III as $CrK(SO_4)_2$
Lead	3.85	Reproduction	Metallic lead
Nickel	77.4	Mortality, Growth, Behavior	Nickel sulfate

[A]TRVs from ORNL (1996), unless otherwise noted.
[B]For organic chemicals, this column indicates when toxicity data for a related chemical was used as a surrogate for the COPC. For inorganic chemicals, the chemical form used to derive the TRV is indicated.
NA = TRV not available.

Chemicals were identified for further evaluation by comparing estimated exposure concentrations to TRVs. Estimated exposure concentrations for the COPCs are compared to TRVs by creating a ratio (termed the environmental effects quotient (EEQ) of the estimated exposure concentration to the TRV. If the EEQ is less than or equal to 1.0 (indicating the exposure concentration is less than or equal to the TRV), then adverse effects are considered unlikely. If the EEQ is greater than 1.0 (indicating the exposure concentration is greater than the TRV), there is a potential for adverse effects to occur. Uncertainties associated with these risk estimates are briefly discussed below and are discussed in greater detail in Section 1.5.

1.4.1 Terrestrial Life

1.4.1.1 Terrestrial Plants. Organic and inorganic chemicals identified as COPCs in the surface soils of RFAAP were compared to available terrestrial plant TRVs in Table 1–17. It should be noted, however, there is uncertainty associated with the lack of toxicity information for antimony, calcium, iron, magnesium, potassium, and sodium, which were identified as COPCs in RFAAP surface soil.

Maximum detected concentrations of all organic COPCs remained below the terrestrial plant TRVs. Maximum detected concentrations exceeded terrestrial plant TRVs for 12 of the 13 inorganic COPCs having TRVs. Chemicals with maximum surface soil concentrations that exceeded TRVs and the associated EEQs (listed in parentheses) include the following:

- Aluminum (2,200),
- Chromium (1,600),
- Lead (141),
- Mercury (57),
- Vanadium (45),
- Nickel (23),
- Silver (17),
- Barium (8.0),
- Zinc (4.3),
- Copper (3.4),
- Cadmium (2.7), and
- Manganese (2.7).

1.4.1.2 Soil Invertebrates. Chemicals identified as COPCs in the surface soils of RFAAP were compared to available earthworm TRVs in Table 1–18. It should be noted, however, there is uncertainty associated with the lack of toxicity information for the inorganic chemicals aluminum, antimony, barium, beryllium, calcium, iron, magnesium, manganese, potassium, silver, sodium, and vanadium, which were identified as COPCs in RFAAP surface soil.

The maximum detected concentrations of all organic COPCs remained below the earthworm TRVs and it is reasonable to conclude these chemicals will not adversely affect soil invertebrates. Chemicals with maximum surface soil concentrations that exceeded TRVs and the associated EEQs (listed in parentheses) include the following:

- Chromium (4,000),
- Mercury (170),
- Lead (14),
- Copper (6.7),
- Nickel (3.5), and
- Zinc (2.1).

Table 1–17
Comparison of Maximum Detected Surface Soil Concentrations to Terrestrial Plant TRVs for COPCs

(Concentrations in ug/kg organics; mg/kg inorganics)

Chemical	Maximum Surface Soil Concentration	Terrestrial Plant TRV[A]	Environmental Effects Quotient (EEQ)[B] Ratio of Maximum Detected Surface Soil Concentrations to Plant TRVs
PAHs:			
Acenaphthene	280	20,000	<0.1
Benz[*a*]anthracene	770	20,000	<0.1
Benzo[*b*]fluoranthene	1,500	20,000	<0.1
Benzo[*g,h,i*]perylene	960	20,000	<0.1
Benzo[*k*]fluoranthene	440	20,000	<0.1
Chrysene	810	20,000	<0.1
Fluoranthene	630	20,000	<0.1
Naphthalene	210	20,000	<0.1
Phenanthrene	1,300	20,000	<0.1
Pyrene	1,200	20,000	<0.1
Other Semivolatile Organics:			
Di-n-butylphthalate	820	200,000	<0.1
Diethylphthalate	68.0	100,000	<0.1
Bis(2-ethylhexyl)phthalate	7,900	100,000	<0.1
Inorganics:			
Aluminum	110,000	50	**2,200**
Antimony	60.8	NA	—
Barium	4,000	500	**8.0**
Beryllium	3.89	10	0.4
Cadmium	10.7	4	**2.7**
Calcium	42,800	NA	—
Chromium	1,600	1	**1,600**
Copper	336	100	**3.4**
Iron	44,500	NA	—
Lead	7,070	50	**141**
Magnesium	27,000	NA	—
Manganese	1,330	500	**2.7**
Mercury	17.0	0.3	**57**
Nickel	704	30	**23**
Potassium	3,080	NA	—
Silver	33.0	2	**17**
Sodium	805	NA	—
Vanadium	89.9	2	**45**
Zinc	214	50	**4.3**

[A]TRV information is presented in Table 1–11.
[B]Ratios greater than 1 are indicated with boldface type.
NA = TRV not available.
— = EEQ could not be calculated.

Table 1–18
Comparison of Maximum Detected Surface Soil Concentrations to Earthworm TRVs for COPCs

(Concentrations in ug/kg organics; mg/kg inorganics)

Chemical	Maximum Surface Soil Concentration	Earthworm TRV[A]	Environmental Effects Quotient (EEQ)[B] Ratio of Maximum Detected Surface Soil Concentrations to Earthworm TRVs
PAHs:			
Acenaphthene	280	30,000	<0.1
Benz[*a*]anthracene	770	30,000	<0.1
Benzo[*b*]fluoranthene	1,500	30,000	<0.1
Benzo[*g,h,i*]perylene	960	30,000	<0.1
Benzo[*k*]fluoranthene	440	30,000	<0.1
Chrysene	810	30,000	<0.1
Fluoranthene	630	30,000	<0.1
Naphthalene	210	30,000	<0.1
Phenanthrene	1,300	30,000	<0.1
Pyrene	1,200	30,000	<0.1
Other Semivolatile Organics:			
Di-n-butylphthalate	820	200,000	<0.1
Diethylphthalate	68.0	200,000	<0.1
Bis(2-ethylhexyl)phthalate	7,900	200,000	<0.1
Inorganics:			
Aluminum	110,000	NA	—
Antimony	60.8	NA	—
Barium	4,000	NA	—
Beryllium	3.89	NA	—
Cadmium	10.7	20	0.5
Calcium	42,800	NA	—
Chromium	1,600	0.4	**4,000**
Copper	336	50	**6.7**
Iron	44,500	NA	—
Lead	7,070	500	**14**
Magnesium	27,000	NA	—
Manganese	1,330	NA	—
Mercury	17.0	0.1	**170**
Nickel	704	200	**3.5**
Potassium	3,080	NA	—
Silver	33.0	NA	—
Sodium	805	NA	—
Vanadium	89.9	NA	—
Zinc	214	100	**2.1**

[A]TRV information is presented in Table 1–11.
[B]Ratios greater than 1 are indicated with boldface type.
NA = TRV not available.
— = EEQ could not be calculated.

1.4.1.3 Terrestrial Wildlife. Potential adverse effects to terrestrial wildlife from the ingestion of food items, surface water, and abiotic media (e.g., soil, sediment) were evaluated in the ERA. Chemical concentrations were estimated for the evaluation of potential adverse effects to herbivorous small mammals (voles), vermivorous birds (robins) and small mammals (shrews), piscivorous birds (great blue heron), piscivorous/aquatic invertebrate-eating small mammals (mink), and avian (red-tailed hawks) and mammalian (red foxes) small mammal predators. The results of dose-based comparisons for the chemicals of potential bioaccumulative concern are summarized in Tables 1–19 through 1–25 for the indicator species selected for evaluation. The results of these comparisons are discussed below for each of the receptors. It should be noted, however, TRVs were not available for a number of the organic and inorganic COPCs. COPCs lacking TRVs are shown in the summary tables for each indicator species.

Herbivorous Mammals: Meadow Vole Ingestion of Terrestrial Plants, Surface Soil, and Surface Water. EEQs for voles were less than one for all organic COPCs, while EEQs were greater than one for 13 of the 15 inorganic COPCs having TRVs. EEQs (listed in parentheses) were greater than one for the following COPCs:

- Aluminum (19,266),
- Antimony (164),
- Lead (162),
- Barium (137),
- Methylmercury (97),
- Chromium (89), and
- Vanadium (84).

Beryllium, cadmium, copper, manganese, mercury, and nickel also exceeded their TRVs to a lesser extent (EEQs ranging from 1.1 for beryllium to 4.0 for copper).

Vermivorous Birds: Robin Ingestion of Earthworms, Surface Soil, and Surface Water. With the exception of di-n-butylphthalate (EEQ of 6.8) and bis(2-ethylhexyl)phthalate (EEQ of 6.5), EEQs for robins were less than one for all organic COPCs. All inorganic COPCs with available TRVs had EEQs (listed in paratheses) greater than one and included the following:

- Aluminum (909),
- Chromium (1,451),
- Lead (1,665),
- Methylmercury (2,570),
- Barium (174),
- Mercury (34), and
- Zinc (13).

Cadmium, copper, manganese, nickel, and vanadium also exceeded their TRVs (EEQs ranging from 1.2 for manganese to 8.2 for nickel).

Vermivorous Small Mammals: Shrew Ingestion of Earthworms, Surface Soil, and Surface Water. EEQs for shrews were less than one for all organic COPCs, while EEQs for shrews were greater than one for 13 of the 15 inorganic COPCs having TRVs. EEQs (listed in parentheses) were greater than one for the following:

- Aluminum (33,580),
- Antimony (286),
- Barium (237),
- Chromium (155),
- Lead (282),
- Methylmercury (170), and
- Vanadium (224).

Beryllium, cadmium, copper, manganese, mercury, and nickel also exceeded their TRVs (EEQs ranging from 1.9 for beryllium to 7.0 for copper).

Table 1–19
Comparison of Estimated Total Ingested Dose to Meadow Vole TRVs for COPCs
Maximum Case Scenario

Chemical	Dose (mg/kg bw-d)				Vole TRV[A] (mg/kg bw-d)	Ratio of Estimated Total Dose to TRVs[B]
	Prey	Surface Soil	Surface Water	Total		
PAHs:						
Acenaphthene	0.0840	0.00202	0	0.0860	0.91	<0.1
Benz[*a*]anthracene	0.231	0.00554	0	0.237	0.91	0.3
Benzo[*b*]fluoranthene	0.450	0.0108	0	0.461	0.91	0.5
Benzo[*g,h,i*]perylene	0.288	0.00691	0	0.295	0.91	0.3
Benzo[*k*]fluoranthene	0.132	0.00317	0	0.135	0.91	0.1
Chrysene	0.243	0.00583	0	0.249	0.91	0.3
Fluoranthene	0.189	0.00454	0	0.194	0.91	0.2
Naphthalene	0.0630	0.00151	0	0.0645	0.91	<0.1
Phenanthrene	0.390	0.00936	0	0.399	0.91	0.4
Pyrene	0.360	0.00864	0	0.369	0.91	0.4
Other Semivolatile Organics:						
Di-n-butylphthalate	0.246	0.00590	0.000130	0.252	500	<0.1
Diethylphthalate	0.0204	0.000490	0.00104	0.0219	4165	<0.1
Bis(2-ethylhexyl)phthalate	2.37	0.0569	0	2.43	16.6	0.1
Inorganics:						
Aluminum	33,000	792	0.0959	33,792	1.754	**19,266**
Antimony	18.2	0.438	0	18.7	0.114	**164**
Barium	1,200	28.8	0.00346	1,229	9	**137**
Beryllium	1.17	0.0280	0	1.20	1.11	**1.1**
Cadmium	3.21	0.0770	0	3.29	1.62	**2.0**
Calcium	12,840	308	1.48	13,150	NA	—
Chromium	480	11.5	0	492	5.51	**89**
Copper	101	2.42	0	103	25.5	**4.0**
Iron	13,350	320	0	13,670	NA	—
Lead	2,121	50.9	0.00328	2,172	13.44	**162**
Magnesium	8,100	194	0.477	8,295	NA	—
Manganese	399	9.58	0.00274	409	148	**2.8**
Mercury	5.10	0.122	0	5.22	2.18	**2.4**
Methylmercury	5.10	0.122	0	5.22	0.054	**97**
Nickel	211	5.07	0.000533	216	67.18	**3.2**
Potassium	924	22.2	0.157	946	NA	—
Silver	9.90	0.238	0	10.1	23.7	0.4
Sodium	242	5.80	1.26	249	NA	—
Vanadium	27.0	0.647	0	27.6	0.327	**84**
Zinc	64.2	1.54	0.000676	65.7	268.7	0.2

[A]TRV information is presented in Table 1–13.
[B]Ratios greater than one are indicated in boldface type.
NA = TRV not available.
— = Ratio of the estimated total dose to the TRV could not be calculated.

Table 1–20
Comparison of Estimated Total Ingested Dose to American Robin TRVs for COPCs
Maximum Case Scenario

Chemical	Dose (mg/kg bw-d)				Robin TRV[A] (mg/kg bw-d)	Ratio of Estimated Total Dose to TRVs[B]
	Earthworm	Surface Soil	Surface Water	Total		
PAHs:						
Acenaphthene	0.249	0.00473	0	0.254	3.37	<0.1
Benz[*a*]anthracene	0.685	0.0130	0	0.698	3.37	0.2
Benzo[*b*]fluoranthene	1.34	0.0254	0	1.36	3.37	0.4
Benzo[*g,h,i*]perylene	0.854	0.0162	0	0.871	3.37	0.3
Benzo[*k*]fluoranthene	0.392	0.00744	0	0.399	3.37	0.1
Chrysene	0.721	0.0137	0	0.735	3.37	0.2
Fluoranthene	0.561	0.0107	0	0.571	3.37	0.2
Naphthalene	0.187	0.00355	0	0.190	3.37	<0.1
Phenanthrene	1.16	0.0220	0	1.18	3.77	0.3
Pyrene	1.07	0.0203	0	1.09	3.37	0.3
Other Semivolatile Organics:						
Di-n-butylphthalate	0.730	0.0139	0.000140	0.744	0.11	**6.8**
Diethylphthalate	0.0605	0.00115	0.00112	0.0628	0.11	0.6
Bis(2-ethylhexyl)phthalate	7.03	0.134	0	7.16	1.1	**6.5**
Inorganics:						
Aluminum	97,900	1,860	*0.103*	99,760	*109.7*	***909***
Antimony	54.1	1.03	0	55.1	NA	---
Barium	3,560	67.6	0.00372	3,628	20.8	**174**
Beryllium	3.46	0.0658	0	3.53	NA	---
Cadmium	9.52	0.181	0	9.70	1.45	**6.7**
Calcium	38,092	724	1.60	38,817	NA	---
Chromium	1,424	27.1	0	1,451	1	**1,451**
Copper	299	5.68	0	305	47	**6.5**
Iron	39,605	752	0	40,357	NA	---
Lead	6,292	120	0.00353	6,412	3.85	**1,665**
Magnesium	24,030	457	0.514	24,487	NA	---
Manganese	1,184	22.5	0.00295	1,206	997	**1.2**
Mercury	15.1	0.287	0	15.4	0.45	**34**
Methylmercury	15.1	0.287	0	15.4	0.006	**2,570**
Nickel	627	11.9	0.000574	638	77.4	**8.2**
Potassium	2,741	52.1	0.169	2,793	NA	---
Silver	29.4	0.558	0	29.9	NA	---
Sodium	716	13.6	1.35	731	NA	---
Vanadium	80.0	1.52	0	81.5	11.4	**7.2**
Zinc	190	3.62	0.000728	194	14.5	**13**

[a]TRV information is presented in Table 1–15.
[b]Ratios greater than one are indicated in boldface type.
NA = TRV not available.
— = Ratio of the estimated total dose to the TRV could not be calculated.

Table 1–21
Comparison of Estimated Total Ingested Dose to Short-tailed Shrew TRVs for COPCs
Maximum Case Scenario

Chemical	Dose (mg/kg bw-d)				Shrew TRV[A] (mg/kg bw-d)	Ratio of Estimated Total Dose to TRVs[B]
	Earthworm	Surface Soil	Surface Water	Total		
PAHs:						
Acenaphthene	0.174	0.0226	0	0.196	1.19	0.2
Benz[*a*]anthracene	0.477	0.0621	0	0.539	1.19	0.5
Benzo[*b*]fluoranthene	0.930	0.121	0	1.05	1.19	0.9
Benzo[*g,h,i*]perylene	0.595	0.0774	0	0.673	1.19	0.6
Benzo[*k*]fluoranthene	0.273	0.0355	0	0.308	1.19	0.3
Chrysene	0.502	0.0653	0	0.567	1.19	0.5
Fluoranthene	0.391	0.0508	0	0.441	1.19	0.4
Naphthalene	0.130	0.0169	0	0.147	1.19	0.1
Phenanthrene	0.806	0.105	0	0.911	1.19	0.8
Pyrene	0.744	0.0967	0	0.841	1.19	0.7
Other Semivolatile Organics:						
Di-n-butylphthalate	0.508	0.0661	0.000223	0.575	654	<0.1
Diethylphthalate	0.0422	0.00548	0.00178	0.0494	5450	<0.1
Bis(2-ethylhexyl)phthalate	4.90	0.637	0	5.53	21.8	0.3
Inorganics:						
Aluminum	68,200	8,866	0.165	77,066	2.295	**33,580**
Antimony	37.7	4.90	0	42.6	0.149	**286**
Barium	2,480	322	0.00593	2,802	11.8	**237**
Beryllium	2.41	0.314	0	2.73	1.45	**1.9**
Cadmium	6.63	0.862	0	7.50	2.12	**3.5**
Calcium	26,536	3,450	2.54	29,988	NA	—
Chromium	992	129	0	1,121	7.21	**155**
Copper	208	27.1	0	235	33.4	7.0
Iron	27,590	3,587	0	31,177	NA	—
Lead	4,383	570	0.00562	4,953	17.58	**282**
Magnesium	16,740	2,176	0.818	18,917	NA	—
Manganese	825	107	0.00471	932	193	**4.8**
Mercury	10.5	1.37	0	11.9	2.86	**4.2**
Methylmercury	10.5	1.37	0	11.9	0.07	**170**
Nickel	436	56.7	0.000914	493	87.91	**5.6**
Potassium	1,910	248	0.270	2,158	NA	—
Silver	20.5	2.66	0	23.1	24.4	0.9
Sodium	499	64.9	2.15	566	NA	—
Vanadium	55.7	7.25	0	63.0	0.428	**147**
Zinc	133	17.2	0.001160	150	351.7	0.4

[A]TRV information is presented in Table 1–13.
[B]Ratios greater than one are indicated in boldface type.
NA = TRV not available.
— = Ratio of the estimated total dose to the TRV could not be calculated.

Table 1–22
Comparison of Estimated Total Ingested Dose to Great Blue Heron TRVs for COPCs
Maximum Case Scenario

Chemical	Dose (mg/kg bw-d)				Heron TRV[A] (mg/kg bw-d)	Ratio of Estimated Total Dose to TRVs[B]
	Prey	Sediment	Surface Water	Total		
Lagoon						
Other Semivolatile Organics:						
Di-n-butylphthalate	NC	0	0.0000450	0.0000450	0.11	<0.1
Diethylphthalate	NC	0	0.000360	0.000360	0.11	<0.1
Inorganics:						
Aluminum	NC	0	0.0332	0.0332	109.7	<0.1
Calcium	NC	0	0.513	0.513	NA	—
Magnesium	NC	0	0.196	0.196	NA	—
Manganese	NC	0	0.000950	0.000950	997	<0.1
Potassium	NC	0	0.0545	0.0545	NA	—
Sodium	NC	0	0.435	0.435	NA	—
New River						
Explosives:						
2,4,6-Trinitrotoluene	3.78	0	0	3.78	NA	—
Other Semivolatile Organics:						
Bis(2-ethylhexyl)phthalate	0.918	0	0	0.918	1.1	0.8
Di-n-butylphthalate	1.80	0	0	1.80	0.11	**16**
Diethylphthalate	0.864	0	0	0.864	0.11	**7.9**
Dimethylphthalate	1.15	0	0	1.15	0.11	**10**
n-Nitrosodiphenylamine	0.360	0	0	0.360	NA	—
Inorganics:						
Arsenic	2.00	0	0	2.00	2.5	0.8
Barium	80.5	0	0.00120	80.5	20.8	**3.9**
Beryllium	0.486	0	0	0.486	NA	—
Chromium	7.20	0	0	7.20	1	**7.2**
Lead	612	0	0.00113	612	3.85	**159**
Nickel	6.08	0	0	6.08	77.4	<0.1

[A]TRV information is presented in Table 1–16.
[B]Ratios greater than one are indicated in boldface type.
NA = TRV not available.
— = Ratio of the estimated total dose to the TRV could not be calculated.
NC = not calculated.

Table 1–23
Comparison of Estimated Total Ingested Dose to Mink TRVs for COPCs

Maximum Case Scenario

Chemical	Dose (mg/kg bw-d)				Mink TRV[A] (mg/kg bw-d)	Ratio of Estimated Total Dose to TRVs[B]
	Prey	Sediment	Surface Water	Total		
Lagoon						
Other Semivolatile Organics:						
Di-n-butylphthalate	NC	0	0.000180	0.000180	229	<0.1
Diethylphthalate	NC	0	0.00144	0.00144	1907	<0.1
Inorganics:						
Aluminum	NC	0	0.133	0.133	0.803	0.2
Calcium	NC	0	2.05	2.05	NA	—
Magnesium	NC	0	0.783	0.783	NA	—
Manganese	NC	0	0.00380	0.00380	68	<0.1
Potassium	NC	0	0.218	0.218	NA	—
Sodium	NC	0	1.74	1.74	NA	—
New River						
Explosives:						
2,4,6-Trinitrotoluene	4.62	0	0	4.62	NA	—
Other semivolatile Organics:						
Bis(2-ethylhexyl)phthalate	1.12	0	0	1.12	7.6	0.1
Di-n-butylphthalate	2.20	0	0	2.20	229	<0.1
Diethylphthalate	1.06	0	0	1.06	1907	<0.1
Dimethylphthalate	1.41	0	0	1.41	7.6	0.2
n-Nitrosodiphenylamine	0.440	0	0	0.440	NA	—
Inorganics:						
Arsenic	2.44	0	0	2.44	0.052	**47**
Barium	98.3	0	0.00479	98.3	4.1	**24**
Beryllium	0.594	0	0	0.594	0.51	**1.2**
Chromium	8.80	0	0	8.80	2.52	**3.5**
Lead	748	0	0.00454	748	6.15	**122**
Nickel	7.44	0	0	7.44	30.77	0.2

[A]TRV information is presented in Table 1–14.
[B]Ratios greater than one are indicated in boldface type.
NA = TRV not available.
NC = Not calculated.
— = Ratio of the estimated total dose to the TRV could not be calculated.

Table 1–24
Comparison of Estimated Total Ingested Dose to Red-tailed Hawk TRVs for COPCs
Maximum Case Scenario

Chemical	Dose (mg/kg bw-d)				Hawk TRV[A] (mg/kg bw-d)	Ratio of Estimated Total Dose to TRVs[B]
	Prey	Surface Soil	Surface Water	Total		
PAHs:						
Acenaphthene	0.0308	0	0	0.0308	3.37	<0.1
Benz[*a*]anthracene	0.0847	0	0	0.0847	3.37	<0.1
Benzo[*b*]fluoranthene	0.165	0	0	0.165	3.37	<0.1
Benzo[*g,h,i*]perylene	0.106	0	0	0.106	3.37	<0.1
Benzo[*k*]fluoranthene	0.0484	0	0	0.0484	3.37	<0.1
Chrysene	0.0891	0	0	0.0891	3.37	<0.1
Fluoranthene	0.0693	0	0	0.0693	3.37	<0.1
Naphthalene	0.0231	0	0	0.0231	3.37	<0.1
Phenanthrene	0.143	0	0	0.143	3.77	<0.1
Pyrene	0.132	0	0	0.132	3.37	<0.1
Other Semivolatile Organics:						
Di-n-butylphthalate	0.0902	0	0	0.0903	0.11	0.8
Diethylphthalate	0.00748	0	0.000456	0.00794	0.11	<0.1
Bis(2-ethylhexyl)phthalate	0.869	0	0	0.869	1.1	0.8
Inorganics:						
Aluminum	12,100	0	0.0421	12,100	109.7	**110**
Antimony	6.69	0	0	6.69	NA	---
Barium	440	0	0.00152	440	20.8	**21**
Beryllium	0.428	0	0	0.428	NA	---
Cadmium	1.18	0	0	1.18	1.45	0.8
Calcium	4,708	0	0.650	4,709	NA	---
Chromium	176	0	0	176	1	**176**
Copper	37.0	0	0	37.0	47	0.8
Iron	4,895	0	0	4,895	NA	---
Lead	778	0	0.00144	778	3.85	**202**
Magnesium	2,970	0	0.209	2,970	NA	---
Manganese	146	0	0.00120	146	997	0.1
Mercury	1.87	0	0	1.87	0.45	**4.2**
Methylmercury	1.87	0	0	1.87	0.006	**312**
Nickel	77.4	0	0.000234	77.4	77.4	**1.0**
Potassium	339	0	0.0690	339	NA	---
Silver	3.63	0	0	3.63	NA	---
Sodium	88.6	0	0.551	89.1	NA	---
Vanadium	9.89	0	0	9.89	11.4	0.9
Zinc	23.5	0	0.000296	23.5	14.5	**1.6**

[A]TRV information is presented in Table 1-15.
[B]Ratios greater than one are indicated in boldface type.
NA = TRV not available.
— = Ratio of the estimated total dose to the TRV could not be calculated.

Table 1–25
Comparison of Estimated Total Ingested Dose to Red Fox TRVs for COPCs
Maximum Case Scenario

Chemical	Dose (mg/kg bw-d)				Fox TRV[A] (mg/kg bw-d)	Ratio of Estimated Total Dose to TRVs[B]
	Prey	Surface Soil	Surface Water	Total		
PAHs:						
Acenaphthene	0.0392	0.00110	0	0.0403	0.29	0.1
Benz[*a*]anthracene	0.108	0.00302	0	0.111	0.29	0.4
Benzo[*b*]fluoranthene	0.210	0.00588	0	0.216	0.29	0.7
Benzo[*g,h,i*]perylene	0.134	0.00376	0	0.138	0.29	0.5
Benzo[*k*]fluoranthene	0.0616	0.00172	0	0.0633	0.29	0.2
Chrysene	0.113	0.00318	0	0.117	0.29	0.4
Fluoranthene	0.0882	0.00247	0	0.0907	0.29	0.3
Naphthalene	0.0294	0.000823	0	0.0302	0.29	0.1
Phenanthrene	0.182	0.00510	0	0.187	0.29	0.6
Pyrene	0.168	0.00470	0	0.173	0.29	0.6
Other Semivolatile Organics:						
Di-n-butylphthalate	0.115	0.00321	0.0000850	0.118	157	<0.1
Diethylphthalate	0.00952	0.000267	0.000680	0.0105	1310	<0.1
Bis(2-ethylhexyl)phthalate	1.11	0.0310	0	1.14	5.2	0.2
Inorganics:						
Aluminum	15,400	431	0.0627	15,831	0.551	**28,732**
Antimony	8.51	0.238	0	8.75	0.036	**243**
Barium	560	15.7	0.00226	576	2.8	**206**
Beryllium	0.545	0.0152	0	0.560	0.35	**1.6**
Cadmium	1.50	0.0419	0	1.54	0.509	**3.0**
Calcium	5,992	168	0.969	6,161	NA	—
Chromium	224	6.27	0	230	1.73	**133**
Copper	47.0	1.32	0	48.4	8	**6.0**
Iron	6,230	174	0	6,404	NA	—
Lead	990	27.7	0.00214	1,018	4.22	**241**
Magnesium	3,780	106	0.312	3,886	NA	—
Manganese	186	5.21	0.00179	191	46	4.2
Mercury	2.38	0.0666	0	2.45	0.69	**3.5**
Methylmercury	2.38	0.0666	0	2.45	0.01	**245**
Nickel	98.6	2.76	0.000349	101	21.12	**4.8**
Potassium	431	12.1	0.103	443	NA	—
Silver	4.62	0.129	0	4.75	5.87	0.8
Sodium	113	3.16	0.821	117	NA	—
Vanadium	12.6	0.352	0	12.9	0.103	**126**
Zinc	30.0	0.839	0.000442	30.8	84.5	0.4

[A]TRV information is presented in Table 1–13.
[B]Ratios greater than one are indicated in boldface type.
NA = TRV not available.
— = Ratio of the estimated total dose to the TRV could not be calculated.

Piscivorous Birds: Heron Ingestion of Aquatic Life, Sediment, and Surface Water.

Lagoons. No organic or inorganic COPCs exceeded their TRVs for heron exposure to the lagoons. However, risk estimates were based only on exposure to chemicals from surface water ingestion. The other samples taken in the lagoons were classified as surface soil. Therefore, exposure to chemicals from the ingestion of aquatic prey and sediment were not included within this model and there is uncertainty associated with the conclusion that these chemicals are unlikely to adversely affect piscivorous birds in this area.

New River. The EEQ (listed in parentheses) for heron was greater than one for three of the four organics with available TRVs:

- Di-n-butylphthalate (16),
- Diethylphthalate (7.9), and
- Dimethylphthalate (10).

Calculated doses of the inorganic COPCs exceeded their TRVs for the following:

- Lead (159),
- Chromium (7.2), and
- Barium (3.9).

Piscivorous/Aquatic Invertebrate-Eating Small Mammals: Mink Ingestion of Aquatic Life, Sediment, and Surface Water.

Lagoons. EEQs for mink remained below one for all organic and inorganic COPCs with available TRVs. However, risk estimates were based only on exposure to chemicals from surface water ingestion. The other samples taken in the lagoons were classified as surface soil. Therefore, exposure to chemicals from the ingestion of aquatic prey and sediment were not included within this model. There is uncertainty associated with the conclusion that these chemicals are unlikely to adversely affect piscivorous small mammals in this area.

New River. The EEQs for mink were less than one for all organic COPCs having TRVs in this area. EEQs (listed in parantheses) were greater than one for five of the six inorganic COPCs having TRVs and included the following:

- Lead (122),
- Arsenic (47),
- Barium (24),
- Beryllium (1.2), and
- Chromium (3.5).

Small-Mammal Eating Birds: Red-Tailed Hawk Ingestion of Terrestrial Prey, Surface Soil, and Surface Water. EEQs for red-tailed hawks were less than one for all organic COPCs, while EEQs (listed in parentheses) were greater than one for seven of the 12 inorganic COPCs having TRVs and included the following:

- Aluminum (110),
- Chromium (176),
- Lead (202), and
- Methylmercury (312).

Barium, mercury, nickel, and zinc approximated or exceeded their TRVs (EEQs ranging from 1.0 for nickel to 21 for barium).

Small-Mammal Eating Mammals: Red Fox Ingestion of Terrestrial Prey, Surface Soil, and Surface Water. EEQs for red fox were less than one for all organic COPCs, while EEQs (listed in parentheses) were greater than one for 13 of the 15 inorganic COPCs having TRVs and included the following:

- Aluminum (28,732),
- Antimony (243),
- Barium (206),
- Chromium (133),
- Lead (241),
- Methylmercury (245), and
- Vanadium (126).

Beryllium, cadmium, copper, manganese, mercury, and nickel also exceeded their TRVs (EEQs ranging from 1.6 for beryllium to 6.0 for copper).

Summary of Terrestrial Wildlife Risk Characterization. The potential for adverse effects to terrestrial wildlife at RFAAP may result from exposure to chemicals in surface soil, terrestrial prey (modeled from surface soil), sediment, aquatic prey (modeled from sediment), and/or surface water. Sediment- and soil-associated barium, chromium, lead, and, to a lesser extent, beryllium and di-n-butylphthalate pose potential risks to terrestrial wildlife at RFAAP. Soil-associated aluminum, antimony, cadmium, copper, manganese, mercury, nickel, vanadium, zinc, methylmercury, and, to a lesser extent, bis(2-ethylhexyl)phthalate pose potential risks to terrestrial wildlife at RFAAP. Finally, the sediment-associated chemicals which pose potential risks to terrestrial wildlife are arsenic, diethylphthalate, and dimethylphthalate. However, there is uncertainty associated with these conclusions as samples from the SWMU 31 lagoons were classified as surface soil samples in this screening-level risk assessment.

1.4.2 Aquatic Life

1.4.2.1 Benthic Organisms. COPCs in the sediments of RFAAP were compared to available TRVs (Table 1–26). It should be noted, however, there is uncertainty associated with the lack of toxicity information for the organic COPCs dimethylphthalate, n-nitrosodiphenylamine, and 2,4,6-trinitrotoluene, and the inorganic COPCs barium and beryllium.

The PAHs chrysene, fluoranthene, phenanthrene, and pyrene were identified as COPCs in the New River sediment. The maximum detected concentrations of these COPCs did not exceed their respective TRVs. The maximum detected concentrations of two organic COPCs with available TRVs exceeded their TRVs (EEQs in parentheses):

- Diethylphthalate (6.9), and
- Bis(2-ethylhexyl)phthalate (28).

Maximum detected concentrations of chromium and mercury did not exceed TRVs. EEQs (listed in parentheses) were greater than one for the following:

- Lead (73),
- Arsenic (1.4),
- Nickel (1.6).

1.4.2.2 Aquatic Organisms. COPCs in surface water were compared to available surface water TRVs (Table 1–27). It should be noted, however, there is uncertainty associated with the lack of toxicity information for the inorganic chemicals calcium, magnesium, potassium, and sodium, which were identified as COPCs in each of the lagoon groupings. The only inorganic COPC for which a TRV was available was aluminum, which exceeded its surface water TRV (EEQ of 8.5).

Lagoon 1. Di-n-butylphthalate was the only organic chemical identified as a COPC in Lagoon 1 surface water. The maximum detected concentration of this compound did not exceed the surface water TRV (EEQ of <0.1). The only inorganic COPC for which a TRV was available was aluminum, which exceeded its surface water TRV (EEQ of 8.5).

Table 1–26

Comparison of Maximum Detected Sediment Concentrations to Sediment TRVs for COPCs at Radford Main Manufacturing Plant

(Concentrations in ug/kg for organics; mg/kg for inorganics)

Chemical	Maximum Sediment Concentration[A]	Sediment TRV[B]	Environmental Effects Quotient (EEQ)[C] Ratio of Maximum Detected Sediment Concentrations to Sediment TRVs
New River			
Other Semivolatile Organics:			
Di-n-butylphthalate	10,000	13,000 [D]	0.8
Diethylphthalate	4,800	700 [D]	**6.9**
Dimethylphthalate	6,400	NA	—
Bis(2-ethylhexyl)phthalate	5,100	182 [E]	**28**
n-Nitrosodiphenylamine	2,000	NA	—
PAHs:			
Chrysene	140	384	0.4
Fluoranthene	160	600	0.3
Phenanthrene	160	240	0.7
Pyrene	210	665	0.3
Explosives:			
2,4,6-Trinitrotoluene	21,000	NA	—
Inorganics:			
Arsenic	11.1	8.2	**1.4**
Barium	447	NA	—
Beryllium	2.70	NA	—
Chromium	40.0	81	0.5
Lead	3,400	46.7	**73**
Mercury	0.125	0.15	0.8
Nickel	33.8	20.9	**1.6**

[A]Each value represents the maximum detected concentration in sediment for each chemical and given area.
[B]Values are ER-L from Long et al. (1995) unless otherwise noted.
[C]Ratios greater than 1 are indicated with boldface type.
[D]Value is SQB calculated from Tier II secondary chronic value (Jones et al., 1997); based on 1.21 % organic carbon content.
[E]Value is TEL from MacDonald (1996).
NA = TRV not available.
— = EEQ could not be calculated.

Table 1–27
Comparison of Maximum Detected Surface Water Concentrations to Surface Water TRVs for COPCs at Radford Main Manufacturing Plant

(Concentrations in ug/L)

Chemical	Maximum Surface Water Concentration	Surface Water TRV	Environmental Effects Quotient (EEQ)[A] Ratio of Maximum Detected Surface Water Concentrations to Surface Water TRVs
Lagoon 1			
Organics:			
Di-n-butylphthalate	1.00	35 [B]	<0.1
Inorganics:			
Aluminum	738	87 [C]	**8.5**
Calcium	11,400	NA	—
Magnesium	4,350	NA	—
Potassium	1,150	NA	—
Sodium	5,700	NA	—
Lagoon 2			
Organics:			
Diethylphthalate	3.00	210 [B]	<0.1
Inorganics:			
Aluminum	297	87 [C]	**3.4**
Calcium	10,500	NA	—
Magnesium	4,040	NA	—
Potassium	1,210	NA	—
Sodium	9,660	NA	—
Lagoon 3			
Organics:			
Diethylphthalate	8.00	210 [B]	<0.1
Inorganics:			
Aluminum	585	87 [C]	**6.7**
Calcium	9,710	NA	—
Magnesium	3,670	NA	—
Manganese	21.1	120 [B]	0.2
Potassium	1,110	NA	—
Sodium	8,480	NA	—
New River			
Inorganics:			
Lead	25.2	1.19 [D]	**21**

[A]Ratios greater than 1 are indicated with boldface type.
[B]Value is Tier II from Suter and Tsao 1996.
[C]Value is from Federal Ambient Water Quality Criteria.
[D]Value is hardness dependent; based on 46.2 mg/L $CaCO_3$.
NA = TRV not available.
— = EEQ could not be calculated.

Lagoon 2. Diethylphthalate was the only organic chemical identified as a COPC in Lagoon 2 surface water. The maximum detected concentration of this compound did not exceed the surface water TRV (EEQ of <0.1). The only inorganic COPC for which a TRV was available was aluminum, which exceeded its surface water TRV (EEQ of 3.4).

Lagoon 3. Diethylphthalate was the only organic chemical identified as a COPC in Lagoon 3 surface water. The maximum detected concentration of this compound did not exceed the surface water TRV (EEQ of <0.1). The only inorganic COPCs for which TRVs were available were aluminum and manganese, with only aluminum exceeding its surface water TRV (EEQ of 6.7).

New River. There were no organic compounds identified as COPCs in New River surface water. Lead was identified as an inorganic COPC in surface water and the maximum detected concentration exceeded its TRV (EEQ of 21).

1.5 UNCERTAINTIES

This screening-level ERA incorporates a number of uncertainties associated with the estimates of ecological risk due to the conservative screening approach. Accordingly, the risks in this ERA are likely to be overestimated. A listing of uncertainties associated with areas in the screening-level ERA are presented in Table 1–28.

Table 1–28
Uncertainties

Area of Uncertainty	Basis of Uncertainty	Effect of Uncertainty
ENVIRONMENTAL SAMPLING		
Sampling design	Biased to sampling areas of suspected contamination	Overestimate risks
DATA SUMMARIZATION		
Treatment of duplicates/ pairs	Use the maximum detected concentration of chemicals between duplicate/paired samples	Overestimate risks
Arithmetic mean	Mean calculated using detected concentration and half the detection limit of nondetected chemicals	Overestimates risks if detection limits are high
SELECTION OF COPCs		
Detection limits of non-detects	Detection limit of nondetect may be > screening level but not selected as COPC	Underestimate risks
IDENTIFICATION OF POTENTIAL EXPOSURE PATHWAYS/INDICATOR SPECIES		
Lack of exposure data for plants	No evaluation of plant exposure via foliar uptake, uptake from surface water or sediment	Underestimate risks
Lack of exposure data for wildlife	No evaluation of terrestrial wildlife exposure via dermal absorption or inhalation	Underestimate risks
EXPOSURE PARAMETER ESTIMATION		
Accumulation factors	Assume accumulation factor is one for all chemicals in prey	Under/overestimate risks depending on accumulative properties
Location of prey	Assume all prey is obtained from impacted on-site area	Overestimate risks for species with large foraging range
Ingestion of maximum concentrations	Assume ingestion of maximum detected chemical concentration in prey and abiotic media	Overestimate risks
TOXICITY VALUES		
Surrogate TRVs for chemicals	Use surrogate chemical TRVs for chemicals that lack TRVs	Under/overestimate risks depending on chemical surrogate
Derived/extrapolated TRVs	Derive/extrapolate TRVs for indicator species using TRVs for other species	Under/overestimate risks depending on species' differences
Chemical bioavailablity	On-site bioavailability of chemicals is asumed to be similar to chemical bioavailability in tests used for TRV derivation	Under/overestimate risks depending on conditions on-site relative to those for the TRV derivation
ASSESSMENT OF RISKS		
Assessment based on TRV comparison	Characterize risks, or lack of, based on comparison of dose to TRVs	Under/overestimate risks depending on comparison
Missing samples	Limited or lack of samples for a specific data grouping	Under/overestimate risks depending on chemical concentrations
Extrapolation to population	Assume individual risks are population risks	Under/overestimate risks depending on individual and population

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The main areas of uncertainty associated with the ERA are grouped under the following categories:

- Environmental Sampling and Analysis and Selection of Chemicals for Analysis;
- Identification of Exposure Pathways/Receptors for Evaluation and Exposure Parameter Estimation;
- Analysis of Toxicological Data; and
- Assessment of Risks.

1.5.1 Environmental Sampling and Analysis and Selection of COPCs

The sample design is likely to have the greatest impact on the evaluation of risks to ecological resources. Samples were biased in areas of likely contamination. As a result, chemical concentrations detected in environmental media and estimated exposure concentrations are likely to overestimate the potential for adverse effects to ecological resources.

Uncertainties are also associated with the analysis and summarization of chemical data. The maximum detected concentration of a chemical detected in duplicate or paired samples was the concentration considered throughout the ERA. Selecting the maximum concentration of a chemical detected in duplicate samples for use in the ERA is a conservative measure and may overestimate risks. In addition, the arithmetic mean concentration of a chemical detected in a particular media at RFAAP was calculated using concentrations for samples in which the chemical was detected and one half the quantitation limit of the chemical for samples in which it was not detected. This approach has the potential to overestimate risks in cases where the resulting arithmetic mean is greater than the maximum detected concentration. However, this condition did not impact the results of the screening assessment in which maximum detected concentrations of chemicals were used for assessment of risks.

In the selection of COPCs, the greatest uncertainty results from comparing screening levels to the maximum detected chemical concentration. The objective of this selection method is to screen out chemicals that do not have the potential to adversely effect ecological receptors. Selection of a chemical as a COPC based on its maximum detected concentration may result in COPCs that could later be determined as unlikely to adversely affect ecological receptors at the site.

In addition, nondetected chemicals were not selected as COPCs regardless of their quantitation limits. A nondetect could occur at any concentration below its quantitation limit and, possibly, above its screening level. This presents uncertainties in the ERA in cases where the quantitation limit of the chemical is greater than its screening level. Appendix B includes tables listing all nondetected chemicals by media at RFAAP, their quantitation limits, and screening values. This masking effect (quantitation limit is greater than screening level) occurred for approximately 72% of the nondetects with screening values in surface soil, 22% in surface water, and 69% in sediment, with usually one to two orders of magnitude difference between each chemical's detection limit and its screening value.

1.5.2 Identification of Exposure Pathways/Receptors for Evaluation and Exposure Parameter Estimation

The potential for adverse effects to terrestrial wildlife from the dermal absorption or inhalation of chemicals could not be evaluated because of a lack of exposure data. However, based on the COPCs detected in the sampled media these potential exposure pathways are unlikely to occur or to result in adverse effects to terrestrial species and the inclusion of these pathways is unlikely to significantly alter the risk estimates. For terrestrial wildlife, dermal absorption is also limited by fur and feathers. In addition, the potential for adverse effects to plants from chemicals via foliar uptake or uptake from water or sediment could not be evaluated because of a lack of exposure data. Because these pathways could not be considered, risks to plants resulting from exposure to chemicals at RFAAP may have been underestimated.

A major source of uncertainty in the ERA is associated with the estimation of terrestrial wildlife exposure to COPCs. Generally, the models were created to represent a worst case scenario of possible risks to terrestrial wildlife, and thus, many conservative assumptions were incorporated into the models. For example, an accumulation factor of one was used to estimate chemical concentrations in prey (e.g., earthworms, amphibians, fish). Use of this accumulation factor is expected to provide a conservative estimate of accumulation for all chemicals, although for a few chemicals this accumulation factor may underestimate accumulation. It was also assumed that all ingested prey contain concentrations of COPCs equal to the maximum detected concentration of the COPCs detected in abiotic media (e.g., soil, sediment). Additionally, receptors were assumed to obtain all prey items from within the study area at RFAAP.

This assumption is particularly conservative for great blue heron, which have foraging ranges of up to 24 km (Dowd and Flake 1985; Parnell and Soots 1978). This approach is consistent with the objectives of the screening-level assessment, which is to estimate an absolute worst case scenario under which risks would not be underestimated. It is expected, however, that such a conservative scenario would greatly overestimate risk.

1.5.3 Analysis of Toxicological Data

There are a number of uncertainties associated with the toxicity values used for the evaluation of potential adverse effects to ecological receptors, including the applicability of the available toxicity data to the species occurring at RFAAP. For example, Federal AWQC were used to evaluate the potential for adverse effects to aquatic life from the presence of chemicals in surface water. However, many of the species for which the AWQC were designed may not have the same sensitivity to the COPCs as species actually occurring in the on-site water bodies. Depending on the species occurring in these water bodies, the toxicity values may over- or underestimate the potential for adverse effects to aquatic life.

In the absence of site-specific information on the bioavailability and form of chemicals, the bioavailability of chemicals to ecological receptors at RFAAP is assumed to be the same as the bioavailability in the toxicity tests used to derive toxicity values. The bioavailability of chemicals for tests used to derive toxicity values is usually high relative to the bioavailability of chemicals in the environment. COPCs to which receptors are exposed are also conservatively assumed to be present in their most toxic chemical form found in the environment. Toxicity values based on those chemical forms are used in the screening assessment. Availability and chemical form are affected by factors such as pH, moisture, temperature, microbial activity, and interaction with other chemicals. Given the relatively conservative nature of the toxicity values in terms of chemical bioavailability and form, it is likely the potential for adverse effects was overestimated.

Further uncertainty is associated with substituting toxicity criteria derived for a specific chemical for a different, but related, chemical for which toxicity criteria have not been derived. For example, an earthworm TRV derived for fluorene was used to evaluate all PAH COPCs. Eisler (1987a) states that low molecular weight PAHs containing fewer benzene rings are significantly more toxic than higher molecular weight PAHs containing a greater number of benzene rings. Because fluorene has a lower molecular weight and contains fewer benzene rings than all other PAH COPCs except naphthalene, the use of the fluorene TRV for all other PAHs will tend to overestimate risks for all other PAHs except naphthalene. Use of the fluorene TRV for naphthalene may underestimate the risk of this PAH to earthworms.

Another source of uncertainty is associated with the extrapolation of terrestrial wildlife intake-based TRVs. Uncertainty increases when TRVs are based on toxicological data for a species other than the evaluated species of concern and when TRVs are based on toxicological data from acute or subchronic, rather than chronic, studies. For example, an avian TRV for silver was derived from subchronic toxicological data for rats. These uncertainties associated with wildlife TRVs should be considered when making risk management decisions.

Finally, there is uncertainty associated with the elimination of chemicals from further evaluation in exposure pathways due to the absence of toxicity values. Because the risk from these chemicals can not be evaluated, there is the potential to underestimate risks to ecological receptors exposed to these chemicals.

1.5.4 Assessment of Risks

The most apparent uncertainty is the extrapolation of assumptions about the potential for adverse effects from individual organisms to populations or communities. For the higher trophic level terrestrial species, the ERA made conclusions about the potential for adverse effects to individual organisms. Very few models are available to extrapolate the potential for adverse effects from the individual level to the population or community level. Because of the limited availability of such models, certain assumptions had to be made about the overall potential for adverse effects to ecological receptors. It was generally assumed if there is no potential for direct adverse effects to individual organisms then it is also unlikely for there to be the potential for direct adverse effects to populations or communities. Similarly, it was assumed that if there is the potential for adverse effects to individual organisms there is also the potential for adverse effects to populations or communities. Risks may have been overestimated by this latter assumption.

In addition, the assessment of risks was based on the comparison of exposure dose to toxicity values from the literature. As discussed earlier, there are many uncertainties associated with those toxicity values, and thus, with the assessment of risks based upon them. Finally, there is uncertainty associated with the lack of, or limited number of, samples within particular data groupings. Because samples collected in the lagoons in SWMU 31 were classified as surface soil rather than sediment, the risks to piscivorous birds, piscivorous mammals, and benthic organisms may be underestimated in this ERA. The number of samples from the New River was very limited and intended to represent locations adjacent to potential source areas. As a result, these samples are probably not representative of the overall river.

1.6 SUMMARY OF SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT

Based on an analysis of the wildlife species likely to occur on RFAAP and the COPCs in the environmental media, the following ecological receptors and routes of exposure were evaluated and risks estimated:

- **Terrestrial plant exposure to chemicals in surface soil.** Available toxicity information suggests that organic COPCs are unlikely to adversely affect terrestrial plants in RFAAP. The maximum detected concentrations of aluminum, barium, chromium, lead, mercury, nickel, silver, vanadium exceeded their TRVs. Several other inorganic COPCs also exceeded their TRVs, though generally to a lesser extent (EEQs of 8.0 of less).

- **Terrestrial invertebrate community (as represented by earthworms) exposure to chemicals in surface soil.** Available toxicity information suggests that organic COPCs are unlikely to adversely affect soil invertebrates within the RFAAP. Chromium, copper, lead, and mercury exceeded their TRVs. A few other inorganic COPCs exceeded their TRVs, but to a lesser extent than for the other inorganic COPCs (EEQs of 3.5 or less).

- **Herbivorous mammal (as represented by meadow vole) exposure to chemicals in terrestrial plants, surface soil, and surface water.** Available toxicity information suggests that organic COPCs are unlikely to adversely affect herbivorous mammals in RFAAP. The calculated doses of aluminum, antimony, barium, chromium, lead, methylmercury, and vanadium exceeded their TRVs. The doses of several other inorganic chemicals also exceeded their TRVs, though generally to a lesser extent (EEQs of 4.0 or less).

- **Vermivorous bird (as represented by robins) and small mammal (as represented by shrews) exposure to chemicals in earthworms, surface soil, and surface water.** Results of the screening model indicates that organic COPCs are unlikely to adversely affect vermivorous birds in RFAAP. Of the inorganic COPCs, the estimated doses of aluminum, barium, chromium, lead, mercury, methylmercury, and zinc exceeded their TRVs. The calculated doses of several other inorganic chemicals also exceeded their TRVs, though generally to a lesser extent than for the other inorganic COPCs (EEQs of 8.2 or less).

  Doses of organic COPCs did not exceed their TRVs for vermivorous mammals in RFAAP. Accordingly, these chemicals are unlikely to adversely affect vermivorous mammals. Of the inorganic COPCs, the estimated doses of aluminum, antimony, barium, chromium, lead, methylmercury, and vanadium exceeded their TRVs. Estimated doses of a number of other inorganic COPCs exceeded their TRVs, though to a lesser extent (EEQs of 7.0 or less).

- **Predatory bird (as represented by red-tailed hawk) and mammal (as represented by red fox) exposure to chemicals in small mammals and surface water.** Available toxicity information suggests that organic COPCs are unlikely to adversely affect predatory birds in RFAAP. The estimated doses of aluminum, barium, chromium, lead, and methylmercury exceeded their TRVs. The estimated doses of mercury, nickel, and zinc also approximated or just exceeded their TRVs (EEQs of less than 4.2).

  Available toxicity information suggests that organic COPCs are unlikely to adversely affect predatory birds in RFAAP. Estimated doses of aluminum, antimony, barium, chromium, lead, methylmercury, and vanadium exceeded their TRVs. The estimated doses of several other inorganic chemicals slightly exceeded their TRVs (EEQs of 6.0 or less).

- **Piscivorous bird (as represented by heron) and small mammal (as represented by mink) exposure to chemicals in aquatic life, sediment, and surface water.** The estimated doses of all organic and inorganic COPCs did not exceed their TRVs for heron in the lagoons (SWMU 31) of RFAAP. Results of the screening model indicates that organic COPCs are unlikely to adversely impact piscivourous birds. However, the data set for these habitats is incomplete and there is uncertainty associated with the conclusion that piscivorous birds are unlikely to be adversely affected in this aquatic habitat. Of the inorganic COPCs, the calculated dose of lead exceeded its TRV in the New River. The estimated doses of chromium and barium exceeded their TRVs to a lesser extent (EEQs of 7.2 or less).

  The estimated doses of all organic and inorganic COPCs did not exceed their TRVs for mink in the lagoons (SWMU 31) of RFAAP. However, the data set for these habitats is incomplete and there is uncertainty associated with the conclusion that piscivorous mammals are unlikely to be adversely affected in this aquatic habitat. Doses of organic COPCs did not exceed their TRVs for piscivorous mammals in the New River. Therefore, these chemicals are unlikely to adversely affect piscivorous mammals in RFAAP. Among the inorganic COPCs, the calculated doses of arsenic, barium, and lead exceeded their TRVs in the New River. The estimated dose of beryllium and chromium slightly exceeded their TRVs (EEQs of 3.5 or less).

- **Aquatic life exposure to chemicals in surface water.** A limited number of organic COPCs were detected in the surface water bodies selected for evaluation at RFAAP. None of these organic COPCs exceeded their TRVs in the surface water bodies of RFAAP and it is unlikely that organic chemicals are adversely affecting aquatic organisms in RFAAP water bodies. Of the inorganic COPCs, the maximum detected concentration of aluminum slightly exceeded its TRV in the surface water of the three lagoons in SWMU 31 (EEQs of 8.5 of less). In addition, lead exceeded its TRV in the New River surface water.

- **Benthic-dwelling aquatic life exposure to chemicals in sediment.** Results of the screening model indicates that organic COPCs are unlikely to adversely impact benthic organisms. Of the inorganic COPCs for the New River sediment, the maximum detected concentration of lead exceeded its TRV. Arsenic and nickel also exceeded their TRVs, but to much lesser extent (EEQs of 1.6 or less).

It should be noted the objective of the screening process conducted in the ERA is to eliminate chemicals that will not adversely affect ecological resources. Exceedance of the screening TRVs, however, does not indicate adverse effects are occurring, but only indicates there is the potential for adverse effects. Section 2.0, Risk Evaluation and Management, provides a detailed evaluation of the ERA results.

SECTION 2

2.0 RISK EVALUATION AND MANAGEMENT

The purpose of this section is to more closely examine and evaluate the results of the screening-level ERA and to determine the need for further investigation in each SWMU or other area of interest within the Main Manufacturing Area of RFAAP. This section considers additional factors that will help in further interpreting the results of the screening assessment and determining the need for additional investigation and/or action.

Consistent with USEPA (1997) guidance, highly conservative assumptions were used in the screening-level ERA to provide an upper bound estimate of risk to ecological resources. Such an approach meets with the objectives of the screening-level assessment, which is to screen out all chemicals that do not have the potential to adversely affect ecological resources. These conservative assumptions are likely to greatly overestimate actual levels of risk to most ecological receptors. The results of this comprehensive data evaluation are intended to help in making risk management decisions about the need for further investigation and/or remediation.

2.1 CONCENTRATIONS OF CHEMICALS AT BACKGROUND LOCATIONS

Chemicals were selected as COPCs in the screening-level ERA based only on the comparison of maximum detected concentrations to conservative literature-based toxicity values (e.g., Region III BTAG Screening Levels). The approach used to derive these toxicity values, however, did not account for the naturally occurring concentrations of these chemicals in the environment. Accordingly, some inorganic chemicals occurring at concentrations above toxicity values may not reflect site-related contamination, but instead, may reflect naturally elevated regional concentrations. If chemicals are present at naturally occurring concentrations, it can be assumed that exposure or toxicity was overestimated in the screening-level model. Inorganic chemicals in soil were evaluated to determine if they are occurring at concentrations above background (Appendix C). Background concentrations in sediment and surface water were unavailable for comparison. Chemicals were not recommended for further evaluation or remediation if they were detected at concentrations approximating background.

2.2 EXPOSURE ASSUMPTIONS

Conservative exposure assumptions were used in the screening-level ERA to ensure risks to ecological receptors were not underestimated at that stage of the investigation. More realistic exposure assumptions were used in this phase to further evaluate the potential for adverse effects to ecological resources.

A mean case exposure scenario was used to evaluate the ecological risks indicated by the maximum case exposure model. Arithmetic mean concentrations were used instead of maximum detected concentrations to estimate exposure to terrestrial wildlife species, based on the assumption that mobile wildlife species are unlikely to be exposed to only the highest concentrations detected on-site. Chemicals were not recommended for further evaluation or remediation if the mean case exposure model did not indicate the potential for adverse effects to terrestrial wildlife.

Maximum detected concentrations also were used in the screening-level ERA to evaluate the potential for adverse effects to terrestrial plants, soil invertebrates, and benthic organisms. Use of the maximum detected concentration is appropriate for these relatively immobile receptors because exceedance of a toxicity value at a single sample location indicates the potential for adverse effects at that location. The overall potential for adverse effects is determined by considering the extent and magnitude of contamination.

2.3 SPATIAL DISTRIBUTION OF CONTAMINANTS

The distribution of a chemical in the environment is evaluated to more accurately characterize the potential for adverse effects to ecological resources. The screening-level ERA did not give detailed consideration to the distribution of on-site contaminants, both in terms of the size of the area impacted by a contaminant and the type/quality of habitat affected. This distribution, however, has direct implications on the potential for chemicals to adversely affect a population or community. For example, a chemical occurring at a high concentration within a localized area may have a more limited potential to adversely affect a population/community than the same chemical occurring at lower concentrations over a larger area, particularly if the habitat in the latter area is of greater value to the ecological receptor of concern. Trends in chemical concentration between samples are plotted for selected chemicals in Appendix D through Appendix F.

2.4 TOXICOLOGICAL DATA

The screening-level ERA used conservative toxicological endpoints when evaluating the potential for adverse effects to ecological resources. Toxicological endpoints were reviewed as part of the risk management process to determine if risks indicated by the screening-level ERA are acceptable. For example, NOAELs were used in the screening-level ERA as TRVs to screen the potential for chemicals to adversely affect terrestrial wildlife. However, the level that is protective to wildlife is expected to fall somewhere between the NOAEL and the LOAEL. Chemicals were not recommended for further evaluation or remediation if the estimated exposure concentrations/doses did not exceed LOAELs. If a LOAEL was not available for a chemical, then it was estimated by adjusting the NOAEL upward by a factor of ten, consistent with the adjustment factor used for most chemicals in Sample et al. (1996) to estimate a NOAEL from a LOAEL.

2.5 HABITAT QUALITY

The screening-level ERA identified ecological receptors for evaluation based on consideration of the general habitat types present at RFAAP. Detailed consideration was not given to the quality of the habitat within a SWMU and the implications of the habitat quality on ecological receptors expected to occur in the area. Further consideration is given in this risk management phase, as needed, to the quality of habitat provided in each area of concern and the implications of that habitat quality on the potential for adverse effects to ecological receptors to determine if risks indicated by the screening-level ERA are acceptable.

2.6 RISK EVALUATION

The following sections briefly summarize the results of the screening-level ERA for the indicator species/exposure pathways selected for evaluation. More detailed consideration is then given, based on the factors discussed above, to evaluate the potential for chemicals to adversely affect ecological receptors and the need for further investigation/evaluation. The accompanying tables (Tables 2–1 through 2–8) present the results discussed here and include chemicals lacking TRVs.

2.6.1 Terrestrial Plants

Maximum detected concentrations of all organic COPCs remained below the terrestrial plant TRVs. Of the inorganic COPCs, the maximum detected concentrations of aluminum, barium, chromium, lead, mercury, nickel, silver, vanadium grossly exceeded their TRVs (EEQs greater than 8.0) suggesting there is the potential for these chemicals to adversely affect terrestrial plants. Several other inorganic COPCs (cadmium, copper, and zinc) also exceeded their TRVs, though generally to a lesser extent (EEQs of 4.3 or less).

It is recommended the following chemicals be eliminated from further consideration based on the reasons described below:

Aluminum.

- The highest aluminum concentrations were detected in samples from the lagoons in SWMU 31, where aluminum concentrations were up to 6 times greater than at other onsite locations. Risks in the lagoon area, however, are likely to have been overstated by the screening-level assessment for the following reasons:
  - — The lagoons do not provide habitat for terrestrial plants and this potential exposure pathway is incomplete for this area.
  - — Aluminum concentrations in the lagoons most likely result from the aluminum sulfate flocculant used at the RFAAP water treatment facility to clarify drinking water. Aluminum flocculant does not provide a highly bioavailable form of aluminum to plants.
- Concentrations at all other onsite sample locations, although above the TRV, were much lower and were less than two times background concentrations.
- Concentrations detected at background locations were above the TRV (EEQs of up to 382) used to screen the potential for adverse effects to terrestrial plants. Efroymson et al. (1997a), the source of this TRV, indicate that terrestrial plant TRVs which are exceeded by background levels may be a poor

measure of risk to the plant community. This is because inorganic chemicals detected in background at concentrations above TRVs are likely to reflect local/regional soil types and the TRV may not accurately represent the local/regional form or bioavailability of aluminum.

Barium, Chromium, and Silver.

- The highest concentrations of these chemicals were detected in one SWMU 17 sample (17ASB105). This sample was taken from the active debris burning pit which does not provide habitat for terrestrial plants.
- Concentrations of barium and silver did not exceed TRVs at any other sample locations, while chromium was detected above its TRV at other locations (EEQs up to 190). However, barium and chromium concentrations are less than five times background at all other onsite sample locations and silver concentrations are less than two times background at all other onsite sample locations.

Nickel. Detected concentrations exceeded the TRV to the greatest extent (EEQs up to 23) in two samples (17ASB105 and RDSX*33). However, the following factors must be considered:

- Sample 17ASB105 was taken from the active debris burning pit and does not provide habitat for terrestrial plants.
- The concentration at sample RSDX*33 in SWMU 71 is 12 times greater than any other sample location in SWMU 71, indicating nickel has a very limited distribution onsite.
- Nickel in soil is strongly bound to iron or manganese and is unavailable for uptake by plants (ATSDR 1990).

Vanadium.

- The maximum detected concentration exceeded the TRV (EEQ of 45). However, vanadium does not appear to be a site-related chemical for the following reasons:
  - It was detected at similar concentrations throughout RFAAP.
  - There is no clear spatial pattern in the vanadium concentration that could suggest a source area (see Appendix D).
  - The maximum detected onsite concentration was only slightly greater (1.5 times greater) than the maximum background concentration (Appendix C)
- Concentrations detected at background locations were above the TRV (EEQ of up to 30) (as discussed above for aluminum), indicating the screening-level TRV may not be representative of the form or bioavailability of vanadium at RFAAP.

Several other inorganic chemicals (cadmium, copper, and zinc) were detected at concentrations exceeding their TRVs, though at lower concentrations relative to their TRVs (EEQs of 4.3 or less). The occurrences were in isolated samples or in samples where concentrations approximated background. It is recommended that no further consideration be given to these chemicals.

Chemicals with the potential to adversely affect terrestrial plants that may warrant further consideration include the following:

Lead.

- Concentrations exceeded the terrestrial plant TRV at many locations in SWMU 17 (EEQs up to 82), SWMU 39 (EEQs up to 141), and the Former Lead Furnace Area (EEQs up to 6). The Former Lead Furnace Area does not warrant further consideration because the soil with elevated lead levels has already been removed.
- Onsite concentrations were up to 28 times greater than background.

Mercury. Concentrations exceeded the terrestrial plant TRV (EEQ of 57) in one sample (RDSX*39) from the flash burn parts area of SWMU 71. This area may represent a localized mercury "hot spot" because this concentration was 57 times greater than at any other onsite location and samples in close proximity (approximately 15 ft) did not have elevated mercury concentrations (less than 0.3 mg/kg). This location represents a potential source area and may warrant further consideration.

2.6.2 Terrestrial Invertebrates

The maximum detected concentrations of all organic COPCs remained below the available earthworm TRVs and it is reasonable to conclude these chemicals are not adversely affecting soil invertebrates. Of the inorganic COPCs, maximum detected concentrations exceeded available earthworm TRVs for chromium (EEQ of 4,000) and mercury (EEQ of 170). Lead (EEQ of 14), copper (EEQ of 6.7), nickel (EEQ of 3.5), and zinc (EEQ of 2.1) also exceeded their TRVs.

Chromium, copper, lead, and mercury were detected at the highest concentrations relative to their TRVs, indicating the potential for adverse effects to soil invertebrates. It is recommended that chromium be eliminated from further consideration based on the following reasons:

Chromium.

- The highest concentration was detected in a sample from SWMU 17 (17ASB105), where the chromium concentration was 8 times greater than at other onsite locations. This sample, however, was taken from an active debris burning pit which does not provide habitat for soil invertebrates.
- Concentrations at other locations, although above TRVs (EEQs up to 500), were less than five times background concentrations.
- Concentrations detected at background locations were above the soil invertebrate TRV (EEQs of up to 100). Efroymson et al. (1997b), the source of this TRV, indicate that soil invertebrate TRVs which are exceeded by background levels may be a poor measure of risk to the soil invertebrate community. This is because inorganic chemicals detected in background at concentrations above TRVs are likely to reflect local/regional soil types and the TRV may not accurately represent the local/regional form or bioavailability of chromium.

Although nickel and zinc were detected at concentrations above their TRVs, the maximum detected concentrations of all these chemicals only slightly exceeded their TRVs (EEQs of less than 3.5), and it is recommended that no further consideration be given to these chemicals.

Chemicals with the potential to adversely affect soil invertebrates that may warrant further consideration include the following:

Copper.

- Concentrations exceeded the TRV (EEQs up to 6.7) at isolated locations in SWMU 39 (sample 39SB1A) and 71 (samples RDSX*33 and RDSX*39). Both of these areas provide viable habitats for soil invertebrates.
- Concentrations were up to 14 times greater than background.

Lead.

- Concentrations exceeded the TRV (EEQs up to 14) at isolated sample locations within SWMU 17 (17ASS3) and SWMU 39 (39SB1A). Both of these areas provide viable habitat for soil invertebrates. Concentrations of lead in these locations were up to 10 times greater than detected in nearby sample locations.
- The detected concentration in a sample from SWMU 17 (17ASB105) also exceeded the earthworm TRV (EEQ of 8). This sample, however, was taken from the active debris burning pit in SWMU 17 which does not provide habitat for soil invertebrates. Accordingly, lead at this location does not warrant further consideration.
- Concentrations were up to 28 times greater than background in areas providing viable habitat for earthworms.

Mercury.

- The highest concentration was detected in a sample (RDSX*39) collected from the flash burn parts area of SWMU 71 and there is the potential for adverse effects to soil invertebrates at this area. This area may represent a localized "hot spot" because this concentration was 57 times greater than detected at any other onsite location and samples in close proximity (approximately 15 ft) did not have elevated mercury concentrations (less than 0.3 mg/kg). This location represents a potential chemical source area and warrants further consideration.
- Concentrations slightly exceeded the earthworm TRV (EEQs less than 3) at several other sample locations in SWMU 17 and SWMU 71. Based on the slight exceedance of the TRVs, the recommended risk management decision is no further evaluation in these areas.

2.6.3 Terrestrial Wildlife

The potential for a variety of different terrestrial wildlife to be adversely affected by the consumption of chemicals in food items and through the inadvertent ingestion of abiotic media (e.g., soil, sediment) was evaluated in the screening-level ERA.

Risk estimates for each terrestrial wildlife species were recalculated under a more realistic exposure model to further evaluate the potential for adverse effect to terrestrial wildlife. A mean exposure concentration was used instead of a maximum detected concentration to estimate exposure to chemicals in food and abiotic media. Use of the mean concentration is considered a more realistic indicator of potential exposure than the maximum concentration because of the mobility of terrestrial wildlife.

In addition to the recalculation of the exposure scenario, the level of toxicity value exceedance was considered in detail when further evaluating the potential for adverse effects to terrestrial wildlife. NOAELs were used in the screening-level assessment as TRVs for evaluating the potential for adverse effects to terrestrial wildlife, while doses falling between NOAELs and LOAELs are likely to be adequate for the protection of wildlife. Accordingly, chemicals exceeding the NOAELs but not the LOAELs were not recommended for further evaluation based on a risk management decision.

Herbivorous Mammals: Meadow Vole Ingestion of Terrestrial Plants, Surface Soil, and Surface Water. For the maximum exposure scenario, EEQs were greater than one for aluminum, antimony, barium, beryllium, cadmium, chromium, copper, lead, manganese, mercury, methylmercury, nickel, and vanadium (EEQs ranging from 1.1 for beryllium to 19,266 for aluminum). For the mean case scenario, EEQs remained above one for aluminum, antimony, barium, chromium, copper, lead, manganese, methylmercury, and vanadium (EEQs ranging from 1.1 for copper to 7,444 for aluminum) (Table 2–1). It is recommended the following chemicals be eliminated from consideration based on the reasons described below:

Aluminum.

- The estimated dose for the mean case scenario greatly exceeded the TRV (EEQ of 744 when compared to the LOAEL). This exceedance was primarily due to elevated soil concentrations in samples from the SWMU 31 lagoons, where aluminum concentrations were up to 6 times greater than at other onsite locations. These lagoons, however, are unlikely to support plant life and this exposure pathway is incomplete for voles.
- Concentrations in soil outside the lagoon area approximated or only slightly exceeded background.

Antimony, Barium, and Chromium. The EEQs remained slightly above one (EEQs up to 3.0) when the estimated doses for the mean case scenario were compared to LOAELs. However, elevated concentrations (9 to 40 times background) were detected in only one sample (17ASB105) taken from the bottom of an active burn pit. This area does not support plant life and the exposure pathway is incomplete for voles in this area.

Copper and Manganese. EEQs fell below one when estimated doses in the mean case scenario were compared to LOAELs.

Table 2–1
Comparison of Estimated Total Ingested Dose to Meadow Vole TRVs for COPCs
Mean Case Scenario

Chemical	Dose (mg/kg bw-d)				Vole TRV[A] (mg/kg bw-d)	Ratio of Estimated Total Dose to TRVs[B]
	Prey	Surface Soil	Surface Water	Total		
PAHs:						
Acenaphthene	0.0540	0.00130	0	0.0553	0.91	<0.1
Benz[*a*]anthracene	0.0330	0.000792	0	0.0338	0.91	<0.1
Benzo[*b*]fluoranthene	0.0735	0.00176	0	0.0753	0.91	<0.1
Benzo[*g,h,i*]perylene	0.0480	0.00115	0	0.0492	0.91	<0.1
Benzo[*k*]fluoranthene	0.0254	0.000609	0	0.0260	0.91	<0.1
Chrysene	0.0342	0.000821	0	0.0350	0.91	<0.1
Fluoranthene	0.0351	0.000842	0	0.0359	0.91	<0.1
Naphthalene	0.0684	0.00164	0	0.0700	0.91	<0.1
Phenanthrene	0.0570	0.00137	0	0.0584	0.91	<0.1
Pyrene	0.0561	0.00135	0	0.0574	0.91	<0.1
Other Semivolatile Organics:						
Di-*n*-butylphthalate	0.293	0.00704	0.000130	0.301	500	<0.1
Diethylphthalate	0.250	0.00599	0.00056	0.256	4165	<0.1
Bis(2-ethylhexyl)phthalate	0.801	0.0192	0	0.820	16.6	<0.1
Inorganics:						
Aluminum	12,750	306	0.0702	13,056	1.754	**7,444**
Antimony	2.60	0.0624	0	2.66	0.114	**23.4**
Barium	96.0	2.30	0.00261	98.3	9	**11**
Beryllium	0.468	0.0112	0	0.479	1.11	0.4
Cadmium	0.393	0.00943	0	0.402	1.62	0.2
Calcium	2,400	57.6	1.37	2,459	NA	---
Chromium	36.0	0.864	0	36.9	5.51	**6.7**
Copper	27.1	0.649	0	27.7	25.5	**1.1**
Iron	9,000	216	0	9,216	NA	---
Lead	192	4.61	0.00153	197	13.44	**15**
Magnesium	2,604	62.5	0.523	2,667	NA	---
Manganese	175	4.20	0.00274	179	148	**1.2**
Mercury	0.282	0.00677	0	0.289	2.18	0.1
Methylmercury	0.282	0.00677	0	0.289	0.054	**5.3**
Nickel	20.4	0.490	0.000533	20.9	67.18	0.3
Potassium	546	13.1	0.151	559	NA	---
Silver	0.585	0.0140	0	0.599	23.7	<0.1
Sodium	150	3.60	1.03	155	NA	---
Vanadium	18.9	0.453	0	19.3	0.327	**59**
Zinc	32.1	0.770	0.000494	32.9	268.7	0.1

[A]TRV information is presented in Table 1–13.
[B]Ratios greater than one are indicated in boldface type.
NA = TRV not available.
— = Ratio of the estimated total dose to the TRV could not be calculated.

Lead. The estimated dose slightly exceeded the vole TRV (EEQ of 1.5 when compared to the LOAEL), with risk being driven primarily by elevated concentrations in samples from SWMU 17 (17ASB105, 17ASS3) and SWMU 39 (39SB1A). However, the screening assessment conservatively assumed a soil-to-plant uptake of one for lead. When a more realistic soil-to-plant uptake factor for lead (0.027, dry weight, presented in Baes et al., 1984) is considered, the mean lead concentration in plants becomes 5.2 mg/kg wet weight (assuming 70% water content from USEPA 1993). When the dose from ingestion of plants is recalculated and incorporated into the total dose to voles, the EEQ falls below one (0.05) when compared to the LOAEL.

Methylmercury.

- The EEQ remained only slightly above one (EEQ of 1.1) when the estimated dose for the mean case scenario was compared to the LOAEL.
- Assuming mercury is entirely in its methylated form in the screening-level assessment is highly conservative because methylmercury is the most toxic form of mercury in the environment (Eisler 1987b). If, for example, risks to voles are recalculated for the mean exposure scenario assuming just 7% of the mercury is present in soil as inorganic mercury the EEQ drops below one when compared to the LOAEL. Information presented by Hempel et. al. (1995) suggests that most mercury in surface soil is present in its inorganic form. It is reasonable to conclude that at least 7% of mercury is present as inorganic mercury at RFAAP and that adverse effects to herbivorous mammals from methylmercury exposure are unlikely.

Vanadium. The EEQ remained above one (EEQ of 5.9) when the dose for the mean case scenario was compared to the LOAEL. However, the following factors must be considered:

- The maximum detected concentration onsite was only 1.5 times the maximum background concentration (Appendix C).
- There is no spatial pattern in concentration (Appendix D), suggesting vanadium is not a localized contaminant.

Vermivorous Birds: Robin Ingestion of Earthworms, Surface Soil, and Surface Water. For the maximum exposure scenario, EEQs were greater than one for di-n-butylphthalate, bis(2-ethylhexyl)phthalate, and 12 inorganic COPCs (aluminum, barium, cadmium, chromium, copper, lead, manganese, mercury, methylmercury, nickel, vanadium, zinc). For the mean exposure scenario, EEQs remained above one for di-n-butylphthalate, diethylphthalate, bis(2-ethylhexyl)phthalate, aluminum, barium, chromium, copper, lead, mercury, methylmercury, vanadium, and zinc (Table 2–2). It is recommended the following chemicals be eliminated from further consideration based on the reasons described:

Bis(2-ethylhexyl)phthalate, Diethylphthalate, and Di-n-butylphthalate. EEQs fell below one when estimated doses for the mean case scenario were compared to LOAELs.

Aluminum.

- The estimated dose for the mean case scenario exceeded the TRV (EEQ of 35 when compared to the LOAEL). This exceedance was primarily due to elevated aluminum concentrations in soil samples from the SWMU 31 lagoons, where aluminum concentrations were up to 6 times greater than at other onsite locations. These lagoons, however, are unlikely to support soil invertebrates and this pathway is incomplete for robins in this area.
- Soil concentrations outside the lagoon area approximated or only slightly exceeded background.

Barium and Chromium. EEQs remained above one (EEQs of 7.0 and 21.8, respectively) when estimated doses for the mean case scenario were compared to LOAELs. However, these COPCs were detected at elevated concentrations (8 times greater than concentrations detected in all other soil samples) in one sample (17ASB105). This sample was collected from the bottom of an active burn pit that does not provide a habitat for soil invertebrates.

Table 2–2
Comparison of Estimated Total Ingested Dose to American Robin TRVs for COPCs
Mean Case Scenario

Chemical	Dose (mg/kg bw-d)				Robin TRV[A] (mg/kg bw-d)	Ratio of Estimated Total Dose to TRVs[B]
	Earthworm	Surface Soil	Surface Water	Total		
PAHs:						
Acenaphthene	0.160	0.00304	0	0.163	3.37	<0.1
Benz[*a*]anthracene	0.0979	0.00186	0	0.0998	3.37	<0.1
Benzo[*b*]fluoranthene	0.218	0.00414	0	0.222	3.37	<0.1
Benzo[*g,h,i*]perylene	0.142	0.00271	0	0.145	3.37	<0.1
Benzo[*k*]fluoranthene	0.0753	0.00143	0	0.0767	3.37	<0.1
Chrysene	0.101	0.00193	0	0.103	3.37	<0.1
Fluoranthene	0.104	0.00198	0	0.106	3.37	<0.1
Naphthalene	0.203	0.00386	0	0.207	3.37	<0.1
Phenanthrene	0.169	0.00321	0	0.172	3.77	<0.1
Pyrene	0.166	0.00316	0	0.170	3.37	<0.1
Other Semivolatile Organics:						
Di-n-butylphthalate	0.870	0.0165	0.000140	0.887	0.11	**8.1**
Diethylphthalate	0.740	0.0141	0.000602	0.755	0.11	**6.9**
Bis(2-ethylhexyl)phthalate	2.38	0.0451	0	2.42	1.1	**2.2**
Inorganics:						
Aluminum	37,825	719	0.0756	38,544	109.7	**351**
Antimony	7.72	0.147	0	7.86	NA	---
Barium	285	5.41	0.00281	290	20.8	**14**
Beryllium	1.39	0.0264	0	1.41	NA	---
Cadmium	1.17	0.0222	0	1.19	1.45	0.8
Calcium	7,120	135	1.47	7,257	NA	---
Chromium	107	2.03	0	109	1	**109**
Copper	80.3	1.53	0	81.8	47	**1.7**
Iron	26,700	507	0	27,207	NA	---
Lead	570	10.8	0.00165	580	3.85	**151**
Magnesium	7,725	147	0.563	7,873	NA	---
Manganese	519	9.86	0.00295	529	997	0.5
Mercury	0.837	0.0159	0	0.852	0.45	**1.9**
Methylmercury	0.837	0.0159	0	0.852	0.006	**142**
Nickel	60.5	1.15	0.000574	61.7	77.4	0.8
Potassium	1,620	30.8	0.162	1,651	NA	---
Silver	1.74	0.0330	0	1.77	NA	---
Sodium	445	8.46	1.11	455	NA	---
Vanadium	56.0	1.06	0	57.0	11.4	**5.0**
Zinc	95.2	1.81	0.000532	97.0	14.5	**6.7**

[A]TRV information is presented in Table 1–15.
[B]Ratios greater than one are indicated in boldface type.
NA = TRV not available.
— = Ratio of the estimated total dose to the TRV could not be calculated.

Copper. The dose for the mean case scenario only slightly exceeded the LOAEL (EEQ of 1.3) primarily due to elevated concentrations in three soil samples in SWMU 71 (samples RDSX*33 and RDSX*39) and SWMU 39 (sample 39SB1A). However, the following factors must be considered:

- Copper found in soil is generally strongly bound to dust or soil (ATSDR 1990).
- Copper does not readily bioaccumulate in the terrestrial food web and the assumption of an accumulation factor of one in the screening-level ERA likely overestimated the exposure concentrations. For example, using an soil-to-earthworm accumulation factor of 0.52 (wet weight, from Beyer and Stafford 1993) to recalculate the dose to robins from ingestion of earthworms results in an EEQ of 0.7 when compared to the LOAEL.

Mercury. The EEQ fell below one when estimated dose for the mean case scenario was compared to the LOAEL.

Vanadium and Zinc. The EEQ fell below one when estimated doses for the mean case scenario were compared to LOAELs.

Chemicals that may warrant further evaluation based on their potential to adversely affect vermivorous birds include the following:

Lead.

- The estimated dose in the mean case scenario exceeded the TRV (EEQ of 15 when compared to the LOAEL) primarily due to elevated soil concentrations in several locations in SWMU 17 and SWMU 39.
- Detected soil concentrations were up to 28 times greater than maximum detected background concentrations.
- When a more realistic soil-to-earthworm bioaccumulation factor for lead (0.45, wet weight, presented in Beyer and Stafford 1993) is considered, the mean lead concentration in earthworms becomes 288 mg/kg wet weight. When the dose from ingestion of worms is recalculated and incorporated into the total dose to robins, the LOAEL is still exceeded (EEQ of 6.9).

Methylmercury.

- The estimated dose for the mean case scenario exceeded the TRV (EEQ of 13.3 when compared to the LOAEL).
- The detected soil concentration greatly exceeded background (340 times) in a sample (RDSX*39) within SWMU 71. This area is a viable foraging area for robins and could act as a source of mercury to other areas.

Vermivorous Small Mammals: Shrew Ingestion of Earthworms, Surface Soil, and Surface Water. For the maximum exposure scenario, EEQs were greater than one for aluminum, antimony, barium, beryllium, cadmium, chromium, copper, lead, manganese, mercury, methylmercury, nickel, and vanadium (EEQs ranging from 1.9 for beryllium to 33,580 for aluminum). For the mean exposure scenario, EEQs remained above one for aluminum, antimony, barium, chromium, copper, lead, manganese, methylmercury, and vanadium (Table 2–3). However, it is recommended the following chemicals be eliminated from further evaluation for the reasons described below:

Aluminum.

- The estimated dose for the mean case scenario exceeded the TRV (EEQ of 1,297 when compared to the LOAEL). This exceedance was primarily due to elevated soil concentrations in samples from the SWMU 31 lagoons, where aluminum concentrations were up to 6 times greater than at other onsite locations. These lagoons, however, are unlikely to support soil invertebrates and this pathway is incomplete for shrews in this area.
- Soil concentrations outside the lagoon area approximated or only slightly exceeded background.

Antimony, Barium, and Chromium. The estimated doses in the mean case scenario exceeded TRVs (EEQs up to 4.1 when compared to the LOAEL). However, the following factors must be considered:

Table 2–3
Comparison of Estimated Total Ingested Dose to Short-tailed Shrew TRVs for COPCs
Mean Case Scenario

Chemical	Dose (mg/kg bw-d)				Shrew TRV[A] (mg/kg bw-d)	Ratio of Estimated Total Dose to TRVs[B]
	Earthworm	Surface Soil	Surface Water	Total		
PAHs:						
Acenaphthene	0.112	0.0145	0	0.126	1.19	0.1
Benz[*a*]anthracene	0.0682	0.00887	0	0.0771	1.19	<0.1
Benzo[*b*]fluoranthene	0.152	0.0197	0	0.172	1.19	0.1
Benzo[*g,h,i*]perylene	0.0992	0.0129	0	0.112	1.19	<0.1
Benzo[*k*]fluoranthene	0.0525	0.00682	0	0.0593	1.19	<0.1
Chrysene	0.0707	0.00919	0	0.0799	1.19	<0.1
Fluoranthene	0.0725	0.00943	0	0.0820	1.19	<0.1
Naphthalene	0.141	0.0184	0	0.160	1.19	0.1
Phenanthrene	0.118	0.0153	0	0.133	1.19	0.1
Pyrene	0.116	0.0151	0	0.131	1.19	0.1
Other Semivolatile Organics:						
Di-n-butylphthalate	0.606	0.0788	0.000223	0.685	654	<0.1
Diethylphthalate	0.516	0.0671	0.00096	0.584	5450	<0.1
Bis(2-ethylhexyl)phthalate	1.66	0.215	0	1.87	21.8	<0.1
Inorganics:						
Aluminum	26,350	3,426	0.120	29,776	2.295	**12,974**
Antimony	5.38	0.699	0	6.07	0.149	**41**
Barium	198	25.8	0.00448	224	11.8	**19**
Beryllium	0.967	0.126	0	1.09	1.45	0.8
Cadmium	0.812	0.106	0	0.918	2.12	0.4
Calcium	4,960	645	2.34	5,607	NA	—
Chromium	74.4	9.67	0	84.1	7.21	**12**
Copper	55.9	7.27	0	63.2	33.4	**1.9**
Iron	18,600	2,418	0	21,018	NA	—
Lead	397	51.6	0.00263	448	17.58	**26**
Magnesium	5,382	700	0.896	6,082	NA	—
Manganese	361	47.0	0.00471	408	193	**2.1**
Mercury	0.583	0.0758	0	0.659	2.86	0.2
Methylmercury	0.583	0.0758	0	0.659	0.07	**9.4**
Nickel	42.2	5.48	0.000914	47.6	87.91	0.5
Potassium	1,128	147	0.259	1,275	NA	—
Silver	1.21	0.157	0	1.37	24.4	<0.1
Sodium	310	40.3	1.77	352	NA	—
Vanadium	39.0	5.07	0	44.1	0.428	**103**
Zinc	66.3	8.62	0.000847	75.0	351.7	0.2

[A]TRV information is presented in Table 1–13.
[B]Ratios greater than one are indicated in boldface type.
NA = TRV not available.
— = Ratio of the estimated total dose to the TRV could not be calculated.

- Risks were primarily driven by soil concentrations in one SWMU 17 sample (17ASB105), in which detected concentrations were 6 to 8 times greater than concentrations in all other samples. This sample was collected from the bottom of an active burning pit that does not provide habitat for soil invertebrates.
- Detected concentrations were substantially above background (9 to 40 times) in only one sample location (17ASB105).

Copper. The dose for the mean case scenario slightly exceeded the shrew LOAEL (EEQ of 1.4) due primarily to elevated concentrations in three soil samples in SWMU 71 (samples RDSX*33 and RDSX*39) and SWMU 39 (sample 39SB1A). However, the following factors must be considered:

- Copper found in soil at hazardous waste sites is generally strongly bound to dust or soil (ATSDR 1990).
- Copper does not readily bioaccumulate in the terrestrial food web and the assumption of an accumulation factor of one in the screening-level ERA likely overestimated the exposure concentrations. For example, using an soil-to-earthworm accumulation factor of 0.52 (wet weight, from Beyer and Stafford 1993) to recalculate the dose to shrews from ingestion of earthworms results in an EEQ of 0.8 when compare to the LOAEL.

Lead. The estimated dose in the mean case scenario slightly exceeded the TRV (EEQ of 2.6) due to elevated soil concentrations in locations in SWMU 17 and SWMU 39. However, when a more realistic soil-to-earthworm bioaccumulation factor for lead (0.45, wet weight, presented in Beyer and Stafford 1993) is considered, the mean lead concentration in earthworms becomes 288 mg/kg wet weight. When the dose from ingestion of worms is recalculated and incorporated into the total dose to shrews, the LOAEL is only slightly exceeded (EEQ of 1.3).

Manganese. The EEQ fell below one when the estimated dose for the mean case scenario was compared to the LOAEL.

Vanadium. The estimated dose for the mean case scenario exceeded the LOAEL (EEQ of 10.3). However, the following factors must be considered:

- The maximum concentration detected onsite was only slightly elevated (1.5 times) above the maximum detected background concentration.
- There was no spatial trend in concentrations throughout RFAAP suggesting it is not a site-specific contaminant.

Methylmercury. Methylmercury may warrant further evaluation based on its potential to adversely affect vermivorous mammals for the following reasons:

- The estimated dose for the mean case scenario remained above the shrew TRV (EEQ of 1.9 when compared to the LOAEL).
- The detected concentration was elevated substantially above background (340 times background) in one sample (RDSX*39) within SWMU 71. This area provides viable habitat and foraging area for shrews and could act as a source of mercury to other areas.

Predatory Birds: Red-Tailed Hawk Ingestion of Terrestrial Prey and Surface Water. For the maximum exposure scenario, EEQs approximated or exceeded one for aluminum, barium, chromium, lead, mercury, methylmercury, nickel, and zinc (EEQs ranging from 1.0 for nickel to 312 for methylmercury). For the mean exposure scenario, EEQs approximated or exceeded one for di-n-butylphthalate, aluminum, barium, chromium, lead, and methylmercury (Table 2–4). However, it is recommended the following chemicals be eliminated from further evaluation:

Di-n-butylphthalate. The EEQ fell below one when the estimated dose for the mean case scenario was compared to the LOAEL.

Table 2–4
Comparison of Estimated Total Ingested Dose to Red-tailed Hawk TRVs for COPCs
Mean Case Scenario

Chemical	Dose (mg/kg bw-d)				Hawk TRV[A] (mg/kg bw-d)	Ratio of Estimated Total Dose to TRVs[B]
	Prey	Surface Soil	Surface Water	Total		
PAHs:						
Acenaphthene	0.0198	0	0	0.0198	3.37	<0.1
Benz[*a*]anthracene	0.0121	0	0	0.0121	3.37	<0.1
Benzo[*b*]fluoranthene	0.0270	0	0	0.0270	3.37	<0.1
Benzo[*g,h,i*]perylene	0.0176	0	0	0.0176	3.37	<0.1
Benzo[*k*]fluoranthene	0.00931	0	0	0.00931	3.37	<0.1
Chrysene	0.0125	0	0	0.0125	3.37	<0.1
Fluoranthene	0.0129	0	0	0.0129	3.37	<0.1
Naphthalene	0.0251	0	0	0.0251	3.37	<0.1
Phenanthrene	0.0209	0	0	0.0209	3.77	<0.1
Pyrene	0.0206	0	0	0.0206	3.37	<0.1
Other Semivolatile Organics:						
Di-n-butylphthalate	0.108	0	0.00006	0.108	0.11	1.0
Diethylphthalate	0.0915	0	0.000245	0.0918	0.11	0.8
Bis(2-ethylhexyl)phthalate	0.294	0	0	0.294	1.1	0.3
Inorganics:						
Aluminum	4,675	0	0.0308	4,675	109.7	**43**
Antimony	0.954	0	0	0.954	NA	—
Barium	35.2	0	0.00115	35.2	20.8	**1.7**
Beryllium	0.172	0	0	0.172	NA	—
Cadmium	0.144	0	0	0.144	1.45	<0.1
Calcium	880	0	0.599	881	NA	—
Chromium	13.2	0	0	13.2	1	**13**
Copper	9.92	0	0	9.92	47	0.2
Iron	3,300	0	0	3,300	NA	—
Lead	70.4	0	0.000673	70.4	3.85	**18**
Magnesium	955	0	0.229	955	NA	—
Manganese	64.1	0	0.00120	64.1	997	<0.1
Mercury	0.103	0	0	0.103	0.45	0.2
Methylmercury	0.103	0	0	0.103	0.006	**17**
Nickel	7.48	0	0.000234	7.48	77.4	<0.1
Potassium	200	0	0.0661	200	NA	—
Silver	0.215	0	0	0.215	NA	—
Sodium	55.0	0	0.453	55.5	NA	—
Vanadium	6.92	0	0	6.92	11.4	0.6
Zinc	11.8	0	0.000217	11.8	14.5	0.8

[A]TRV information is presented in Table 1–15.
[B]Ratios greater than one are indicated in boldface type.
NA = TRV not available.
— = Ratio of the estimated total dose to the TRV could not be calculated.

Aluminum.

- The estimated dose for the mean case scenario exceeded the TRV (EEQ of 4.3 when compared to the LOAEL). This exceedance was primarily due to elevated soil concentrations in samples from the SWMU 31 lagoons, where aluminum concentrations were up to 6 times greater than at other onsite locations. These lagoons, however, are unlikely to support small mammals and this pathway is incomplete for hawks in this area.
- Concentrations in soil outside the lagoon area approximated or only slightly exceeded background.

Barium. The EEQ fell below one when estimated dose for the mean case scenario was compared to the LOAEL.

Chromium. The dose for the mean case scenario slightly exceeded the TRV (EEQ of 2.6 when compared to the LOAEL). However, this exceedance was primarily due to the elevated soil concentration in one sample (17ASB105), which was 8 times greater than concentrations in any other soil samples. This sample was collected from the bottom of an active debris burning pit that does not provide a habitat for small mammals.

Lead.

- The estimated dose in the mean case scenario slightly exceeded the TRV (EEQ of 1.8 when compared to the LOAEL) with risk being primarily driven by elevated concentrations in soil in locations in SWMU 17 and SWMU 39.
- Lead does not accumulate in the terrestrial food web and an accumulation factor of one is expected to overestimate risks. Ingestion of food containing biologically incorporated lead (in prey) is, accordingly, considered unlikely to cause adverse effects in predatory species (Eisler 1988).

Methylmercury. Methylmercury may warrant further evaluation as a potential risk to predatory birds for the following reasons:

- The dose for the mean case scenario remained above the TRV (EEQ of 1.6).
- The detected soil concentration was 340 times greater than background in one sample (RDSX*39) within SWMU 71. This area provides viable habitat and foraging area for hawks.

Predatory Mammals: Red Fox Ingestion of Terrestrial Prey, Surface Soil, and Surface Water. For the maximum exposure scenario, EEQs were greater than one for aluminum, antimony, barium, beryllium, cadmium, chromium, copper, lead, manganese, mercury, methylmercury, nickel, and vanadium. For the mean exposure scenario, EEQs remained above one for aluminum, antimony, barium, chromium, copper, lead, manganese, methylmercury, and vanadium (EEQs ranging from 1.6 for copper to 11,101 for aluminum) (Table 2-5). However, it is recommended the following chemicals be eliminated from further consideration for the reasons detailed below:

Aluminum.

- The estimated dose for the mean case scenario exceeded the TRV (EEQ of 1,110 when compared to the LOAEL). This exceedance was primarily due to elevated soil concentrations in samples from the SWMU 31 lagoons, where aluminum concentrations were up to 6 times greater than at other onsite locations. These lagoons, however, are unlikely to support small mammals and this pathway is incomplete for fox in this area.
- Soil concentrations outside the lagoon area approximated or only slightly exceeded background.

Antimony, Barium, Chromium. The estimated doses in the mean case scenario slightly exceeded TRVs (EEQs up to 3.5) when compared to LOAELs. However, the following factors must be considered:

- Risks were primarily driven by soil concentrations in one sample (17ASB105), in which detected concentrations were 6 to 8 times greater than concentrations in all other samples. This sample was collected from the bottom of an active burning pit that does not provide habitat for small mammals.
- Detected concentrations were substantially above background (9 to 40 times) only in sample 17ASB105.

Table 2–5
Comparison of Estimated Total Ingested Dose to Red Fox TRVs for COPCs
Mean Case Scenario

Chemical	Dose (mg/kg bw-d)				Fox TRV[A] (mg/kg bw-d)	Ratio of Estimated Total Dose to TRVs[B]
	Prey	Surface Soil	Surface Water	Total		
PAHs:						
Acenaphthene	0.0252	0.000706	0	0.0259	0.29	<0.1
Benz[*a*]anthracene	0.0154	0.000431	0	0.0158	0.29	<0.1
Benzo[*b*]fluoranthene	0.0343	0.000960	0	0.0353	0.29	0.1
Benzo[g,*h,i*]perylene	0.0224	0.000627	0	0.0230	0.29	<0.1
Benzo[*k*]fluoranthene	0.0118	0.000332	0	0.0122	0.29	<0.1
Chrysene	0.0160	0.000447	0	0.0164	0.29	<0.1
Fluoranthene	0.0164	0.000459	0	0.0168	0.29	<0.1
Naphthalene	0.0319	0.000894	0	0.0328	0.29	0.1
Phenanthrene	0.0266	0.000745	0	0.0273	0.29	<0.1
Pyrene	0.0262	0.000733	0	0.0269	0.29	<0.1
Other Semivolatile Organics:						
Di-n-butylphthalate	0.137	0.00383	0	0.141	157	<0.1
Diethylphthalate	0.116	0.00326	0.000366	0.120	1310	<0.1
Bis(2-ethylhexyl)phthalate	0.374	0.0105	0	0.384	5.2	<0.1
Inorganics:						
Aluminum	5,950	167	0.0459	6,117	0.551	**11,101**
Antimony	1.21	0.0340	0	1.25	0.036	**35**
Barium	44.8	1.25	0.00171	46.1	2.8	**16**
Beryllium	0.218	0.00612	0	0.225	0.35	0.6
Cadmium	0.183	0.00514	0	0.189	0.509	0.4
Calcium	1,120	31.4	0.893	1,152	NA	—
Chromium	16.8	0.470	0	17.3	1.73	**10**
Copper	12.6	0.354	0	13.0	8	**1.6**
Iron	4,200	118	0	4,318	NA	—
Lead	89.6	2.51	0.00100	92.1	4.22	22
Magnesium	1,215	34.0	0.342	1,250	NA	—
Manganese	81.6	2.29	0.00179	83.9	46	**1.8**
Mercury	0.132	0.00368	0	0.135	0.69	0.2
Methylmercury	0.132	0.00368	0	0.135	0.01	**14**
Nickel	9.52	0.267	0.000349	9.79	21.12	0.5
Potassium	255	7.13	0.0986	262	NA	—
Silver	0.273	0.00764	0	0.281	5.87	<0.1
Sodium	70.0	1.96	0.676	72.6	NA	—
Vanadium	8.81	0.247	0	9.05	0.103	**88**
Zinc	15.0	0.419	0.000323	15.4	84.5	0.2

[A]TRV information is presented in Table 1–13.
[B]Ratios greater than one are indicated in boldface type.
NA = TRV not available.
— = Ratio of the estimated total dose to the TRV could not be calculated.

Copper. The estimated dose in the mean case scenario only slightly exceeded the TRV (EEQ of 1.2 when compared to the LOAEL) with risks being primarily driven by elevated concentrations detected in three soil samples in SWMU 71 (samples RDSX*33 and RDSX*39) and SWMU 39 (sample 39SB1A). However, the following factors must be considered:

- Copper found in soil at hazardous waste sites is generally strongly bound to dust or soil (ATSDR 1990).
- Copper does not readily bioaccumulate in the terrestrial food web and the assumption of an accumulation factor of one in the screening-level ERA likely overestimated the exposure concentrations.

Lead.

- The estimated dose slightly exceeded the TRV (EEQ of 2.2 when compared to the LOAEL) in the mean case scenario, with risks being primarily driven by elevated soil concentrations detected in locations in SWMU 17 and SWMU 39.
- Lead does not accumulate in the terrestrial food web and the assumption of an accumulation factor of one is expected to overestimate risks. Ingestion of food containing biologically incorporated lead (in prey) is, accordingly, considered unlikely to cause adverse effects in predatory species (Eisler 1988).

Manganese. The EEQ for manganese fell below one when the estimated dose in the mean scenario was compared to the LOAEL.

Vanadium. The estimated dose in the mean case scenario exceeded the TRV (EEQ of 8.8 when compared to the LOAEL). However, the following factors must be considered:

- The maximum concentration detected onsite was only 1.5 times the maximum detected background concentration.
- There was no spatial trend in concentration indicating vanadium is not a localized contaminant.

Methylmercury. Methylmercury may warrant further evaluation based on its potential to adversely affect predatory mammals at RFAAP for the following reasons:

- The estimated dose exceeded the LOAEL (EEQ of 7.9) in the mean case scenario.
- The detected concentration was 340 times greater than the maximum detected background concentration in a sample (RDSX*39) within SWMU 71. This area provides viable habitat and foraging area for red fox.

Piscivorous Birds: Heron Ingestion of Aquatic Life, Sediment, and Surface Water.

Lagoons. For both the maximum and the mean exposure scenarios, EEQs fell below one for all COPCs (Table 1–23 and Table 2–6). However, it should be noted that risks were calculated based only on estimates of chemical ingestion from surface water. Other samples collected in the lagoons were classified as surface soil. As a result, the exposure model assumes there is no chemical exposure for heron from sediments or prey within the lagoons (modeled from sediment). The recommended risk management decision is further evaluation of chemicals for this potential exposure pathway in the lagoons because of the uncertainty in the results of this exposure model.

New River. For the maximum exposure scenario, EEQs were greater than one for di-n-butylphthalate, diethylphthalate, dimethylphthalate, barium, chromium, and lead. EEQs remained above one in the mean exposure scenario (Table 2–6) for all of these chemicals (EEQs ranging from 2.3 for barium to 111 for lead). However, it is recommended the following chemicals be eliminated from further consideration for this exposure pathway in the New River for the reasons detailed below:

Diethylphthalate, Dimethylphthalate, and Di-n-butylphthalate. EEQs fell below one when the estimated dose in the mean case scenario was compared to LOAELs.

Barium.

- The estimated dose in the mean case scenario only slightly exceeded the TRV (EEQ of 1.1 when compared to the LOAEL).

Table 2–6
Comparison of Estimated Total Ingested Dose to Great Blue Heron TRVs for COPCs
Mean Case Scenario

Chemical	Dose (mg/kg bw-d)				Heron TRV[A] (mg/kg bw-d)	Ratio of Estimated Total Dose to TRVs[B]
	Prey	Sediment	Surface Water	Total		
Lagoon						
Other Semivolatile Organics:						
Di-n-butylphthalate	NC	0	0.0000450	0.0000450	0.11	<0.1
Diethylphthalate	NC	0	0.000195	0.000195	0.11	<0.1
Inorganics:						
Aluminum	NC	0	0.0243	0.0243	109.7	<0.1
Calcium	NC	0	0.474	0.474	NA	—
Magnesium	NC	0	0.181	0.181	NA	—
Manganese	NC	0	0.000950	0.000950	997	<0.1
Potassium	NC	0	0.0521	0.0521	NA	—
Sodium	NC	0	0.358	0.358	NA	—
New River						
Explosives:						
2,4,6-Trinitrotoluene	1.38	0	0	1.38	NA	—
Othersemivolatile Organics:						
Bis(2-ethylhexyl)phthalate	0.335	0	0	0.335	1.1	0.3
Di-n-butylphthalate	0.679	0	0	0.679	0.11	**6.2**
Diethylphthalate	0.302	0	0	0.302	0.11	**2.7**
Dimethylphthalate	0.387	0	0	0.387	0.11	**3.5**
n-Nitrosodiphenylamine	0.137	0	0	0.137	NA	—
Inorganics:						
Arsenic	0.821	0	0	0.821	2.5	0.3
Barium	47.0	0	0.00113	47.0	20.8	**2.3**
Beryllium	0.254	0	0	0.254	NA	—
Chromium	6.21	0	0	6.21	1	**6.2**
Lead	429	0	0.000531	429	3.85	**111**
Nickel	3.26	0	0	3.26	77.4	<0.1

[A]TRV information is presented in Table 1–16.
[B]Ratios greater than one are indicated in boldface type.
NA = TRV not available.
NC = Not calculated.
— = Ratio of the estimated total dose to the TRV could not be calculated.

- Barium does not accumulate in fish tissue. Therefore, it is unlikely to adversely affect heron.

Chromium. The dose slightly exceeds the TRV (EEQ of 1.2) in the mean exposure scenario. However, the following factors must be considered:

- Chromium was detected in only two sediment samples (samples NRSE4 and SPG3SE1). Sample SPG3SE1 was taken from a spring near the New River (which is hydrologically connected by groundwater to SWMU 17). Because of its small size, the spring is unlikely to support fish, which are the primary aquatic prey for heron.
- Concentrations detected in New River sediment (maximum concentration of 40 mg/kg) remained below the ER-L value (81 mg/kg), which was established for the protection of benthic organisms. Although the ER-L value was derived for the protection of benthic organisms and not for the protection of piscivorous birds, it can serve as a relative value by which to gauge chemical concentrations in sediment.

Lead. Lead may warrant further evaluation based on its potential to adversely affect piscivorous birds foraging in the New River for the following reasons:

- The estimated dose in the mean case scenario exceeded the TRV (EEQ of 11.1 when compared to the LOAEL).
- Elevated concentrations (up to 3,400 mg/kg) were detected in New River sediments at multiple locations.
- Lead is concentrated by biota from the aquatic environment (Eisler 1988) including fish (Sample et al. 1996), which is the primary prey for heron.

Piscivorous/Aquatic Invertebrate-Eating Small Mammals: Mink Ingestion of Aquatic Life, Sediment, and Surface Water.

Lagoons. For both the maximum and the mean exposure scenarios, EEQs fell below one for all COPCs (Table 1–24 and Table 2–7). However, it should be noted that risks were calculated based only on estimates of chemical ingestion from surface water. Other samples collected in the lagoons were classified as surface soil. As a result, the exposure model assumes there is no chemical exposure for mink from sediments or prey within the lagoons (modeled from sediment). The recommended risk management decision is further evaluation of chemicals for this potential exposure pathway in the lagoons because of the uncertainty in the results of this exposure model.

New River. For the maximum exposure scenario, EEQs were greater than one for arsenic, barium, beryllium, chromium, and lead. EEQs remained above one in the mean exposure scenario (Table 2–7) for arsenic, barium, chromium, and lead (EEQs ranging from 3 for chromium to 85 for lead). However, it is recommended the following chemicals be eliminated from further consideration for this exposure pathway in the New River for the reasons detailed below:

Arsenic. The estimated dose to mink slightly exceeds the mink LOAEL in the mean exposure scenario (EEQ of 1.9). However, the following factors must be considered:

- Arsenic was detected in only two sediment samples (samples NRSE5 and SPG3SE1). Sample SPG3SE1 was taken from a spring near the New River (which is hydrologically connected by groundwater to SWMU 17). Because of its small size, the spring is unlikely to support fish, which is the primary aquatic prey item for mink.
- Concentrations detected in New River sediment (maximum of 5.7 mg/kg) remained below the ER-L value (8.2 mg/kg) and the TEL (5.9 mg/kg), both of which were established for the protection of benthic organisms. Although these latter toxicity values were designed for the protection of benthic organisms and not for the protection of piscivorous/aquatic invertebrate-eating small mammals, they provide a relative value by which to gauge chemical concentrations in sediment.

Table 2–7
Comparison of Estimated Total Ingested Dose to Mink TRVs for COPCs
Mean Case Scenario

Chemical	Dose (mg/kg bw-d)				Mink TRV[A] (mg/kg bw-d)	Ratio of Estimated Total Dose to TRVs[B]
	Prey	Sediment	Surface Water	Total		
Lagoon						
Other Semivolatile Organics:						
Di-n-butylphthalate	NC	0	0.000180	0.000180	229	<0.1
Diethylphthalate	NC	0	0.000779	0.000779	1907	<0.1
Inorganics:						
Aluminum	NC	0	0.0972	0.0972	0.803	0.1
Calcium	NC	0	1.90	1.90	NA	—
Magnesium	NC	0	0.724	0.724	NA	—
Manganese	NC	0	0.00380	0.00380	68	<0.1
Potassium	NC	0	0.208	0.208	NA	—
Sodium	NC	0	1.43	1.43	NA	—
New River						
Explosives:						
2,4,6-Trinitrotoluene	1.69	0	0	1.69	NA	—
Other Semivolatile Organics:						
Bis(2-ethylhexyl)phthalate	0.409	0	0	0.409	7.6	<0.1
Di-n-butylphthalate	0.829	0	0	0.829	229	<0.1
Diethylphthalate	0.370	0	0	0.370	1907	<0.1
Dimethylphthalate	0.473	0	0	0.473	7.6	<0.1
n-Nitrosodiphenylamine	0.168	0	0	0.168	NA	—
Inorganics:						
Arsenic	1.00	0	0	1.00	0.052	**19**
Barium	57.4	0	0.00452	57.4	4.1	**14**
Beryllium	0.310	0	0	0.310	0.51	0.6
Chromium	7.59	0	0	7.59	2.52	**3.0**
Lead	524	0	0.00212	524	6.15	**85**
Nickel	3.98	0	0	3.98	30.77	0.1

[A]TRV information is presented in Table 1–14.
[B]Ratios greater than one are indicated in boldface type.
NA = TRV not available.
NC = Not calculated.
— = Ratio of the estimated total dose to the TRV could not be calculated.

Barium.

- The estimated dose only slightly exceeded the LOAEL in the mean exposure scenario (EEQ of 1.4).
- Barium does not accumulate in fish tissue. Therefore, it is unlikely to adversely affect mink.

Chromium. The EEQ fell below one when the estimated dose for the mean case scenario was compared to the LOAEL.

Lead. Lead may warrant further evaluation based on its potential to adversely affect piscivorous mammals foraging in the New River for the following reasons:

- The estimated dose in the mean case scenario exceeded the TRV (EEQ of 8.5 when compared to the LOAEL).
- It was detected at elevated concentrations (up to 3,400 mg/kg) in New River sediments at multiple locations.
- Lead is concentrated by biota from the aquatic environment (Eisler 1988), including in fish (Sample et al. 1996), which is the primary prey for mink.

2.6.4 Aquatic Organisms

A limited number of organic COPCs were detected in the surface water at RFAAP, none of which exceeded their TRVs in the maximum case scenario. Several inorganic COPCs were detected in the lagoons in SWMU 31. Aluminum (EEQ ranging from 3.4 to 8.5 in Lagoons 1,2,3) was the only COPC exceeding its TRV in the lagoons. In the New River, the maximum detected lead concentration exceeded its TRV (EEQ of 21).

In the mean case scenario (Table 2–8), aluminum in Lagoon 1, 2, and 3 was detected at concentrations exceeding its TRV (EEQs of less than 9). However, the following factors must be considered:

- Water treatment using aluminum sulfate often increases the concentration of aluminum in water (NRC 1977).
- Assuming the water treatment plant is the source of aluminum to the lagoons, this form of aluminum is not highly bioavailable to aquatic organisms and unlikely to affect aquatic organisms (USEPA 1988).
- No surface water reference/background samples were collected. However, aluminum concentrations detected in surface water are consistent with those detected in unimpacted freshwater creeks in the mid-Atlantic region (USAEC 1995).

Lead. Lead may warrant further evaluation based on its potential to adversely affect aquatic life in the New River because of the following:

- In the mean case scenario for the New River, it exceeded the TRV (EEQ of 10).
- Elevated lead concentrations (maximum concentration of 25 μg/l) were detected at several sample locations.
- Lead is bioaccumulated by biota from the aquatic environment (Eisler 1988).

2.6.5 Benthic Organisms

Several organic and inorganic COPCs were detected in the sediment of the New River in RFAAP. The organic COPCs exceeding sediment TRVs in the maximum case scenario were diethylphthalate and bis(2-ethylhexyl)phthalate. The maximum concentrations of arsenic, lead, and nickel also exceeded their respective TRVs in sediments (EEQs ranging from 1.4 for arsenic to 73 for lead).

It is recommended the following chemicals be eliminated from further evaluation for the reasons detailed below:

Bis(2-ethylhexyl)phthalate.

- The EEQ falls to 1.9 when the maximum detected concentration of bis(2-ethylhexyl)phthalate in sediments is compared to the probable effects level from MacDonald et al. (1996).

Table 2–8
Comparison of Mean Detected Surface Water Concentrations to Surface Water TRVs for COPCs at Radford Main Manufacturing Plant

(Concentrations in µg/L)

Chemical	Mean Surface Water Concentration	Surface Water TRV	Environmental Effects Quotient (EEQ)[A] Ratio of Mean Detected Surface Water Concentrations to Surface Water TRVs
Lagoon 1			
Organics:			
di-n-Butylphthalate	1.00	35 [B]	<0.1
Inorganics:			
Aluminum	738	87 [C]	**8.5**
Calcium	11,400	NA	—
Magnesium	4,350	NA	—
Potassium	1,150	NA	—
Sodium	5,700	NA	—
Lagoon 2			
Organics:			
Diethylphthalate	3.00	210 [B]	<0.1
Inorganics:			
Aluminum	297	87 [C]	**3.4**
Calcium	10,500	NA	—
Magnesium	4,040	NA	—
Potassium	1,210	NA	—
Sodium	9,660	NA	—
Lagoon 3			
Organics:			
Diethylphthalate	8.00	210 [B]	<0.1
Inorganics:			
Aluminum	585	87 [C]	**6.7**
Calcium	9,710	NA	—
Magnesium	3,670	NA	—
Manganese	21.1	120 [B]	0.2
Potassium	1,110	NA	—
Sodium	8,480	NA	—
New River			
Inorganics:			
Lead	11.8	1.19 [D]	**10**

[A]Ratios greater than 1 are indicated with boldface type.
[B]Value is Tier II from Suter and Tsao 1996.
[C]Value is from Federal Ambient Water Quality Criteria.
[D]Value is hardness dependent; based on 46.2 mg/L $CaCO_3$.
NA = TRV not available.
— = EEQ could not be calculated.

- Bis(2-ethylhexyl)phthalate was only detected in one sample (sample NRSE4-2) collected from the New River downstream of SWMU 13, and was not detected in another sample collected in the same location on a different date (sample NRSE4).

Diethylphthalate. The maximum detected concentration of this COPC exceeded its TRV (EEQ of 6.9). However, it was only detected in one sample (sample NRSE4-2) collected from the New River downstream of SWMU 13. It was not detected in another sample collected in the same location on a different date (sample NRSE4).

Arsenic.

- The maximum New River sediment concentration only slightly exceeded the TRV (EEQ of 1.4).
- EEQ fell below one when the maximum chemical concentration was compared to the more realistic ER-M value (ER-M of 70 mg/kg for arsenic).

Nickel.

- The maximum sediment concentration only slightly exceeded its TRV (EEQ of 1.6).
- The EEQ fell below one when the chemical concentration was compared to the ER-M value (ER-M of 51.6 mg/kg for nickel).

Lead. Lead may warrant further evaluation as a potential risk to benthic organisms in New River sediment because the concentration remained in exceedance (EEQ of 15.5) even when compared to the effects range-median (ER-M).

SECTION 3

3.0 REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR). 1990-1994. Toxicological Profiles. U.S. Department of Health and Human Services. Public Health Service.

Baes, C.F., R.D. Sharp, A.L. Sjoreen, and R.W. Shor. 1984. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture. Health and Safety Research Division, Oak Ridge National Laboratory. ORNL-5786.

Beyer, W.N., E. Conner, and S. Gerould. 1994. Estimates of Soil Ingestion by Wildlife. J. Wildl. Manage. 58:375-382.

Beyer, W.N. and C. Stafford. 1993. Survey and evaluation of contaminants in earthworms and in soils derived from dredged material at confined disposal facilities in the Great Lakes region. Environ. Monitor. Assess. 24:151-165.

Calder, W.A. and E.J. Braun. 1983. Scaling of osmotic regulation in mammals and birds. Am. J. Physiol. 224:R601-R606.

Craighead, J.J. and F.C. Craighead. 1956. Hawks, owls, and wildlife. Harrisburg, PA: The Stackpole Co. and Washington, DC: Wildl. Manage Inst.

Dowd, E., and L.D. Flake. 1985. Foraging habitats and movements of great blue herons in a prairie river ecosystem, South Dakota. J. Field Ornithol. 56:379-387.

Dunning, J.B. 1984. Body weights of 686 species of North American birds. West. Bird Banding Assoc. Monogr. No. 1., Eldon Publ. Co., Cave Crk, AZ. 38pp.

Efroymson, R.A., M.E. Will, and G.W. Suter II. 1997a. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-85/R3.

Efroymson, R.A., M.E. Will, and G.W. Suter II. 1997b. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-126/R2.

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

Eisler, R. 1987b. Mercury Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. Contaminant Hazard Reviews, Biological Report 85. April 1987.

Eisler, R. 1988. Lead Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. Contaminant Hazard Reviews, Biological Report 14. April 1988.

Elias, M. and D. Trumbo. 1998. Ecological Risk Assessment Report, Radford Army Ammunition Plant. ICF Kaiser Engineers, Inc., Edgewood, MD.

Hempel, M., R. Wiken, R. Miess, J. Hertwich, and K. Beyer. 1995. Mercury Contaminated Sites—Behavior of Mercury and its Species in Lyster Experiments. Water, Air, and Soil Pollution 80:1089–1098.

Jones, D.S., G.W. Suter II, and R.N. Hull. 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 Revision. Prepared for U.S. Department of Energy, Office of Environmental Management. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-95/R4.

Kushlan, J.A. 1978. Feeding ecology of wading birds. In: Sprunt, A., J. Ogden, S. Winckler, eds. Wading Birds. Natl. Audubon Soc. Res. Rep. 7:249-296.

Long, E.R., and L.G. Morgan. 1990. The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program. National Oceanic and Atmospheric Administration (NOM), National Ocean Service, Seattle, Washington.

Long, E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder. 1995. Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments. Environmental Management 19(1):81-97.

MacDonald, D.D., R.S. Carr, F.D. Calder, E.R. Long, and C.G. Ingersoll. 1996. Development and evaluation of sediment quality guidelines for Florida coastal waters. Ecotoxicology 5:253-278.

Mitchell, J.L. 1961. Mink movements and populations on a Montana river. J. Wildl. Manage. 25:48-54.

Nagy, K.A. 1987. Field Metabolic Rate and Food Requirement Scaling in Mammals and Birds. Ecol. Monogr. 57:111-128.

National Research Council (NRC). 1977. Drinking Water and Health. Safe Drinking Water Committee, National Research Council. National Academy of Sciences, Washington, D.C.

Oak Ridge National Laboratory (ORNL). 1996. Screening Benchmarks for Ecological Risk Assessment, Version 1.6. Environmental Sciences and Health Sciences Research Divisions, Oak Ridge National Laboratory, Oak Ridge, TN.

Ontario Ministry of the Environment and Energy (OMEE). 1993. Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. Water Resources Branch, Ontario Ministry of the Environment and Energy.

Parnell, J.F., and R.F. Soots. 1978. The Use of Dredge Islands by Wading Birds. Wading birds. Nat. Audubon Soc. Res. Rep. 7:105-111.

Sample, B.E, Opresko, D.M. and G.W. Suter II. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. ES/ER/TM-86/R3. Risk Assessment Program, Health Sciences Research Division, Oak Ridge National Laboratory, Oak Ridge, TN.

Sample, B.E. and G.W. Suter II. 1994. Estimating Exposure of Terrestrial Wildlife to Contaminants. ES/ERITM-125. Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN.

Schafer, E.W., Jr., Bowles, W.A., Jr., and J. Hurlbut. 1983. The Acute Oral Toxicity, Repellency, and Hazard Potential of 998 Chemicals to One or More Species of Wild and Domestic Birds. Arch. Environm. Contam. Toxicol. 12:355-382.

Suter II, G.W, and C.L. Tsao. 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision. Risk Assessment Program, Health Sciences Research Division, Oak Ridge National Laboratory. ES/ER/TM-96/R2.

Suter II, G.W. 1993. Ecological Risk Assessment. Lewis Publishers, Chelsea, Ml.

U.S. Army Environmental Center. 1995. Reference Sampling and Analysis Program at the U.S. Army Aberdeen Proving Ground, Soil, Sediment, and Surface Water Reference Data Report. Performed by ICF Kaiser Engineers, Abingdon, MD.

U.S. Environmental Protection Agency (USEPA). 1988. Ambient Water Quality Criteria for Aluminum – 1988. Office of Water. Washington, D.C. EPA/440/5-86-008.

U.S. Environmental Protection Agency (USEPA). 1989a. Risk Assessment Guidance for Superfund. Volume 1: Human Health Evaluation Manual. Interim Final. OSWER Directive 9285.7-01a. September 29, 1989.

U.S. Environmental Protection Agency (USEPA). 1989b. Risk Assessment Guidance for Superfund. Volume II: Environmental Evaluation Manual. Interim Final. EPA/540/1-89/001. March 1989.

U.S. Environmental Protection Agency (USEPA). 1992. Framework for Ecological Risk Assessment. Risk Assessment Forum. Washington, D.C. EPA/630/R-92/001.

U.S. Environmental Protection Agency (USEPA). 1993. Wildlife Exposure Factors Handbook. Volume I of II. Office of Research and Development, Washington, D.C., EPA/630/R-93/187a.

U.S. Environmental Protection Agency (USEPA). 1995a. Quality Criteria for Water, 1995. Draft. Health and Ecological Criteria Division, Office of Water. Washington, D.C.

U.S. Environmental Protection Agency, Region III (USEPA). 1995b. Region III BTAG Screening Levels. Draft.

U.S. Environmental Protection Agency, Region III (USEPA). 1995c. Innovative Approaches for Validation of Organic and Inorganic Data – Standard Operating Procedures. June 1995.

U.S. Environmental Protection Agency (USEPA). 1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. Edison, NJ.

Wentsel, R.S., R.T. Checkai, T.W. LaPoint, M. Simini, D. Ludwig, and L. Brewer. 1994. Procedural Guidelines for Ecological Risk Assessments at U.S. Army Sites. Volume 1. Aberdeen Proving Ground, MD. ERDEC-TR-221.

APPENDIX A

Appendix A

Biological Survey

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COMMONWEALTH of VIRGINIA

Biological Survey of the Radford Army Ammunition Plant; including Threatened, Endangered, and Species of Concern

Final Report, May, 1999

By:

Virginia Department of Game and Inland Fisheries
Wildlife Diversity Division
Verona, Va.

For:

Alliant Techsystems, INC.
Radford Army Ammunition Plant
Radford, Va.

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Table of Contents

Introduction

This report is in fulfillment of Contract No. DAAA09-91-Z-001, Purchase Order No. VE-10818 and Purchase Order No. VE-10817. This report presents the results of two years of fieldwork at the Radford Army Ammunition Plant (RAAP). The major objectives of the project included sampling the flora and fauna of each facility, typing and delineation of the major habitat community types at each facility, and providing management recommendations for both community types and threatened, endangered or species of concern.

Endangered, Threatened, and Species of Concern Lists

We defined E&T species as those listed by the federal and state regulatory agencies, the U.S. Fish and Wildlife Service, Virginia Department of Agriculture and Consumer Services (plants and insects), and the Virginia Department of Game and Inland Fisheries (animals excluding insects). Because the federal government does not maintain a legal description or listing of Species of Concern, we used those for the state of Virginia. For animal taxa, we used the Species of Concern list maintained by the Virginia Department of Game and Inland Fisheries. For plant taxa, we used the Rare Vascular Plant List of the Virginia Department of Conservation and Recreation, Natural Heritage Program. Neither Federal nor State governments maintain community lists that provided status of Endangered, Threatened, or Special Concern. While legal status is not presented for community types, several community types are presented that are considered rare or unique by plant ecologists in Virginia.

Description of Rank, Status, and Information Presented for each Community Type

For each major community type, information including species rank and status, community description, rare species and community accounts, management recommendations, taxa lists, and maps for each facility is provided.

Status and Rank Descriptions: Each rare and unique species is identified in a table at the beginning of each community type. The species scientific name, common name, global rank, state rank, federal status, and state status is presented. The scientific name and common name follow current field guides identified in the reference.

Global and state ranks are defined by natural heritage programs and The Nature Conservancy based on the range-wide status of a species or variety. Ranks are defined as follows.

G1 = Extremely rare and critically imperiled with 5 or fewer occurrences or very few remaining individuals; or because of some factor(s) making it especially vulnerable to extinction.

G2 = Very rare and imperiled with 6 to 20 occurrences or few remaining individuals; or because of some factor(s) making it especially vulnerable to extinction.

G3 = Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range; or vulnerable to extinction because of other factors. Usually fewer than 100 occurrences are documented.

G4 = Common and apparently secure globally, though it may be rare in parts of its range, especially at the periphery.

G5 = Very common and demonstrably secure globally, though it may be rare in parts of its range, especially at the periphery.

GH = Formerly part of the world's biota with expectation that it may be rediscovered.

GX = Believed to be extinct throughout its range with virtually no likelihood of rediscovery.

GU = Possibly rare, but status uncertain and more data needed.

G? = Unranked, or, if following ranking, rank uncertain (ex. G3?).

G_Q = the taxon has a questionable taxonomic assignment, such as G3Q.

G_T_ = signifies the rank of a subspecies or variety. For example, a G5T1 would apply to a subspecies of a species that is demonstrably secure globally (G5) but the subspecies warrants a rank of T1, critically imperiled.

S1 = Extremely rare and critically imperiled with 5 or fewer occurrences or very few remaining individuals in Virginia; or because of some factor(s) making it especially vulnerable to extirpation in Virginia.

S2 = Very rare and imperiled with 6 to 20 occurrences or few remaining in Virginia; or because of some factor(s) making it vulnerable to extirpation in Virginia.

S3 = Rare to uncommon in Virginia with between 20 and 100 occurrences; may have fewer occurrences if found to be common or abundant at some of these locations; may be somewhat vulnerable to extirpation in Virginia.

S4 = Common and apparently secure with more than 100 occurrences; may have fewer occurrences with numerous large populations.

S5 = Very common and demonstrably secure in Virginia.

SH = Formerly part of the Virginia biota with expectation that it may be rediscovered.

SX = Believed extirpated from Virginia with virtually no likelihood of rediscovery.

SE = Exotic; not believed to be a native component of Virginia's flora.

SR = Reported for Virginia, but without persuasive documentation which would provide a basis for either accepting of rejecting the report.

SU = Possibly rare, but status uncertain and more data needed.

S_?= Rank uncertain, for example S2? denotes a species or variety which may range from S1 to S3, another example is SE?, meaning a taxon may or may not be native to Virginia.

Federal ranks are those assigned by the U.S. Fish and Wildlife Service under the Endangered Species Act of 1973. Ranks are defined as follows.

FE = Federal Endangered. Those species of plants or animals in danger of extinction throughout all or a significant portion of their ranges.

FT = Federal Threatened. Those species of plants or animals which are likely to become endangered species within the foreseeable future throughout all or a significant portion of its range.

C1 = Category 1. Taxa for which substantial information exists to support the proposal to list the taxon as endangered or threatened.

State ranks for fauna (excluding endangered insects) are those assigned by the Virginia Department of Game and Inland Fisheries under Virginia's Endangered Species Act of 1972, amended in 1977. State ranks for flora and insects are those assigned by the Virginia Department of Agriculture and Consumer Services under Virginia's Endangered Plant and Insect Species Act of 1979. The rank of special concern (SC) does not apply to plants or insects. Ranks are defined as follows.

SE = State Endangered. Any species which is in danger of extinction throughout all or a significant portion of its range, other than a species of the class Insecta deemed to be a pest and whose protection under the provisions of the article (3.1-1021) would present an overriding risk to the health or economic welfare of the Commonwealth.

ST = State Threatened. Any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

SC = Special Concern. Any species which is restricted in distribution, uncommon, ecologically specialized, or threatened by other imminent factors.

Because a category of special concern does not exist for state flora, we used the Virginia Department of Conservation and Recreation, Division of Natural Heritage's Rare Vascular Plant list. The ranks are as follows.

Rare List = Includes all plants believed to be sufficiently rare or threatened to merit an inventory of their status and locations.

Watchlist = Includes plants which are uncommon or of uncertain status in Virginia.

Information Descriptions: A community description identifies the common flora and physical features that define the community type. Rare species and community accounts describe the locations and status of each species or community. Management recommendations are provided for both the community type and any Threatened, Endangered or Species of Concern associated with the community type. Both flora and fauna taxa lists are provided for each community type. Some of the smaller community types (e.g., Calcareous Fen) were not specifically sampled for fauna, but were part of a larger sampling effort. For these community types, fauna lists for the surrounding habitat is referenced. A map of each facility shows the community types delineated along with other physical features (roads, streams, rivers, etc.). Lastly, a combined list of all flora and fauna found at each facility is provided in Appendix B.

Housing of Specimens

As part of the sampling process, representative specimens were collected from several of the taxa. These specimens will be housed in different collections depending on the taxa. Plants are housed at the Massey Herbarium at the Virginia Polytechnic Institute and State University. Reptiles, amphibians, and invertebrates are housed at the Virginia Museum of Natural History in Martinsville and Blacksburg. Mammals are housed at the Virginia Commonwealth University in Richmond.

Sampling Techniques

Sampling effort and techniques varied across taxa. The following is an overview of the sampling techniques used by taxa.

Plants: Plants were sampled by walking each community type and recording all species observed. When rare plants were encountered, detailed surveys were made to determine the number and distribution of the species.

Invertebrates: Invertebrates were sampled using sweep nets, light traps, seine, pitfall traps, and hand collections. Effort was not evenly distributed across the community types. When a rare invertebrate was encountered, additional survey efforts were conducted to determine the number and distribution of the species.

Fish: Fish were sampled using backpack electroshocker, seines, and visual observations. Surveys included the New River within the boundaries of the Arsenal and the tributaries and ponds within the Arsenal boundaries.

Reptiles and Amphibians: Reptiles and amphibians were sampled using time constrained searches, road surveys, pitfall traps, cover traps, seines, and visual observations. Sampling efforts were not uniform across community types.

Birds: Birds were sampled by auditory and visual recognition. Surveys included walking through community types and recording all birds heard or seen within the community type. Sampling efforts were not uniform across community types.

Mammals: Mammals were sampled using pitfall traps, Sherman live traps, snap traps, mist nets, and visual observations. Sampling efforts were not uniform across community types.

Geographic Information System (GIS) and Maps

The location of the rare plants and animals, delineation of community types, sample points and associated species were initially located on enlarged U.S.G.S. topographic maps. These points were then digitized into ArcInfo/ArcView GIS files from which report maps were generated. The ArcView files and associated data are provided in addition to the final report. This GIS layer should provide a useful tool in any planning efforts that require the information collected through this contract.

NATURAL COMMUNITIES

Upland Forest
Limestone Barren
Xeric Calcareous Cliff
Calcareous Fen
Piedmont/Mountain Bottomland Forest
Sand/Gravel/Mud Bar and Shore

Community Type: Upland Forest
(including Dry Calcareous Forest/Woodland, Chestnut Oak, and Mesic Calcareous Forest)

Acreage: Acres (Hectares) Total: 957 (388) Main: 717 (291) New River: 240 (97)

Community Type Location Maps: Figure 1 and Figure 2

Rare Species Site Maps for Flora: Figure 3 and Figure 4

Rare Species Site Maps for Fauna: N/A

Sample Site Maps for Fauna: Figures 7 through 16

Rare and Unique Species & Communities

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
Community Type					
N/A	Xeric Calcareous Cliff	N/A	N/A	N/A	N/A
Plants					
Blephilia hirsuta	Hairy woodmint	G5?	S3	N/A	Watchlist
Carex hirtifolia	Pubescent sedge	G5	S3	N/A	Watchlist
Cystopteris tennesseensis	Tennessee bladderfern	G5	S1	N/A	Rare List
Hydrastis canadensis	Golden-seal	G4	S3	N/A	Watchlist
Juglans cinerea	Butternut	G4	S3?	N/A	Watchlist
Panax quinquifolius	American ginseng	G4	S4	N/A	Watchlist
Rhamnus lanceolata	Lance-leaved buckthorn	G4G5T?	S3	N/A	Watchlist

COMMUNITY DESCRIPTIONS

Three distinct vegetative communities are combined under the Upland Forest Community due to the great similarities and overlap in fauna. Each community type is described below including the associated rare and unique flora. However, the general species lists are combined into one list at the end of this section.

Dry Calcareous Forest/Woodland

This community occurs both at the New River and Main facilities on steep to moderate slopes underlain by limestone. Low outcrops may be frequent and scree or loose rocks of variable size are usually scattered over the surface. Slopes are dry due to shallow rocky soils and either solar heating or wind on SE-W aspects. The forest canopy is relatively low and may be thin in rockier sites. The forest is characterized by the presence of *Quercus muhlenbergii*, Chinquapin Oak, usually mixed with (but sometimes replaced by) an assemblage of non-oak hardwoods such as *Celtis occidentalis*, *Ulmus rubra, Acer saccharum/nigrum*, *Carya* spp., and *Fraxinus americana*. The subcanopy is usually thin and composed of *Ostrya virginiana*, *Cercis canadensis*, *Cornus florida*, and saplings of canopy trees. A variant of this community with *Quercus rubra* co-dominant in the overstory and *Hamamelis virginiana* in the subcanopy occurs along the SW-facing slope above the railroad north from Pepper. Herb cover and diversity is typically considerable in this community type, but herbs are sparse at the Pepper locality probably as an artifact of logging history in which an even-aged and relatively young canopy has created more shady conditions less favorable to herbs. Characteristic herbs in this community type are *Bromus pubescens*, *Festuca subverticillata*, *Muhlenbergia sobolifera, Sphenopholis nitida*, *Carex digitalis*, *Carex laxiflora*, *Carex platyphylla*, *Allium cernuum*, *Hypoxis hirsuta*, *Aquilegia canadensis*, *Cimicifuga racemosa*, *Taenidia integerrima*, *Asclepias quadrifolia*, *Scutellaria nervosa*, *Galium circaezans*, *Houstonia longifolia*, *Erigeron pulchellus*, and *Senecio obovatus*.

Rare species: *Cystopteris tennesseensis*
Juglans cinerea
Rhamnus lanceolata

This community is relatively free of invasive exotics in most situations. *Lonicera maackii* and *Ailanthus altissima* are the two species most often encountered *with Berberis thunbergii* less frequently so.

Mesic Calcareous Forest (also called Rich Cove/Mesic Slope Forest)

Mesic calcareous forest occurs over limestone and is often transitional to dry calcareous forest/woodland. It occupies upland flats, lower slopes, ravines, karst areas, and slopes of various aspects where moisture conditions are moderate. Soils are better developed and support a diverse assemblage of herbaceous species. At the Arsenal, this community is interspersed with dry calcareous forest/woodland with which it is mapped as a single unit. Compared with the dry calcareous forest/woodland, mesic calcareous forest is recognized in the field by its shadier conditions and higher canopy with more of a mixture of hardwoods. Rocks and outcropping may or may not be present. Except for local dominance by spicebush (*Lindera benzoin*), the shrub layer is usually sparse or absent unless invasive exotic species are present. Although many hardwood species are shared between these two communities, the composition shifts. Drought tolerant species such as *Quercus muhlenbergii* and *Carya* ssp. become less frequent whereas *Acer saccharum* increases along with *Juglans nigra*, *Liriodendron tulipifera*, *Tilia americana, Aesculus sp.*, and *Prunus serotina*. The herb layer is diverse, especially in spring. Characteristic species *include Deparia acrostichoides*, *Diplazium pycnocarpon*, *Poa sylvestris*, *Carex blanda*, *Carex communis*, *Carex copulata*, *Carex hitchcockiana*, *Carex oligocarpa*, *Arisaema triphyllum*, *Disporum*, *Smilacina racemosa*, *Trillium grandiflorum*, *Delphinium tricorne*, *Caulophyllum thalictroides*, *Jeffersonia diphylla*, *Sedum ternatum*, *Hackelia virginiana*, *Senecio aureus*.

Rare species: *Carex hirtifolia*
Hydrastis canadensis
Panax quinquifolius
Blephilia hirsuta

Note: Numerous sites are transitional between the more mesic community described above and the dry calcareous forest/woodland. In addition, aerial photos reveal the forest was timbered in the 1930's and therefore, has not yet reached a climax community. This disturbance also allowed invasion by exotic species such *as Poa trivialis*, *Microstegium vimineum*, *Ornithogalum umbellatum*, *Berberis thunbergii*, *Cardamine hirsuta*, and *Duchesnea indica*, which are prevalent in many areas.

Chestnut Oak Forest (Scarlet Oak Variant)

This community type occupies only small portions of the Main facility where the underlying bedrock is in the Price Formation. The rock types are shales and thin-bedded sandstones. The soil is, therefore, more acidic than that derived on limestone formations which underlie the rest of the two sites. Despite this fact, in ravines and on northerly slopes, more mesic forests develop. Chestnut Oak Forest occurs on ridgetops, upper slopes, and lower down on SE-SW slopes. The sites are well drained and site quality is poor. The forest is characterized by having mixed oaks and pines, scattered heaths, and very sparse herb cover. The ground layer is predominantly woody with low ericaceous shrubs or tree seedlings. Chestnut oak (*Quercus prinus*) and scarlet oak (*Q. coccinea*) dominate the overstory with the following species being frequent: *Quercus alba*, *Q. velutina*, and pines (*Pinus strobus*, *P. virginiana*, and *P. pungens*). Other frequent tree species are *Nyssa sylvatica* and *Acer rubrum* in the overstory and *Amelanchier arborea*, *Cornus florida*, and *Oxydendron arboreum* in the subcanopy. The shrub layer is principally comprised of *Vaccinium pallidum*, *V. stamineum*, and *Gaylussacia baccata*. This community is positionally at the very edge of the Price Formation and is transitional to more mesic forest types adjacent to it. The herb-poor feature of the community may be due in part to the dense shade produced by hardwood resprouting following recent timbering of the forest. A few characteristic herbs are *Carex pensylvanica*, *C. digitalis*, *Cypripedium acaule*, *Polygala paucifiora*, and *Monotropa hypopithys*.

Rare species: None

Note: Ericaceous shrubs occur occasionally in small patches in other community types where the soil is rocky and acidic due to either chert or tertiary gravels at or near the surface. These sites, nevertheless, support a more mesic assemblage of species than would be found in the Chestnut Oak Community.

RARE SPECIES & COMMUNITY ACCOUNTS

Xeric Calcareous Cliff: This is a unique natural community that is addressed separately in this report. This community type is recognized under the Oak-Hickory Forest community because it is surrounded by forest habitat and management in this area may affect the cliff. Specific management recommendations for the xeric calcareous cliff and surrounding area are made under the community type, Xeric Calcareous Cliff (page 21).

Hairy Woodmint (*Blephilia hirsuta*): Hairy woodmint was found at both the Main and New River facilities with the species being almost weedy in mesic successional woodland. Many hundreds of plants occur in sinkholes and ravines just north of the residential area at the Main facility. The species was heavily browsed by deer to the point that a concerted effort had to be made to find flowering plants where the species had been seen in great abundance earlier in the season. At the New River facility, a much smaller population was found in successional, grazed woodland in Hazel Hollow.

Pubescent Sedge (*Carex hirtifolia*): Pubescent sedge was found only at the Main facility. Two populations, relatively close together, occur in karst topography in the Mesic Calcareous Forest natural community. It occurs on gentle slopes and flats where rich colluvium supports a grass/sedge-dominated spring flora in mixed open hardwoods with scattered spicebush. Numerous plants occur in each population.

Tennessee Bladderfern (*Cystopteris tennesseensis*): This species was known previously only from two small populations in Montgomery County. It is not surprising, then, that the Tennessee bladderfern should be found at the Main facility. What is surprising is its great abundance. Literally thousands of plants were found in crevices and pockets of limestone outcrops (rarely also on tree bases nearby) scattered along the S-SE facing bluff of New River from just W of the Burning Ground for about 2.25 km upstream. Rocks in this section have numerous small solution holes which are favored sites. Interestingly, *Cystopteris bulbifera*, the common bulblet fern, seems to be absent from this same area.

Goldenseal (*Hydrastis canadensis*): Goldenseal was found only at the Main facility at one location in a Mesic Calcareous Forest community. The site was fairly recently timbered and is now in a shady, briery, successional stage. The small population contains a few dozen small plants.

Butternut (*Juglans cinerea*): Butternut is not a rare species but is maintained on the list because disease is apparently causing its decline. A single medium sized tree was found at the Main facility in Mesic Calcareous Forest at the toe of a S-facing river bluff. Although noted only once, the species occurs with some regularity in dry to mesic calcareous forests and probably occurs at other places at the Arsenal as well.

Ginseng (*Panax quinquifolius*): Ginseng was found only at the New River facility in Mesic Calcareous Forest in Hazel Hollow. This wide-ranging species is maintained on the rare plant list due chiefly to pressures on the species from collecting because of its value as a medicinal herb. It typically occurs in rich deciduous forest. The precise location of this species was not recorded, inadvertently, hence its location is not mapped.

Lance-leaved Buckthorn (*Rhamnus lanceolatas*): Lance-leaved buckthorn was found only at one place at the Main facility. A single, heavily browsed stem only about two decimeters high, is all that was seen. This species was seen on a small, NW-facing dry calcareous woodland near the water tower above the road to Gate 4. Good habitat is available at both facilities for this characteristically local species.

MANAGEMENT RECOMMENDATIONS

General Recommendations

With the existing diversity of habitat types at the Arsenal, active management for Upland Forests should be limited to allow the forests to mature. There is sufficient habitat in grassland and early successional forests that creation of these habitats within the upland forests is unnecessary. Allowing the forests to mature will naturally create habitat features (snags, small openings, cavity trees, down logs, etc.) over time that will benefit a variety of wildlife.

A management alternative that can be applied is the creation of "soft edges" in areas where forests adjoin grasslands. To create a soft edge, a 60 to 100 foot buffer should be established. Within the first 30 to 50 feet of the edge, 75% of the trees should be removed. Within the next 30 to 50 feet, 50% of the trees should be removed to provide a soft succession from grassland to forest. This will allow a continuum of succession between open field and forest that provides cover, herbaceous and woody forage, and nesting habitat for edge species. Of concern in the "soft edges" will be the invasion of exotic species such as multiflora rose, barberry, and autumn olive. Manual removal of exotics and the planting of native shrubs is recommended.

Rare Species and Community Recommendations

Hairy Woodmint (*Blephilia hirsuta*): The hairy woodmint is a species of deep woods or mesic successional woodlands. This species needs a canopy cover and deep, humus-rich soil. The general recommendation of allowing the forest to mature will provide sufficient habitat for this species.

Pubsecent Sedge (*Carex hirtifolia*): This sedge prefers open forests with well drained, loose or humus-rich soil. Mature hardwoods with an open understory are preferred. The general recommendation of allowing the forest to mature will provide sufficient habitat for this species.

Tennessee Bladderfern (*Cystopteris tennesseensis*): The large expanse of this population indicates that it is self maintaining at the Main facility. Again, this is a species that prefers a mature hardwood forest with open canopy. The general recommendation of allowing the forest to mature will provide sufficient habitat for this species.

Goldenseal (*Hydrastis canadensis*): Hydrastis typically grows in mesic mixed hardwood forests. Allowing forest succession to advance and develop a mature canopy is the best management for this species.

Butternut (*Juglans cinerea*): The threat to this species is a fungal pathogen and not management induced as far as we know. Because of this, the only recommendation is to maintain forest cover in areas where it occurs.

Ginseng (*Panax quinquifolius*): This is a species associated with mature forests. Maintenance of mature forests should allow this plant to persist.

Lance-leaved Buckthorn (*Rhamnus lanceolatas*): Browsing and/or grazing is the main pressure on this species at present. Caging of the existing plants could be beneficial in allowing them to mature. Because this species root-sprouts readily, caging should extend well beyond the existing above ground shoots. This plant is largely dioecious so recruitment of additional plants for cross pollination is recommended.

TAXA LISTS

PLANTS

Family	Scientific Name	Common Name
Aceraceae	*Acer rubrum*	red maple
Aceraceae	*Acer saccharum/nigrum*	sugar maple
Amaryllidaceae	*Hypoxis hirsuta*	common goldstargrass
Apiaceae	*Taenidia integerrima*	yellow pimpernel
Araceae	*Arisaema triphyllum*	jack-in-the-pulpit
Araliaceae	*Panax quinquifolius*	ginseng
Asclepiadacea	*Asclepias quadrifolia*	four-leaved milkweed
Asteracea	*Erigeron pulchellus*	Robin's plantain
Asteracea	*Senecio aureus*	golden ragwort
Asteracea	*Senecio obovatus*	squaw-weed
Berberidaceae	*Berberis thunbergii*	Japanese barberry
Berberidaceae	*Caulophyllum thalictroides*	blue cohosh
Berberidaceae	*Jeffersonia diphylla*	twinleaf
Betulaceae	*Ostrya virginiana*	hop hornbeam
Boraginaceae	*Hackelia virginiana*	beggar's-lice
Brassicaceae	*Cardamine hirsuta*	hairy bittercress
Caprifoliaceae	*Lonicera maackii*	honeysuckle
Cornaceae	*Cornus florida*	flowering dogwood
Cornaceae	*Nyssa sylvatica*	black gum
Crassulaceae	*Sedum ternatum*	wild stonecrop
Cyperaceae	*Carex blanda*	woodland sedge
Cyperaceae	*Carex communis*	fibrous-root sedge
Cyperaceae	*Carex copulata*	coupled sedge
Cyperaceae	*Carex digitalis*	slender wood sedge
Cyperaceae	*Carex hirtifolia*	pubescent sedge
Cyperaceae	*Carex hitchcockiana*	Hitchcock's sedge
Cyperaceae	*Carex laxiflora*	loose-flowered sedge
Cyperaceae	*Carex oligocarpa*	eastern few-fruit sedge
Cyperaceae	*Carex pensylvanica*	Pennsylvania sedge
Cyperaceae	*Carex platyphylla*	broad-leaved sedge
Dryopteridaceae	*Cystopteris tennesseensis*	Tennessee bladderfern
Dryopteridaceae	*Deparia acrostichoides*	silver spleenwort
Dryopteridaceae	*Diplazium pycnocarpon*	glade fern
Ericaceae	*Gaylussacia baccata*	black huckleberry
Ericaceae	*Monotropa hypopithys*	pinesap
Ericaceae	*Oxydendron arboreum*	sourwood
Ericaceae	*Vaccinium pallidum*	upland low blueberry
Ericaceae	*Vaccinium stamineum*	squaw huckleberry
Fabaceae	*Cercis canadensis*	redbud
Fagaceae	*Quercus alba*	white oak

Fagaceae	*Quercus coccinea*	scarlet oak
Fagaceae	*Quercus muhlenbergii*	chinquapin oak
Fagaceae	*Quercus prinus*	chestnut oak
Fagaceae	*Quercus rubra*	red oak
Fagaceae	*Quercus velutina*	black oak
Hamamelidaceae	*Hamamelis virginiana*	witch hazel
Juglandaceae	*Juglans cinerea*	butternut
Juglandaceae	*Juglans nigra*	black walnut
Lamiaceae	*Blephilia hirsuta*	hairy woodmint
Lamiaceae	*Scutellaria nervosa*	veined skullcap
Lauraceae	*Lindera benzoin*	spicebush
Liliaceae	*Allium cernuum*	wild onion
Liliaceae	*Disporum lanuginosum*	yellow mandrin
Liliaceae	*Smilacina racemosa*	false solomon's seal
Liliaceae	*Trillium grandiflorum*	large flowered trillium
Liliaceae	*Ornithogalum umbellatum*	star of bethlehem
Magnoliaceae	*Lireodendron tulipifera*	tulip tree
Oleaceae	*Fraxinus americana*	white ash
Orchidaceae	*Cypripedium acaule*	pink lady's slipper
Pinaceae	*Pinus pungens*	tablemountain pine
Pinaceae	*Pinus strobus*	white pine
Pinaceae	*Pinus virginiana*	Virginia pine
Poaceae	*Bromus pubescens*	common eastern brome sedge
Poaceae	*Festuca subverticillata*	nodding fescue
Poaceae	*Microstegium vimineum*	eulalia
Poaceae	*Muhlenbergia sobolifera*	cliff muhly
Poaceae	*Poa sylvestris*	woodland bluegrass
Poaceae	*Poa trivialis*	rough bluegrass
Poaceae	*Sphenopholis nitida*	shiny wedge grass
Polygalaceae	*Polygala pauciflora*	flowering wintergreen
Ranunculaceae	*Aquilegia canadensis*	wild columbine
Ranunculaceae	*Cimicifuga racemosa*	black snakeroot
Ranunculaceae	*Delphinium tricorne*	dwarf larkspur
Ranunculaceae	*Hydrastis canadensis*	goldenseal
Rhamnaceae	*Rhamnus lanceolata*	lance-leaved buckthorn
Rosaceae	*Amelanchier arborea*	common serviceberry
Rosaceae	*Duchesnea indica*	Indian strawberry
Rosaceae	*Prunus serotina*	black cherry
Rubiacea	*Galium circaezans*	wild liquorice
Rubiacea	*Houstonia longifolia*	long-leaved summer bluets
Simarubaceae	*Ailanthus altissima*	tree of heaven
Tiliaceae	*Tilia americana*	basswood
Ulmaceae	*Celtis occidentalis*	hackberry
Ulmaceae	*Ulmus rubra*	slippery elm

INVERTEBRATES

Class: Arachnida
Order: Araneae

Family	Scientific Name	Common Name
Agelenidae	*Cicurina pallida*	
Agelenidae	*Cryphoeca montana*	
Agelenidae	*Cybaeus sp.*	
Agelenidae	*sp.*	
Agelenidae	*Wadotes bimucronatus*	
Agelenidae	*Wadotes calcaratus*	
Agelenidae	*Wadotes hybridus*	
Agelenidae	*Wadotes sp*	
Anyphaenidae	*Anyphaena fraterna*	
Anyphaenidae	*Anyphaena celer*	
Araneidae	*Araneus sp.*	
Araneidae	*Araneus marmoreus*	
Araneidae	*Meta menardi*	
Araneidae	*Micrathena gracilis*	
Araneidae	*Micrathena mitrata*	
Araneidae	*Neoscona pratensis*	
Araneidae	*Verrucosa arenata*	
Clubionidae	*Agroeca minuta*	
Clubionidae	*Castianeira cingulata*	
Clubionidae	*Castianeira sp.*	
Clubionidae	*Castianeira variata*	
Clubionidae	*Clubiona excepta*	
Dysderidae	*Dysdera crocata*	
Gnaphosidae	*Callilepis pluto*	
Gnaphosidae	*Cesonia bilineata*	
Gnaphosidae	*Drassyllus novus*	
Gnaphosidae	*Haplodrassus sp.*	
Gnaphosidae	*Litopyllus temporarius*	
Hahniidae	*Neoantistae agilis*	
Leptonetidae	*Leptoneta sp.*	
Linyphiidae	*Tapinopa bilineata*	
Lycosidae	*Allocosa funerea*	
Lycosidae	*Arctosa virgo*	
Lycosidae	*Gladicosa gulosa*	
Lycosidae	*Pirata montanus*	
Lycosidae	*Pirata sedentarius*	
Lycosidae	*Schizocosa ocreata*	
Philodromidae	*Philodromus marxi*	
Philodromidae	*Philodromus exilis*	

Salticidae	*Neon nellii*	
Salticidae	*Zygoballus nervosus*	
Theridiidae	*Achaearanea rupicola*	
Theridiidae	*Achaearnea tepidariorum*	
Theridiidae	*Dipoena nigra*	
Theridiidae	*sp.*	
Theridiidae	*Theridion albidum*	
Thomisidae	*Tmarus angulatus*	
Thomisidae	*Xysticus ferox*	

Class: Brachiopoda
Order: Cladocera

Specimen not identified beyond Order.

Class: Chilopoda
Order: Scolopendromopha

Family	**Scientific Name**	**Common Name**
Cryptopidae	*Scolocryptops sexspinosus*	Centipede

Class: Diplopoda
Order: Polydesmida

Family	**Scientific Name**	**Common Name**
Xystodesmidae	*Gyalostethus monticolens*	Millipede
Xystodesmidae	*Nannaria ericacea*	Millipede

Class: Insecta
Order: Coleoptera

Family	**Scientific Name**	**Common Name**
Carabidae	*Agonum sp.*	ground beetle
Carabidae	*Amphasia interstitialis*	ground beetle
Carabidae	*Chlaenius aestivus*	ground beetle
Carabidae	*Chlaenius impunctifrons*	ground beetle
Carabidae	*Dicaelus elongatus*	ground beetle
Carabidae	*Dicaelus teter*	ground beetle
Carabidae	*Lebia analis*	ground beetle
Carabidae	*Lebia atriventris*	ground beetle
Carabidae	*Lebia fuscata*	ground beetle
Carabidae	*Lebia solea*	ground beetle
Carabidae	*Poecilus sp.*	ground beetle
Carabidae	*Pseudauphasia senicea*	ground beetle
Carabidae	*Pterostichus sp.*	ground beetle

Carabidae	*Steriolophus comma*	ground beetle
Lampyridae	*sp.*	firefly
Scarabaeidae	*Geotropes opacus*	scarab beetle
Scarabaeidae	*Phyllophaga sp.*	scarab beetle
Staphylinidae	*Geodromicus brunneus*	rove beetle
Staphylinidae	*Platydraeus sp.*	rove beetle

Class: Insecta
Order: Diptera

Family	Scientific Name	Common Name
Cecidomyiidae	*sp.*	gall gnat
Culicidae	*sp.*	mosquito
Ptychopteridae	*sp.*	phantom crane fly
Tachinidae	*sp.*	tachinid fly

Class: Insecta
Order: Heteroptera

Family	Scientific Name	Common Name
Lygalidae	*Myodocha serripes*	seed bug
Lygalidae	*Xestocoris nitens*	seed bug
Pentatomidae	*Acrosternum hilare*	stink bug
Pentatomidae	*Dendrocoris humeralis*	stink bug

Class: Insecta
Order: Hymenoptera

Family	Scientific Name	Common Name
Apidae	*sp.*	apidid bee
Formicidae	*Stenamma meridionale*	myrmicinae (ant)
Tenthredinidae	*sp.*	common sawfly

Class: Insecta
Order: Lepidoptera

Family	Scientific Name	Common Name
Arctiidae	*Halysidota tessellaris*	banded tussock moth
Arctiidae	*Haploa lecontei*	Leconte's haploa
Arctiidae	*Holomelina aurantiaca*	orange holomelina
Arctiidae	*Holomelina opella*	tawny holomelina
Arctiidae	*Holomelina sp.*	holomelina
Arctiidae	*Pyrrharctia isabella*	isabella tiger moth
Arctiidae	*Spilisoma virginica*	Virginian tiger moth
Geometridae	*Eulithis diversilineata*	lesser grapevine looper moth

Geometridae	*Nacophora quernaria*	oak beauty
Hesperidae	*Epargyreus clarus*	silver-spotted skipper
Hesperidae	*Erynnis baptisiae*	wild indigo duskywing
Hesperidae	*Erynnis brizo*	sleepy duskywing
Hesperidae	*Erynnis icelus*	dreamy duskywing
Hesperidae	*Erynnis juvenalis*	Juvena'ls duskywing
Lasiocampidae	*Malacosoma disstria*	forest tent caterpillar moth
Lycaenidae	*Callophrys henrici*	Henry's elfin
Lycaenidae	*Celastrina l. ladon "neglecta"*	summer azure
Lycaenidae	*Celastrina l. ladon "violocea"*	spring azure
Lycaenidae	*Celastrina neglectamajor*	Appalachian azure
Lycaenidae	*Everes comyntas*	eastern tailed blue
Lycaenidae	*Satyrium calanus*	banded hairstreak
Lycaenidae	*Satyrium titus*	coral hairstreak
Noctuidae	*Abargrotis alternata*	greater red dart
Noctuidae	*Acronicta americana*	American dagger moth
Noctuidae	*Acronicta inclara*	unclear dagger moth
Noctuidae	*Acronicta sp.*	dagger moth
Noctuidae	*Anagrapha falcifera*	celery looper moth
Noctuidae	*Caenurgina erechtea*	forage looper moth
Noctuidae	*Cerma cerintha*	tufted bird-dropping moth
Noctuidae	*Leucania sp.*	wainscot sp.
Noctuidae	*Lithacodia carneola*	pink-barred lithacodia
Noctuidae	*Xestia dolosa*	greater black-letter dart
Notodonitidae	*Nadata gibbosa*	white-dotted prominent
Notodonitidae	*Symmerista albifrons*	white-headed prominent
Nymphalidae	*Cercyonis pegala*	common wood nymph
Nymphalidae	*Danaus plexippus*	monarch
Nymphalidae	*Limenitis arthemis astyanax*	red-spotted purple
Nymphalidae	*Megisto cymela*	little wood satyr
Nymphalidae	*Nymphalis antiopa*	mourning cloak
Nymphalidae	*Phyciodes tharos*	pearl crescent
Nymphalidae	*Polygonia comma*	eastern comma
Nymphalidae	*Polygonia interrogationis*	question mark
Nymphalidae	*Speyeria aphrodite*	aphrodite fritillary
Nymphalidae	*Speyeria cybele*	great spangled fritillary
Papilionidae	*Battus philenor*	pipevine swallowtail
Papilionidae	*Papilio glaucus*	eastern tiger swallowtail
Pieridae	*Anthocharis midea*	falcate orangetip
Pieridae	*Colias eurytheme*	orange sulfer
Pieridae	*Colias philodice*	clouded sulfer
Pieridae	*Pieris rapae*	cabage white
Saturniidae	*Anisota stigma*	spiny oakworm moth
Saturniidae	*Drycampa rubicunda*	rosy maple moth

Class: Insecta
Order: Neuroptera

Family	Scientific Name	Common Name
Corydalidae	*Chauliodes sp.*	dobsonfly
Corydalidae	*Neohermis sp.*	dobsonfly
Corydalidae	*sp.*	dobsonfly
Sialidae	*sp.*	alderfly

Class: Insecta
Order: Odonata

Family	Scientific Name	Common Name
Gomphidae	*Ophiogomphus rupinsulensis*	rusty snaketail
Libellulidae	*Sympetrum vicinum*	yellow-legged meadowhawk

Class: Insecta
Order: Psocoptera

Specimen not identified beyond Order.

Class: Insecta
Order: Thysanura

Family	Scientific Name	Common Name
Machilidae	*Machilis sp.*	bristletail

Class: Malacostraca
Order: Isopoda

Family	Scientific Name	Common Name
Trichoniscidae	*Hyloniscus sp.*	pill bug

FISH

Family	Scientific Name	Common Name
Catastomidae	*Catostomus commersoni*	white sucker
Centrarchidae	*Micropterus dolomieui*	smallmouth bass
Cyprinidae	*Campostoma anomalum*	central stoneroller
Cyprinidae	*Climostomus funduloides*	rosyside dace
Cyprinidae	*Luxilus albeolus*	white shiner
Cyprinidae	*Nocomis leptocephalus*	bluehead chub
Cyprinidae	*Notropis telescopus*	telescope shiner
Cyprinidae	*Phoxinus oreas*	mountain redbelly dace

Cyprinidae	*Rhinichthys atratulus*	blacknose dace
Ictaluridae	*Noturus insignis*	margined madtom
Percidae	*Etheostoma flabellare*	fantail darter

REPTILES AND AMPHIBIANS

Family	**Scientific Name**	**Common Name**
Ambystomatidae	*Ambystoma jeffersonianum*	Jefferson salamander
Ambystomatidae	*Ambystoma maculatum*	spotted salamander
Bufonidae	*Bufo americanus*	American toad
Bufonidae	*Bufo woodhousii*	Fowler's toad
Colubridae	*Coluber constrictor*	northern black racer
Colubridae	*Elaphe obsoleta*	black rat snake
Colubridae	*Thamnophis sirtalis*	eastern garter snake
Emydidae	*Terrapene carolina*	eastern box turtle
Hylidae	*Hyla versicolor*	gray treefrog
Hylidae	*Pseudacris crucifer*	spring peeper
Phrynosomatidae	*Sceloporus undulatus*	fence lizard
Plethodontidae	*Desmognathus fuscus*	northern dusky salamander
Plethodontidae	*Eurycea cirrigera*	southern two-lined salamander
Plethodontidae	*Plethodon cinereus*	redback salamander
Plethodontidae	*Plethodon glutinosus*	slimy salamander
Plethodontidae	*Plethodon wehrlei*	Wehrle's salamander
Ranidae	*Rana sylvatica*	wood frog
Salamandridae	*Notophthalmus viridescens*	red-spotted newt

BIRDS: Status code definitions; B = breeding, M = migrant, R = resident, U = undetermined, and W = winter.

Family	**Scientific name**	**Species**	**Status**
Accipitridae	*Accipiter striatus*	sharp-shinned hawk	B
Accipitridae	*Buteo jamaicensis*	red-tailed hawk	R
Alcedinidae	*Ceryle alcyon*	belted kingfisher	R
Bombycillidae	*Bombycilla cedrorum*	cedar waxwing	R
Cathartidae	*Cathartes aura*	turkey vulture	R
Cathartidae	*Coragyps atratus*	black vulture	R
Columbidae	*Zenaida macroura*	mourning dove	R
Corvidae	*Corvus brachyrhynchos*	American crow	R
Corvidae	*Corvus corax*	common raven	W
Corvidae	*Cyanocitta cristata*	blue jay	R
Emberizidae	*Agelaius phoeniceus*	red-winged blackbird	B
Emberizidae	*Cardinalis cardinalis*	northern cardinal	R
Emberizidae	*Dendroica coronata*	yellow-rumped warbler	W
Emberizidae	*Dendroica magnolia*	magnolia warbler	M
Emberizidae	*Dendroica petechia*	yellow warbler	B

Emberizidae	*Dendroica trichas*	common yellowthroat	B
Emberizidae	*Dendroica virens*	black-throated green warbler	B
Emberizidae	*Helmitheros vermivorus*	worm-eating warbler	B
Emberizidae	*Icterus galbula*	northern oriole	B
Emberizidae	*Junco hyemalis*	northern junco	W
Emberizidae	*Melospiza georgiana*	swamp sparrow	U
Emberizidae	*Melospiza melodia*	song sparrow	R
Emberizidae	*Mniotilta varia*	black-and-white warbler	B
Emberizidae	*Molothrus ater*	brown-headed cowbird	B
Emberizidae	*Oporornis formosus*	Kentucky warbler	B
Emberizidae	*Parula americana*	northern parula	B
Emberizidae	*Passerina cyanea*	indigo bunting	B
Emberizidae	*Pipilo erythrophthalmus*	eastern towhee	B
Emberizidae	*Piranga olivacea*	scarlet tanager	B
Emberizidae	*Seiurus aurocapillus*	ovenbird	B
Emberizidae	*Seiurus motacilla*	Louisiana waterthrush	B
Emberizidae	*Setophaga ruticilla*	American redstart	B
Emberizidae	*Spizella passerina*	chipping sparrow	B
Emberizidae	*Spizella pusilla*	field sparrow	B
Emberizidae	*Zonotrichia albicollis*	white-throated sparrow	W
Fringillidae	*Carduelis tristis*	American goldfinch	R
Fringillidae	*Carpodacus purpureus*	purple finch	W
Hirundinidae	*Progne subis*	purple martin	B
Muscicapidae	*Catharus guttatus*	hermit thrush	M
Muscicapidae	*Hylocichla mustelina*	wood thrush	B
Muscicapidae	*Polioptila caerulea*	blue-gray gnatcatcher	B
Muscicapidae	*Regulus satrapa*	golden-crowned kinglet	W
Muscicapidae	*Sialia sialis*	eastern bluebird	R
Muscicapidae	*Turdus migratorius*	American robin	R, M
Paridae	*Parus atricapillus*	black-capped chickadee	W
Paridae	*Parus bicolor*	tufted titmouse	R
Paridae	*Parus carolinensis*	carolina chickadee	R
Phasianidae	*Bonasa umbellus*	ruffed grouse	R
Phasianidae	*Meleagris gallopavo*	wild turkey	R
Picidae	*Colaptes auratus*	northern flicker	R
Picidae	*Dryocopus pileatus*	pileated woodpecker	R
Picidae	*Melanerpes carolinus*	red-bellied woodpecker	R
Picidae	*Picoides pubescens*	downy woodpecker	R
Picidae	*Picoides villosus*	hairy woodpecker	R
Picidae	*Sphyrapicus varius*	yellow-bellied sapsucker	U
Sittidae	*Sitta canadensis*	red-breasted nuthatch	W
Sittidae	*Sitta carolinensis*	white-breasted nuthatch	B
Strigidae	*Bubo virginianus*	great horned owl	R
Strigidae	*Otus asio*	eastern screech owl	R
Strigidae	*Strix varia*	barred owl	R

Sturnidae	*Sturnus vulgaris*	European starling	R
Troglodytidae	*Thryothorus ludovicianus*	carolina wren	B
Troglodytidae	*Troglodytes troglodytes*	winter wren	U
Tyrannidae	*Contopus virens*	eastern pewee	B
Tyrannidae	*Empidonax virescens*	acadian flycatcher	B
Tyrannidae	*Myiarchus crinitus*	great crested flycatcher	B
Tyrannidae	*Sayornis phoebe*	eastern phoebe	B
Tyrannidae	*Tyrannus tyrannus*	eastern kingbird	B
Vireonidae	*Vireo flavifrons*	yellow-throated vireo	B
Vireonidae	*Vireo gilvus*	warbling vireo	B
Vireonidae	*Vireo griseus*	white-eyed vireo	B
Vireonidae	*Vireo olivaceus*	red-eyed vireo	B

MAMMALS

Family	**Scientific Name**	**Common Name**
Cervidae	*Odocoileus virginianus*	white-tailed deer
Diedelphidae	*Didelphis virginiana*	Virginia opossum
Dipodidae	*Zapus hudsonius*	meadow jumping mouse
Mephitidae	*Mephitis mephitis*	striped skunk
Muridae	*Microtis pennsylvanicus*	meadow vole
Muridae	*Microtis pinetorum*	woodland vole
Muridae	*Peromyscus leucopus*	white-footed mouse
Procyonidae	*Procyon lotor*	common raccoon
Sciuridae	*Marmota monax*	woodchuck
Sciuridae	*Sciurus carolinensis*	eastern gray squirrel
Sciuridae	*Sciurus niger*	eastern fox squirrel
Sciuridae	*Tamias striatus*	eastern chipmunk
Soricidae	*Blarina brevicauda*	northern short-tailed shrew
Soricidae	*Cryptotis parva*	least shrew
Soricidae	*Sorex fumeus*	smoky shrew
Talpidae	*Parascalops breweri*	hairy-tailed mole

Community Type: Limestone Barren

Acreage: Acres (Hectares) Total: 1.3 (0.5) Main: N/A New River: 1.3 (0.5)

Community Type Location Maps: Figure 2

Rare Species Site Maps for Flora: Figure 4

Rare Species Site Maps for Fauna: N/A

Sample Site Maps for Fauna: N/A

Rare and Unique Species & Communities

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
Plants					
Carex meadii	Mead's sedge	G4G5	S3	N/A	Watchlist
Linum sulcatum	Grooved yellow flax	G5T5	S3	N/A	Watchlist

COMMUNITY DESCRIPTION

This naturally open, grass-dominated community occurs at two places on the New River facility. Limestone underlies the community and weathers to a thin, gravelly soil, often barren in patches, with low scattered bedrock exposures often being present. It occurs on mid- and upper slopes with a southerly or westerly aspect. Typically this community develops in areas where bedrock is unusually high in magnesium (dolomitic), but whether or not this is the case at the Arsenal has not been determined. The openings are not completely open but rather have a scattering of red cedars, pines, and a few small hardwood trees or shrubs thus forming a mosaic of small openings interspersed among trees. Pines are the principal invaders and, due to fire suppression, threaten the continued existence of the community. Two features serve to distinguish this community from artificially open, grass-dominated sites that share many plant species. One feature is a greater diversity of species without any clear dominance of one or two species. The second is the presence of a number of rare species, which for whatever reason, haven't spread into the abundance of cleared pasturelands in the region. These species are testament to the presence of naturally open habitat prior to European settlement. Past history of these sites has complicated precise delineation of the community. The openings have been enhanced at both locations by the clearing of adjacent land that would previously have been transitional to forest. The effect is to create an abrupt border to adjacent forest thus giving the appearance of an old field to the entire area including the barren. Characteristic herbs include *Ophioglossum engelmannii, Andropogon gerardii, Bouteloua curtipendula, Muhlenbergia capillaris, Carex meadii, Linum sulcatum*, and *Scutellaria leonardii*. Invasive exotics are, for the most part, lacking. The most frequent wide-ranging species are *Danthonia spicata*, *Panicum oligosanthes* var. *scribnerianum*, *Schizachyrium scoparium*, and *Tridens flavus*. Also frequent are *Carex hirsutella*, *Carex pensylvanica*, *Asclepias verticillata*, *Asclepias viridiflora*, *Aster undulatus*, *Kuhnia eupatorioides*, and *Solidago nemoralis*.

RARE SPECIES & COMMUNITY ACCOUNTS

Mead's Sedge (*Carex meadii*): Mead's sedge occurs only at the New River facility in or adjacent to the Limestone Barren natural communities. Two populations were found. One population occupied an area approximately 20 x 24 meters near the crest of a gentle South-facing slope. Only 2 fertile culms were present in the entire patch. Common associates were *Carex hirsutella*, *Carex umbellata*, and *Schizachyrium scoparium*. The second site is on a dry westerly slope in sucessional woodland where several subpopulations occur in proximity. This sedge occurs in dry or seasonally moist basic soils at scattered locations across Virginia. This is the first report of this species for the New River Valley. It is notable not only as a rare species, but also as an indicator of prairie or savanna-like conditions prior to European settlement.

Grooved Yellow Flax (*Linum sulcatum*): Grooved yellow flax was found only at the New River facility where it is restricted to the two Limestone Barren natural communities. The eastern site contains an estimated several dozen plants. This small annual species tends to occur in slightly eroded spots where space hasn't been preempted by perennial species. Only a few plants were noted at the western barren where cover is more uniform. This species is often considered a midwestern species, occurring locally in prairie-like habitats to the east.

MANAGEMENT RECOMMENDATIONS

General Recommendations

Limestone barrens are largely an edaphic climax community in which fire appears to play a significant role. However, fire frequency and intensity have not been fully researched, but it seems likely that an infrequent but hot fire is needed. Fuel loads probably accumulate rather slowly so it may take up to five years before a fire should be presribed. To get back to the arrested succession stage, grazing animals should be removed so fuels can begin to accumulate. In addition, all the pines and some of the cedars within the barren should be cut and removed. Any large mature pines in immediately adjacent areas should be cut to prevent further seed dispersal in the barren. In this new condition, the barren may be restored and maintained by occassional fire.

Rare Species and Community Recommendations

Mead's Sedge (*Carex meadii*) and Grooved Yellow Flax (*Linum sulcatum*): Both of these plants are habitat dependent. Without the availability of barren-type habitat they probably won't persist. The general recommendations listed above should be sufficient to maintain these two rare plants.

TAXA LISTS

For a list of the animal taxa that may be associated with limestone barrens, see taxa lists under Early Successional community type.

PLANTS

Family	Scientific Name	Common Name
Asclepiadaceae	*Asclepias verticillata*	whorled milkweed
Asclepiadaceae	*Asclepias viridiflora*	green milkweed
Asteraceae	*Aster undulatus*	wavy-leaf aster
Asteraceae	*Kuhnia eupatorioides*	false boneset
Asteraceae	*Solidago nemoralis*	oldfield goldenrod
Cyperaceae	*Carex hirsutella*	hirsute sedge
Cyperaceae	*Carex meadii*	Mead's sedge
Cyperaceae	*Carex pensylvanica*	Pennsylvania sedge
Lamiaceae	*Scutellaria leonardii*	shale skullcap
Linaceae	*Linum sulcatum*	grooved yellow flax
Ophioglossaceae	*Ophioglossum engelmannii*	limestone adders-tongue
Poaceae	*Andropogon gerardii*	big bluestem
Poaceae	*Bouteloua curtipendula*	side-oats grama grass
Poaceae	*Danthonia spicata*	poverty oat-grass
Poaceae	*Muhlenbergia capillaris*	long-awn hairgrass
Poaceae	*Panicum oligosanthes var. scribnerianum*	Scribner's panic grass
Poaceae	*Schizachyrium scoparium*	little bluestem
Poaceae	*Tridens flavus*	redtop

Community Type: Xeric Calcareous Cliff

Acreage: Acres (Hectares) Total:1.7 (0.7) Main: 1.7 (0.7) New River: N/A

Community Type Location Maps: Figure 1

Rare Species Site Maps for Flora: Figure 3

Rare Species Site Maps for Fauna: N/A

Sample Site Maps for Fauna: N/A

Rare and Unique Species & Communities

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
Plants					
Clematis coactilis	Virginia White-haired leatherflower	G2G3	S2S3	N/A	Rare List
Pellaea glabella	Smooth cliff-brake	G5T?	SU	N/A	Watchlist

COMMUNITY DESCRIPTION

This community type is found only at the Main facility where exposed limestone cliffs occur on steep south and west-facing bluffs of New River where erosion resistant strata outcrop to slope. Cliffs are generally on dry exposures high on the slope but may extend downslope diagonally following the bedding plane of the resistant rock strata. The community is distinguished by absence of a closed canopy, open exposures of bare rock, and plants being limited to crevices, ledges, soil pockets, and edges. Numerous other smaller cliffs occur under a forest canopy and are not included in this community due to their shaded and more mesic conditions. Scattered trees and shrubs (usually small) may occur around edges and in deeper crevices between outcrops. Typical woody species are *Quercus muhlenbergii, Fraxinus americana, Juniperus virginiana, Celtis occidentalis, Celtis tenuifolia, Cercis canadensis, Viburnum prunifolium, Toxicodendron radicans, Rhus aromatica*, and *Ostrya virginiana*. Characteristis herbaceous species are rock-loving heliophytes such as *Asplenium ruta-muraria, Pellaea glabella, Melica mutica, Muhlenbergia sobolifera, Carex eburnea, Aquilegia canadensis, Draba ramosissima, Sedum glaucophyllum, Aster oblongifolius*, and *Solidago sphacelata*.

Due to the open nature of the habitat and its being prone to disturbance from ice storms (tree fall and broken canopies), this habitat is often colonized by weedy native taxa in addition to exotics. Common examples are *Chenopdium album, Lepidium virginicum, Euphorbia nutans, Solanum ptycanthum, Bidens bipinnata, and Verbesina* *occidentalis*. The most frequent invasive exotic species are *Marrubium vulgare, Nepeta cataria, Verbascum thapsus, Verbascum phlomoides, Lonicera maackii*, and *Carduus nutans*.

RARE SPECIES & COMMUNITY ACCOUNTS

Virginia White-haired Leatherflower (*Clematis coactilis*): This clematis is a Virginia endemic known from only 7 counties in the Ridge and Valley Province. It occurs at the Main facility near Pepper in the Dry Calcareous Forest/Woodland and Xeric Calcareous Cliff natural communities on the bluff above the railroad. A few plants occur on exposed ledges of the cliff, but many more occur over a larger area where low bedrock exposures support thin, dry, rocky woodland.

Smooth Cliffbrake (*Pellaea glabella*): Smooth cliffbrake was found at four places at the Main facility. Each population of only a few plants occurs on cliff faces, usually southerly facing and exposed to the sun. This species normally occurs in the most precipitous sites available. Undoubtedly, additional plants could be found with further exploration. *Pellaea glabella* occurs on quite a few other limestone cliffs along New River and was, therefore, expected at this Site.

MANAGEMENT RECOMMENDATIONS

General Recommendations

Due to the steep precipitous rocky slopes characterizing this community, we do not anticipate that disturbance will occur at these sites. Therefore, no management recommendations are presribed for this site. The proximity of weed-dominated habitats such as railroad, roadsides, and open fields will, unfortunately, insure a continuous supply of seeds of exotic species for dispersal into this community.

Rare Species and Community Recommendations

Virginia White-haired Leatherflower (*Clematis coactilis*) and Smooth Cliffbrake (*Pellaea glabella*): Both plant species grow on rocks or in rocky soil and should persist as long as this habitat exist. Without disturbance, these sites and this community is self maintaining. No management recommendations are prescribed for these species.

TAXA LISTS

For a list of the animal taxa that may be associated with the xeric calcareous cliffs, see the taxa lists under the Upland Forest community type.

PLANTS

Family	Scientific Name	Common Name
Anacardiaceae	*Rhus aromatica*	fragrant sumac
Anacardiaceae	*Toxicodendron radicans*	poison ivy
Asteraceae	*Aster oblongifolius*	shale barren aster
Asteraceae	*Solidago sphacelata*	false goldenrod
Betulaceae	*Ostrya virginiana*	hop hornbeam
Brassicaceae	*Draba ramosissima*	rocktwist
Caprifoliaceae	*Viburnum prunifolium*	black haw
Crassulaceae	*Sedum glaucophyllum*	cliff stonecrop
Cupressaceae	*Juniperus virginiana*	red cedar
Cyperaceae	*Carex eburnea*	ebony sedge
Fabaceae	*Cercis canadensis*	redbud
Fagaceae	*Quercus muhlenbergii*	chinquapin oak
Oleaceae	*Fraxinus americana*	white ash
Poaceae	*Melica mutica*	two-flower melic
Poaceae	*Muhlenbergia sobolifera*	cliff muhly
Polypodiaceae	*Asplenium ruta-muraria*	rue spleenwort
Polypodiaceae	*Pellaea glabella*	smooth cliffbrake
Ranunculaceae	*Aquilegia canadensis*	wild columbine
Ulmaceae	*Celtis occidentalis*	hackberry
Ulmaceae	*Celtis tenuifolia*	dwarf hackberry

Community Type: Calcareous Fen

Acreage: Acres (Hectares) Total: 0.3 (0.1) Main: N/A New River: 0.3 (0.1)

Community Type Location Maps: Figure 2

Rare Species Site Maps for Flora: Figure 4

Rare Species Site Maps for Fauna: N/A

Sample Site Maps for Fauna: N/A

Rare and Unique Species & Communities

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
Plants					
Carex interior	Inland sedge	G5	S1	N/A	Rare List
Carex schweinitzii	Schweinitz's sedge	G3	S1	N/A	Rare List
Carex suberecta	Prairie straw sedge	G4	S3	N/A	Watchlist
Carex tetanica	Rigid sedge	G4G5	S3	N/A	Watchlist
Juncus brachycephalus	Small-headed rush	G5	S2	N/A	Rare List

COMMUNITY DESCRIPTION

This community is known from only a single location at the New River facility. It is characterized by nearly flat topography, permanently to semi-permanently saturated soil fed by mineral rich water of relatively high pH. The site is slightly elevated from the adjacent stream thus protecting it from flooding and allowing drainage so that saturated conditions are maintained by continual replenishment by fresh groundwater. Vegetation is virtually completely herbaceous and strongly zonal depending on small variations in hydrology.

The flora is dominated by grasses, sedges, and rushes with an admixture of broad-leaved species. Characteristic species include several rare taxa as well as *Muhlenbergia sylvatica*, *Carex pellita*, *Carex stricta*, *Juncus dudleyi*, and *Rudbeckia fulgida*. The only invasive exotic noted was *Cirsium arvense* in areas transitional to meadow.

Note: Several other sites at the New River facility contain one or several of the species named above or others commonly associated with fens (*Liparis loeselii*, in particular), but these sites are too small and lack sufficient development to be considered fens in the community sense.

RARE SPECIES & COMMUNITY ACCOUNTS

Inland Sedge (*Carex interior*): This sedge was found only in the Calcareous Fen natural community at the New River facility. A scattering of plants occurs mixed with other sedges along rivulets and in a broad zone peripheral to the *Carex schweinitzii* patch. This occurrence in Pulaski County is one of only about 5 known populations in Virginia.

Schweinitz's Sedge (*Carex schweinitzii*): This sedge, so characteristic of intensely marly sites, was found only in the Calcareous Fen natural community at the New River facility. Here it occupies a single contiguous patch in the central wettest portion of the fen. Numerous fertile culms were observed at the site on June 18, 1997.

Prairie Straw Sedge (*Carex suberecta*): Prairie straw sedge is a species associated with fens and other alkaline wetland habitats. The species was found only at the New River facility at three locations. At the Calcareous Fen community, numerous plants co-occur with other prairie fen sedge species in the central portion of the wetland. The second population occurs in the small marsh area adjacent to Big Pond. The third population was comprised of scattered individuals along the small stream with *Spiranthes lucida*. A careful search of other streambanks at the New River facility would be likely to turn up additional locations for this species.

Rigid Sedge (*Carex tetanica*): This sedge occurs in a variety of open or shrubby, calcareous wetlands. It was found at the New River facility at the same locations as *Carex suberecta*. It too might be found elsewhere especially since it is often overlooked because of soon being overtopped by more robust species that typically occur with it.

Small-headed Rush (*Juncus brachycephalus*): This rush species was found at both facilities, one place at the Main facility and several at the New River facility. The Main facility population is in the shallows along the S shore of the manmade pond 2 kilometers NE of the Main Gate. At the New River facility, it occurs at the Calcareous Fen natural community, at Big Pond, and scattered along limy spring branches in several places. It prefers perennially wet ground with a fresh supply of highly alkaline water. It matures very late in the season and is difficult to identify until then, so there could be other populations that went undetected. Water with a high pH seems to be the critical factor for this species.

MANAGEMENT RECOMMENDATIONS

General Recommendations

The primary threat to this community type and associated species is hydrologic. Any factor that would unnaturally raise or lower the water table would be detrimental. The site is probably best managed in concert with the surrounding grassland community with woody vegetation being controlled by mowing. The fen, however, would need less frequent mowing and should be done only late in the season during dry years when the ground is firm. However, if woody plants are not invading, then mowing is unnecessary since a dense thatch of herbaceous cover would naturally retard woody plant invasion. This community type in Virginia typically contains some shrubs and small trees, so some woody growth should not be viewed with alarm unless it threatens to close the community with a canopy cover. Currently, there are some shrub plantings that have been introduced and herbecide used around these plantings. It is recommended that these plantings be removed and that herbicide not be used in this area.

Rare Species and Community Recommendations

Inland Sedge (*Carex interior*), Schweinitz's Sedge (*Carex schweinitzii*), Prairie Straw Sedge (*Carex suberecta*), Rigid Sedge (*Carex tetanica*), and Small-headed Rush (*Juncus bracgycephalus*): All of these species are habitat dependent with the primary factor being the need for a continuous supply of fresh groundwater and drainage such that stagnant conditions do not develop. These species are sun-loving and would benefit from management that maintains openness and reduces invasion of woody plants. The general recommendations made above will provide for the promotion of these species.

TAXA LISTS

For a list of the animal taxa that may be associated with calcareous fens, see the fauna taxa lists under the Grassland Community type.

PLANTS

Family	Scientific Name	Common Name
Asteraceae	*Cirsium arvense*	Canada thistle
Asteraceae	*Rudbeckia fulgida*	brilliant coneflower
Cyperaceae	*Carex interior*	inland sedge
Cyperaceae	*Carex pellita*	wooly sedge
Cyperaceae	*Carex schweinitzii*	Schweinitz's sedge
Cyperaceae	*Carex stricta*	tussock sedge
Cyperaceae	*Carex suberecta*	prairie straw sedge
Cyperaceae	*Carex tetanica*	rigid sedge
Juncaceae	*Juncus brachycephalus*	Small-headed rush
Juncaceae	*Juncus dudleyi*	Dudley's rush
Orchidaceae	*Liparis loeselii*	Loesel's twayblade
Poaceae	*Muhlenbergia sylvatica*	woodland muhly

Community Type: Piedmont/Mountain Bottomland Forest

Acreage: Acres (Hectares) Total: 151 (61) Main: 151 (61) New River: N/A

Community Type Location Maps: Figure 1

Rare Species Site Maps for Flora: Figure 3

Rare Species Site Maps for Fauna: N/A

Sample Site Maps for Fauna: Figures 7, 9, 11, 13, and 15

Rare and Unique Species & Communities

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
Plants					
*Carex cherokeensis**	Cherokee sedge	N/A	N/A	N/A	N/A
Carex conjuncta	Soft fox sedge	G4G5	S3	N/A	Watchlist
Hasteola suaveolens	Sweet-scented Indian plantain	G3G4	S2	N/A	Rare List

* This is a new species to Virginia, therefore there is no state rank or status.

COMMUNITY DESCRIPTION

This community type occurs only at the Main facility along the New River and Stroubles Creek and is derived on alluvial deposits on floodplains, riverbanks, and creekbanks. Alluvium may be deep and well drained silt and sand or, closer to the stream level, rocky and seasonally wet. Floodplains vary from a few to many meters wide with the outer edge variously contoured from a high berm to being deeply channeled. The community typically has a mixed hardwood canopy and an open understory with a great diversity of herbaceous species. Character tree species are *Platanus occidentalis* and *Acer saccharinum* on the riverbank, and *Acer negundo*, *Prunus serotina*, *Celtis occidentalis*, *Ulmus rubra*, *Juglans nigra*, and occassionally *Carya cordiformis* on the floodplain. In one small area *Halesia carolina* grows, a species which is locally common but occurs only along the New River in Virginia. In Spring, *Poa trivialis* and *Senecio aureus* dominate the herb layer in some areas. By late in the season a rank weedy growth reaches head high or more with *Verbesina alternifolia* and *Laportea canadensis* being principal species. Characteristic herbs are *Bromus latiglumis*, *Chasmanthium latifolium*, *Cinna arundinacea*, *Elymus riparius*, *Elymus virginicus*, *Allium canadense*, *Urtica gracilis*, *Chaerophyllum procumbens*, *Stachys hispida*, and *Silphium perfoliatum* var. *connatum*.

This community type at the Arsenal has a relatively low diversity in the herbaceous flora and a great abundance of invasive exotics such as *Microstegium vimineum*, *Alliaria petiolata*, and *Cardamine hirsuta*. This is indicative of former disturbance and perhaps grazing. Aerial photos of the area prior to development show that the floodplain areas were almost entirely open farmland. Consequently, only small areas supported riparian forest and these would likely be subject to invasion of ruderal and alien species due to edge effects. Absence of many native bottomland species is evidence of the extremely limited extent of the community at an earlier time. Much of the bottomland is now in pine plantation or in various stages of old field and dominated by a few hardwood species that have seeded in from adjacent areas. Principal among these is *Acer negundo* which can almost totally dominate the canopy.

RARE SPECIES & COMMUNITY ACCOUNTS

Cherokee Sedge (*Carex cherokeensis*): As a new record for Virginia, this species is noteworthy, but may not warrant being on the rare plant list if its occurrence here is unnatural as would appear to be the case. Three clones 2-3 meters across were found at the Main facility in a shady flat just back of the top of the riverbank near gate 19-1. This plant is the only species in one section of what appears to be an old roadbed. The 1937 aerial photo shows this being the location of the state road that served the farm that previously occupied the Site. The rhizomes of this species vaguely show annual increments of persistent leaf bases. Comparing this with the size of the clones, it appears that the species has been growing here for quite a long time, perhaps several decades. How it got here originally can only be the subject of conjecture. The occurrence in Pulaski County, Virginia, is roughly 350 km from the next nearest location.

Soft Fox Sedge (*Carex conjuncta*): This sedge is a species of bottomland hardwood forests and was found only at one location along the New River. A single plant was found in wet ground a short distance back from the river shore in an area subject to flooding. This species occurs in widely scattered localities in Virginia, but this constitutes the first record for the New River drainage in Virginia. Although a thorough search for additional plants was not made, good quality habitat for this species is limited due to the farming history of the site and conversion to pine plantation.

Sweet-scented Indian Plantain (*Hasteola suaveolens*): A single patch of this species was found at the Main facility at the top of the floodplain levee opposite Whitethorne. The patch measured 10 meters long by 8 meters wide and consisted of 80-100 flowering stems on 26 August 1998. Despite this being a rare and localized native species, it grows in the midst of exotics here. It occurs in a small break in a canopy of Populus alba. Herbaceous associates on this date were limited almost entirely to three species: Microstegium vimineum, Verbesina alternifolia, and Eupatorium rugosum. The tall stature of Hasteola may be a significant factor in its ability to persist among other competitors. In the Spring, large basal leaves may give it an advantage over Alliaria and other early season exotics in this habitat.

MANAGEMENT RECOMMENDATIONS

General Recommendations

Bottomland hardwood forests have become a scarce community west of the Blue Ridge in Virginia. Because of the scarcity of this community type and the diversity it provides to the Arsenal's habitat types, we recommend the expansion and promotion of bottomland hardwood forests on the Arsenal. At present the existing bottomland forest is too small and narrow to achieve a representative and functional community. Much of the historical and potential habitat is either in pine plantation or open. It is recommended that the open areas and pine plantations be converted to bottomland hardwood forest. To achieve this, the following recommendations are provided.

The existing pine plantations are at an age that a harvest would be commercially beneficial. After harvest, these areas should be planted with bottomland hardwood species. This approach would initially cause the release of exotics that currently exists in the area. However, with plantings and controll of exotics, a natural bottomland hardwood community can be developed.

Open areas should be planted in bottomland hardwood species. Plantings will need to be managed until they are established and free from competition.

In areas where hardwoods are coming in naturally, a selective cut that removes pines is recommended. Hardwood plantings should be incorporated as well as a control program for invasive exotics.

In the existing bottomland hardwood forest, physical removal of invasive woody shrubs (e.g., barberry, honeysuckle, privet, etc.) is recommended. Currently, because the existing bottomland forest is narrow, light is able to penetrate deep into the forest and promote establishment of exotics. A subcanopy planting at the forest edge would help reduce the overabundance of light getting into the interior.

Lastly, the establishment of a bottomland hardwood forest will take both time and an aggressive campaign to both promote bottomland species and control invasive exotics. However, the outcome of this effort would be the establishment of a unique community type that adds to the diversity found at the Arsenal.

Rare Species and Community Recommendations

Cherokee Sedge (*Carex cherokeensis*): Current knowledge of this species is limited and we don't know what is needed or preferred by this species. However, the absence of flowering culms suggests the site is too shady. A light overstory reduction could be applied to see if this promotes flowering.

Soft Fox Sedge (*Carex conjuncta*): This species requires forested wetlands where flooding provides early season moisture. The existance of Claytor Lake dam has probably affected the normal flood regime in this area. Natural conditions will have to apply for the promotion of this species.

Sweet-scented Indian Plantain (*Hasteola suaveolens*): There appears to be an absence of new plants being recruited into the population. Like *Carex conjuncta*, the existence of Claytor Lake dam has probably affected the natural flood regime needed by these species. Both species require a natural disturbance to create the conditions these species like. Natural conditions will have to apply for the promotion of this species.

TAXA LISTS

PLANTS

Family	Scientific Name	Common Name
Aceraceae	*Acer negundo*	boxelder
Aceraceae	*Acer saccharinum*	sugar maple
Asteraceae	*Hasteola suaveolens*	sweet-scented Indian plantain
Asteraceae	*Senecio aureus*	golden ragwort
Asteraceae	*Silphium perfoliatum var. connatum*	cup-plant
Asteraceae	*Verbesina alternifolia*	wingstem
Brassicaceae	*Alliaria petiolata*	garlic mustard
Brassicaceae	*Cardamine hirsuta*	hairy bittercrest
Cyperaceae	*Carex cherokeensis*	Cherokee sedge
Cyperaceae	*Carex conjuncta*	soft fox sedge
Juglandaceae	*Carya cordiformis*	bitternut hickory
Juglandaceae	*Juglans nigra*	black walnut
Lamiaceae	*Stachys hispida*	bristly hedgenettle
Liliaceae	*Allium canadense*	meadow garlic
Platanaceae	*Platanus occidentalis*	sycamore
Poaceae	*Bromus latiglumis*	broad-glumed brome grass
Poaceae	*Chasmanthium latifolium*	river-oats
Poaceae	*Cinna arundinacea*	wood reedgrass
Poaceae	*Elymus riparius*	river wild rye
Poaceae	*Elymus virginicus*	Virginia wild rye
Poaceae	*Microstegium vimineum*	eulalia
Poaceae	*Poa trivialis*	rough bluegrass
Rosaceae	*Prunus serotina*	black cherry
Styracaceae	*Halesia carolina*	silverbell
Ulmaceae	*Celtis occidentalis*	hackberry
Ulmaceae	*Ulmus rubra*	slippery elm
Umbelliferae	*Chaerophyllum procumbens*	spreading chervil
Urticaceae	*Laportea canadensis*	wood nettle
Urticaceae	*Urtica gracilis*	stinging nettle

INVERTEBRATES

Class: Arachnida

Order: Araneae

Family	Scientific Name	Common Name
Araneidae	*sp.*	
Clubionidae	*Clubiona obesa*	

Clubionidae	*sp.*	
Dictynidae	*Dictyna sublata*	
Linyphiidae	*Nereine variabilis*	
Philodromidae	*Philodromus minutus*	
Philodromidae	*Philodromus rufus*	
Pisauridae	*Dolomedes sp.*	
Salticidae	*Eris marginata*	
Salticidae	*Hentzia mitrata*	
Salticidae	*Phidippus whitmanii*	
Salticidae	*sp.*	
Salticidae	*Thiodina sylvana*	
Tetragnathidae	*Pachygnatha autumnalis*	
Tetragnathidae	*Pachynatha furcillata*	
Tetragnathidae	*Tetragnatha elongata*	
Tetragnathidae	*Tetragnatha laborisoa*	
Tetragnathidae	*Tetragnatha straminea*	
Tetragnathidae	*Tetragnatha versicolor*	
Thomisidae	*Misumenops sp.*	

Class: Bivalvia
Order: Unionoida

Family	Scientific Name	**Common Name**
Unionidae	*Cyclonaias tuberculata*	Purple wartyback
Unionidae	*Eliptio dilitata*	Spike
Unionidae	*Lampsilis fasciola*	Wavy ray lampmussel
Unionidae	*Lampsilis ovata*	Pocketbook
Unionidae	*Lasmigona subviridis*	Green floater
Unionidae	*Tritigonia verrucossa*	Pistol grip

Class: Bivalvia
Order: Veneroida

Family	Scientific Name	**Common Name**
Corbiculidae	*Corbicula fluminea*	Asian clam

Class: Gastropoda
Order: Architaenioglossa

Family	*Scientific Name*	**Common Name**
Vivaparidae	*Campeloma decisum*	Aquatic snail

Class: Gastropoda

Order: Basommatophora

Family	*Scientific Name*	Common Name
Ancylidae	*Ferrissia rivularis*	Aquatic snail
Planorbidae	*Helisoma anceps*	Aquatic snail
Physidae	*Physella gyrina*	Aquatic snail

Class: Gastropoda
Order: Neotaenioglossa

Family	*Scientific Name*	Common Name
Pleuroceridae	*Leptoxis dilatata*	Aquatic snail

Class: Insecta
Order: Coleoptera

Family	Scientific Name	Common Name
Carabidae	*Chlaenius nemoralis*	ground beetle
Carabidae	*Clivina bipustulata*	ground beetle

Class: Insecta
Order: Diptera

Family	Scientific Name	Common Name
Anthomyiidae	*sp.*	anthomyiid fly
Asilidae	*sp.*	robber fly
Blephariceridae	*sp.*	net-winged midge
Curtonotidae	*sp.*	curtonotid fly
Lauxaniidae	*sp.*	lauxaniid fly
Muscidae	*sp.*	muscid fly
Rhagionidae	*sp.*	snipe fly
Scathophagidae	*sp.*	scathophagid fly
Sepsidae	*sp.*	scavenger fly
Tephritidae	*sp.*	fruit fly
Xylophagidae	*sp.*	xylophagid fly

Class: Insecta
Order: Heteroptera

Family	Scientific Name	Common Name
Psyllidae	*sp.*	stink bug

Class: Insecta

Order: Hymenoptera

Family	Scientific Name	Common Name
Pergidae	*sp.*	pergid sawfly
Sphecidae	*sp.*	sphecid wasp

Class: Insecta

Order: Lepidoptera

Family	Scientific Name	Common Name
Arctiidae	*Halysidota tessellaris*	banded tussock moth
Geometridae	*Biston betularia cognataria*	pepper-and-salt geometer
Geometridae	*Campaea perlata*	pale beauty
Geometridae	*Euchlaena amoenaria*	deep yellow euchlaena
Geometridae	*Eulithis diversilineatat*	lesser grapevine looper moth
Geometridae	*Heliomata cycladata*	common spring moth
Geometridae	*Lambdina pellucidaria*	yellow-headed looper moth
Geometridae	*Pobole sp.*	
Geometridae	*Semiothisa promiscuata*	promiscuous angle
Hesperidae	*Ancyloxypha numitor*	least skipper
Hesperidae	*Atalopedes campestris*	sachem
Hesperidae	*Epargyreus clarus*	silver-spotted skipper
Hesperidae	*Lerema accius*	clouded skipper
Hesperidae	*Panaquina ocola*	ocola skipper
Limacodidae	*Packardia geminata*	slug caterpillar moth
Lycaenidae	*Celastrina l. ladon "neglecta"*	summer azure
Lycaenidae	*Celastrina l. ladon "violocea"*	spring azure
Lycaenidae	*Everes comyntas*	eastern tailed blue
Noctuidae	*Lacinipolia renigera*	bristly cutworm moth
Noctuidae	*Mocis texana*	Texas mocis
Noctuidae	*Orthodes cynica*	cynical quaker
Noctuidae	*Xestia bicarnea*	pink-spotted dart
Noctuidae	*Xestia dolosa*	greater black-letter dart
Noctuidae	*Zale galbanata*	maple zale
Noctuidae	*Zale metatoides*	washed-out zale
Nymphalidae	*Asterocampa c. celtis*	hackberry emperor
Nymphalidae	*Asterocampa c. clyton*	tawny emperor
Nymphalidae	*Cercyonis pegala*	common wood nymph
Nymphalidae	*Chlosyne nycteis*	silvery checkerspot
Nymphalidae	*Danaus plexippus*	monarch
Nymphalidae	*Enodia anthedon*	northern pearly eye
Nymphalidae	*Limenitis arthemis astyanax*	red-spotted purple
Nymphalidae	*Megisto cymela*	little wood satyr
Nymphalidae	*Phyciodes tharos*	pearl crescent
Nymphalidae	*Polygonia comma*	eastern comma

Nymphalidae	*Polygonia interrogationis*	question mark
Nymphalidae	*Speyeria aphrodite*	aphrodite fritillary
Nymphalidae	*Speyeria cybele*	great spangled fritillary
Nymphalidae	*Vanessa atalanta*	red admiral
Papilionidae	*Battus philenor*	pipevine swallowtail
Papilionidae	*Papilio glaucus*	eastern tiger swallowtail
Pieridae	*Colias eurytheme*	orange sulfer
Pieridae	*Colias philodice*	clouded sulfer
Pieridae	*Phoebis sennae*	cloudless sulpher
Pieridae	*Pieris rapae*	cabage white
Pyralidae	*Desmia funeralis*	grape leaffolder moth
Saturniidae	*Dryocampa rubicunda*	rosy maple moth
Sphingidae	*Ceratomia catalpae*	catalpa sphinx
Tortricidae	*sp.*	tortricid moth
Yponomeutidae	*Atteva punctella*	ailanthus webworm moth

Class: Insecta
Order: Thysanoptera

Specimen not identified beyond Order.

Class: Malacostraca
Order: Decapoda

Family	Species	Common Name
Cambaridae	*Cambarus sciotensis*	
Cambaridae	*Orconectes chasmodactylus*	New River cray fish
Cambaridae	*Orconectes virilis*	virile crayfish

FISH

Family	Species	Common Name
Catastomidae	*Catostomus commersoni*	white sucker
Catastomidae	*Hypentelium nigricans*	northern hogsucker
Centrarchidae	*Ambloplites rupestris*	rock bass
Centrarchidae	*Lepomis auritus*	redbreast sunfish
Centrarchidae	*Lepomis macrochirus*	bluegill
Centrarchidae	*Micropterus dolomieui*	smallmouth bass
Centrarchidae	*Micropterus punctulatus*	spotted bass
Centrarchidae	*Micropterus salmoides*	largemouth bass
Cottidae	*Cottus bairdi*	mottled sculpin
Cyprinidae	*Campostoma anomalum*	central stoneroller
Cyprinidae	*Climostomus funduloides*	rosyside dace
Cyprinidae	*Cyprinella galactura*	whitetail shiner
Cyprinidae	*Luxilus albeolus*	white shiner

Cyprinidae	*Nocomis leptocephalus*	bluehead chub
Cyprinidae	*Nocomis micropogon*	river chub
Cyprinidae	*Nocomis platyrhychus*	bigmouth chub
Cyprinidae	*Notropis hudsonius*	spottail shiner
Cyprinidae	*Notropis telescopus*	telescope shiner
Cyprinidae	*Pimephales notatus*	bluntnose minnow
Cyprinidae	*Rhinichthys atratulus*	blacknose dace
Esocidae	*Esox masquinongy*	muskellunge
Ictaluridae	*Noturus insignis*	margined madtom
Ictaluridae	*Pylodictis olivaris*	flathead catfish
Percichthyidae	*Morone sp.*	bass
Percidae	*Etheostoma blennioides*	greenside darter
Percidae	*Etheostoma flabellare*	fantail darter
Percidae	*Perca flavescens*	yellow perch
Percidae	*Percina caprodes*	logperch
Percidae	*Percina gymnocephala*	Appalachia darter
Percidae	*Percina roanoka*	Roanoke darter

Reptiles and Amphibians

Family	Scientific Name	Common Name
Bufonidae	*Bufo americanus*	American toad
Chelydridae	*Chelydra serpentina*	snapping turtle
Colubridae	*Nerodia sipedon*	northern water snake
Colubridae	*Regina septemvittata*	queen snake
Emydidae	*Pseudemys concinna concinna*	eastern river cooter
Plethodontidae	*Eurycea cirrigera*	southern two-lined salamander
Plethodontidae	*Desmognathus fuscus*	northern dusky salamander
Plethodontidae	*Desmognathus quadramaculatus*	backbelly salamander

Birds: Status code definitions; B = breeding, M = migrant, R = resident, U = undetermined, and W = winter.

Family	Scientific name	Species	Status
Accipitridae	*Accipiter striatus*	sharp-shinned hawk	B
Alcedinidae	*Ceryle alcyon*	belted kingfisher	R
Anatidae	*Aix sponsa*	wood duck	B
Anatidae	*Anas acuta*	northern pintail	W
Anatidae	*Anas americana*	American wigeon	W
Anatidae	*Anas platyrhynchos*	mallard duck	R
Anatidae	*Anas rubripes*	American black duck	R, M
Anatidae	*Anas strepera*	gadwall	W
Anatidae	*Branta canadensis*	Canada goose	R, M
Anatidae	*Bucephala albeola*	bufflehead	W
Anatidae	*Lophodytes cucullatus*	hooded merganser	W

Ardeidae	*Ardea herodias*	great blue heron	R
Ardeidae	*Casmerodius albus*	great egret	M
Charadriidae	*Charadrius vociferus*	killdeer	R
Columbidae	*Zenaida macroura*	mourning dove	R
Columbidae	*Columba livia*	rock dove	R
Corvidae	*Corvus brachyrhynchos*	American crow	R
Corvidae	*Cyanocitta cristata*	blue jay	R
Cuculidae	*Coccyzus americanus*	yellow-billed cuckoo	B
Cuculidae	*Coccyzus erythropthalmus*	black-billed cuckoo	B
Emberizidae	*Cardinalis cardinalis*	northern cardinal	R
Emberizidae	*Dendroica donimica*	yellow-throated warbler	B
Emberizidae	*Dendroica palmarum*	palm warbler	M
Emberizidae	*Dendroica petechia*	yellow warbler	B
Emberizidae	*Dendroica striata*	blackpoll warbler	M
Emberizidae	*Geothlypis trichas*	common yellowthroat	B
Emberizidae	*Icterus galbula*	northern oriole	B
Emberizidae	*Icterus spurius*	orchard oriole	B
Emberizidae	*Melospiza melodia*	song sparrow	R
Emberizidae	*Molothrus ater*	brown-headed cowbird	B
Emberizidae	*Parula americana*	northern parula	B
Emberizidae	*Passerina cyanea*	indigo bunting	B
Emberizidae	*Pipilo erythrophthalmus*	eastern towhee	B
Emberizidae	*Piranga olivacea*	scarlet tanager	B
Emberizidae	*Quiscalus quiscula*	common grackle	B
Emberizidae	*Seiurus motacilla*	Louisana waterthrush	B
Emberizidae	*Setophaga ruticilla*	American redstart	B
Fringillidae	*Carduelis tristis*	American goldfinch	R
Hirundinidae	*Hirundo rustica*	barn swallow	B
Hirundinidae	*Stelgidopteryx serripennis*	rough-winged swallow	B
Hirundinidae	*Tachycineta bicolor*	tree swallow	B
Laridae	*Larus delawarensis*	ring-billed gull	M
Muscicapidae	*Polioptila caerulea*	blue-gray gnatcatcher	B
Paridae	*Parus bicolor*	tufted titmouse	R
Paridae	*Parus carolinensis*	Carolina chickadee	R
Phalacrocoracidae	*Phalacrocorax auritus*	double-crested cormorant	M
Phasianidae	*Meleagris gallopavo*	wild turkey	R
Picidae	*Colaptes auratus*	northern flicker	R
Picidae	*Dryocopus pileatus*	pileated woodpecker	R
Picidae	*Picoides pubescens*	downy woodpecker	R
Picidae	*Picoides villosus*	hairy woodpecker	R
Podicipedidae	*Podilymbus podiceps*	pied-billed grebe	W
Rallidae	*Fulica americana*	American coot	W
Scolopacidae	*Actitis macularia*	spotted sandpiper	B
Troglodytidae	*Thryothorus ludovicianus*	carolina wren	B
Tyrannidae	*Contopus virens*	eastern pewee	B

Tyrannidae	*Empidonax virescens*	acadian flycatcher	B
Tyrannidae	*Sayornis phoebe*	eastern phoebe	B
Tyrannidae	*Tyrannus tyrannus*	eastern kingbird	B
Vireonidae	*Vireo gilvus*	warbling vireo	B
Vireonidae	*Vireo olivaceus*	red-eyed vireo	B

MAMMALS

Family	**Scientific Name**	**Common Name**
Cervidae	*Odocoileus virginianus*	white-tailed deer
Diedelphidae	*Didelphis virginiana*	Virginia opossum
Soricidae	*Blarina brevicauda*	northern short-tailed shrew
Soricidae	*Cryptotis parva*	least shrew
Mephitidae	*Mephitis mephitis*	striped skunk
Muridae	*Peromyscus leucopus*	white-footed mouse
Procyonidae	*Procyon lotor*	common raccoon
Sciuridae	*Marmota monax*	woodchuck
Sciuridae	*Sciurus carolinensis*	eastern gray squirrel
Sciuridae	*Sciurus niger*	eastern fox squirrel
Sciuridae	*Tamias striatus*	eastern chipmunk

Community Type: Sand/Gravel/Mud Bar & Shore

Acreage: Acreage to small to calculate. Only located at the Main facility.

Community Type Location Maps: Figure 1

Rare Species Site Maps for Flora: Figure 3

Rare Species Site Maps for Fauna: N/A

Sample Site Maps for Fauna: N/A

Rare and Unique Species & Communities

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
Plants					
Sagittaria rigida	Sessile-fruited arrowhead	G5	S1	N/A	Rare List
*Eleocharis intermedia**	Matted spikerush	G5	S1	N/A	Rare List

* Not found on Arsenal property along the New River, but may occur there some years as it was found nearby in this habitat.

COMMUNITY DESCRIPTION

This open shoreline habitat occurs only along the New River at the Main facility. The substrate is predominantly coarse to fine-grained alluvium although small bedrock exposures may be present. These habitats are occasionally exposed to intermittently flooded, but late season drawdown produces a diagnostic annual, herb-dominated flora within the river channel on newly exposed substrates. The community is a dynamic one in which flooding disturbs and shifts sediment and scours vegetation with enough frequency to maintain an open successional disclimax. Trees and shrubs are sparse to entirely absent. One distinctive subtype of this community is the waterwillow bar in which waterwillow, *Justicia americana*, occurs almost exclusively as an emergent species in shallows with a substrate of coarse gravel. A few other species such as *Schoenoplectus pungens* and *Schoenoplectus validus* are sparse but typical associates. Characteristic herbs of the drawdown flora are *Echinochloa muricata*, *Eragrostis frankii*, *Eragrostis hypnoides*, *Panicum capillare*, *Cyperus bipartitus*, *Cyperus esculentus*, *Cyperus flavescens*, *Cyperus tenuifolius*, *Eleocharis obtusa*, *Polygonum hydropiper*, *Gratiola neglecta*, *Mollugo verticillata*, *Chenopodium ambrosioides*, and *Rorippa sylvestris*.

Note: The disturbance and openness of this habitat lends it to invasion by weedy species, native and exotic. Typical native weeds include *Panicum dichotomiflorum*, *Solanum carolinense*, and *Datura stamonium*. Invasive exotics include *Arthraxon hispidus*, *Digitaria ischaemum*, *Microstegium vimineum*, *Murdannia keisak*, *Polygonum caespitosum*, and *Euphorbia maculata*.

RARE SPECIES & COMMUNITY ACCOUNTS

Sessile-fruited Arrowhead (*Sagittaria rigida*): A single small population was found on the shore of New River very close to the downstream end of the Arsenal property. Only a few plants flowered but none set seed. Several visits to the station revealed that plants had been uprooted by the turbulence of rising water released from Claytor Lake Dam. Plants were observed lying flat nearly uprooted but readily resprouting from small roots still lodged in the silt/sand substrate. This population is a range extension southward from Augusta County, Virginia. The failure to set seed may indicate the population may have grown vegetatively from a single individual. A second population was found about 14-15 km upstream (off Arsenal property) where the same phenomenon was observed.

Matted Spikerush (*Eleocharis intermedia*): Many hundreds of plants of this spikerush were found in the small manmade pond at the Main facility about 2 km NE of the Main Gate. In 1997 the pond dried out completely and this species nearly carpeted the normally shallow water section along the S and SE shore. In 1998, despite extreme drought, many fewer plants were evident. The only fruiting plants occupied a small delta of the feeding stream. Non-flowering emergent plants occupied a narrow zone to several inches water depth, but many fewer than in 1997. A few plants occurred in muddy places along the stream just above the pond.

MANAGEMENT RECOMMENDATIONS

General Recommendations

This community is self-maintaining as long as the river is free flowing and floods occassionally. No management recommendations are proposed.

Rare Species and Community Recommendations

No management recommendations are proposed.

TAXA LISTS

For a list of the animal species that may be associated with Sand/Gravel/Mud Bar & Shore habitat, see the fauna taxa lists under the Piedmont/Mountain Bottomland Forest Community type.

PLANTS

Family	Scientific Name	Common Name
Acanthaceae	*Justicia americana*	water willow
Aizoaceae	*Mollugo verticillata*	carpetweed
Alismataceae	*Sagittaria rigida*	sessile-fruited arrowhead
Brassicaceae	*Rorippa sylvestris*	creeping yellow cress
Chenopodiaceae	*Chenopodium ambrosioides*	Mexican tea
Commelinaceae	*Murdannia keisak*	marsh dewflower
Cyperaceae	*Cyperus bipartitus*	A flatsedge
Cyperaceae	*Cyperus esculentus*	yellow nut sedge
Cyperaceae	*Cyperus flavescens*	yellow flatsedge
Cyperaceae	*Cyperus tenuifolius*	
Cyperaceae	*Eleocharis intermedia*	matted spikerush
Cyperaceae	*Eleocharis obtusa*	blunt spikerush
Cyperaceae	*Schoenoplectus pungens*	common threesquare
Cyperaceae	*Schoenoplectus validus*	soft-stem bullrush
Euphorbiaceae	*Euphorbia maculata.*	spotted spurge
Poaceae	*Arthraxon hispidus*	joint-head arthraxon
Poaceae	*Digitaria ischaemum*	smooth crabgrass
Poaceae	*Echinochloa muricata*	rough barnyard grass
Poaceae	*Eragrostis frankii*	Frank's lovegrass
Poaceae	*Eragrostis hypnoides*	creeping lovegrass
Poaceae	*Microstegium vimineum*	eulalia
Poaceae	*Panicum capillare*	witch grass
Poaceae	*Panicum dichotomiflorum*	fall witch grass
Polygonaceae	*Polygonum caespitosum*	long-bristled smartweed
Polygonaceae	*Polygonum hydropiper*	common smartweed
Scrophulariaceae	*Gratiola neglecta*	clammy hedge-hyssop
Solanaceae	*Datura stamonium*	jimson weed
Solanaceae	*Solanum carolinense*	horse nettle

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ARTIFICIAL COMMUNITIES

Grassland
Successional Woodland/Forest
Pine Plantation
Wet Meadow/Marsh and Ponds

Community Type: Grassland

Acreage: Acres (Hectares) Total: 4,379 (1,173) Main: 2,500 (1012) New River: 1,879 (761)

Community Type Location Maps: Figure 1 and Figure 2

Rare Species Site Maps for Flora: Figure 3 and Figure 4

Rare Species Site Maps for Fauna: Figure 5 and Figure 6

Sample Site Maps for Fauna: Figures 7 through 16

Rare and Unique Species & Communities

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
Community Type					
N/A	Calcareous Fen	N/A	N/A	N/A	N/A
Plants:					
Carex mesochorea	Midland Sedge	G4G5	SU	N/A	Watchlist
Onosmodium hispidissimum	Shaggy False Gromwell			N/A	Watchlist
Invertebrates:					
Speyeria idalia	Regal Fritillary	G3	S1	N/A	ST
Birds:					
Ammodramus henslowii	Henslow's Sparrow	G4	S1	N/A	ST
Lanius ludovicianus	Loggerhead Shrike	G5	S2	N/A	ST

COMMUNITY DESCRIPTION

The grassland community is an aggregation of several community types that are so intermingled delineation is impractical. Grassland may conveniently be subdivided into old field, meadow, and cultivated field. The term old field is used here to denote areas that were formerly open and subsequently abandoned but are still open. In most cases these areas were formerly pasture or hayfield. Trees or shrubs may be present individually or in small groups, but a canopy is lacking. Where shrub invasion has progressed to form larger patches, a shrubland subtype is recognizable. Old fields, in most cases, are dominated by native, warm-season species with a wide variety of other grasses, sedges, and herbs mixed in. The two dominants are little bluestem, *Schizachyrium scoparium*, and broomsedge, *Andropogon virginicus*, with others such as *Tridens flavus*, *Panicum oligosanthes*, *Panicum anceps*, *Eragrostis spectabilis*, *Setaria* *glauca*, *Sorghastrum nutans*, and *Paspalum* being frequent. Much of the old field community is mowed infrequently to help keep woody plants in check.

Meadows are areas that are mowed regularly and, in most cases, have been planted in forage grasses for haying. These are typically non-native, cool-season species such as *Festuca elatior*, *Poa pratensis*, *Phleum pratense*, *Agrostis gigantea*, *Bromus inermis*, *Dactylis glomerata*, and *Arrhenatherum elatius*. These species may also be mixed with native species characteristic of old fields.

Cultivated fields are areas that have been plowed and seeded with various cover crops. These areas have a major ruderal component that persists after abandonment. Principal weed species are *Cirsium arvense*, *Carduus acanthoides*, *Carduus nutans*, *Erechtites hieracifolia*, *Hypochaeris radicata*, *Verbascum thapsus*, *Hieracium pilosella*, *Datura stramonium*, etc.

Past history of various segments of the grassland community greatly influences the composition of species occupying them today. This has created a blending of features and a complex mosaic. Being artificial communities, it is reasonable to consider this a large variable community type.

RARE SPECIES & COMMUNITY ACCOUNTS

Calcareous Fen: This is a unique natural community that is addressed separately in this report. This community type is recognized under the grassland community type because it is surrounded by grassland habitat and management in this area may affect the fen. Specific management recommendations for the fen and surrounding area are made under the community type, Calcareous Fen (page 24).

Midland Sedge (*Carex mesochorea*): The midland sedge is found only at the New River facility at widely separate locations. It occurs in grassland areas dominated by little bluestem (*Schizachyrium scoparium*) with a mixture of other grasses, sedges, and forbs. Although mapped at only two locations, the habitat is abundant and certainly the species exists elsewhere.

Shaggy False Gromwell (*Onosmodium hispidissimum*): Shaggy false gromwell is scattered in old fields at the Dublin Site where it occurs with sufficient frequency that mapping it was deemed impractical. The preferred habitat of this species is dry, open, grassy limestone hills, especially in the vicinity of bedrock outcrops. This habitat occurs in abundance at Dublin. The species occurs as scattered individuals or in small groups in areas that have not been seeded in cool season grasses and converted to hay meadow.

Regal Fritillary (*Speyeria idalia*): This is a large "brushfoot" butterfly belonging to the Nymphalidae family. The genus *Speyeria* refers to the "silver fritillaries" identified by silver spots on the underside of the hindwings. The regal fritillary is a rare butterfly that is declining in much of its range. The characteristic habitat of this species is tall-grass prairies and other open sites including damp meadows, marshes, wet fields, and mountain pastures.

Females have one brood per year between mid-June and mid-August. Females walk through vegetation and lay single eggs on various plants, usually near violets (bird's foot violet, *Viola pedata,* the host plant for the caterpillar). The caterpillars hatch in the fall (first-instar) and overwinter without feeding. In the spring they complete their development, feeding on the leaves of the host plant. Adults are often found at flowers, especially milkweeds, mints, and thistles.

Regal fritillaries were found at both the New River and Main facilities. A single population of approximately 20 individuals was observed at the Main facility (Figure 5). At the New River facility, two populations were observed with 4 and 6individuals Observed. In addition, regal fritillaries were observed at two other locations on the New River facility (Figure 6). The Arsenal appears to support the only remaining breeding sites for regal fritillaries in Virginia (Steve Roble, pers. comm.).

Henslow's Sparrow (*Ammodramus henslowii*): The Henslow's sparrow belongs to the Emberizidae family in the perching order, Passeriformes. This is a shy, secretive sparrow that is more frequently identified by song than by sight. It is not considered common anywhere within its range, with the exception of very localized colonies. This species is considered declining throughout its range due to loss and degredation of habitat

Henslow's sparrows were observed only at the New River facility. Due to their rare status we spent additional time delineating the areas utilized by these. Four colonies representing approximately 16 males were delineated at the New River site (Figure # 6). These sites are close to each other and were determined by mapping interactions between singing males.

Loggerhead Shrike (*Lanius ludovicianus*): The loggerhead shrike belongs to the shrike family (Lanidae) in the order of perching birds, Passeriformes. The loggerhead shrike is a rare bird that is declining in the eastern United States. In Virginia the shrike is estimated to be declining at a rate of 10% per year. The characteristic habitat of this species includes pasture, savannah, and open brushland.

While we did not observe loggerhead shrikes during this survey period, loggerhead shrikes have been observed at the New River facility on several other occasions (Clyde Kessler and Betsy Stinson, pers. comm.).

MANAGEMENT RECOMMENDATIONS

General Grassland Habitat Management

With over 4,000 acres of grassland habitat, management for a variety of grassland species can be achieved. Initial emphasis should be placed on rare species management in areas where they occur. Specific management recommendations for rare species are listed below in the section Rare Species and Community Management.

The following grassland management recommendations emphasize bird species for several reasons. First, grassland bird species have demonstrated some of the greatest population declines among migratory birds. Second, there is little previous work that provides grassland management guidelines for other taxa. Third, management for grassland birds should provide appropriate habitat for other grassland associated taxa.

Several factors influence grassland bird diversity and populations including habitat fragmentation, vegetative composition, vegetative density, and vegetative height. Short grass monocultures (e.g. fescue) provide poor habitat and are not extensively used by grassland species. Heterogeneous fields of warm and cool season grasses provide a mix of vegetation height and density. In addition, a moderate to low percentage of forbs, mixed with the grasses, is preferred by most grassland birds. With the abundance of grassland habitat at each plant, management areas can be created in which vegetation height and density is configured for different grassland birds. Species that prefer short, sparse vegetation include killdeer, vesper sparrow, upland sandpiper, mourning dove, and horned lark. Species that prefer intermediate vegetation height and density include Northern bobwhite, savannah sparrow, Eastern meadowlark, grasshopper sparrow, field sparrow, and song sparrow. Species preferring tall, dense vegetation include red-winged blackbird, common yellowthroat, bobolink, Henslow's sparrow and sedge wren.

In general, we recommend the conversion of cool season grasses (K-31 fescue) back to native grasses and forbs. This effort would entail the killing of fescue through herbicides and possibly fire. Seeding with native grasses and forbs would follow. The native plants can and do provide adequate forage for both livestock and native wildlife.

Management units should be large, preferably more than 250 acres in area. Maintenance options for grassland habitats include periodic fire, grazing or mowing. Because of the explosive nature of the materials manufactured and stored at RAAP, mowing and grazing have historically been used to retain open habitat. However, use of prescribed fire may be a good option in some areas.

Fire can be utilized as an effective and often preferred method for managing grasslands. Fire should be applied in early spring (March to early April) or late fall (October and November). Management units should be burned on a rotational schedule with 20-30% of the area burned annually. Where grasslands border forest edge, allow the fire to burn into the edge. This will help to establish and maintain a "soft edge" between grassland and forest. Research has indicated that "sharp edges" have a higher nest predation rate than "soft edges."

Grazing, if properly controlled, can be an appropriate management tool. Depending on the species that is being managed for, grazing intensity and rotation can be varied. The most desirable grazing practice would be to keep grazing pressure light and use a rotation system where some sections are grazed and others are left idle. For example, an area could be divided into thirds, with the three subunits receiving light, moderate, and no grazing regimes on an annual rotation pattern.

Currently, mowing and haying are being used to control vegetation at both facilities. Management of these practices can provide and enhance habitat for grassland birds. There is a wide range of nesting dates for migratory and non-migratory grassland birds. In addition, several species can have multiple broods through the spring, summer and into the fall. However, most birds will be nesting and raising young from early April through late July and early August. With this in mind, mowing and haying of non-essential areas should be postponed until mid-August. This will allow nesting birds the opportunity to rear at least one and potentially two broods. Mowing and haying should be managed on a rotational basis (see recommendations under Henslow's sparrow, page 49).

In addition to the above practices, the VDGIF establishes and manages food plots for wildlife in cooperation with RAAP. While this is an appropriate management tool for grassland species and should continue, it should be done with caution. First, food plots will allow invasion of non-native plants and increase competition with native species. Second, placement of new food plots should avoid the locations of breeding Henslow's sparrow and regal fritillary sites until the effects of these practices can be evaluated. If food plots are utilized by either Henslow's sparrow or regal frillary, then management should be geared to the life history needs of these species. It is recommended that food plots be limited to the meadows and cultivated fields that have been historically disturbed and are dominated by non-native plants. The establishment of food plots should be done on a limited basis and management rotated through established plots in lieu of creating new ones. In addition, food plots should emphasize establishing native grasses and forbs. The GIS maps will provide a valuable tool for managers to locate food plots and describe management areas.

In areas where the grassland adjoins forest, a "soft edge" should be created. To create a soft edge, a 60 to 100 foot buffer should be established. Within the first 30 to50 feet of the edge, 75% of the trees should be removed. Within the next 30 to 50 feet, 50% of the trees should be removed to provide a gradual succession from grassland to forest.

Lastly, the use of broadcast herbicides and pesticides should be conducted on a limited basis and with the purpose of promoting native plants and wildlife. The thistle eradication program should be reviewed and limited to exotic thistles using spot treatment of individual plants. Thistles are an important nectar source for regal fritillaries and food source for grassland birds.

Rare Species and Community Management

Midland Sedge (*Carex mesochorea*): Management should include additional surveys to identify the overall distribution and locate areas supporting *Carex mesochorea*. Little is known of the management requirements for this plant and the general recommendations for grassland management are considered sufficient to maintain this species. However, food plots should be avoided in areas supporting *Carex mesochorea*.

Shaggy False Gromwell (*Onosmodium hispidissimum*): Current grassland management is sufficient for the maintenance of this species. No additional management is needed.

Regal Fritillary (*Speyeria idalia*): Management for regal fritillaries will require maintenance of grassland habitat that includes bird's foot violet, milkweeds, mints, and thistle. Field surveys should be conducted between June and July to determine the areas utilized by regal fritillaries. No vegetation removal should be conducted in these areas until after the brood season (late August). No broadcast herbicides or pesticides should be applied in these areas at any time.

Management for regal fritillaries should follow that described for Henslow's sparrow (see below). Mowing must be light, not conducted during the brood season, and based on a rotational schedule with the purpose of controlling woody vegetation. It is recommended that management areas be established with the existing known areas as the core area for the management units. An additional area equaling 20-30% of the core management unit should be managed around each core area. This will hopefully allow expansion of the populations.

Henslow's Sparrow (*Ammodramus henslowii*): Henslow's sparrow habitat is comprised of tall dense vegetation with little to no woody vegetation. In addition, these birds are sensitive to disturbance and will abandon nesting areas when disturbed. This was evident in both the 1997 and 1998 field seasons when singing males were displaced due to haying in June and July.

Maintenance of tall dense grassland habitat will be essential for maintaining Henslow's sparrow populations. Mowing, grazing or fire can be utilized to maintain and promote grassland habitat. It is recommended that field surveys be conducted in the spring (late April, May, and June) to determine areas where Henslow's sparrows will be breeding. Removal of vegetation in these areas should not commence until after the breeding season, mid to late August.

Fire and light grazing have limited benefit for Henslow's sparrow. While Henslow's sparrow has been documented using lightly grazed pastures, the species is generally not associated with grazed areas. Fire can be used as a management tool for Henslow's sparrow, but mixed results have been reported. Several authors have reported Henslow's sparrow not utilizing fields that have been burned in the spring. However, in North Carolina, two pocosin sites were utilized the following year after burning (the exact time of burn was not reported). If burning is used as a management tool, management areas should be established where only 20-30% of the area is burned per year on a rotational basis. Burn areas should be evaluated for Henslow's sparrow use before additional burning is prescribed.

Mowing appears to be the best management tool for maintaining grassland habitats for Henslow's sparrow. However, it has been noted that recently mowed areas are avoided like recently burned areas. Mowing must be light, not conducted during the nesting season, and based on a rotational schedule with the purpose of controlling woody vegetation. It is recommended that management areas be established with the existing known colonies as the core area for the management units. An additional area equaling 20-30% of the core management unit should be managed around each core area for Henslow's sparrows. This will hopefully allow expansion of the populations.

Management of these areas should include a rotational mowing schedule of 20-30% of the area per year in late August. This will allow sufficient time for the birds to raise their first brood undisturbed. In addition, this will leave enough time for regrowth to provide standing dead vegetation the following spring. If possible "sloppy mowing" (leaving patches of unmowed vegetation) or contour mowing (mowing in strips) should occur. Some success has been documented where patches in fields are left undisturbed.

Loggerhead Shrike (*Lanius ludovicianus*): Unlike the Henslow's sparrow, the loggerhead shrike requires short grass with trees and shrubs for nest placement and hunting perches. Luukkonen found that pastures with eastern red cedar or hawthorn provided the most important nesting habitat for Virginia shrikes. In addition, Luukkonen found that shrikes were twice as productive in grazed grasslands than in other habitats. This corresponds to the areas where shrikes have been observed at the New River facility. All observations have occurred in the eastern section of the facility outside the fenced area where cattle grazing occurs.

A behavioral characteristic of the loggerhead shrike is the impaling of prey on barbed wire or thorny bushes and trees. This behavior has resulted in the shrike being nicknamed the "butcher bird." The loss of barbed wire, thorny trees, and shrubs has been suggested as a reason for shrikes abandoning or not utilizing apparently adequate habitat.

Management for the loggerhead shrike should be conducted in the area where birds have been historically observed. Grazing in this area should continue, however, on a rotational basis. The area should be divided with barbed wire fence to create management units and provide potential perches and projections for impaling prey. Shrubby fence rows should be encouraged that include black locust, hawthorn, and red cedar. In addition, these trees should be allowed to establish in small groups intermixed throughout the management unit. Fencing and rotational grazing should help the establishment of shrub areas.

Lastly, while declining and degraded habitats are considered one reason for declining shrike populations, areas of "good shrike habitat" exist that do not support shrikes. The exact reasons for shrike declines are still not fully understood. Therefore, management for optimum shrike habitat may not result in shrike occupancy. However, habitat management for shrikes is still recommended until the reasons for shrike declines are better understood.

TAXA LISTS

PLANTS:

Family	Scientific Name	Common Name
Poaceae	*Schizachyrium scopariu*	little bluestem
Poaceae	*Andropogon virginicus*	brooomsedge
Poaceae	*Tridens flavus*	purpletop
Poaceae	*Panicum oligosanthes scribnerianum*	Scribner's panic grass
Poaceae	*Panicum ancep*	flat-stemmed panic grass
Poaceae	*Eragrostis spectabilis*	purple lovegrass
Poaceae	*Setaria glauc*	yellow foxtail
Poaceae	*Sorghastrum nutans*	Indian grass
Poaceae	*Paspalum*	paspalum
Poaceae	*Festuca elatio*	tall fescue
Poaceae	*Poa pratensis*	Kentucky bluegrass
Poaceae	*Phleum pratense*	timothy
Poaceae	*Agrostis gigantea*	redtop
Poaceae	*Bromus inermis*	awnless brome grass
Poaceae	*Dactylis glomerata*	orchard grass
Poaceae	*Arrhenatherum elatius*	tall oatgrass
Asteraceae	*Cirsium arvense*	Canada thistle
Asteraceae	*Carduus acanthoides*	spine plumeless thistle
Asteraceae	*Carduus nutans*	nodding thistle
Asteraceae	*Erechtites hieracifolia*	fireweed
Asteraceae	*Hypochaeris radicata*	cat's-ear
Scrophulariaceae	*Verbascum thapsus*	common mullein
Asteraceae	*Hieracium pilosella*	mouse-eared hawkweed
Solanaceae	*Datura stramonium*	jimson weed

INVERTEBRATES:

Class: Arachnida
Order: Araneae

Family	Scientific Name	Common Name
Agelenidae	*Cicurina robusta*	
Amaurobiidae	*sp.*	
Antrodiaetidae	*Antrodiaetus unicolor*	
Araneidae	*Acanthepeira sp.*	
Araneidae	*Araneus pratensis*	
Araneidae	*Argiope trifasciata*	
Araneidae	*Cyclosa conica*	

Araneidae	*Eustala anastera*	
Araneidae	*Mangora gibberosa*	
Araneidae	*Micrathena gracilis*	
Araneidae	*Micrathena mitrata*	
Araneidae	*Neoscona arabesca*	
Araneidae	*Neoscona pratensis*	
Atypidae	*Sphodros niger*	
Clubionidae	*Clubiona johnsoni*	
Clubionidae	*Clubiona sp.*	
Clubionidae	*Trachelas deceptus*	
Gnaphosidae	*Drassodes neglectus*	
Gnaphosidae	*Drassyllus creolus*	
Gnaphosidae	*Drassyllus depressus*	
Gnaphosidae	*Drassyllus sp.*	
Gnaphosidae	*Haplodrassus signifer*	
Gnaphosidae	*Zelotes hentzi*	
Linyphiidae	*Bathyphantes pallida*	
Linyphiidae	*Centromerus persoluta*	
Linyphiidae	*Centromerus cornupalpis*	
Linyphiidae	*Ceraticelus unk.*	
Linyphiidae	*Grammonata inornata*	
Linyphiidae	*sp.*	
Linyphiidae	*Stemonyphantes blauveltae*	
Lycosidae	*Allocosa fenerea*	
Lycosidae	*Hogna frondicola*	
Lycosidae	*Hogna helluo*	
Lycosidae	*Hogna punctulata*	
Lycosidae	*Hogna rabida*	
Lycosidae	*Hogna sp.*	
Lycosidae	*Pardosa milvina*	
Lycosidae	*Pirata insularis*	
Lycosidae	*Pirata sp.*	
Lycosidae	*Schizocosa avida*	
Lycosidae	*Schizocosa bilineata*	
Lycosidae	*Schizocosa saltatrix*	
Lycosidae	*sp.*	
Lycosidae	*Varacosa avara*	
Mimetidae	*Mimetus epeiroides*	
Oxyopidae	*Oxyopes salticus*	

Philodromidae	*Philodromus sp.*	
Philodromidae	*Thanatus formicinus*	
Philodromidae	*Thanatus rubicellus*	
Philodromidae	*Tibellus duttoni*	
Pisauridae	*Dolomedes triton*	
Pisauridae	*Pisaurina mira*	
Salticidae	*Eris sp.*	
Salticidae	*Evarcha hoyi*	
Salticidae	*Habrocestum pulex*	
Salticidae	*Marpissa pikei*	
Salticidae	*Metaphidippus galathea*	
Salticidae	*Metaphidippus protervus*	
Salticidae	*Phidippus audax*	
Salticidae	*Phidippus clarus*	
Tetragnathidae	*Pachygnatha tristriata*	
Tetragnathidae	*Tetragnatha pallescens*	
Tetragnathidae	*Tetragnatha sp.*	
Theridiidae	*Achaearanea globosa*	
Theridiidae	*Theridion sp.*	
Theridiidae	*Thymoites sp.*	
Thomisidae	*Misumena vatia*	
Thomisidae	*Ozyptila monroensis*	
Thomisidae	*Xysticus ferox*	
Thomisidae	*Xysticus gulosus*	
Thomisidae	*Xysticus luctans*	
Thomisidae	*Xysticus sp.*	

Class: Diplopoda
Order: Callipodida

Family	Scientific Name	Common Name
Abacionidae	*Abacion tesselatum*	millipede

Class: Diplopoda
Order: Julida

Family	Scientific Name	Common Name
Julidae	*Ophyiulus pilosus*	millipede

Class: Diplopoda
Order: Polydesmida

Family	Scientific Name	Common Name
Xystodesmidae	*Brachoria separanda calcaria*	millipede
Xystodesmidae	*Nannari sp.*	millipede

Class: Insecta
Order: Coleoptera

Family	Scientific Name	Common Name
Cantharidae	*sp.*	soldier beetle
Carabidae	*Chlaenius lithophilus*	ground beetle
Carabidae	*Cyclotrachelus iuveuis*	ground beetle
Carabidae	*Lebia grandis*	ground beetle
Carabidae	*Lebia viridis*	ground beetle
Carabidae	*Pterostichus trinarius*	ground beetle
Carabidae	*Rhadine caudata*	ground beetle
Carabidae	*Scaphinutus elevatus*	ground beetle
Carabidae	*Scarites subterraneus*	ground beetle
Carabidae	*Sphaeroderus stenostomus*	ground beetle
Chrysomelidae	*Chrysolina inornata*	leaf beetle
Chrysomelidae	*sp.*	leaf beetle
Chrysomelidae	*Stenispa metallica*	leaf beetle
Coccinellidae	*sp.*	ladybird beetle
Dytiscidae	*sp.*	predaceous diving beetle
Elateridae	*sp.*	click beetle
Endomychidae	*Stenotarsus hispidus*	handsome fungus beetle
Meloidae	*Meloe angusticollis*	blister beetle
Scarabaeidae	*Copris minutus*	scarab beetle
Scarabaeidae	*Copris tullius*	scarab beetle
Scarabaeidae	*Euphoria inda*	scarab beetle
Staphylinidae	*Olophrum obtectum*	rove beetle
Staphylinidae	*Pinophilus laticeps*	rove beetle

Class: Insecta
Order: Collembola

Family	Scientific Name	Common Name
Entomobryidae	*sp.*	springtail
Isotomidae	*sp.*	springtail

Class: Insecta
Order: Diptera

Family	Scientific Name	Common Name
Acroceridae	*sp.*	small-headed fly
Chironomidae	*sp.*	midge
Chloropidae	*sp.*	frit fly
Dolichopodidae	*sp.*	long-legged fly
Drosophilidae	*sp.*	pomace fly
Mycetophilidae	*sp.*	fungus gnat
Otitidae	*sp.*	picture-winged fly
Sciomyzidae	*sp.*	marsh fly
Stratiomyiidae	*sp.*	soldier fly
Tabanidae	*sp.*	deer fly

Class: Insecta
Order: Ephemeroptera

Family	Scientific Name	Common Name
Heptageniidae	*sp.*	mayfly

Class: Insecta
Order: Heteroptera

Family	Scientific Name	Common Name
Lygalidae	*Cryphula trimaculata*	seed bug
Lygalidae	*Cymus angustatus*	seed bug
Lygalidae	*Melaiiocorypha bicrucis*	seed bug
Lygalidae	*Oedancala dorsalis*	seed bug
Lygalidae	*Phlegyas abbreviatus*	seed bug
Lygalidae	*Pseudopachybrachius basilis*	seed bug
Miridae	*Lopidea robiniae*	leaf bug
Miridae	*Megaloceraea recticornis*	leaf bug
Pentatomidae	*Mosmidea lergeus*	stink bug
Pentatomidae	*sp.*	stink bug
Reduviidae	*Fitchia aptera*	assassin bug
Reduviidae	*Melanolestes abdominalis*	assassin bug
Reduviidae	*sp.*	assassin bug

Class: Insecta
Order: Homoptera

Family	Scientific Name	Common Name
Aphididae	*sp.*	aphid
Cicadellidae	*sp.*	leaf hopper

Class: Insecta
Order: Hymenoptera

Family	Scientific Name	Common Name
Anthoporidae	*sp.*	apidid bee
Braconidae	*sp.*	brachonid
Chalcidoidea	*sp.*	chalsid
Formicidae	*Campanotus sp.*	formicinae (ant)
Formicidae	*Crematogastor sp.*	myrmicinae (ant)
Formicidae	*Formica sp.*	formicinae (ant)
Formicidae	*sp.*	ponerinae (ant)
Halictidae	*sp.*	halictid bee
Ichneumonidae	*sp.*	ichneumon
Ichneumonidae	*sp.*	ichneumon bee
Megachilidae	*sp.*	leafcutting bee
Mutillidae	*sp.*	velvet ant
Proctotrupoidea	*sp.*	proctotrupids
Vespidae	*sp.*	vespid wasp

Class: Insecta
Order: Lepidoptera

Family	Scientific Name	Common Name
Arctiidae	*Ecpantheria scribonia*	giant leopard moth
Arctiidae	*Haploa lecontei*	Leconte's haploa
Geometridae	*Euchlaena amoenaria*	deep yellow euchlaena
Geometridae	*Orthonama centrostrigaria*	bent-line carpet
Geometridae	*Patalene olyzonaria puber*	juniper geometer
Geometridae	*Synchlora aerata*	wavy-lined emerald
Geometridae	*Trichodezia albovittata*	white-striped black
Geometridae	*Xanthotype urticaria*	false crocus geometer
Hesperidae	*Ancyloxypha numitor*	least skipper
Hesperidae	*Atalopedes campestris*	sachem
Hesperidae	*Atrytone logan*	Delaware skipper
Hesperidae	*Atrytonopsis hianna*	dusted skipper
Hesperidae	*Epargyreus clarus*	silver-spotted skipper
Hesperidae	*Erynnis baptisiae*	wild indigo duskywing

Hesperidae	*Erynnis horatius*	Horace's duskywing
Hesperidae	*Erynnis icelus*	dreamy duskywing
Hesperidae	*Erynnis juvenalis*	Juvenal's duskywing
Hesperidae	*Euphyes vestris*	dun skipper
Hesperidae	*Lerema accius*	clouded skipper
Hesperidae	*Nastra iherminier*	swarthy skipper
Hesperidae	*Panaquina ocola*	ocola skipper
Hesperidae	*Pholisora catullus*	common sootywing
Hesperidae	*Poanes hobomok*	hobomok skipper
Hesperidae	*Poanes zabulon*	zabulon skipper
Hesperidae	*Polites origenes*	crossline skipper
Hesperidae	*Polites peckius*	Peck's skipper
Hesperidae	*Polites themistocles*	tawny-edged skipper
Hesperidae	*Pompeius verna*	little glassywing
Hesperidae	*Pyrgus communis*	common checkered skipper
Hesperidae	*Thorybes bathyllus*	southern cloudywing
Hesperidae	*Thorybes pylades*	northern cloudywing
Hesperidae	*Thymelicus lineola*	European skipper
Hesperidae	*Wallengrenia egeremet*	northern broken dash
Lasiocampidae	*Artace cribraria*	dot-lined white
Lycaenidae	*Callophrys gryneus*	olive hairstreak
Lycaenidae	*Everes comyntas*	eastern tailed blue
Lycaenidae	*Feniseca tarquinius*	harvester
Lycaenidae	*Lycaena Phlaeas*	American copper
Lycaenidae	*Satyrium titus*	coral hairstreak
Lycaenidae	*Strymon melinus humuli*	gray hairstreak
Noctuidae	*Acronicta lithospila*	streaked dagger moth
Noctuidae	*Agrostis venerabilis*	venerable dart
Noctuidae	*Caenurgina crassiuscula*	clover looper moth
Noctuidae	*Euparthenos nubilis*	locust underwing
Noctuidae	*Heliothis zea*	corn earworm moth
Noctuidae	*Pseudaletia unipuncta*	armyworm moth
Noctuidae	*Spodoptera ornithogalli*	yellow-striped armyworm moth
Noctuidae	*Spodpotera frugiperda*	fall armyworm moth
Noctuidae	*Xestia badinodis*	pale-banded dart
Noctuidae	*Zanclognatha sp.*	
Nymphalidae	*Asterocampa c. celtis*	hackberry emperor
Nymphalidae	*Boloria bellona*	meadow fritillary
Nymphalidae	*Cercyonis pegala*	common wood nymph
Nymphalidae	*Chlosyne nycteis*	silvery checkerspot
Nymphalidae	*Danaus plexippus*	monarch
Nymphalidae	*Euptoieta claudia*	variegated fritillary
Nymphalidae	*Junonia coenia*	common buckeye
Nymphalidae	*Libytheana carinenta*	American snout
Nymphalidae	*Limenitis arthemis astyanax*	red-spotted purple

Nymphalidae	*Megisto cymela*	little wood satyr
Nymphalidae	*Phyciodes tharos*	pearl crescent
Nymphalidae	*Speyeria aphrodite*	aphrodite fritillary
Nymphalidae	*Speyeria cybele*	great spangled fritillary
Nymphalidae	*Speyeria idalia*	regal fritillary
Nymphalidae	*Vanessa virginiensis*	American lady
Nymphalidae	*Vanessa cardui*	painted lady
Papilionidae	*Battus philenor*	pipevine swallowtail
Papilionidae	*Papilio cresphontes*	giant swallowtail
Papilionidae	*Papilio glaucus*	eastern tiger swallowtail
Papilionidae	*Papilio polyxenes*	black swallowtail
Papilionidae	*Papilio troilus*	spicebush swallowtail
Pieridae	*Colias eurytheme*	orange sulfer
Pieridae	*Colias philodice*	clouded sulfer
Pieridae	*Eurema nicippi*	sleepy orange
Pieridae	*Pieris rapae*	cabage white
Sphingidae	*Manduca sexta*	Carolina sphinx
Sphingidae	*Hemaris diffinis*	snowberry clearwing
Yponomeutidae	*Atteva punctella*	ailanthus webwom moth

Class Insecta:
Order: Odonata

Family	**Scientific Name**	**Common Name**
Aeshnidae	*Anax junius*	common green darner
Aeshnidae	*Anax longipes*	comet darner
Calopterygidae	*Calopteryx maculata*	ebony jewelwing
Coenagrionidae	*Amphiagrion saucium*	eastern red damsel
Coenagrionidae	*Argia fumipennis violacea*	variable dancer
Coenagrionidae	*Enallagma aspersum*	azure bluet
Coenagrionidae	*Enallagma civile*	familiar bluet
Coenagrionidae	*Ischnura hastata*	citrine forktail
Coenagrionidae	*Ischnura verticalis*	eastern forktail
Gomphidae	*Dromogomphus spinosus*	black-shouldered spinyleg
Gomphidae	*Lanthus vernalis*	southern pygmy clubtail
Gomphidae	*Stylurus spiniceps*	arrow clubtail
Lestidae	*Lestes disjunctus australis*	common spreadwing
Lestidae	*Lestes eurinus*	amber-winged spreadwing
Lestidae	*Lestes rectangularis*	slender spreadwing
Libellulidae	*Celithemis elisa*	calico pennant
Libellulidae	*Libellula pulchella*	twelve-spotted skimmer
Libellulidae	*Perithemis tenera*	eastern amberwing

Libellulidae	*Sumpetrum vicinum*	yellow-legged meadowhawk
Libellulidae	*Sympetrum rubicundulum*	ruby meadowhawk
Libellulidae	*Tramea lacerata*	black saddlebags
Liebellulidae	*Sympetrum rubicundulum*	ruby meadowhawk
Macromiidae	*Macromia illinoisensis illinoisensis*	Illinois river cruiser

Class: Insecta
Order: Orthoptera

Family	Scientific Name	Common Name
Blatellidae	*Parcoblatta sp.*	cockroach
Mantidae	*sp.*	mantis

Class: Insecta
Order: Plecoptera

Specimen not identified beyond order.

Class: Insecta
Order: Siphonoptera

Specimen not identified beyond order.

Class: Insecta
Order: Trichoptera

Family	Scientific Name	Common Name
Leptoceridae	*Mystacides sp.*	caddisfly
Limnephilidae		caddisfly
Polycentropodidae	*Polycentropus sp.*	caddisfly

Class: Malacostraca
Order: Isopoda

Family	Scientific Name	Common Name
Asellidae	*Caecidotea sp.*	isopod
Oniscidae	*Cylisticus sp.*	pill bug
Oniscidae	*Trachelipus sp.*	pill bug

Class: Malacostraca
Order: Amphipoda

Family	Scientific Name	Common Name

Crangonyctidae	*Gammarus minus*	amphipod
Crangonyctidae	*Stygobromus abditus*	amphipod

REPTILES AND AMPHIBIANS:

Family	Scientific Name	Common Name
Ambystomatidae	*Ambystoma jeffersonianum*	Jefferson salamander
Ambystomatidae	*Ambystoma maculatum*	spotted salamander
Bufonidae	*Bufo americanus*	American toad
Chelydridae	*Chelydra serpentina*	snapping turtle
Colubridae	*Coluber constrictor*	northern black racer
Colubridae	*Diadophis punctatus*	ringneck snake
Colubridae	*Elaphe obsoleta*	black rat snake
Colubridae	*Lampropeltis triangulum*	eastern milk snake
Colubridae	*Nerodia sipedon*	northern water snake
Colubridae	*Regina septemvittata*	queen snake
Colubridae	*Thamnophis sirtalis*	eastern garter snake
Emydidae	*Chrysemys picta*	eastern painted turtle
Emydidae	*Terrapene carolina*	eastern box turtle
Hylidae	*Pseudacris crucifer*	spring peeper
Hylidae	*Pseudacris triseriata*	upland chorus frog
Plethodontidae	*Eurycea cirrigera*	southern two-lined salamander
Plethodontidae	*Eurycea longicauda*	longtail salamander
Plethodontidae	*Desmognathus fuscus*	northern dusky salamander
Salamandridae	*Notophthalmus viridescens*	red-spotted newt
Plethodontidae	*Plethodon wehrlei*	Wehrle's salamander
Plethodontidae	*Pseudotriton ruber*	northern red salamander
Ranidae	*Rana catesbeiana*	bullfrog
Ranidae	*Rana clamitans*	green frog
Ranidae	*Rana sylvatica*	wood frog

FISH:

Family	Scientific Name	Common Name
Centrarchidae	*Lepomis cyanellus*	green sunfish
Centrarchidae	*Lepomis macrochirus*	bluegill
Centrarchidae	*Lepomis cyanellus* x *L. macrochirus*	green sunfish x bluegill
Centrarchidae	*Micropterus salmoides*	largemouth bass
Cyprinidae	*Campostoma anomalum*	central stoneroller
Cyprinidae	*Syprinus carpio*	common carp
Cyprinidae	*Nocomis leptocephalus*	bluehead chub
Cyprinidae	*Phoxinus oreas*	mountain redbelly dace
Cyprinidae	*Rhinichthys atratulus*	blacknose dace
Ictaluridae	*Noturus insignis*	marginated madtom

Salmonidae	*Oncorhynchus mykiss*	rainbow trout
Salmonidae	*Salmo trutta*	brown trout

BIRDS: Status code definitions; B = breeding, M = migrant, R = resident, U = undetermined, and W = winter.

Family	Scientific name	Species	Status
Accipitridae	*Accipiter cooperii*	cooper's hawk	M
Accipitridae	*Buteo jamaicensis*	red-tailed hawk	R
Accipitridae	*Buteo lagopus*	rough-legged hawk	M
Accipitridae	*Circus cyaneus*	northern harrier	M
Accipitridae	*Falco sparverius*	American kestrel	R
Alaudidae	*Eremophila alpestris*	horned lark	B
Anatidae	*Anas platyrhynchos*	mallard duck	R
Anatidae	*Aythya collaris*	ring-necked duck	W
Anatidae	*Lophodytes cucullatus*	hooded merganser	W
Apodidae	*Chaetura pelagica*	chimney swift	B
Ardeidae	*Ardea herodias*	great blue heron	R
Ardeidae	*Butorides striatus*	green heron	R
Bombycillidae	*Bombycilla cedrorum*	cedar waxwing	R
Cathartidae	*Cathartes aura*	turkey vulture	R
Cathartidae	*Coragyps atratus*	black vulture	R
Charadriidae	*Charadrius vociferus*	killdeer	R
Columbidae	*Zenaida macroura*	mourning dove	R
Corvidae	*Corvus brachyrhynchos*	American crow	R
Corvidae	*Cyanocitta cristata*	blue jay	R
Cuculidae	*Coccyzus erythropthalmus*	black-billed cuckoo	B
Emberizidae	*Agelaius phoeniceus*	red-winged blackbird	B
Emberizidae	*Ammodramus henslowii*	Henslow's sparrow	B
Emberizidae	*Ammodramus savannarum*	grasshopper sparrow	B
Emberizidae	*Cardinalis cardinalis*	northern cardinal	R
Emberizidae	*Dendroica coronata*	yellow-rumped warbler	W
Emberizidae	*Dendroica discolor*	prairie warbler	B
Emberizidae	*Dendroica palmarum*	palm warbler	M
Emberizidae	*Dolichonyx oryzivorus*	bobolink	M
Emberizidae	*Geothlypis trichas*	common yellowthroat	B
Emberizidae	*Guiraca caerulea*	blue grosbeak	B
Emberizidae	*Icteria virens*	yellow-breasted chat	B
Emberizidae	*Icterus galbula*	northern oriole	B

Emberizidae	*Icterus spurius*	orchard oriole	B
Emberizidae	*Junco hyemalis*	northern junco	W
Emberizidae	*Melospiza georgiana*	swamp sparrow	U
Emberizidae	*Melospiza melodia*	song sparrow	R
Emberizidae	*Molothrus ater*	brown-headed cowbird	B
Emberizidae	*Passerculus sandwichensis*	savannah sparrow	B
Emberizidae	*Passerina cyanea*	indigo bunting	B
Emberizidae	*Pipilo erythrophthalmus*	eastern towhee	B
Emberizidae	*Piranga olivacea*	scarlet tanager	B
Emberizidae	*Pooecetes gramineus*	vesper sparrow	B
Emberizidae	*Quiscalus quiscula*	common grackle	B
Emberizidae	*Setophaga ruticilla*	American redstart	B
Emberizidae	*Spizella arborea*	American tree sparrow	W
Emberizidae	*Spizella passerina*	chipping sparrow	B
Emberizidae	*Spizella pusilla*	field sparrow	B
Emberizidae	*Sturnella magna*	eastern meadowlark	R
Emberizidae	*Zonotrichia albicollis*	white-throated sparrow	W
Fringillidae	*Carduelis tristis*	American goldfinch	R
Fringillidae	*Carpodacus mexicanus*	house finch	R
Hirundinidae	*Hirundo rustica*	barn swallow	B
Hirundinidae	*Riparia riparia*	bank swallow	B
Hirundinidae	*Stelgidopteryx serripennis*	rough-winged swallow	B
Hirundinidae	*Tachycineta bicolor*	tree swallow	B
Lanidae	*Lanius ludovicianus*	loggerhead shrike	R
Mimidae	*Mimus polyglottos*	northern mockingbird	R
Mimidae	*Toxostoma rufum*	brown thrasher	B
Muscicapidae	*Polioptila caerulea*	blue-gray gnatcatcher	B
Muscicapidae	*Sialia sialis*	eastern bluebird	R
Muscicapidae	*Turdus migratorius*	American robin	R, M
Paridae	*Parus bicolor*	tufted titmouse	R
Paridae	*Parus carolinensis*	carolina chickadee	R
Phasianidae	*Colinus virginianus*	northern bobwhite	R
Phasianidae	*Meleagris gallopavo*	wild turkey	R
Picidae	*Colaptes auratus*	northern flicker	R
Picidae	*Dryocopus pileatus*	pileated woodpecker	R
Picidae	*Picoides pubescens*	downy woodpecker	R
Picidae	*Picoides villosus*	hairy woodpecker	R
Scolopacidae	*Actitis macularia*	spotted sandpiper	B
Scolopacidae	*Gallinago gallinago*	common snipe	B

Scolopacidae	*Scolopax minor*	American woodcock	B
Scolopacidae	*Tringa solitaria*	solitary sandpiper	M
Sittidae	*Sitta carolinensis*	white-breasted nuthatch	R
Strigidae	*Asio flammeus*	short-eared owl	M
Sturnidae	*Sturnus vulgaris*	European starling	R
Trochilidae	*Archilochus colubris*	ruby-throated hummingbird	B
Troglodytidae	*Thryothorus ludovicianus*	carolina wren	B
Troglodytidae	*Troglodytes aedon*	house wren	B
Tyrannidae	*Contopus virens*	eastern pewee	B
Tyrannidae	*Empidonax minimus*	least flycatcher	B
Tyrannidae	*Sayornis phoebe*	eastern phoebe	B
Tyrannidae	*Tyrannus tyrannus*	eastern kingbird	B

MAMMALS:

Family	**Scientific Name**	**Common Name**
Canidae	*Vulpes vulpes*	red fox
Cervidae	*Odocoileus virginianus*	white-tailed deer
Diedelphidae	*Didelphis virginiana*	Virginia opossum
Soricidae	*Blarina brevicauda*	northern short-tailed shrew
Soricidae	*Cryptotis parva*	least shrew
Mephitidae	*Mephitis mephitis*	striped skunk
Muridae	*Peromyscus leucopus*	white-footed mouse
Muridae	*Microtus pennsylvanicus*	meadow vole
Muridae	*Zapus hudsonicus*	meadow jumping mouse
Procyonidae	*Procyon lotor*	common raccoon
Sciuridae	*Marmota monax*	woodchuck
Vespertilionidae	*Eptesicus fuscus*	big-brown bat
Vespertilionidae	*Lasiurus borealis*	red bat

Community Type: Successional Woodland/Forest

Acreage: Acres (Hectares) Total: 669 (271) Main: 323 (131) New River: 346 (140)

Community Type Location Maps: Figure 1 and Figure 2

Rare Species Site Maps for Flora: N/A

Rare Species Site Maps for Fauna: N/A

Sample Site Maps for Fauna: N/A

Rare and Unique Species & Communities

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
Community Type					
N/A	Limestone Barren	N/A	N/A	N/A	N/A

COMMUNITY DESCRIPTION

This artificial community is a heterogeneous mixture of woodland and forest. It is difficult to characterize other than by the presence of a few colonizing woody species and a diverse assemblage of weedy herbaceous species. Old field communities, if left undisturbed, eventually develop a woody canopy. The composition varies considerably depending on many factors. At the Arsenal, past history is particularly important since most of the area is geologically similar. A common type of successional woodland develops when old fields are colonized by red cedar and pines. These typically occupy dry exposures and areas where bedrock is shallow. Old field herbs persist until heavy shade favors bryophytes and lichens. Common bryophytes are *Thuidium* and *Rhytidium rugosum* which may nearly carpet the ground.

More mesic sites with greater soil development typically develop a hardwood canopy with the composition dependent on what colonizing species are nearby and whether or not the site had been grazed. Herbaceous composition is too variable to characterize but weedy and exotic species often predominate. Principal woody colonizers include *Robinia pseudoacacia*, *Ailanthus altissima*, *Prunus serotina*, *Rosa multiflora*, *Berberis thunbergii*, and *Viburnum prunifolium*, and sometimes *Juglans nigra*. Herbaceous species are highly variable from one place to another. At the Arsenal, *Poa trivialis*, *Eupatorium rugosum*, and *Verbesina occidentalis* are somewhat universally present but the community otherwise lacks consistent characteristic species.

RARE SPECIES AND COMMUNITY ACCOUNTS

Limestone Barren: This is a unique natural community that is addressed separately in this report. This community type is recognized under the successional woodland/forest community because it is surrounded by successional habitat and management in this area may affect the barren.

MANAGEMENT RECOMMENDATIONS

General Recommendations

This is a transitional habitat that supports species that are not found in some of the other community types. Although these species are not rare, they do add to the diveristy found at the Arsenal. Maintenance of these areas is recommended and will require physical management to maintain their condition.

The primary recommendation is to remove the livestock that are grazing in these habitats. Grazed woodlands don't make good pasture or good woodlands. Grazing causes soil compaction and introduction of exotic woody species that degrade the woodland quality.

Successional woodlands will need to be thinned as trees mature. This can be applied on an as needed basis. In addition to thinning, the creation of a soft edge next to grassland habitats is recommended. To create a soft edge, a 60 to 100 foot buffer should be established. Within the first 30 to50 feet of the edge, 75% of the trees should be removed. Within the next 30 to 50 feet, 50% of the trees should be removed to provide a soft succession from grassland to forest.

Rare Species and Community Recommendations

Limestone Barren: Specific management recommendations for the limestone barren and surrounding area are made under the community type, Limestone Barren (page 18).

TAXA LISTS

PLANTS

Family	Scientific Name	common name
Asteraceae	*Eupatorium rugosum*	white snakeroot
Asteraceae	*Verbesina occidentalis*	small yellow crownbeard
Berberidaceae	*Berberis thunbergii*	Japanese barberry
Caprifoliaceae	*Viburnum prunifolium*	black haw
Fabaceaea	*Robinia pseudoacacia*	black locust
Hylocomiaceae	*Rhytidium rugosum*	
Juglandaceae	*Juglans cinerea*	butternut
Poaceae	*Poa trivialis*	rough bluegrass
Rosaceae	*Prunus serotina*	black cherry
Rosaceae	*Rosa multiflora*	multifora rose
Simarubaceae	*Ailanthus altissima*	tree of heaven
Thuidiaceae	*Thuidium sp.*	

INVERTEBRATES

Class: Arachnidae
Order: Araneae

Family	Scientific Name	Common Name
Agelenidae	*Cicurina sp.*	
Anyphaenidae	*Anyphaena celer*	
Anyphaenidae	*Anyphaena sp.*	
Hahniidae	*Neoantistea magna*	
Linyphiidae	*Pityohyphantes costatus*	
Lycosidae	*Allocosa funerea*	
Lycosidae	*Pardosa sexatilis*	
Lycosidae	*Pardosa sp.*	
Lycosidae	*Pirata minutus*	
Lycosidae	*Schizocosa avida*	
Lycosidae	*Schizocosa duplex*	
Salticidae	*Phidippus sp.*	
Theridiidae	*Achaearanea porteri*	

Class: Insecta
Order: Coleoptera

Family	Scientific Name	Common Name

Carabidae	*Pterostichus mutus*	Ground beetle
Endomychidae	*Lycoperdina ferroginea*	Handsome fungus beetle
Lucanidae	*sp.*	Stag beetle
Psephenidae	*sp.*	Water-penny beetle
Staphylinidae	*Arpedium schwarzi*	Rove beetle

Class: Insecta
Order: Diptera

Family	Scientific Name	Common Name
Empididae	*sp.*	Dance fly
Simuliidae	*sp.*	Black fly
Tipulidae	*sp.*	Crane fly

Class: Insecta
Order: Heteroptera

Family	Scientific Name	Common Name
Belostomatidae	*Belostoma fluminea*	Giant water bug

Class: Insecta
Order: Hymenoptera

Family	Scientific Name	Common Name
Colletidae	*sp.*	Colletid bee

Class: Insecta
Order: Lepidoptera

Family	Scientific Name	Common Name
Arctiidae	*sp.*	Tiger moth
Hesperidae	*Ancyloxypha numitor*	Least skipper
Hesperidae	*Atalopedes campestris*	Sachem
Hesperidae	*Atrytonopsis hianna*	Dusted skipper
Hesperidae	*Thorybes bathyllus*	Southern cloudywing
Hesperidae	*Thorybes pylades*	Northern cloudywing
Lycaenidae	*Celastrina l. ladon "neglecta"*	Summer azure
Lycaenidae	*Celastrina l. ladon "violocea"*	Spring azure
Lycaenidae	*Everes comyntas*	Eastern tailed blue
Nymphalidae	*Cercyonis pegala*	Common wood nymph
Nymphalidae	*Danaus plexippus*	Monarch
Nymphalidae	*Limenitis arthemis astyanax*	Red-spotted purple
Nymphalidae	*Megisto cymela*	Little wood satyr
Nymphalidae	*Phyciodes tharos*	Pearl crescent

Nymphalidae	*Speyeria aphrodite*	Aphrodite fritillary
Nymphalidae	*Speyeria cybele*	Great spangled fritillary
Papilionidae	*Battus philenor*	Pipevine swallowtail
Papilionidae	*Papilio glaucus*	Eastern tiger swallowtail
Papilionidae	*Papilio troilus*	Spicebush swallowtail
Pieridae	*Colias eurytheme*	Orange sulfer
Pieridae	*Colias philodice*	Clouded sulfer
Pieridae	*Pieris rapae*	Cabage white

Class: Insecta
Order: Neuroptera

Family	Scientific Name	Common Name
Corydalidae	*Nigronia sp.*	Dobsonfly

Class: Insecta
Order: Trichoptera

Family	Scientific Name	Common Name
Hydropsychidae	*Cheumatopsyche sp.*	Caddisfly
Hydropsychidae	*Hydropsyche sp.*	Caddisfly
Hydropsychidae	*Potomyia sp.*	Caddisfly
Philopotamidae	*Chimarra sp.*	Caddisfly
Psychomyiidae	*Lype diversa*	Caddisfly

FISH

No available habitat.

REPTILES AND AMPHIBIANS

Family	Scientific Name	Common Name
Bufonidae	*Bufo americanus*	American toad
Colubridae	*Carphophis a. amoenus*	eastern worm snake
Emydidae	*Terrapene carolina*	eastern box turtle
Hylidae	*Pseudacris crucifer*	spring peeper
Plethodontidae	*Desmognathus fuscus*	northern dusky salamander
Plethodontidae	*Eurycea cirrigera*	southern two-lined salamander
Ranidae	*Rana sylvatica*	wood frog

BIRDS: Status code definitions; B = breeding, M = migrant, R = resident, U = undetermined, and W = winter.

Family	Scientific name	Species	Status
Columbidae	*Zenaida macroura*	mourning dove	R

Corvidae	*Corvus brachyrhynchos*	American crow	R
Corvidae	*Cyanocitta cristata*	blue jay	R
Cuculidae	*Coccyzus americanus*	yellow-billed cuckoo	B
Emberizidae	*Cardinalis cardinalis*	northern cardinal	R
Emberizidae	*Dendroica coronata*	yellow-rumped warbler	W
Emberizidae	*Dendroica fusca*	blackburnian warbler	M
Emberizidae	*Dendroica pensylvanica*	cheastnut-sided warbler	B
Emberizidae	*Dendroica virens*	black-throated green	B
Emberizidae	*Icterus galbula*	northern oriole	B
Emberizidae	*Junco hyemalis*	northern junco	W
Emberizidae	*Melospiza melodia*	song sparrow	R
Emberizidae	*Mniotilta varia*	black-and-white warbler	B
Emberizidae	*Parula americana*	northern parula	B
Emberizidae	*Passerina cyanea*	indigo bunting	B
Emberizidae	*Pheucticus ludovicianus*	rose-breasted grosbeak	B
Emberizidae	*Pipilo erythrophthalmus*	eastern towhee	B
Emberizidae	*Piranga olivacea*	scarlet tanager	B
Emberizidae	*Quiscalus quiscula*	common grackle	B
Emberizidae	*Setophaga ruticilla*	American redstart	B
Emberizidae	*Spizella pusilla*	field sparrow	B
Emberizidae	*Zonotrichia albicollis*	white-throated sparrow	W
Fringillidae	*Carduelis tristis*	American goldfinch	R
Mimidae	*Dumetella carolinensis*	gray catbird	B
Mimidae	*Mimus polyglottos*	northern mockingbird	R
Mimidae	*Toxostoma rufum*	brown thrasher	B
Muscicapidae	*Hylocichla mustelina*	wood thrush	B
Muscicapidae	*Polioptila caerulea*	blue-gray gnatcatcher	B
Muscicapidae	*Turdus migratorius*	American robin	R, M
Paridae	*Parus atricapillus*	black-capped chickadee	W
Paridae	*Parus bicolor*	tufted titmouse	R
Paridae	*Parus carolinensis*	carolina chickadee	R
Phasianidae	*Meleagris gallopavo*	wild turkey	R
Picidae	*Colaptes auratus*	northern flicker	R
Picidae	*Melanerpes carolinus*	red-bellied woodpecker	R
Picidae	*Picoides pubescens*	downy woodpecker	R
Picidae	*Picoides villosus*	hairy woodpecker	R
Picidae	*Sphyrapicus varius*	yellow-bellied sapsucker	W
Scolopacidae	*Scolopax minor*	American woodcock	B
Sittidae	*Sitta carolinensis*	white-breasted nuthatch	R
Troglodytidae	*Thryothorus ludovicianus*	carolina wren	B
Troglodytidae	*Troglodytes aedon*	house wren	B
Tyrannidae	*Contopus virens*	eastern pewee	B
Tyrannidae	*Empidonax virescens*	acadian flycatcher	B
Tyrannidae	*Myiarchus crinitus*	great crested flycatcher	B
Vireonidae	*Vireo flavifrons*	yellow-throated vireo	B
Vireonidae	*Vireo olivaceus*	red-eyed vireo	B

MAMMALS

Family	Scientific Name	Common Name
Canidae	*Vulpes vulpes*	red fox
Cervidae	*Odocoileus virginianus*	white-tailed deer
Diedelphidae	*Didelphis virginiana*	Virginia opossum
Soricidae	*Blarina brevicauda*	northern short-tailed shrew
Soricidae	*Cryptotis parva*	least shrew
Mephitidae	*Mephitis mephitis*	striped skunk
Muridae	*Microtus pennsylvanicus*	meadow vole
Muridae	*Microtis pinetorum*	woodland vole
Muridae	*Peromyscus leucopus*	white-footed mouse
Muridae	*Zapus hudsonicus*	meadow jumping mouse
Procyonidae	*Procyon lotor*	common raccoon
Sciuridae	*Marmota monax*	woodchuck

Community Type: Pine Plantation

Acreage: Acres (Hectares) Total: 771 (313) Main: 357 (145) New River: 414 (168)

Community Type Location Maps: Figure 1 and Figure 2

Rare Species Site Maps for Flora: N/A

Rare Species Site Maps for Fauna: N/A

Sample Site Maps for Fauna: Figures 7 through 16

Rare and Unique Species & Communities

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS

No rare and unique species or communities were found.

COMMUNITY DESCRIPTION

Large acreages of once open land at the Main and New River facilities are now maturing pine forests. Three species of pines are involved, *Pinus strobus* (white pine), *Pinus echinata* (shortleaf pine), and *Pinus taeda* (loblolly pine). White pine stands provide the deepest shade and are nearly devoid of other species, herbaceous or woody. Loblolly and shortleaf are sometimes interplanted elsewhere and support a more diverse but still very meager flora. Numerous dead trees (bark beetle damage) have opened up these stands and allowed invasion and proliferation of woody, especially exotic woody, species. Principal invaders are *Berberis thunbergii*, *Rubus phoenicolasius*, *Lonicera japonica*, *Symphoricarpos orbiculatus*, *Verbesina occidentalis*, and some *Ailanthus altissima*. The most frequent herbs are *Asplenium platyneuron*, *Diphasiastrum digitatum*, *Polystichum acrostichoides*, *Dactylis glomerata*, *Festuca elatior*, *Stellaria media*, *Cardamine hirsuta*, and *Satureja vulgaris*. Herbaceous species are very patchy and vary from place to place but are overwhelmingly exotic species. The invasion of exotic woody species is a major concern for future management.

RARE SPECIES AND COMMUNITY ACCOUNTS

No rare or unique species or communities were found.

MANAGEMENT RECOMMENDATIONS

General Recommendations

This is an artificial habitat type that does not contain any rare or unique species. However, pines do provide habitat cover for some wildlife. Pine stands are successional and will eventually be replaced by hardwoods unless measures to reverse this trend are taken. The pine plantations can be managed on a rotational basis such that young pines are available as wildlife cover. Creating clearings in the pines that will regenerate pine will provide a supply of young pine for wildlife cover. These clearings will require ground disturbance that exposes mineral soil in order for pines to become established. If these areas are invaded by hardwoods, then no management is recommended in order to maintain the pines. In general, hardwood forests are preferred by wildlife over pine plantations.

As mentioned in the management recommendations for the Bottomland Hardwood community type, the pine plantation along the New River should be converted to bottomland hardwoods.

TAXA LISTS

PLANTS

Family	Scientific Name	Common Name
Lycopodiaceae	*Diphasiastrum digitatum*	southern running-pine
Dryopteridaceae	*Polystichum acrostichoides*	Christmas fern
Aseraceae	*Verbesina occidentalis*	small yellow crownbeard
Berberidaceae	*Berberis thunbergii*	Japanese barberry
Brassicaceae	*Cardamine hirsuta*	Hairy bittercrest
Caprifoliaceae	*Lonicera japonica*	Japanese honsuckle
Caprifoliaceae	*Symphoricarpos orbiculatus*	coral-berry
Caryophyllaceae	*Stellaria media*	common chickweed
Lamiaceae	*Satureja vulgaris*	field basil
Pinaceae	*Pinus echinata*	shortlead pine
Pinaceae	*Pinus strobus*	whtie pine
Pinaceae	*Pinus taeda*	loblolly pine
Poaceae	*Dactylis glomerata*	orchard grass
Poaceae	*Festuca elatior*	tall fescue
Aspleniaceae	*Asplenium platyneuron*	ebony spleenwort
Roasaceae	*Rubus phoenicolasius*	wine berry
Simarubaceae	*Ailanthus altissima*	tree of heaven

INVERTEBRATES

Class: Arachnidae

Order: Araneae

Family	Scientific Name	Common Name
Agelenidae	*Coras medicinalis*	
Agelenidae	*Wadotes hybridus*	
Agelenidae	*Wadotes sp.*	
Araneidae	*Mangora placida*	
Clubionidae	*Castianeira longipalpus*	
Clubionidae	*Clubiona abboti*	
Dictynidae	*Dictyna sp.*	
Gnaphosidae	*Drassyllus aprilinus*	
Gnaphosidae	*Drassyllus eremitis*	
Gnaphosidae	*Drassyllus fallens*	
Gnaphosidae	*Zelotes duplex*	
Gnaphosidae	*Zelotes hentzi*	
Linyphiidae	*Cornicularia sp.*	
Linyphiidae	*Lepthyphantes zebra*	
Linyphiidae	*Prolinyphia marginata*	

Linyphiidae	*Tapinopa bilineata*	
Lycosidae	*Hogna frondicola*	
Lycosidae	*Pirata sedentarius*	
Lycosidae	*Schizocosa ocreate*	
Lycosidae	*Schizocosa sp.*	
Lycosidae	*Trabea aurantiaca*	
Mimetidae	*Ero leonina*	
Philodromidae	*Philodromus minutus*	
Pisauridae	*Dolomedes albineus*	
Tetragnathidae	*Leucauge venusta*	
Theridiidae	*Argyrodes trigona*	
Theridiidae	*Enoplognatha marmorata*	
Theridiidae	*Steatoda americana*	
Theridiidae	*Thymoites marxi*	
Thomisidae	*Xysticus bicuspis*	
Thomisidae	*Xysticus elegans*	

Class: Diploda
Order: Polydesmida

Family	Scientific Name	Common Name
Polydesmidae	*Pseudpolydesmus collinus*	millipede

Class: Insecta
Order: Coleoptera

Family	Scientific Name	Common Name
Carabidae	*Apenes lucidula*	ground beetle
Carabidae	*Arisodactylus nigerrimus*	ground beetle
Carabidae	*Arisodactylus nigerrinus*	ground beetle
Carabidae	*Chlaenius emarginatus*	ground beetle
Carabidae	*Dicaelus dilatatus*	ground beetle
Carabidae	*Dicaelus politus*	ground beetle
Carabidae	*Oligthopus parmatus*	ground beetle
Chrysomelidae	*Glyptoscelis pubescens*	leaf beetle
Cucujidae	*sp.*	flat bark beetle
Endomychidae	*Aphorista vittata*	handsome fungus beetle
Endomychidae	*Mycetina perpulchra*	handsome fungus beetle
Haliplidae	*sp.*	crawling water beetle

Class: Insecta
Order: Collembola

Family	Scientific Name	Common Name
Hypogastruidae	*sp.*	springtail

Sminthuridae	*sp.*	springtail

Class: Insecta
Order: Diptera

Family	**Scientific Name**	**Common Name**
Ceratopogonidae	*sp.*	biting midge
Ephydridae	*sp.*	shore fly
Heleomyzidae	*sp.*	heleomyzid fly
Phoridae	*sp.*	humpbacked fly
Pipunculidae	*sp.*	big-headed fly
Sciaridae	*sp.*	dark-winged fungus gnat
Syrphidae	*sp.*	syrphid fly

Class: Insecta
Order: Heteroptera

Family	**Scientific Name**	**Common Name**
Gerridae	*Gerris argenticollis*	water strider
Hebridae	*Merragotta sp.*	velvet water bug

Class: Insecta
Order: Hymenoptera

Family	**Scientific Name**	**Common Name**
Formicidae	*Ambylopone pallipes*	ponerinae (ant)
Formicidae	*sp.*	formicinae (ant)
Formicidae	*sp.*	myrmicinae (ant)
Vespidae	*Dolichovespula maculata*	vespinae (vespid wasp)

Class: Insecta
Order: Neuroptera

Family	**Scientific Name**	**Common Name**
Chrysopidae	*sp.*	green lacewing
Hemerobiidae	*sp.*	lacewing

Class: Insecta
Order: Odonata

Family	**Scientific Name**	**Common Name**
Coenagrionidae	*Agria fumipennis violacea*	variable dancer
Coenagrionidae	*Enallagma signatum*	orange bluet
Coenagrionidae	*Ishnura Hastata*	citrine forktail
Coenagrionidae	*Ishnura verticalis*	eastern forktail

Corduliida	*Epitheca cynosura*	common baskettail
Gomphidae	*Gomphus exilis*	lancet clubtail
Lestidae	*Lestes vigilax*	swamp spreadwing
Libellulidae	*Erythemis simplicicollis*	eastern pondhawk
Libellulidae	*Pachydiplax longipennis*	blue dasher
Gryllacrididae	*sp.*	camel cricket

Class: Insecta
Order: Lepidoptera

Family	Scientific Name	Common Name
Arctiidae	*Estigmene acrea*	salt marsh moth
Arctiidae	*Grammia virgo*	virgin tiger moth
Arctiidae	*Haploa lecontei*	leconte's haploa
Arctiidae	*Holomelina opella*	tawny holomelina
Geometridae	*Epimecis hortaria*	tulip-tree beauty
Geometridae	*Eubaphe mendica*	the beggar
Geometridae	*Eutrapela clemataria*	curve-toothed geometer
Geometridae	*Heterophleps triguttaria*	three-spotted fillip
Geometridae	*Metarranthis hypochraria*	common metarranthis
Geometridae	*Nepytia canosaria*	false hemlock looper moth
Geometridae	*Patalene olyzonaria puber*	juniper geometer
Geometridae	*Scopula inductata*	soft-lined wave
Geometridae	*Scopula limboundata*	large lace-border
Hesperidae	*Ancyloxypha numitor*	least skipper
Hesperidae	*Atalopedes campestris*	sachem
Hesperidae	*Epargyreus clarus*	silver-spotted skipper
Hesperidae	*Erynnis baptisiae*	wild indigo duskywing
Hesperidae	*Erynnis juvenalis*	Juvenal's duskywing
Lasiocampidae	*Malacosoma americanum*	tent caterpillar
Lasiocampidae	*Malacosoma sp.*	tent caterpillar
Limacodidae	*Packardia geminata*	slug catterpillar moth
Lycaenidae	*Callophrys niphon*	eastern pine elfin
Lycaenidae	*Everes comyntas*	eastern tailed blue
Noctuidae	*Caenurgina erechtea*	forage looper moth
Noctuidae	*Feltia jaculifera*	dingy cutworm moth
Noctuidae	*Galgula partita*	the wedgeling
Noctuidae	*Leucania sp.*	armyworm moth
Noctuidae	*Mocis texana*	texas mocis
Noctuidae	*Panthea furcilla*	eastern panthea
Noctuidae	*Plathypena scabra*	green cloverworm moth
Noctuidae	*sp.*	noctuid moth
Noctuidae	*Xestia elimata*	
Nymphalidae	*Cercyonis pegala*	common wood nymph

Nymphalidae	*Chlosyne nycteis*	silvery checkerspot
Nymphalidae	*Danaus plexippus*	monarch
Nymphalidae	*Limenitis arthemis astyanax*	red-spotted purple
Nymphalidae	*Megisto cymela*	little wood satyr
Nymphalidae	*Phyciodes tharos*	pearl crescent
Nymphalidae	*Speyeria aphrodite*	aphrodite fritillary
Nymphalidae	*Speyeria cybele*	great spangled fritillary
Nymphalidae	*Vanessa atalanta*	red admiral
Nymphalidae	*Vanessa virginiensis*	American lady
Papilionidae	*Battus philenor*	pipevine swallowtail
Papilionidae	*Papilio glaucus*	eastern tiger swallowtail
Pieridae	*Colias eurytheme*	orange sulfer
Pieridae	*Colias philodice*	clouded sulfer
Pieridae	*Pieris rapae*	cabage white
Sphingidae	*Hemaris thysbe*	hummingbird clearwing

Class: Malacostraca

Order: Isopoda

Family	Scientific Name	Common Name
Ligiidae	*Ligidium sp.*	pill bug

FISH

REPTILES AND AMPHIBIANS

Family	Scientific Name	Common Name
Ambystomatidae	*Ambystoma jeffersonianum*	Jefferson salamander
Bufonidae	*Bufo americanus*	American toad
Chelydridae	*Chelydra serpentina*	snapping turtle
Colubridae	*Carphophis a. amoenus*	eastern worm snake
Colubridae	*Diadophis punctatus*	ringneck snake
Colubridae	*Elaphe obsoleta*	black rat snake
Colubridae	*Lampropeltis triangulum*	eastern milk snake
Colubridae	*Thamnophis sirtalis*	eastern garter snake
Emydidae	*Chrysemys picta*	eastern painted turtle
Emydidae	*Terrapene c. carolina*	eastern box turtle
Hylidae	*Hyla versicolor*	gray treefrog
Hylidae	*Pseudacris crucifer*	spring peeper
Hylidae	*Pseudacris triseriata*	upland chorus frog
Plethodontidae	*Eurycea cirrigera*	southern two-lined salamander
Plethodontidae	*Eurycea longicauda*	longtail salamander

Plethodontidae	*Plethodon cinereus*	redback salamander
Plethodontidae	*Pseudotriton ruber*	northern red salamander
Ranidae	*Rana catesbeiana*	bullfrog
Ranidae	*Rana clamitans*	green frog

BIRDS: Status code definitions; B = breeding, M = migrant, R = resident, U = undetermined, and W = winter.

Family	Scientific Name	Common Name	Status
Accipitridae	*Buteo jamaicensis*	red-tailed hawk	R
Accipitridae	*Circus cyaneus*	northern harrier	M
Alcedinidae	*Cerule alcyon*	belted kingfisher	B
Anatidae	*Anas crecca*	Green-winged teal	W
Anatidae	*Anas discors*	Blue-winged teal	W
Anatidae	*Anas platyrhynchos*	Mallard duck	R
Anatidae	*Anas rubripes*	American black duck	R, M
Anatidae	*Anas strepera*	Gadwall	W
Anatidae	*Aythya collaris*	Ring-necked duck	W
Anatidae	*Bucephala albeola*	bufflehead	W
Anatidae	*Lophodytes cucullatus*	hooded merganser	W
Apodidae	*Chaetura pelagica*	chimney swift	B
Ardeidae	*Adea herodias*	great blue heron	R
Bombycillidae	*Bombycilla cedrorum*	cedar waxwing	R
Caprimulgidae	*Chordeiles minor*	common nighthawk	B
Certhiidae	*Certhia americana*	brown creeper	
Columbidae	*Zenaida macroura*	mourning dove	R
Corvidae	*Corvus brachyrhynchos*	American crow	R
Corvidae	*Cyanocitta cristata*	blue jay	R
Emberizidae	*Agelaius phoeniceus*	red-winged blackbird	B
Emberizidae	*Cardinalis cardinalis*	northern cardinal	R
Emberizidae	*Dendroica coronata*	yellow-rumped warbler	W
Emberizidae	*Dendroica palmarum*	palm warbler	M
Emberizidae	*Dendroica pinus*	pine warbler	B
Emberizidae	*Dendroica virens*	black-throated green warbler	B
Emberizidae	*Geothlypis trichas*	common yellowthroat	B
Emberizidae	*Junco hyemalis*	northern junco	W
Emberizidae	*Melospiza melodia*	song sparrow	R
Emberizidae	*Molothrus ater*	brown-headed cowbird	B
Emberizidae	*Passerina cyanea*	indigo bunting	B

Emberizidae	*Pipilo erythrophthalmus*	eastern towhee	B
Emberizidae	*Piranga olivacea*	scarlet tanager	B
Emberizidae	*Quiscalus quiscula*	common grackle	B
Emberizidae	*Spizella passerina*	chipping sparrow	B
Emberizidae	*Spizella pusilla*	field sparrow	B
Emberizidae	*Zonotrichia albicollis*	white-throated sparrow	W
Fringillidae	*Carduelis tristis*	American goldfinch	R
Fringillidae	*Carpodacus mexicanus*	house finch	R
Hirundinidae	*Hirundo rustica*	barn swallow	B
Hirundinidae	*Stelgidopteryx serripennis*	rough-winged swallow	B
Mimidae	*Dumetella carolinensis*	gray catbird	B
Mimidae	*Mimus polyglottos*	northern mockingbird	R
Muscicapidae	*Hylocichla mustelina*	wood thrush	B
Muscicapidae	*Polioptila caerulea*	blue-gray gnatcatcher	B
Muscicapidae	*Regulus calendula*	ruby-crowned kniglet	W
Muscicapidae	*Regulus satrapa*	golden-crowned kinglet	W
Muscicapidae	*Sialia sialis*	eastern bluebird	B
Muscicapidae	*Turdus migratorius*	American robin	B, M
Paridae	*Parus bicolor*	tufted titmouse	R
Paridae	*Parus carolinensis*	carolina chickadee	R
Phasianidae	*Meleagris gallopavo*	wild turkey	R
Picidae	*Colaptes auratus*	northern flicker	R
Picidae	*Dryocopus pileatus*	pileated woodpecker	R
Picidae	*Melanerpes carolinus*	red-bellied woodpecker	R
Picidae	*Picoides pubescens*	downy woodpecker	R
Picidae	*Picoides villosus*	hairy woodpecker	R
Podicipedidae	*Podilymbus podiceps*	pied-billed grebe	W
Rallidae	*Fulica americana*	American coot	W
Scolopacidae	*Tringa melanoleuca*	greater yellowlegs	W
Sittidae	*Sitta canadensis*	red-breasted nuthatch	W
Sittidae	*Sitta carolinensis*	white-breasted nuthatch	R
Sittidae	*Sitta pusilla*	brown-headed nuthatch	B
Strigidae	*Otus asio*	eastern screech owl	R
Sturnidae	*Sturnus vulgaris*	European starling	R
Troglodytidae	*Thryothorus ludovicianus*	carolina wren	B
Troglodytidae	*Troglodytes aedon*	house wren	B
troglodytidae	*Troglodytes troglodytes*	winter wren	U
Tyrannidae	*Contopus virens*	eastern pewee	B

Tyrannidae	*Myiarchus crinitus*	great crested flycatcher	B
Tyrannidae	*Sayornis phoebe*	eastern phoebe	B
Tyrannidae	*Tyrannus tyrannus*	eastern kingbird	B
Vireonidae	*Vireo flavifrons*	yellow-throated vireo	B
Vireonidae	*Vireo olivaceus*	red-eyed vireo	B
Vireonidae	*Vireo solitarius*	solitary vireo	M

MAMMALS

Family	Scientific Name	Common Name
Canidae	*Vulpes vulpes*	red fox
Cervidae	*Odocoileus virginianus*	white-tailed deer
Diedelphidae	*Didelphis virginiana*	Virginia opossum
Soricidae	*Blarina brevicauda*	northern short-tailed shrew
Soricidae	*Cryptotis parva*	least shrew
Mephitidae	*Mephitis mephitis*	striped skunk
Muridae	*Microtus pennsylvanicus*	meadow vole
Muridae	*Peromyscus leucopus*	white-footed mouse
Muridae	*Reithrodontomys humillis*	eastern harvest mouse
Muridae	*Zapus hudsonicus*	meadow jumping mouse
Procyonidae	*Procyon lotor*	common raccoon
Sciuridae	*Marmota monax*	woodchuck

Community Type: Wet Meadow/Marsh and Ponds

Acreage: Acres (Hectares) Total:4.2 (0.2) Main: not calculated New River: 4.2 (0.2)

Community Type Location Maps: Figure 1 and Figure 2

Rare Species Site Maps for Flora: Figure 3 and Figure 4

Rare Species Site Maps for Fauna: N/A

Sample Site Maps for Fauna: N/A

Rare and Unique Species & Communities

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
Plants					
Carex suberecta	Prairie straw sedge	G4	S3	N/A	Watchlist
Juncus brachycephalus	Small-headed rush	G5	S2	N/A	Rare List
Liparis loeselii	Bog Twayblade	G5	S2	N/A	Rare List
Spiranthes lucida	Shining ladies'-tresses	G5	S1	N/A	Rare List
Sporobolus asper	Tall Dropseed				

COMMUNITY DESCRIPTIONS

Wetmeadow/Marsh

Small areas of saturated soil conditions bordering spring branches, streams, and ponds support a wetland flora distinct from the upland vegetation. These are mostly too small or linear to map. Groundwater or poor drainage create marshy conditions which support a few unusual species but lack either the specialized species or community structure of the Calcareous Fen community. Typical species of this habitat are *Typha latifolia, Sparganium americanum, Glyceria striata, Leersia oryzoides, Carex frankii, Carex lurida, Carex vulpinoidea, Schoenoplectus validus, Scirpus atrovirens, Scirpus pendulus, Acorus calamus, Juncus dudleyi, Boehmeria cylindrica, Impatiens capensis, Epilobium coloratum, Lycopus uniflorus, Mimulus ringens, Veronica anagalis-aquatica, Eupatorium perfoliatum, Helenium autumnale,* etc. All of these are wide-ranging species that occur in a variety of wetland habitats.

Rare species: *Sporobolus asper*
Carex suberecta
Juncus brachycephalus
Liparis loeselii
Spiranthes lucida

Note: Although these habitats are artificially maintained now, they are significant in providing habitat for these rare species.

Pond

Several artificial ponds provide habitat for submersed aquatic plants and certain animal species that might not otherwise be present on the Site. The emergent flora of this habitat is essentially identical to that of the wetmeadow/marsh community but that habitat lacks submersed species such as *Potamogeton crispus*, *Potamogeton foliosus*, and *Callitriche heterophylla*. This habitat, however, is conspicuously lacking in species diversity.

Rare Species: None

RARE SPECIES AND COMMUNITY ACCOUNTS

Prairie Straw Sedge (*Carex suberecta*): Prairie straw sedge is a species associated with fens and other alkaline wetland habitats. The species was found only at the New River facility at three locations. At the Calcareous Fen community, numerous plants co-occur with other prairie fen sedge species in the central portion of the wetland. The second population occurs in the small marsh area adjacent to Big Pond. The third population was comprised of scattered individuals along the small stream with *Spiranthes lucida*. A careful search of other streambanks at the New River facility would be likely to turn up additional locations for this species.

Small-headed Rush (*Juncus brachycephalus*): This rush species was found at both Sites, one place at the Main facility and several at the New River facility. The population at the Main facility is in the shallows along the S shore of the manmade pond 2 kilometers NE of the Main Gate. At the New River facility, it occurs at the Calcareous Fen natural community, at Big Pond, and scattered along limy spring branches in several places. It prefers perennially wet ground with a fresh supply of highly alkaline water. It matures very late in the season and is difficult to identify until then, so there could be other populations that went undetected. Water with a high pH seems to be the critical factor for this species.

Bog Twayblade (*Liparis loeselii*): Loesel's twayblade was found at two sites at the New River facility. Both were grass and sedge-dominated damp ground along spring branches. Surprisingly, the species wasn't found at the Calcareous Fen which would seem to be an ideal site. This diminutive orchid is very difficult to see when flowering among its graminoid associates. In fruit, its pale yellow-green color aids in spotting it. On August 14, 1997, about 20 fruiting plants were found along about 100 meters of the branch. In 1998, the species was in full flower on June 16 at which time a second small population of only 3 plants was found at another location. This second station may have been destroyed when heavy rains washed out a dam just upstream.

Shining Ladies'-tresses (*Spiranthes lucida*): Shining ladies-tresses was found only at New River as scattered plants along a spring branch through open meadows. Ninty-seven (97) flowering stems (many with one per plant) were counted either when flowering began on June 3 or at its peak on June 16 , 1998. Most plants occurred on or around small limestone bedrock exposures in or beside the branch. Other plants occurred in graminoid cover on the very lip of the streambank. Elsewhere, a dense thatch of competing vegetation may not allow this orchid to grow.

Tall Dropseed (*Sporobolus asper*): Tall dropseed was found at a single location at the New River facility where numerous plants were found on seasonally damp flats along a small stream. Although most plants were found in several denser patches, others occurred individually or in small groups over a 300 meter distance. Most plants occurred laterally to an area disturbed for sewer line construction and subsequently seeded in tall fescue. Some plants had established and were competing reasonably well with the fescue. This disturbance certainly very much reduced the original population.

MANAGEMENT RECOMMENDATIONS

General Recommendations

These communities require management that maintains an open or partial shade environment. These areas should be managed in concert with grassland management (as historically managed) and follow the management recommendations found under that community type (page 44).

Rare Species and Community Recommendations

Prairie Straw Sedge (*Carex suberecta*), Small-headed Rush (*Juncus brachycephalus*), Bog Twayblade (*Liparis loeselii*), Shining Ladies'-tresses (*Spiranthes lucida*), and Tall Dropseed (*Sporobolus asper*): These are all wetland plants that require seasonally wet soils and open sun or partial shade. Disruption of hydrology, either draining or damming, would be detrimental to these species. A dense thatch of cool-season grasses may be limiting expansion of these species with the exception of *Sporobolus*. This area of cool-season grasses can be spot treated with herbecide or manually removed. Management should follow that prescribed for grasslands.

TAXA LISTS

PLANTS

Family	Scientific Name	common name
Arceae	*Acorus calamus*	sweet flag
Balsaminaceae	*Impatiens capensis*	jewelweed
Callitrichaceae	*Callitriche heterophylla*	larger water starwart
Compositae	*Eupatorium perfoliatum*	boneset
Compositae	*Helenium autumnale*	yellow sneezeweed
Cyperaceae	*Carex frankii*	Frank's sedge
Cyperaceae	*Carex lurida*	sallow sedge
Cyperaceae	*Carex suberecta*	prairie straw sedge
Cyperaceae	*Carex vulpinoidea*	fox sedge
Cyperaceae	*Schoenoplectus validus*	soft-stem sedge
Cyperaceae	*Scirpus atrovirens*	woolgrass bulrush
Cyperaceae	*Scirpus pendulus*	reddish bulrush
Juncaceae	*Juncus brachycephalus*	small-headed rush
Juncaceae	*Juncus dudleyi*	
Labiatae	*Lycopus uniflorus*	northern bugleweed
Onograceae	*Epilobium coloratum*	purple-leaved willow-herb
Orchidaceae	*Liparis loeselii*	Loesel's twayblade
Orchidaceae	*Spiranthes lucida*	shining ladies'- tresses
Poaceae	*Glyceria striata*	fowl mannagrass
Poaceae	*Leersia oryzoides*	rice cutgrass
Poaceae	*Sporobolus asper*	tall dropseed
Scropulariaceae	*Mimulus ringens*	common monkey-flower
Scropulariaceae	*Veronica anagalis-aquatica*	water speedwell
Sparganiaceae	*Sparganium americanum*	American burreed
Thyphaceae	*Typha latifolia*	broad-leaved cattail
Urticaceae	*Boehmeria cylindrica*	false nettle
Zosteraceae	*Potamogeton crispus*	curly pondweed
Zosteraceae	*Potamogeton foliosus,*	leafy pondweed

References:

Belden, A. Jr., comp. 1998. Natural heritage resources of Virginia: rare vascular plants. Natural Heritage Technical Report 98-2. Virginia Department of Conservation and Recreation, Division of Natural Heritage, Richmond, Virginia. Unpublished report. January 1998. 36 pages plus appendices.

Brennan, L.A. 1991. How can we reverse the northern bobwhite population decline. Wildlife Soc. Bull. 19:544-555.

Bollinger, E.K., P.B. Bollinger, and T.A. Gavin. 1990. Effects of hay-cropping on eastern populations of the bobolink. Wildlife Soc. Bull. 19:142-150.

Conant, R. and J.T. Collins. 1991. Reptiles and Amphibians of Eastern and Central North America. Houghton Mifflin Company. Boston, Massachusetts. 450 pages.

Covell, C.V., Jr. 1984. Eastern Moths, Peterson Field Guide. Houghton Mifflin Company. Boston, Massachusetts. 496 pages.

Dunkle, S.W. 1989. Dragonflies of the Florida Peninsula, Bermuda and the Bahamas. Scientific Publishers. Gainesville, Florida. 154 pages.

Dunkle, S.W. 1990. Damselflies of Florida, Bermuda and the Bahamas. Scientific Publishers. Gainesville, Florida. 148 pages.

Flora of North American Editorial Committee. 1993. Flora of North America. Vol. 2 Pteridophytes and Gymnosperms. Oxford University Press. New York. 475 pages.

Gleason, H.A. and A. Cronquist. 1991. Manual of Vascular Plants of Northeastern United States and Adjacent Canada. Second Edition. The New York Botantical Garden. N.Y. 910 pages.

Herkert, J.R. 1994. Status and habitat selection of the Henslow's sparrow in Illinois. Wilson Bull. 106(1):35-45.

Herkert, J.R. 1994. The effects of habitat fragmentation on midwestern grassland bird communities. Ecol. Appl. 4:461-471.

Mitchell, J.C. 1994. The Reptiles of Virginia. Smithsonian Institutional Press. Washington and London. 352 pages.

Opler, P.A. and V. Malikul. 1992. A Field Guide to Eastern Butterflies. Peterson Field Guides. Houghton Mifflin Company. Boston, Massachusetts. 396 pages.

Radford, A.E., H.E. Ahles, and C.R. Bell. 1983. Manual of the Vascular Flora of the Carolinas. The University of North Carolina Press, Chapel Hill, N.C. 1,183 pages.

Roble, S. M. 1996. Natural heritage resources of Virginia: rare animal species. Natural Heritage Technical Report 96-11. Virginia Department of Conservation and Recreation, Division of Natural Heritage, Richmond, Virginia. Unpublished report. 23 pages plus appendices.

Schafale, M.P. and A.S. Weakley. 1990. Classification of the natural communities of North Carolina. Third Approximation. N.C. Natural Heritage Program, Division of Parks and Recreation, N.C. Department of Environment, Health, and Natural Resources. 325 pages.

Terwilliger, K.T. (editor). 1991. Virgina's Endangered Species. McDonald and Woodward Publishing Co., Blacksburg, Virginia.672 pages.

Turgeon, D.D., et.al. 1998. Common and Scientific Names of Aquatic Invertebrates from the United States and Canada. American Fisheries Society Special Publication 26. Bethesda, Maryland. 526 pages.

Wengel, S.R. In Preparation. Management reponses of three declining tallgrass prairie sparrows.

Whitaker, J.O. Jr. and W.J. Hamilton, Jr. 1998. Mammals of the Eastern United States, Third Edition. Comstock Publishing Associates. Ithaca, New York. 583 pages.

Zimmerman, J.L. 1988. Breeding season habitat selection by the Henslow's sparrow (*Ammodramus henslowii*) in Kansas. Wilson Bull. 100:17-24.

Zimmerman, J.L. 1992. Density-independent factors affecting the avian diversity of the tallgrass prairie community. Wilson Bull. 104 (1):85-94.

Appendix A: Figures

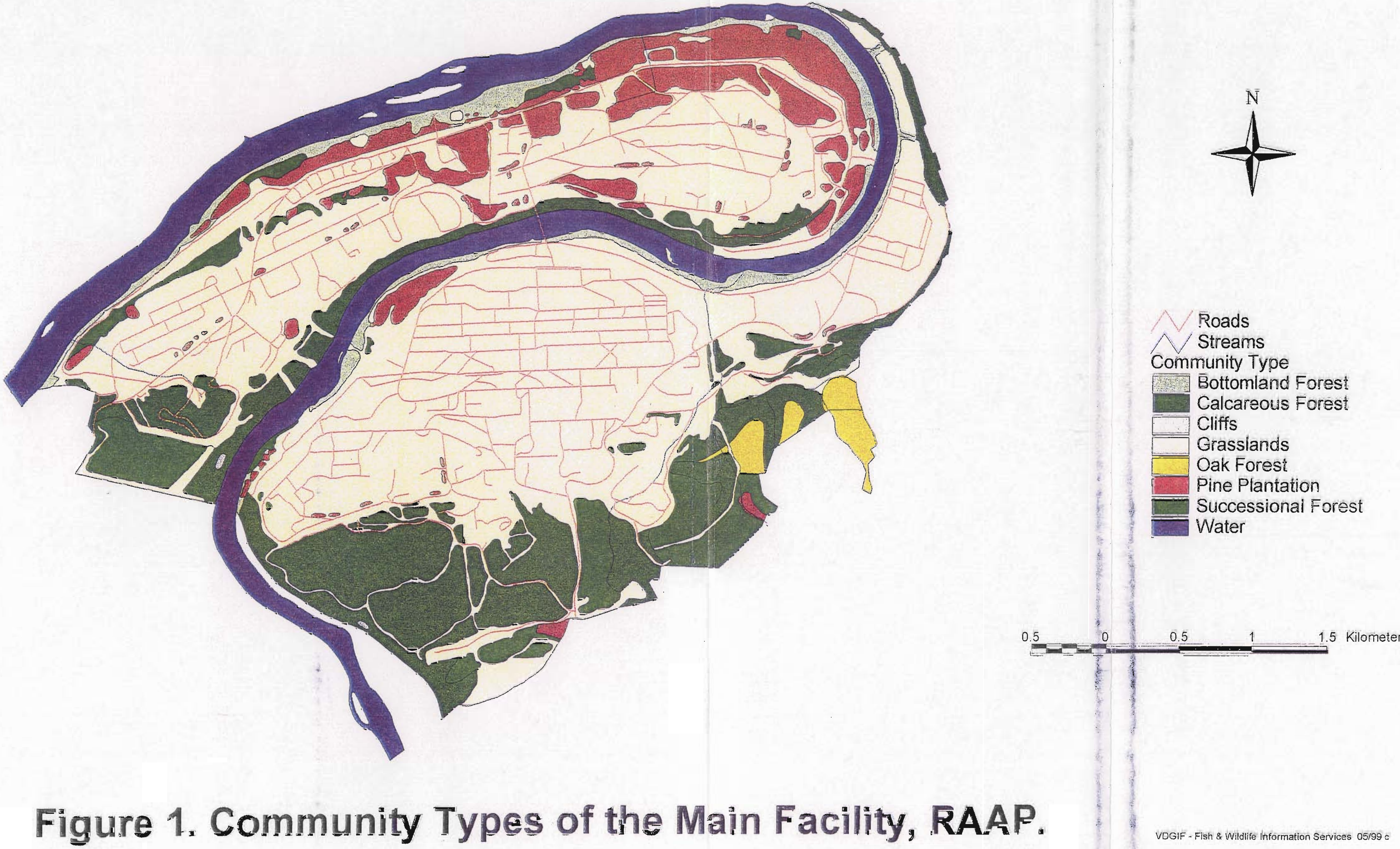

Figure 1. Community Types of the Main Facility, RAAP.

206b

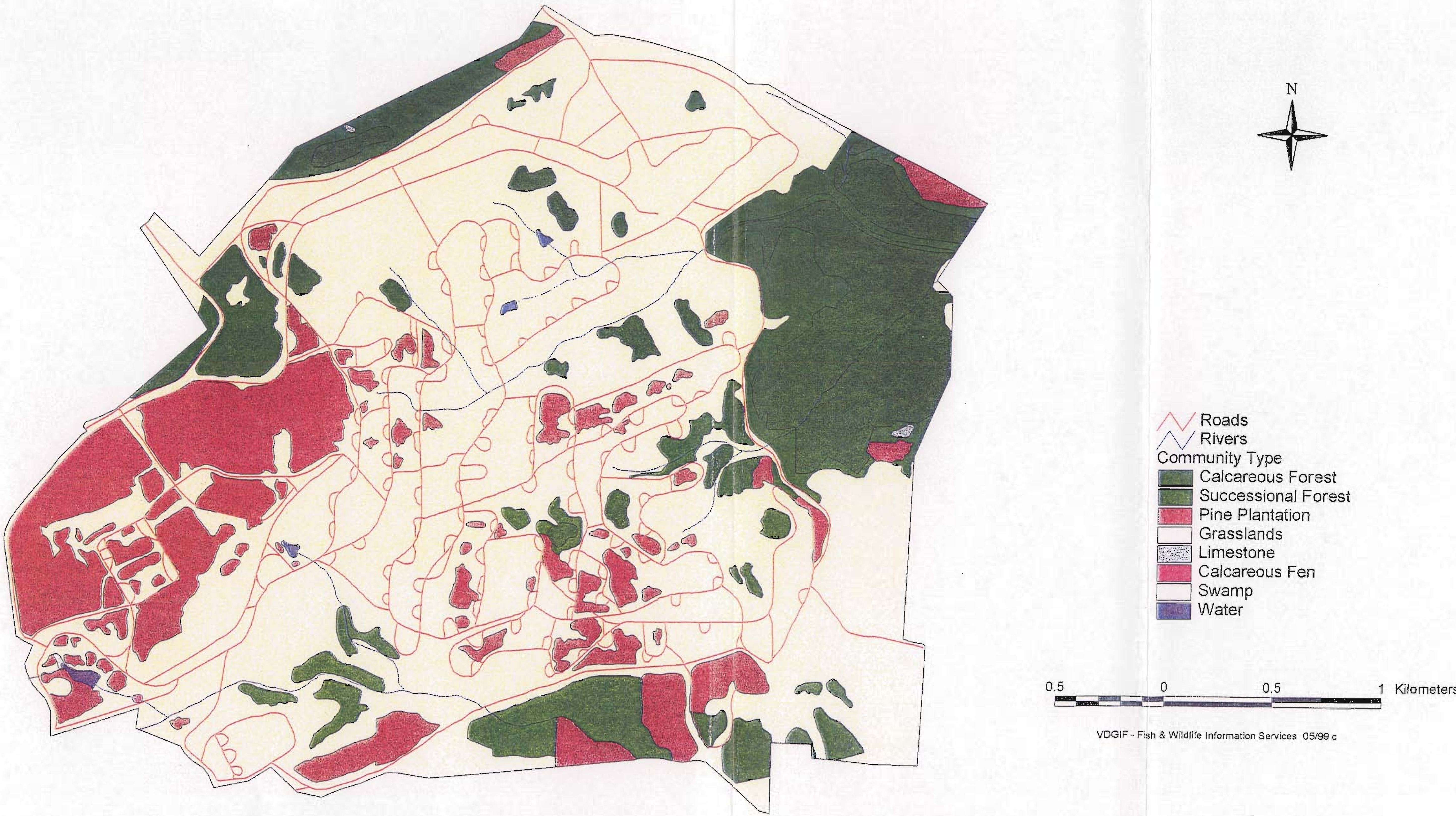

Figure 2. Community Types of the New River Facility, RAAP.

206C

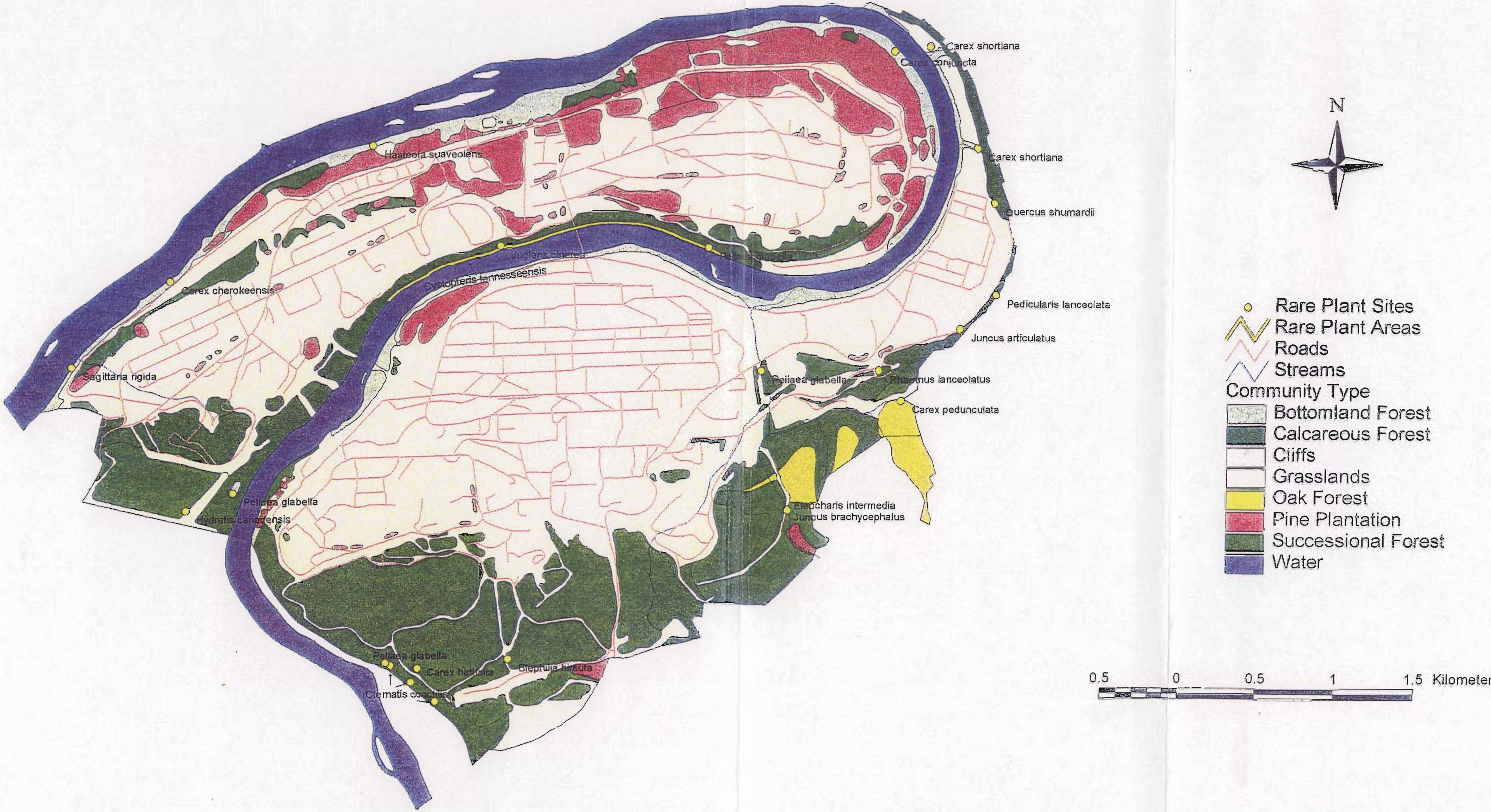

Figure 3. Rare Plant Locations at the Main Facility, RAAP.

VDGIF - Fish & Wildlife Information Services 05/99 c

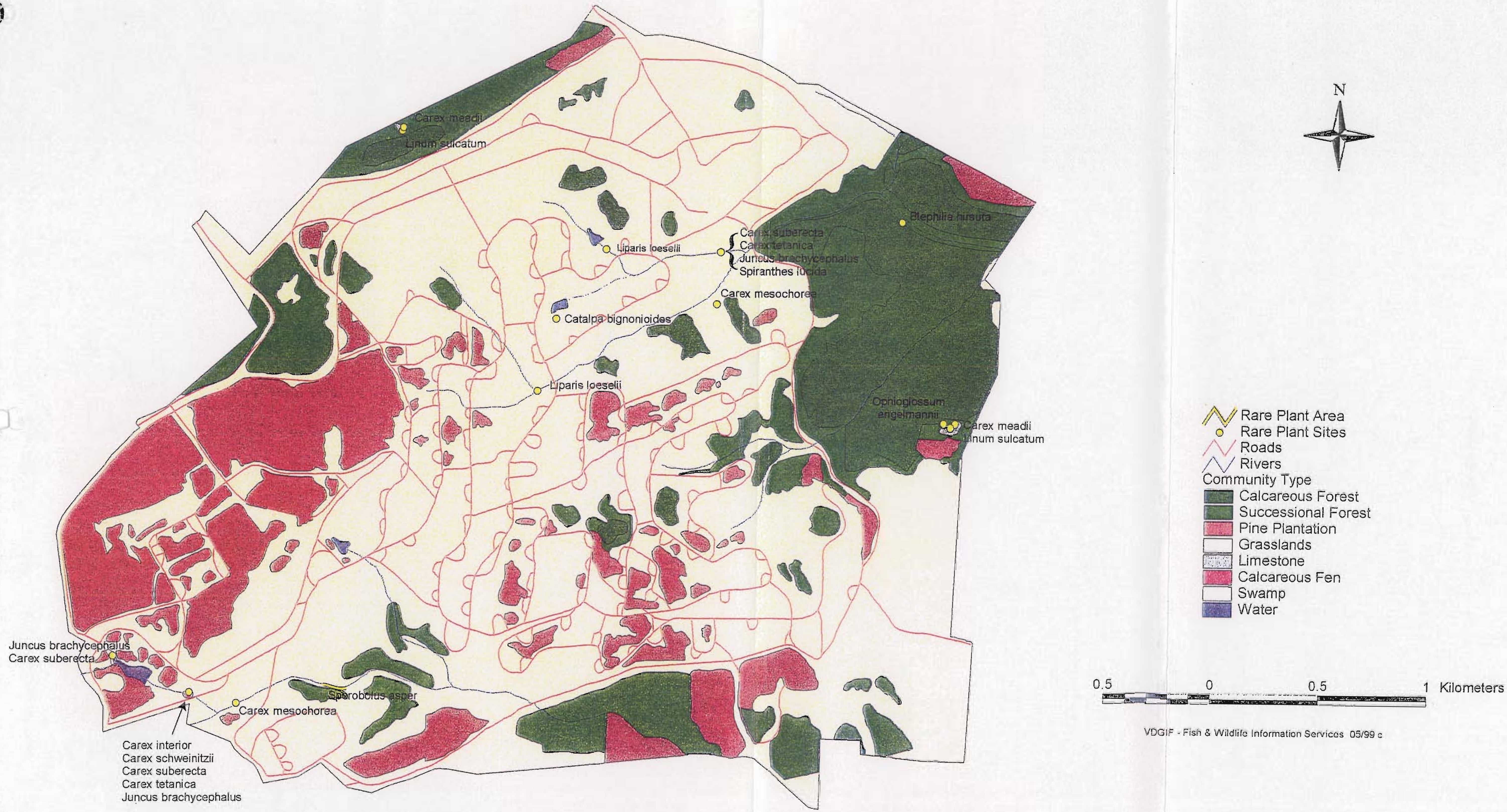

Figure 4. Rare Plant Locations at the New River Facility, RAAP.

Figure 5. Regal Fritillary Site at the Main Facility, RAAP.

VDGIF - Fish & Wildlife Information Services 05/99 c

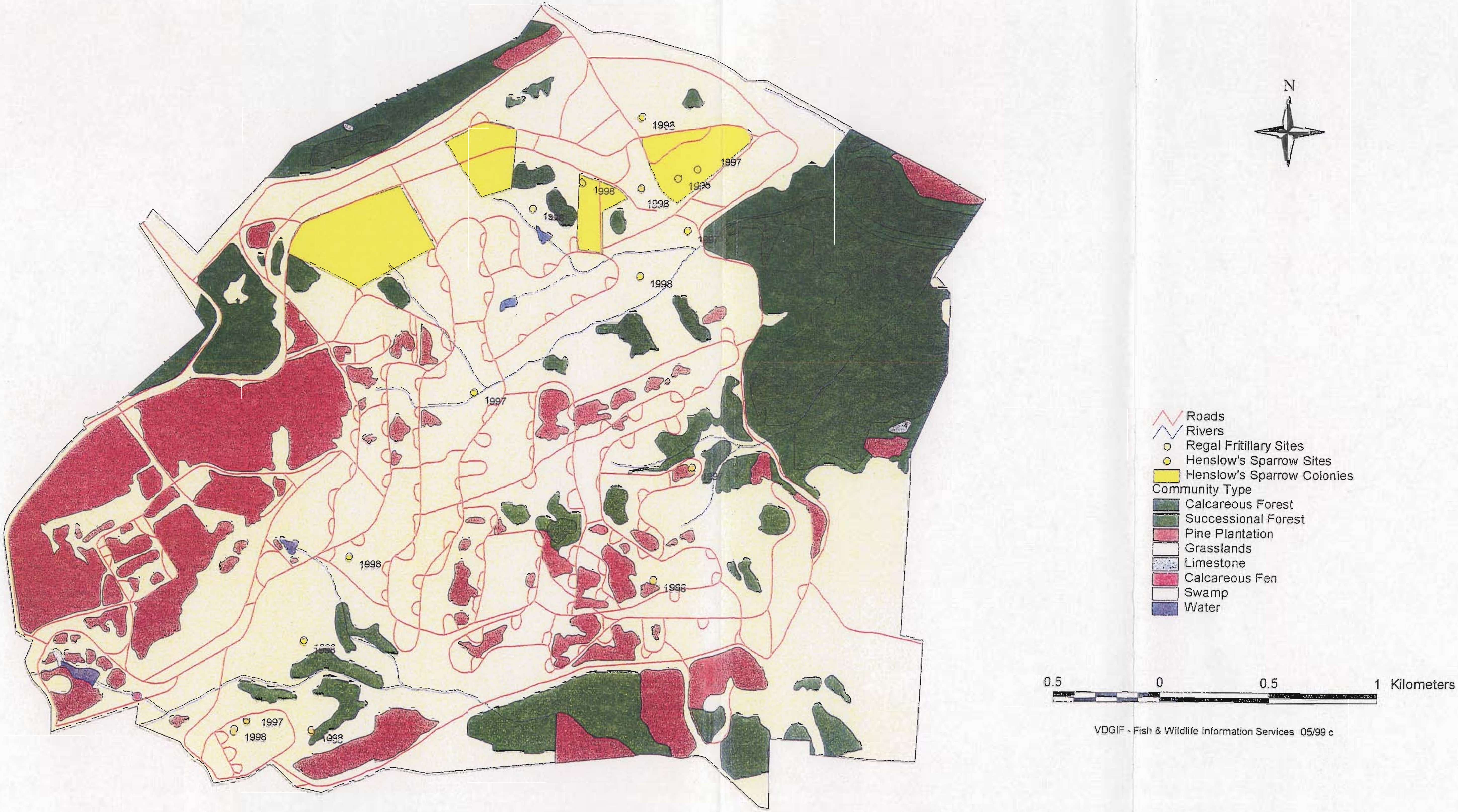

Figure 6. Rare Animal Locations at the New River Facility, RAAP.

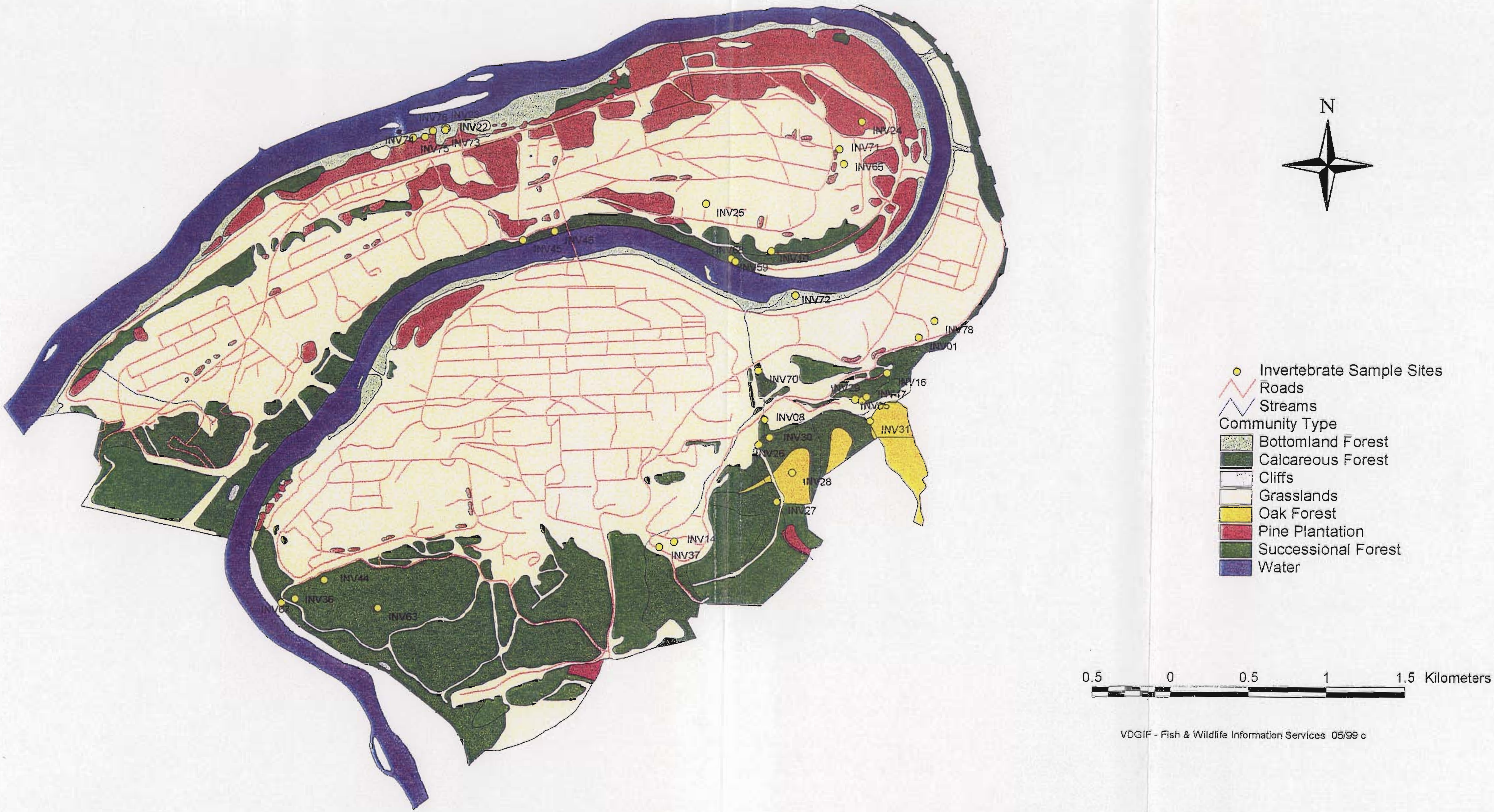

Figure 7. Invertebrate Sample Sites at the Main Facility, RAAP.

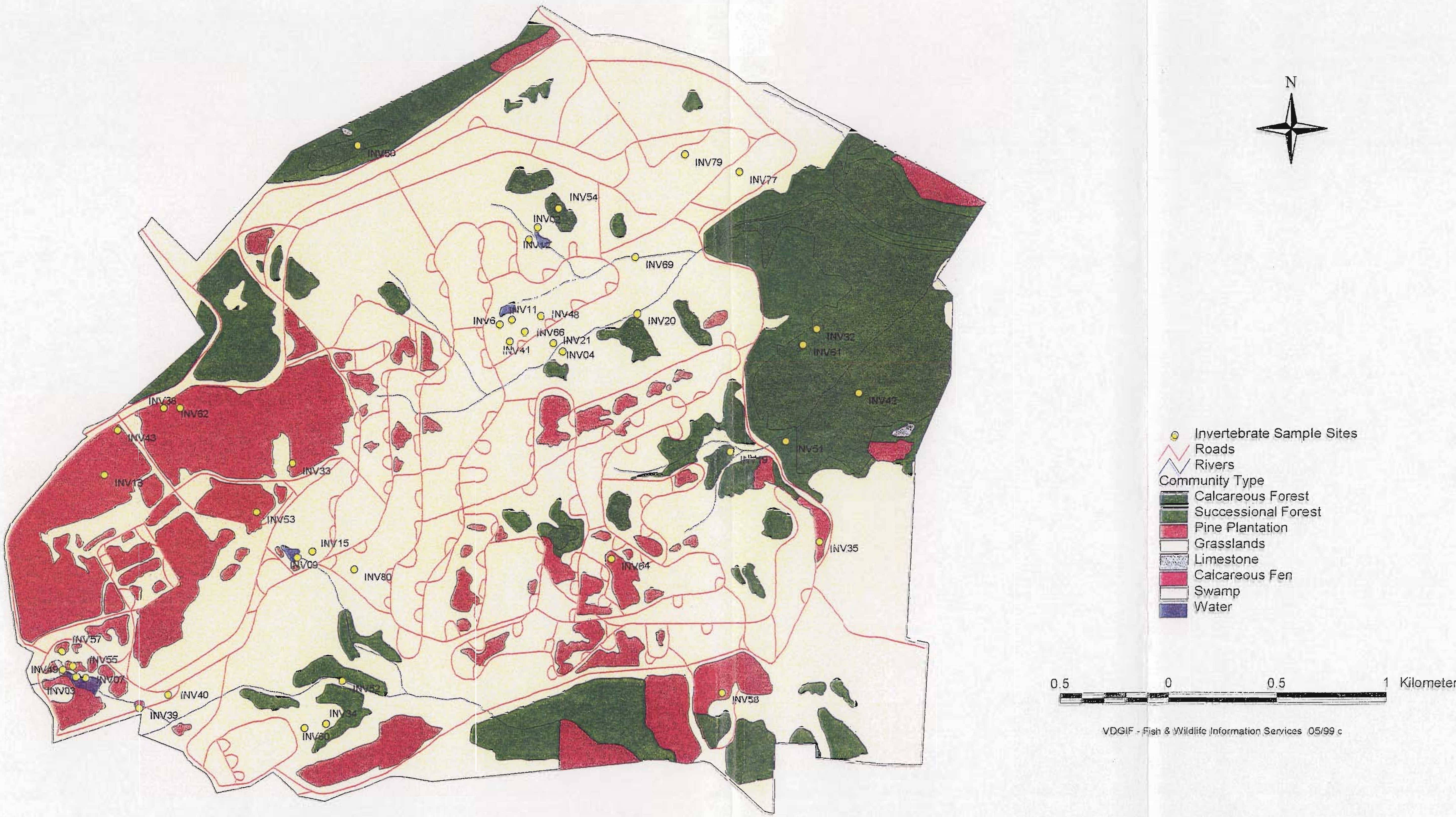

Figure 8. Invertebrate Sampling Sites at the New River Facility, RAAP.

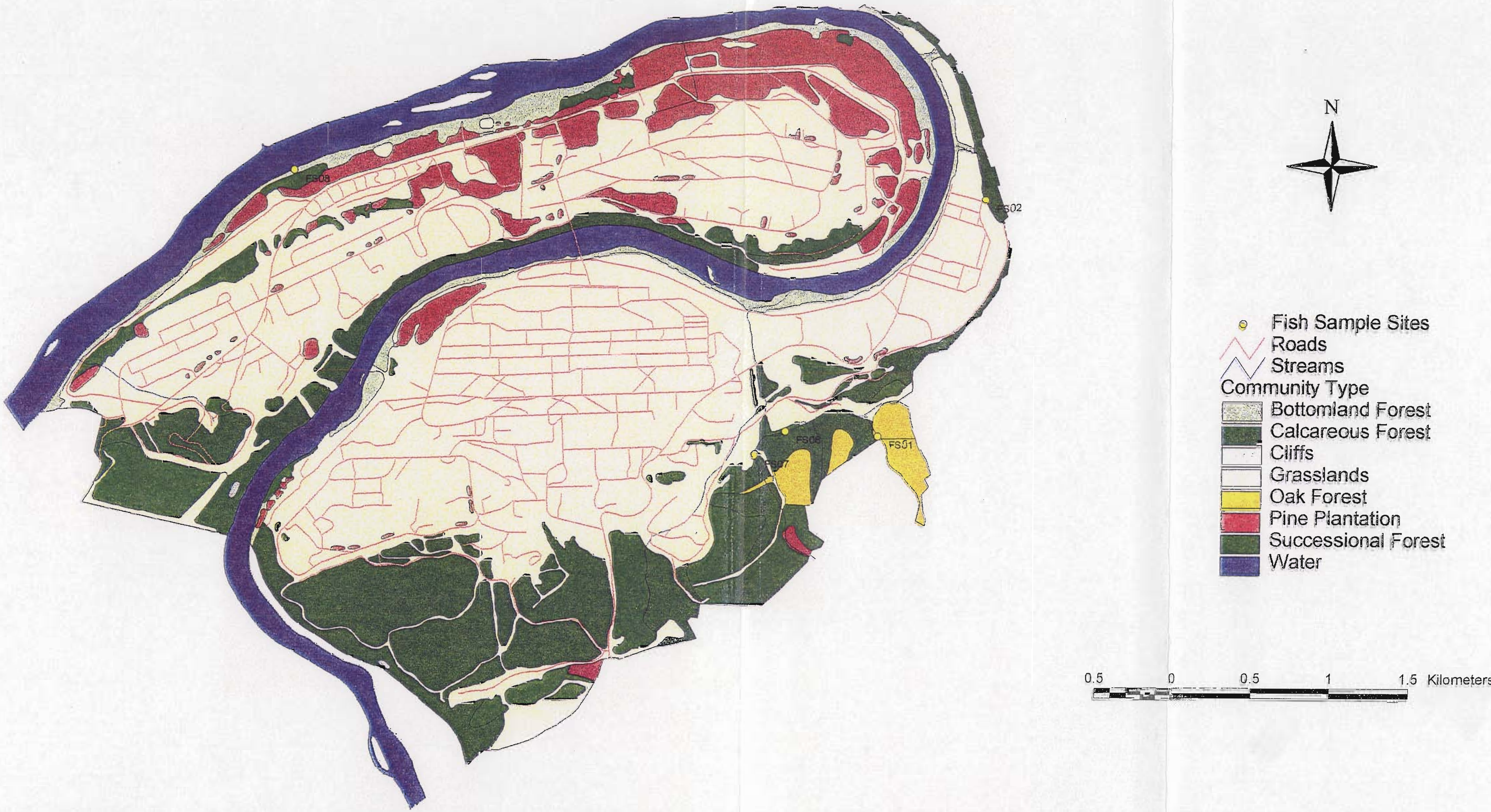

Figure 9. Fish Sample Sites at the Main Facility, RAAP.

VDGIF - Fish & Wildlife Information Services 05/99 c

Figure 10. Fish Sample Sites at the New River Facility, RAAP.

700J

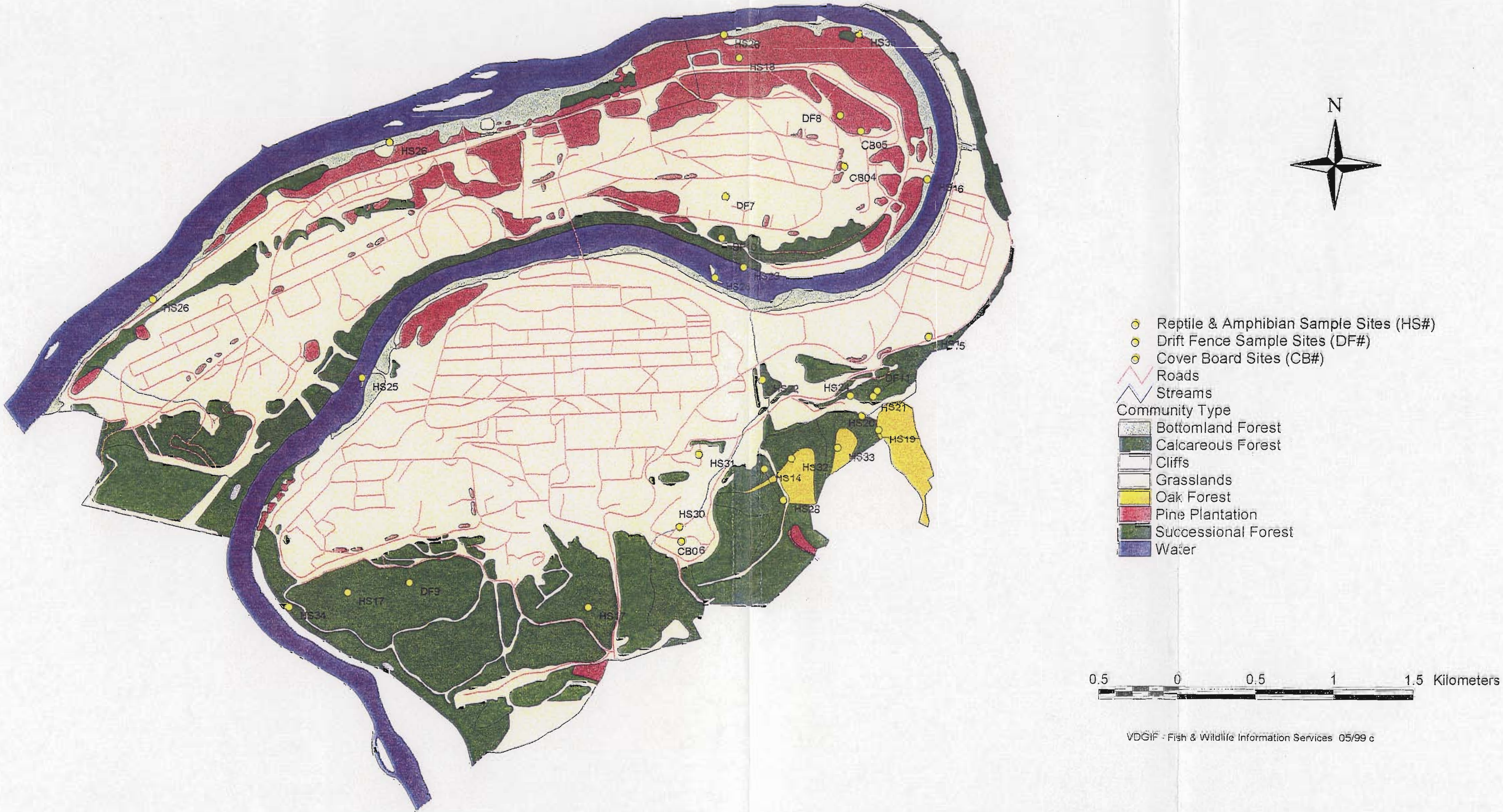

Figure 11. Reptile and Amphibian Sample Sites at the Main Facility, RAAP.

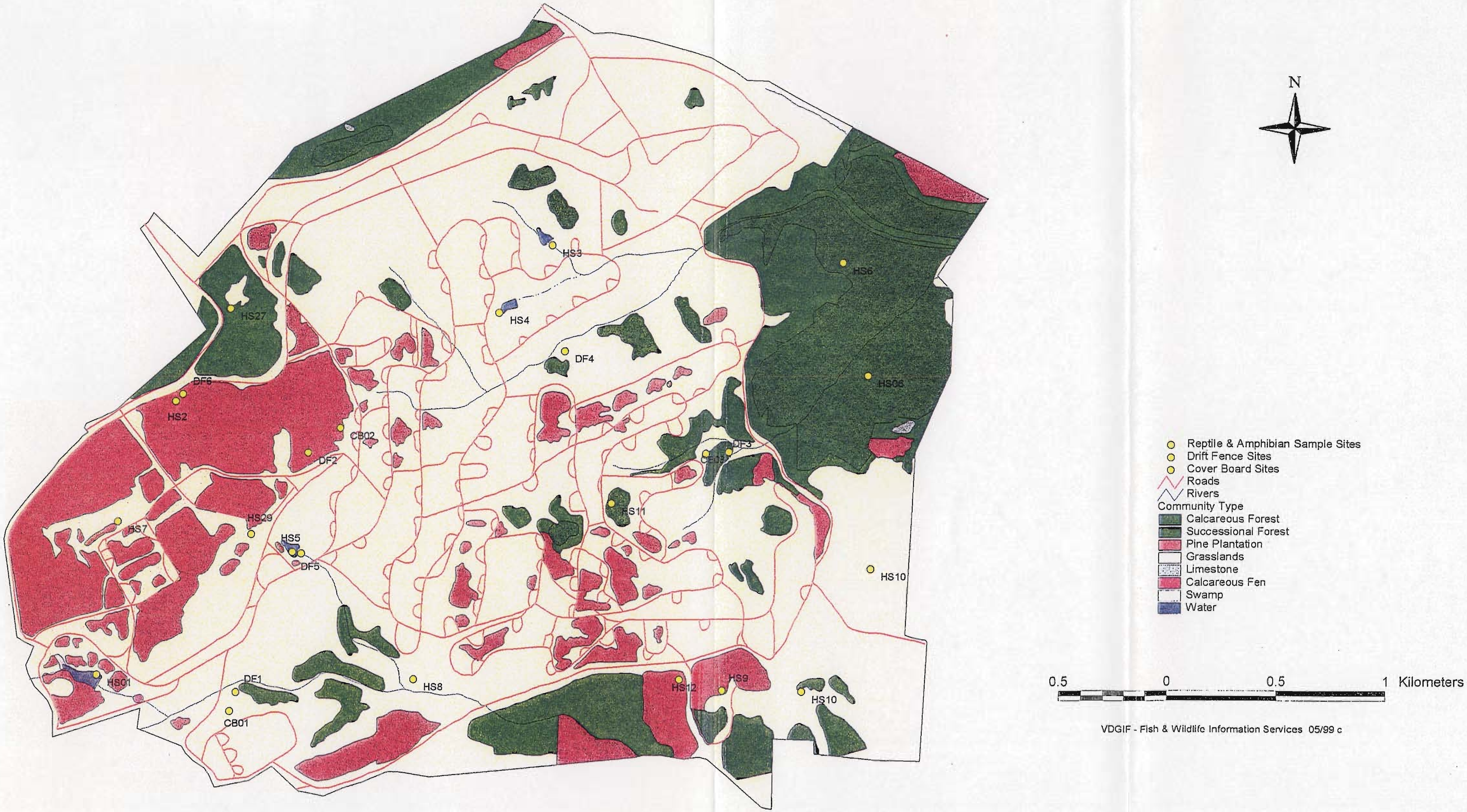

Figure 12. Reptile and Amphibian Sample Sites at the New River Facility, RAAP.

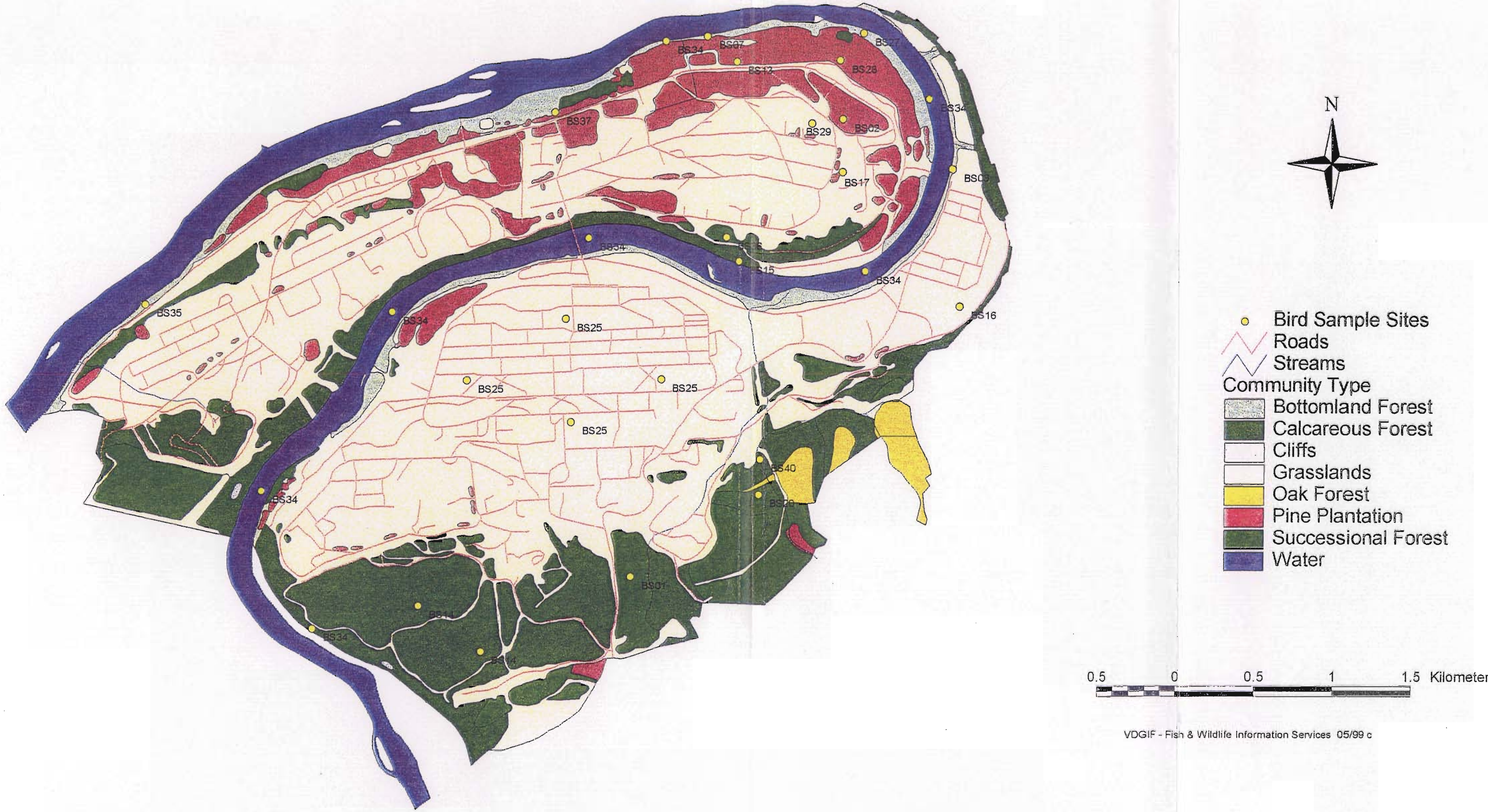

Figure 13. Bird Sample Sites at the Main Facility, RAAP.

Figure 14. Bird Sample Sites at the New River Facility, RAAP.

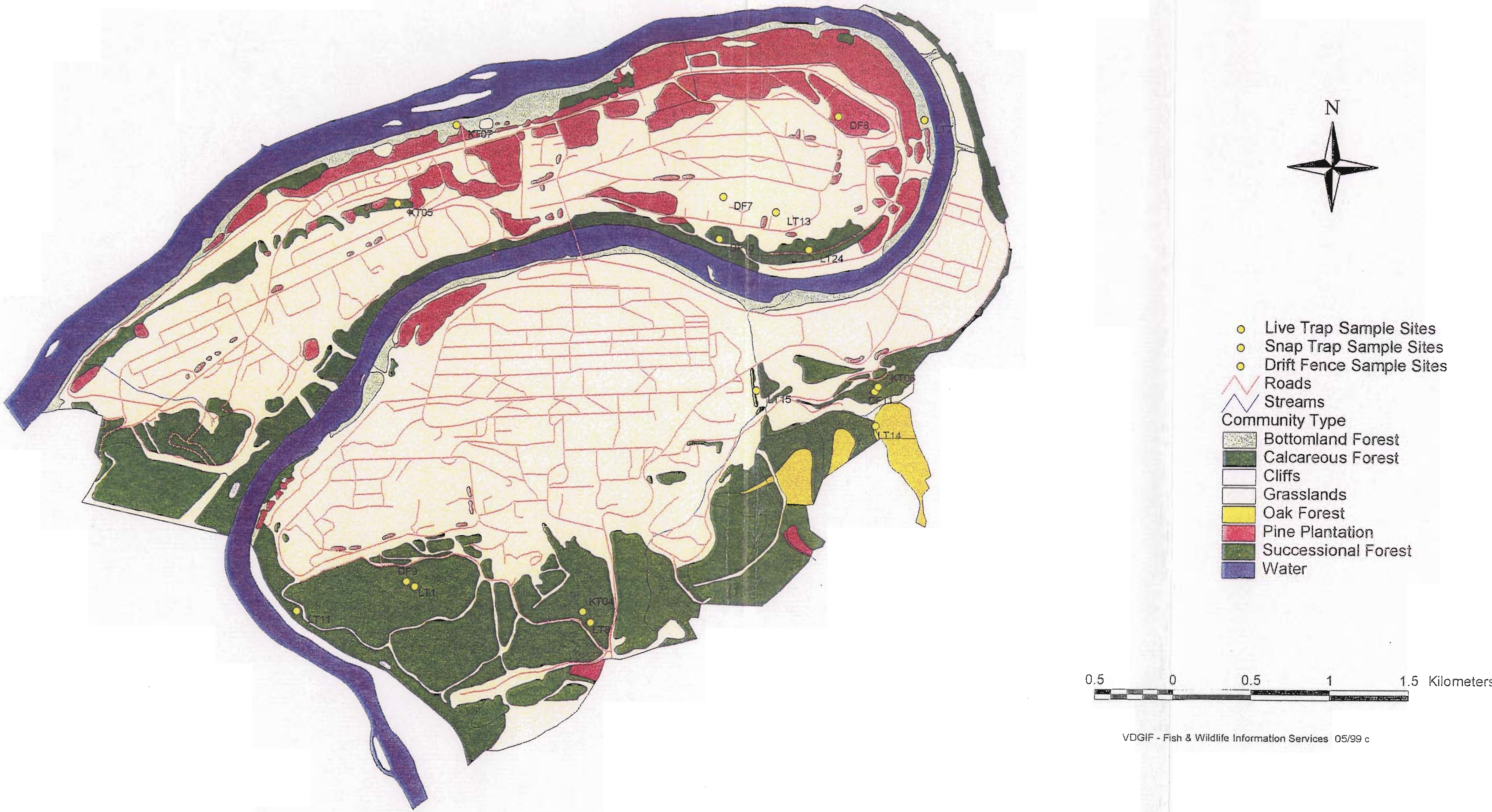

Figure 15. Mammal Sample Sites at the Main Facility, RAAP.

200p

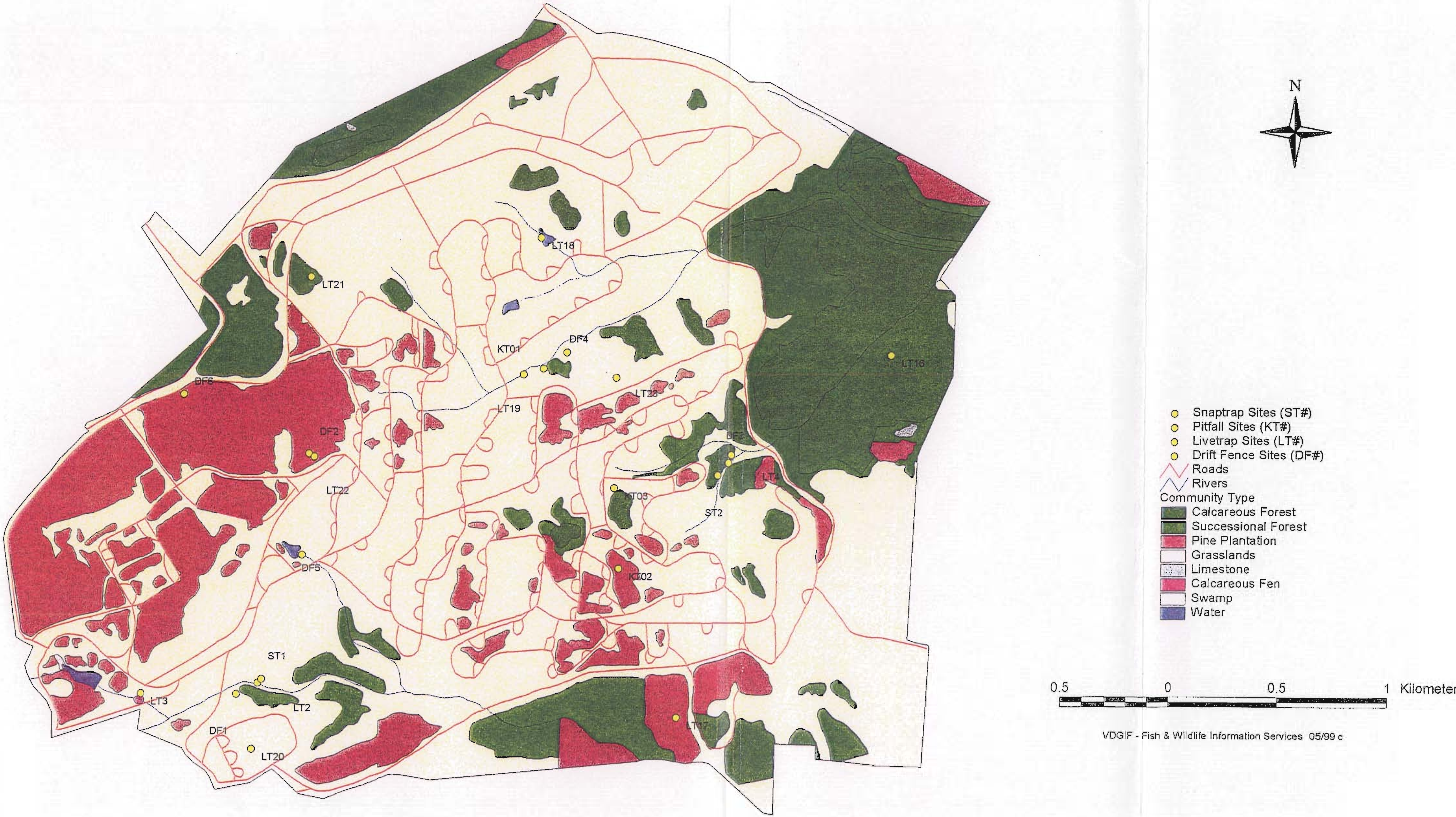

Figure 16. Mammal Sample Sites at the New River Facility, RAAP.

Appendix B: Taxa Lists By Facility

TAXA LISTS FOR THE MAIN FACILITY, RAAP

PLANTS

General Groups	Family	Scientific Name
Pteridophytes		*Adiantum pedatum*
Pteridophytes		*Asplenium platyneuron*
Pteridophytes		*Asplenium resiliens*
Pteridophytes		*Asplenium rhizophyllum*
Pteridophytes		*Asplenium ruta-muraria*
Pteridophytes		*Asplenium trichomanes*
Pteridophytes		*Athyrium felix-femina*
Pteridophytes		*Botrychium dissectum*
Pteridophytes		*Botrychium virginianum*
Pteridophytes		*Cystopteris bulbifera*
Pteridophytes		*Cystopteris protrusa*
Pteridophytes		*Cystopteris tennesseensis*
Pteridophytes		*Dennstaedtia punctilobula*
Pteridophytes		*Deparia acrostichoides*
Pteridophytes		*Diphasiastrum digitatum*
Pteridophytes		*Diplazium pycnocarpon*
Pteridophytes		*Dryopteris carthusiana*
Pteridophytes		*Dryopteris intermedia*
Pteridophytes		*Dryopteris marginalis*
Pteridophytes		*Equisetum arvense*
Pteridophytes		*Equisetum hyemale*
Pteridophytes		*Huperzia lucidula*
Pteridophytes		*Onoclea sensibilis*
Pteridophytes		*Osmunda cinnamomea*
Pteridophytes		*Osmunda claytoniana*
Pteridophytes		*Pellaea atropurpurea*
Pteridophytes		*Pellaea glabella*
Pteridophytes		*Phegopteris hexagonoptera*
Pteridophytes		*Polypodium appalachianum*
Pteridophytes		*Polypodium virginianum*
Pteridophytes		*Polystichum acrostichoides*
Pteridophytes		*Pteridium aquilinum*
Pteridophytes		*Thelypteris noveboracensis*
Pteridophytes		*Woodsia obtusa*
Monocots	Typhaceae	*Typha latifolia*
Monocots	Potamogetonaceae	*Potamogeton illinoensis*
Monocots	Potamogetonaceae	*Potamogeton nodosus*
Monocots	Potamogetonaceae	*Potamogeton pusillus*
Monocots	Alismataceae	*Sagittaria latifolia*
Monocots	Alismataceae	*Sagittaria rigida*
Monocots	Hydrocharitaceae	*Elodea canadensis*

Monocots	Poaceae	*Agrostis perennans*
Monocots	Poaceae	*Andropogon virginicus*
Monocots	Poaceae	*Aristida oligantha*
Monocots	Poaceae	*Aristida purpurascens*
Monocots	Poaceae	*Arrhenatherum elatius*
Monocots	Poaceae	*Arthraxon hispidus*
Monocots	Poaceae	*Bouteloua curtipendula*
Monocots	Poaceae	*Brachyelytrum erectum*
Monocots	Poaceae	*Bromus latiglumis*
Monocots	Poaceae	*Bromus nottowayanus*
Monocots	Poaceae	*Bromus pubescens*
Monocots	Poaceae	*Bromus racemosus*
Monocots	Poaceae	*Bromus sterilis*
Monocots	Poaceae	*Bromus tectorum*
Monocots	Poaceae	*Chasmanthium latifolium*
Monocots	Poaceae	*Cinna arundinacea*
Monocots	Poaceae	*Cynodon dactylon*
Monocots	Poaceae	*Danthonia compressa*
Monocots	Poaceae	*Danthonia spicata*
Monocots	Poaceae	*Dichanthelium acuminatum*
Monocots	Poaceae	*Dichanthelium boscii*
Monocots	Poaceae	*Dichanthelium clandestinum*
Monocots	Poaceae	*Dichanthelium commutatum*
Monocots	Poaceae	*Dichanthelium depauperatum*
Monocots	Poaceae	*Dichanthelium dichotomum var.*
Monocots	Poaceae	*Dichanthelium linearifolium*
Monocots	Poaceae	*Dichanthelium oligosanthes var.*
Monocots	Poaceae	*Digitaria ischaemum*
Monocots	Poaceae	*Digitaria sanguinalis*
Monocots	Poaceae	*Echinochloa crusgali*
Monocots	Poaceae	*Echinochloa muricata*
Monocots	Poaceae	*Eleusine indica*
Monocots	Poaceae	*Elymus hystrix*
Monocots	Poaceae	*Elymus riparius*
Monocots	Poaceae	*Elymus villosus*
Monocots	Poaceae	*Elymus virginicus*
Monocots	Poaceae	*Eragrostis capillaris*
Monocots	Poaceae	*Eragrostis cilianensis*
Monocots	Poaceae	*Eragrostis frankii*
Monocots	Poaceae	*Eragrostis hypnoides*
Monocots	Poaceae	*Eragrostis pectinacea*
Monocots	Poaceae	*Eragrostis spectabilis*
Monocots	Poaceae	*Festuca elatior*
Monocots	Poaceae	*Festuca obtusa*
Monocots	Poaceae	*Glyceria striata*
Monocots	Poaceae	*Leersia oryzoides*
Monocots	Poaceae	*Leersia virginica*

Monocots	Poaceae	*Leptoloma cognata*
Monocots	Poaceae	*Melica mutica*
Monocots	Poaceae	*Microstegium vimineum*
Monocots	Poaceae	*Muhlenbergia frondosa*
Monocots	Poaceae	*Muhlenbergia schreberi*
Monocots	Poaceae	*Muhlenbergia sobolifera*
Monocots	Poaceae	*Muhlenbergia sylvatica*
Monocots	Poaceae	*Muhlenbergia tenuiflora*
Monocots	Poaceae	*Oryzopsis racemosa*
Monocots	Poaceae	*Panicum anceps*
Monocots	Poaceae	*Panicum capillare var. sylvaticum*
Monocots	Poaceae	*Panicum dichotomiflorum*
Monocots	Poaceae	*Paspalum laeve*
Monocots	Poaceae	*Paspalum pubiflorum*
Monocots	Poaceae	*Paspalum setaceum*
Monocots	Poaceae	*Phalaris arundinacea*
Monocots	Poaceae	*Poa compressa*
Monocots	Poaceae	*Poa cuspidata*
Monocots	Poaceae	*Poa pratensis*
Monocots	Poaceae	*Poa sylvestris*
Monocots	Poaceae	*Poa trivialis*
Monocots	Poaceae	*Schizachyrium scoparium*
Monocots	Poaceae	*Setaria faberi*
Monocots	Poaceae	*Setaria geniculata*
Monocots	Poaceae	*Setaria glauca*
Monocots	Poaceae	*Setaria viridis*
Monocots	Poaceae	*Sorghastrum nutans*
Monocots	Poaceae	*Sorghum halepense*
Monocots	Poaceae	*Sphenopholis intermedia*
Monocots	Poaceae	*Sphenopholis nitida*
Monocots	Poaceae	*Sporobolus vaginiflorus (incl.*
Monocots	Poaceae	*Tridens flavus*
Monocots	Cyperaceae	*Carex aggregata*
Monocots	Cyperaceae	*Carex albicans*
Monocots	Cyperaceae	*Carex albursina*
Monocots	Cyperaceae	*Carex annectens*
Monocots	Cyperaceae	*Carex appalachica*
Monocots	Cyperaceae	*Carex blanda*
Monocots	Cyperaceae	*Carex cephalophora*
Monocots	Cyperaceae	*Carex cherokeensis*
Monocots	Cyperaceae	*Carex communis*
Monocots	Cyperaceae	*Carex conjuncta*
Monocots	Cyperaceae	*Carex copulata*
Monocots	Cyperaceae	*Carex digitalis*
Monocots	Cyperaceae	*Carex eburnea*
Monocots	Cyperaceae	*Carex frankii*
Monocots	Cyperaceae	*Carex granularis*

Monocots	Cyperaceae	*Carex grisea*
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Monocots	Cyperaceae	*Carex jamesii*
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Monocots	Cyperaceae	*Carex leptalea*
Monocots	Cyperaceae	*Carex lurida*
Monocots	Cyperaceae	*Carex nigromarginata*
Monocots	Cyperaceae	*Carex normalis*
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Monocots	Cyperaceae	*Carex pedunculata*
Monocots	Cyperaceae	*Carex pensylvanica*
Monocots	Cyperaceae	*Carex platyphylla*
Monocots	Cyperaceae	*Carex prasina*
Monocots	Cyperaceae	*Carex radiata*
Monocots	Cyperaceae	*Carex rosea*
Monocots	Cyperaceae	*Carex rugosperma*
Monocots	Cyperaceae	*Carex scoparia*
Monocots	Cyperaceae	*Carex shortiana*
Monocots	Cyperaceae	*Carex sparganioides*
Monocots	Cyperaceae	*Carex spicata*
Monocots	Cyperaceae	*Carex swanii*
Monocots	Cyperaceae	*Carex torta*
Monocots	Cyperaceae	*Carex tribuloides*
Monocots	Cyperaceae	*Carex umbellata*
Monocots	Cyperaceae	*Carex virescens*
Monocots	Cyperaceae	*Carex vulpinoidea*
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Monocots	Cyperaceae	*Carex woodii*
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Monocots	Cyperaceae	*Cyperus esculentus*
Monocots	Cyperaceae	*Cyperus flavescens*
Monocots	Cyperaceae	*Cyperus lancastriensis*
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Monocots	Cyperaceae	*Cyperus tenuifolius*
Monocots	Cyperaceae	*Eleocharis erythropoda*
Monocots	Cyperaceae	*Eleocharis intermedia*
Monocots	Cyperaceae	*Eleocharis obtusa*
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Monocots	Juncaceae	*Luzula echinata*
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Monocots	Liliaceae	*Erythronium umbillicatum*
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Monocots	Liliaceae	*Melanthium hybridum? (vegetative)*
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Monocots	Liliaceae	*Smilax tamnoides*
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Monocots	Dioscoreaceae	*Dioscorea batatas*
Monocots	Dioscoreaceae	*Dioscorea villosa*
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Monocots	Iridaceae	*Sisyrinchium angustifolium*

Monocots	Iridaceae	*Sisyrinchium atlanticum*
Monocots	Orchidaceae	*Aplectrum hyemale*
Monocots	Orchidaceae	*Cypripedium acaule*
Monocots	Orchidaceae	*Goodyera pubescens*
Monocots	Orchidaceae	*Isotria verticillata*
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Dicots	Urticaceae	*Laportea canadensis*
Dicots	Urticaceae	*Parietaria pensylvanica*
Dicots	Urticaceae	*Pilea pumila*
Dicots	Urticaceae	*Urtica gracilis*
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Dicots	Aristolochiaceae	*Aristolochia serpentaria*
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Dicots	Polygonaceae	*Polygonum hydropiper*
Dicots	Polygonaceae	*Polygonum persicaria*
Dicots	Polygonaceae	*Polygonum punctatum*
Dicots	Polygonaceae	*Polygonum scandens*
Dicots	Polygonaceae	*Polygonum virginianum*
Dicots	Polygonaceae	*Rumex obtusifolius*
Dicots	Chenopodiaceae	*Chenopodium album*
Dicots	Chenopodiaceae	*Chenopodium ambrosoides*
Dicots	Chenopodiaceae	*Chenopodium standleynum*
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Dicots	Aizoaceae	*Mollugo verticillata*
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Dicots	Caryophyllaceae	*Arenaria serpyllifolia*
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Dicots	Caryophyllaceae	*Dianthus armeria*
Dicots	Caryophyllaceae	*Myosoton aquaticum*
Dicots	Caryophyllaceae	*Paronychia canadensis*
Dicots	Caryophyllaceae	*Saponaria officinalis*
Dicots	Caryophyllaceae	*Silene antirrhina*
Dicots	Caryophyllaceae	*Silene stellata*
Dicots	Caryophyllaceae	*Silene virginica*
Dicots	Caryophyllaceae	*Stellaria longifolia*
Dicots	Caryophyllaceae	*Stellaria media*
Dicots	Caryophyllaceae	*Stellaria pubera*
Dicots	Ranunculaceae	*Anemone lancifolia*
Dicots	Ranunculaceae	*Anemone quinquifolia*
Dicots	Ranunculaceae	*Anemone virginiana*
Dicots	Ranunculaceae	*Aquilegia canadensis*
Dicots	Ranunculaceae	*Cimicifuga racemosa*
Dicots	Ranunculaceae	*Clematis coactilis*

Dicots	Ranunculaceae	*Clematis viorna*
Dicots	Ranunculaceae	*Clematis virginiana*
Dicots	Ranunculaceae	*Delphinium tricorne*
Dicots	Ranunculaceae	*Hepatica acutiloba*
Dicots	Ranunculaceae	*Hepatica americana*
Dicots	Ranunculaceae	*Hydrastis canadensis*
Dicots	Ranunculaceae	*Ranunculus abortivus*
Dicots	Ranunculaceae	*Ranunculus alleghaniensis*
Dicots	Ranunculaceae	*Ranunculus recurvatus*
Dicots	Ranunculaceae	*Ranunculus repens*
Dicots	Ranunculaceae	*Thalictrum coriaceum*
Dicots	Ranunculaceae	*Thalictrum dioicum*
Dicots	Ranunculaceae	*Thalictrum thalictroides*
Dicots	Berberidaceae	*Caulophyllum thalictroides*
Dicots	Berberidaceae	*Jeffersonia diphylla*
Dicots	Berberidaceae	*Podophyllum peltatum*
Dicots	Menispermaceae	*Menispermum canadense*
Dicots	Fumariaceae	*Corydalis flavula*
Dicots	Papaveraceae	*Sanguinaria canadensis*
Dicots	Brassicaceae	*Alliaria petiolata*
Dicots	Brassicaceae	*Alyssum alyssoides*
Dicots	Brassicaceae	*Arabis canadensis*
Dicots	Brassicaceae	*Arabis laevigata*
Dicots	Brassicaceae	*Barbarea vulgaris*
Dicots	Brassicaceae	*Camelina microcarpa*
Dicots	Brassicaceae	*Cardamine hirsuta*
Dicots	Brassicaceae	*Cardamine pensylvanica*
Dicots	Brassicaceae	*Dentaria laciniata*
Dicots	Brassicaceae	*Draba ramosissima*
Dicots	Brassicaceae	*Hesperis matronalis*
Dicots	Brassicaceae	*Lepidium campestre*
Dicots	Brassicaceae	*Lepidium virginicum*
Dicots	Brassicaceae	*Nasturtium officinale*
Dicots	Brassicaceae	*Rorippa palustris*
Dicots	Brassicaceae	*Rorippa sylvestris*
Dicots	Brassicaceae	*Sisymbrium altissimum*
Dicots	Brassicaceae	*Thlaspi perfoliata*
Dicots	Podostemonaceae	*Podostemum ceratophyllum*
Dicots	Crassulaceae	*Penthorum sedioides*
Dicots	Crassulaceae	*Sedum glaucophyllum*
Dicots	Crassulaceae	*Sedum ternatum*
Dicots	Saxifragaceae	*Heuchera americana*
Dicots	Saxifragaceae	*Heuchera villosa*
Dicots	Saxifragaceae	*Mitella diphylla*
Dicots	Saxifragaceae	*Saxifraga virginiensis*
Dicots	Rosaceae	*Agrimonia parviflora*
Dicots	Rosaceae	*Agrimonia pubescens*

Dicots	Rosaceae	*Agrimonia rostellata*
Dicots	Rosaceae	*Duchesnia indica*
Dicots	Rosaceae	*Geum canadense*
Dicots	Rosaceae	*Potentilla canadensis*
Dicots	Rosaceae	*Potentilla simplex*
Dicots	Rosaceae	*Rubus alleghaniensis*
Dicots	Rosaceae	*Rubus flagellaris*
Dicots	Rosaceae	*Rubus occidentalis*
Dicots	Rosaceae	*Rubus phoenicalasius*
Dicots	Fabaceae	*Amphicarpa bracteata*
Dicots	Fabaceae	*Apios americana*
Dicots	Fabaceae	*Cassia marilandica*
Dicots	Fabaceae	*Desmodium canescens? (vegetative)*
Dicots	Fabaceae	*Desmodium paniculatum*
Dicots	Fabaceae	*Desmodium rotundifolium*
Dicots	Fabaceae	*Galactia volubilis*
Dicots	Fabaceae	*Kummerowia stipulacea*
Dicots	Fabaceae	*Kummerowia striata*
Dicots	Fabaceae	*Lespedeza cuneata*
Dicots	Fabaceae	*Lespedeza hirta*
Dicots	Fabaceae	*Lespedeza intermedia*
Dicots	Fabaceae	*Lespedeza procumbens*
Dicots	Fabaceae	*Lespedeza repens*
Dicots	Fabaceae	*Lespedeza virginica*
Dicots	Fabaceae	*Melilotus alba*
Dicots	Fabaceae	*Melilotus officinalis*
Dicots	Fabaceae	*Trifolium campestre*
Dicots	Fabaceae	*Trifolium pratense*
Dicots	Fabaceae	*Trifolium repens*
Dicots	Fabaceae	*Vicia caroliniana*
Dicots	Geraniaceae	*Geranium maculatum*
Dicots	Oxalidaceae	*Oxalis corniculata*
Dicots	Oxalidaceae	*Oxalis dillenii*
Dicots	Oxalidaceae	*Oxalis grandis*
Dicots	Oxalidaceae	*Oxalis stricta*
Dicots	Oxalidaceae	*Oxalis violacea*
Dicots	Polygalaceae	*Polygala pauciflora*
Dicots	Polygalaceae	*Polygala verticillata*
Dicots	Euphorbiaceae	*Acalypha rhomboidea*
Dicots	Euphorbiaceae	*Euphorbia commutata*
Dicots	Euphorbiaceae	*Euphorbia maculata*
Dicots	Euphorbiaceae	*Euphorbia nutans*
Dicots	Anacardiaceae	*Toxicodendron radicans*
Dicots	Celastraceae	*Celastrus orbiculatus*
Dicots	Celastraceae	*Celastrus scandens*
Dicots	Balsaminaceae	*Impatiens capensis*
Dicots	Balsaminaceae	*Impatiens pallida*

Dicots	Vitaceae	*Parthenocissus quinquifoliuus*
Dicots	Vitaceae	*Vitis aestivalis*
Dicots	Vitaceae	*Vitis riparia*
Dicots	Malvaceae	*Sida spinosa*
Dicots	Clusiaceae	*Hypericum perforatum*
Dicots	Clusiaceae	*Hypericum punctatum*
Dicots	Violaceae	*Hybanthus concolor*
Dicots	Violaceae	*Viola affinis*
Dicots	Violaceae	*Viola canadensis*
Dicots	Violaceae	*Viola eriocarpa*
Dicots	Violaceae	*Viola fimbriatula*
Dicots	Violaceae	*Viola hirsutella*
Dicots	Violaceae	*Viola palmata*
Dicots	Violaceae	*Viola rafinesquii*
Dicots	Violaceae	*Viola striata*
Dicots	Lythraceae	*Cuphea viscosissima*
Dicots	Lythraceae	*Rotala ramosior*
Dicots	Onagraceae	*Circaea lutetiana*
Dicots	Onagraceae	*Epilobium coloratum*
Dicots	Onagraceae	*Ludwigia palustris*
Dicots	Onagraceae	*Oenothera biennis*
Dicots	Onagraceae	*Oenothera fruticosa*
Dicots	Araliaceae	*Aralia racemosa*
Dicots	Apiaceae	*Conium maculatum*
Dicots	Apiaceae	*Cryptotaenia canadensis*
Dicots	Apiaceae	*Daucus carota*
Dicots	Apiaceae	*Osmorhiza claytonii*
Dicots	Apiaceae	*Osmorhiza longistylis*
Dicots	Apiaceae	*Sanicula canadensis*
Dicots	Apiaceae	*Sanicula odorata*
Dicots	Apiaceae	*Taenidia integerrima*
Dicots	Apiaceae	*Thaspium barbinode*
Dicots	Apiaceae	*Torilis arvensis*
Dicots	Apiaceae	*Zizia aptera*
Dicots	Apiaceae	*Zizia aurea? (vegetative)*
Dicots	Apiaceae	*Zizia trifoliata*
Dicots	Ericaceae	*Chimaphila maculata*
Dicots	Ericaceae	*Epigaea repens*
Dicots	Ericaceae	*Gaultheria procumbens*
Dicots	Ericaceae	*Monotropa hypopithys*
Dicots	Ericaceae	*Monotropa uniflora*
Dicots	Diapensiaceae	*Galax aphylla*
Dicots	Primulaceae	*Lysimachia ciliata*
Dicots	Primulaceae	*Lysimachia nummularia*
Dicots	Primulaceae	*Lysimachia quadrifolia*
Dicots	Primulaceae	*Samolus parviflorus*
Dicots	Gentianaceae	*Gentiana quinquifolia*

Dicots	Gentianaceae	*Sabatia angularis*
Dicots	Apocynaceae	*Apocynum cannabinum*
Dicots	Asclepiadaceae	*Asclepias incarnata*
Dicots	Asclepiadaceae	*Asclepias quadrifolia*
Dicots	Asclepiadaceae	*Asclepias syriaca*
Dicots	Asclepiadaceae	*Asclepias tuberosa*
Dicots	Asclepiadaceae	*Matelea obliqua*
Dicots	Convolvulaceae	*Calystegia sepium*
Dicots	Convolvulaceae	*Calystegia spithamaea*
Dicots	Convolvulaceae	*Cuscuta gronovii*
Dicots	Convolvulaceae	*Ipomoea pandurata*
Dicots	Polemoniaceae	*Phlox ovata*
Dicots	Hydrophyllaceae	*Hydrophyllum canadense*
Dicots	Hydrophyllaceae	*Hydrophyllum virginianum*
Dicots	Hydrophyllaceae	*Phacelia dubia*
Dicots	Boraginaceae	*Cynoglossum officinale*
Dicots	Boraginaceae	*Cynoglossum virginianum*
Dicots	Boraginaceae	*Echium vulgare*
Dicots	Boraginaceae	*Hackelia virginiana*
Dicots	Boraginaceae	*Myosotis macrosperma*
Dicots	Verbenaceae	*Verbena hastata*
Dicots	Verbenaceae	*Verbena simplex*
Dicots	Verbenaceae	*Verbena urticifolia*
Dicots	Lamiaceae	*Blephilia hirsuta*
Dicots	Lamiaceae	*Collinsonia canadensis*
Dicots	Lamiaceae	*Cunila origanoides*
Dicots	Lamiaceae	*Glechoma hederacea*
Dicots	Lamiaceae	*Hedeoma pulegioides*
Dicots	Lamiaceae	*Lamium purpureum*
Dicots	Lamiaceae	*Leonurus cardiaca*
Dicots	Lamiaceae	*Lycopus americanus*
Dicots	Lamiaceae	*Lycopus uniflorus*
Dicots	Lamiaceae	*Lycopus virginicus*
Dicots	Lamiaceae	*Marrubium vulgare*
Dicots	Lamiaceae	*Mentha arvensis*
Dicots	Lamiaceae	*Mentha piperita*
Dicots	Lamiaceae	*Mentha spicata*
Dicots	Lamiaceae	*Monarda fistulosa*
Dicots	Lamiaceae	*Nepeta cataria*
Dicots	Lamiaceae	*Prunella vulgaris*
Dicots	Lamiaceae	*Salvia lyrata*
Dicots	Lamiaceae	*Satureja vulgaris*
Dicots	Lamiaceae	*Scutellaria elliptica*
Dicots	Lamiaceae	*Scutellaria lateriflora*
Dicots	Lamiaceae	*Scutellaria leonardii*
Dicots	Lamiaceae	*Scutellaria nervosa*
Dicots	Lamiaceae	*Scutellaria ovata var. ovata*

Dicots	Lamiaceae	*Scutellaria saxatilis*
Dicots	Lamiaceae	*Scutellaria serrata*
Dicots	Lamiaceae	*Stachys hispida*
Dicots	Lamiaceae	*Teucrium canadense*
Dicots	Lamiaceae	*Trichostema dichotomum*
Dicots	Solanaceae	*Datura stramonium*
Dicots	Solanaceae	*Physalis heterophylla*
Dicots	Solanaceae	*Physalis longifolia var. subglabrata*
Dicots	Solanaceae	*Solanum carolinense*
Dicots	Solanaceae	*Solanum dulcamara*
Dicots	Solanaceae	*Solanum ptycanthum*
Dicots	Scrophulariaceae	*Agalinis tenuifolia*
Dicots	Scrophulariaceae	*Chaenorrhinum minus*
Dicots	Scrophulariaceae	*Gratiola neglecta*
Dicots	Scrophulariaceae	*Lindernia dubia*
Dicots	Scrophulariaceae	*Mimulus alatus*
Dicots	Scrophulariaceae	*Mimulus ringens*
Dicots	Scrophulariaceae	*Pedicularis lanceolata*
Dicots	Scrophulariaceae	*Penstemon laevigatus*
Dicots	Scrophulariaceae	*Scrophularia marilandica*
Dicots	Scrophulariaceae	*Verbascum blattaria*
Dicots	Scrophulariaceae	*Verbascum phlomoides*
Dicots	Scrophulariaceae	*Verbascum thapsus*
Dicots	Scrophulariaceae	*Veronica americana*
Dicots	Scrophulariaceae	*Veronica anagalis-aquatica*
Dicots	Scrophulariaceae	*Veronica arvensis*
Dicots	Scrophulariaceae	*Veronica hederaefolia*
Dicots	Scrophulariaceae	*Veronica officinalis*
Dicots	Scrophulariaceae	*Veronica serpyllifolia*
Dicots	Bignoniaceae	*Campsis radicans*
Dicots	Orobanchaceae	*Conopholis americana*
Dicots	Orobanchaceae	*Epifagus virginiana*
Dicots	Acanthaceae	*Justicia americana*
Dicots	Plantaginaceae	*Plantago aristata*
Dicots	Plantaginaceae	*Plantago lanceolata*
Dicots	Plantaginaceae	*Plantago rugelii*
Dicots	Plantaginaceae	*Plantago virginica*
Dicots	Rubiaceae	*Galium aparine*
Dicots	Rubiaceae	*Galium circaezans*
Dicots	Rubiaceae	*Galium concinnum*
Dicots	Rubiaceae	*Galium parisiense*
Dicots	Rubiaceae	*Galium pedemontanum*
Dicots	Rubiaceae	*Galium pilosum*
Dicots	Rubiaceae	*Galium triflorum*
Dicots	Rubiaceae	*Houstona longifolia*
Dicots	Rubiaceae	*Mitchella repens*
Dicots	Caprifoliaceae	*Lonicera japonica*

Dicots	Caprifoliaceae	*Triosteum perfoliatum*
Dicots	Dipsacaceae	*Dipsacus fullonum*
Dicots	Cucurbitaceae	*Sicyos angulatus*
Dicots	Campanulaceae	*Campanula americana*
Dicots	Campanulaceae	*Campanula divaricata*
Dicots	Campanulaceae	*Lobelia inflata*
Dicots	Campanulaceae	*Lobelia siphilitica*
Dicots	Campanulaceae	*Lobelia spicata var. scaposa*
Dicots	Campanulaceae	*Specularia perfoliata*
Dicots	Asteraceae	*Achillea millefolium*
Dicots	Asteraceae	*Ambrosia artemisiifolia*
Dicots	Asteraceae	*Antennaria parlinii ssp. Fallax*
Dicots	Asteraceae	*Antennaria parlinii ssp. parlinii*
Dicots	Asteraceae	*Antennaria plantaginifolia*
Dicots	Asteraceae	*Artemisia vulgaris*
Dicots	Asteraceae	*Aster cordifolius var. cordifolius*
Dicots	Asteraceae	*Aster cordifolius var. sagittifolius*
Dicots	Asteraceae	*Aster divaricatus*
Dicots	Asteraceae	*Aster laevis*
Dicots	Asteraceae	*Aster lanceolatus*
Dicots	Asteraceae	*Aster lateriflorus*
Dicots	Asteraceae	*Aster oblongifolius*
Dicots	Asteraceae	*Aster pilosus*
Dicots	Asteraceae	*Aster puniceus*
Dicots	Asteraceae	*Aster undulatus*
Dicots	Asteraceae	*Bidens bipinnata*
Dicots	Asteraceae	*Bidens cernua*
Dicots	Asteraceae	*Bidens frondosa*
Dicots	Asteraceae	*Bidens tripartita*
Dicots	Asteraceae	*Cacalia atriplicifolia*
Dicots	Asteraceae	*Carduus acanthoides*
Dicots	Asteraceae	*Carduus nutans*
Dicots	Asteraceae	*Centaurea dubia*
Dicots	Asteraceae	*Centaurea maculosa*
Dicots	Asteraceae	*Chrysanthemum leucanthemum*
Dicots	Asteraceae	*Cichorium intybus*
Dicots	Asteraceae	*Cirsium arvense*
Dicots	Asteraceae	*Cirsium discolor*
Dicots	Asteraceae	*Cirsium vulgare*
Dicots	Asteraceae	*Conoclinium coelestinum*
Dicots	Asteraceae	*Conyza canadensis*
Dicots	Asteraceae	*Coreopsis lanceolata*
Dicots	Asteraceae	*Coreopsis major*
Dicots	Asteraceae	*Crepis capillaris*
Dicots	Asteraceae	*Erechtites hieracifolia*
Dicots	Asteraceae	*Erigeron annuus*
Dicots	Asteraceae	*Erigeron philadelphicus*

Dicots	Asteraceae	*Erigeron pulchellus*
Dicots	Asteraceae	*Erigeron strigosus*
Dicots	Asteraceae	*Eupatorium fistulosum*
Dicots	Asteraceae	*Eupatorium perfoliatum*
Dicots	Asteraceae	*Eupatorium purpureum*
Dicots	Asteraceae	*Eupatorium rugosum*
Dicots	Asteraceae	*Eupatorium serotinum*
Dicots	Asteraceae	*Eupatorium sessilifolium*
Dicots	Asteraceae	*Galinsoga quadriradiata*
Dicots	Asteraceae	*Gnaphalium obtusifolium*
Dicots	Asteraceae	*Gnaphalium purpureum*
Dicots	Asteraceae	*Hasteola suaveolens*
Dicots	Asteraceae	*Helenium autumnale*
Dicots	Asteraceae	*Helianthus divaricatus*
Dicots	Asteraceae	*Heliopsis helianthoides*
Dicots	Asteraceae	*Hieracium pilosella*
Dicots	Asteraceae	*Hieracium pratense*
Dicots	Asteraceae	*Hieracium venosum*
Dicots	Asteraceae	*Hypochoeris radicata*
Dicots	Asteraceae	*Kuhnia eupatorioides*
Dicots	Asteraceae	*Lactuca canadensis*
Dicots	Asteraceae	*Lapsana communis*
Dicots	Asteraceae	*Polymnia canadensis*
Dicots	Asteraceae	*Polymnia uvedalia*
Dicots	Asteraceae	*Rudbeckia triloba*
Dicots	Asteraceae	*Rudbeckis laciniata*
Dicots	Asteraceae	*Senecio anonymous*
Dicots	Asteraceae	*Senecio aureus*
Dicots	Asteraceae	*Senecio obovatus*
Dicots	Asteraceae	*Senecio plattensis*
Dicots	Asteraceae	*Silphium perfoliatum var. connatum*
Dicots	Asteraceae	*Silphium trifoliatum*
Dicots	Asteraceae	*Solidago altissima*
Dicots	Asteraceae	*Solidago arguta*
Dicots	Asteraceae	*Solidago bicolor*
Dicots	Asteraceae	*Solidago canadensis var. hargeri*
Dicots	Asteraceae	*Solidago curtisii*
Dicots	Asteraceae	*Solidago flexicaulis*
Dicots	Asteraceae	*Solidago gigantea*
Dicots	Asteraceae	*Solidago nemoralis*
Dicots	Asteraceae	*Solidago rugosa*
Dicots	Asteraceae	*Solidago sphacelata*
Dicots	Asteraceae	*Solidago ulmifolia*
Dicots	Asteraceae	*Taraxacum officinale*
Dicots	Asteraceae	*Tragopogon dubius*
Dicots	Asteraceae	*Tussilago farfara*
Dicots	Asteraceae	*Verbesina alternifolia*

Dicots	Asteraceae	*Verbesina occidentalis*
Dicots	Asteraceae	*Vernonia noveboracensis*
Trees		*Juniperus virginiana*
Trees		*Pinus pungens*
Trees		*Pinus strobus*
Trees		*Pinus taeda*
Trees		*Pinus virginiana*
Trees		*Tsuga canadensis*
Trees	Salicaceae	*Populus alba*
Trees	Salicaceae	*Salix nigra*
Trees	Juglandaceae	*Carya cordiformis*
Trees	Juglandaceae	*Carya glabra*
Trees	Juglandaceae	*Carya ovata*
Trees	Juglandaceae	*Carya tomentosa*
Trees	Juglandaceae	*Juglans cinerea*
Trees	Juglandaceae	*Juglans nigra*
Trees	Betulaceae	*Betula lenta*
Trees	Betulaceae	*Carpinus caroliniana*
Trees	Betulaceae	*Ostrya virginiana*
Trees	Fagaceae	*Castanea dentata*
Trees	Fagaceae	*Fagus grandifolia*
Trees	Fagaceae	*Quercus alba*
Trees	Fagaceae	*Quercus coccinea*
Trees	Fagaceae	*Quercus falcata*
Trees	Fagaceae	*Quercus muhlenbergii*
Trees	Fagaceae	*Quercus prinus*
Trees	Fagaceae	*Quercus rubra*
Trees	Fagaceae	*Quercus shumardii*
Trees	Fagaceae	*Quercus velutina*
Trees	Ulmaceae	*Celtis occidentalis*
Trees	Ulmaceae	*Celtis tenuifolia*
Trees	Ulmaceae	*Ulmus americana*
Trees	Ulmaceae	*Ulmus rubra*
Trees	Moraceae	*Morus alba*
Trees	Magnoliaceae	*Liriodendron tulipifera*
Trees	Magnoliaceae	*Magnolia acuminata*
Trees	Lauraceae	*Sassafras albidum*
Trees	Platanaceae	*Platanus occidentalis*
Trees	Rosaceae	*Amelanchier arborea*
Trees	Rosaceae	*Crataegus crusgali*
Trees	Rosaceae	*Prunus avium*
Trees	Rosaceae	*Prunus serotina*
Trees	Fabaceae	*Gleditsia triacanthos*
Trees	Fabaceae	*Robinia pseudoacacia*
Trees	Simarubaceae	*Ailanthus altissima*
Trees	Aceraceae	*Acer negundo*
Trees	Aceraceae	*Acer nigrum*

Trees	Aceraceae	*Acer rubrum*
Trees	Aceraceae	*Acer saccharinum*
Trees	Aceraceae	*Acer saccharum*
Trees	Hippocastanaceae	*Aesculus flava*
Trees	Tiliaceae	*Tilia heterophylla*
Trees	Cornaceae	*Cornus florida*
Trees	Cornaceae	*Nyssa sylvatica*
Trees	Ericaceae	*Oxydendron arboreum*
Trees	Oleaceae	*Fraxinus americana*
Trees	Oleaceae	*Fraxinus pennsylvanica*
Trees	Scrophulariaceae	*Paulownia tomentosa*
Shrubs	Salicaceae	*Salix eriocephala*
Shrubs	Betulaceae	*Corylus americana*
Shrubs	Betulaceae	*Corylus cornuta*
Shrubs	Fagaceae	*Castanea pumila*
Shrubs	Berberidaceae	*Berberis canadensis*
Shrubs	Berberidaceae	*Berberis thunbergii*
Shrubs	Annonaceae	*Asimina triloba*
Shrubs	Lauraceae	*Lindera benzoin*
Shrubs	Saxifragaceae	*Hydrangea arborescens*
Shrubs	Hamamelidaceae	*Hamamelis virginiana*
Shrubs	Rosaceae	*Crataegus uniflora*
Shrubs	Rosaceae	*Physocarpus opulifolius*
Shrubs	Rosaceae	*Prunus alleghiensis/americana?*
Shrubs	Rosaceae	*Rosa carolina*
Shrubs	Rosaceae	*Rosa multiflora*
Shrubs	Fabaceae	*Cercis canadensis*
Shrubs	Rutaceae	*Ptelea trifoliata*
Shrubs	Anacardiaceae	*Rhus aromatica*
Shrubs	Anacardiaceae	*Rhus copalina*
Shrubs	Anacardiaceae	*Rhus glabra*
Shrubs	Anacardiaceae	*Rhus typhina*
Shrubs	Staphyleaceae	*Staphylea trifolia*
Shrubs	Rhamnaceae	*Rhamnus lanceolata*
Shrubs	Elaeagnaceae	*Elaeagnus umbellata*
Shrubs	Cornaceae	*Cornus alternifolia*
Shrubs	Cornaceae	*Cornus amomum*
Shrubs	Ericaceae	*Gaylussacia baccata*
Shrubs	Ericaceae	*Kalmia latifolia*
Shrubs	Ericaceae	*Rhododendron maximum*
Shrubs	Ericaceae	*Rhododendron periclymenoides*
Shrubs	Ericaceae	*Vaccinium pallidum*
Shrubs	Ericaceae	*Vaccinium stamineum*
Shrubs	Styracaceae	*Halesia carolina*
Shrubs	Oleaceae	*Chionanthus virginicus*
Shrubs	Caprifoliaceae	*Deutzia scabra*
Shrubs	Caprifoliaceae	*Lonicera maackii*

Shrubs	Caprifoliaceae	*Lonicera morrowii*
Shrubs	Caprifoliaceae	*Sambucus canadensis*
Shrubs	Caprifoliaceae	*Symphoricarpos orbiculatus*
Shrubs	Caprifoliaceae	*Viburnum acerifolium*
Shrubs	Caprifoliaceae	*Viburnum prunifolium*
Shrubs	Caprifoliaceae	*Viburnum rafinesquianum*
Shrubs	Caprifoliaceae	*Viburnum rufidulum*

INVERTEBRATES

Class: Arachnida
Order: Araneae

Family	Scientific Name	Common Name
Agelenidae	*Cicurina pallida*	
Agelenidae	*Cicurina robusta*	
Agelenidae	*Cicurina sp.*	
Agelenidae	*Coras medicinalis*	
Agelenidae	*Cryphoeca montana*	
Agelenidae	*Cybaeus sp.*	
Agelenidae	*Cybaeus unk.*	
Agelenidae	*sp.*	
Agelenidae	*Wadotes bimucronatus*	
Agelenidae	*Wadotes calcaratus*	
Agelenidae	*Wadotes hybridus*	
Agelenidae	*Wadotes sp*	
Agelenidae	*Wadotes sp.*	
Amaurobiidae	*sp.*	
Antrodiaetidae	*Antrodiaetus unicolor*	
Anyphaenidae	*Anyphaena celer*	
Anyphaenidae	*Anyphaena sp.*	
Araneidae	*Acanthepeira sp.*	
Araneidae	*Araneus pratensis*	
Araneidae	*Araneus marmoreus*	
Araneidae	*Cyclosa conica*	
Araneidae	*Eustala anastera*	
Araneidae	*Meta menardi*	
Araneidae	*Micrathena gracilis*	
Araneidae	*Micrthena mitrata*	
Araneidae	*Neoscona arabesca*	
Araneidae	*sp.*	
Araneidae	*Verrucosa arenata*	
Atypidae	*Sphodros niger*	
Clubionidae	*Agroeca minuta*	
Clubionidae	*Castianeira cingulata*	
Clubionidae	*Castianeira longipalpus*	
Clubionidae	*Castianeira variata*	

Clubionidae	*Clubiona obesa*	
Clubionidae	*Clubiona excepta*	
Clubionidae	*Clubiona sp.*	
Clubionidae	*sp.*	
Clubionidae	*Trachelas deceptus*	
Dictynidae	*Dictyna sp.*	
Dictynidae	*Dictyna sublata*	
Dysderidae	*Dysdera crocata*	
Gnaphosidae	*Callilepis pluto*	
Gnaphosidae	*Cesonia bilineata*	
Gnaphosidae	*Drassyllus aprilinus*	
Gnaphosidae	*Drassyllus creolus*	
Gnaphosidae	*Drassyllus depressus*	
Gnaphosidae	*Drassyllus fallens*	
Gnaphosidae	*Drassyllus novus*	
Gnaphosidae	*Drassyllus sp.*	
Gnaphosidae	*Haplodrassus sp.*	
Gnaphosidae	*Litopyllus temporarius*	
Gnaphosidae	*sp.*	
Gnaphosidae	*Zelotes duplex*	
Gnaphosidae	*Zelotes hentzi*	
Hahniidae	*Neoantistae agilis*	
Hahniidae	*Neoantistea magna*	
Linyphiidae	*Bathyphantes pallida*	
Linyphiidae	*Centromerus cornupalpis*	
Linyphiidae	*Lepthyphantes zebra*	
Linyphiidae	*Nereine variabilis*	
Linyphiidae	*Pityohyphantes costatus*	
Linyphiidae	*sp.*	
Linyphiidae	*Stemonypantes blauveltae*	
Linyphiidae	*Stemonyphantes blauveltae*	
Linyphiidae	*Tapinopa bilineata*	
Lycosidae	*Allocosa funerea*	
Lycosidae	*Arctosa virgo*	
Lycosidae	*Gladicosa gulosa*	
Lycosidae	*Hogna frondicola*	
Lycosidae	*Hogna punctulata*	
Lycosidae	*Hogna rabida*	
Lycosidae	*Hogna sp.*	
Lycosidae	*Pardosa sexatilis*	
Lycosidae	*Pardosa sp.*	
Lycosidae	*Pirata minutus*	
Lycosidae	*Pirata montanus*	
Lycosidae	*Pirata sedentarius*	
Lycosidae	*Schizocosa avida*	
Lycosidae	*Schizocosa bilineata*	
Lycosidae	*Schizocosa ocreata*	

Lycosidae	*Schizocosa ocreate*	
Lycosidae	*Schizocosa saltatrix*	
Lycosidae	*sp.*	
Lycosidae	*Varacosa avara*	
Mimetidae	*Mimetus epeiroides*	
Oxyopidae	*Oxyopes salticus*	
Philodromidae	*Ebo Latithorax*	
Philodromidae	*Philodromus minutus*	
Philodromidae	*Philodromus rufus*	
Philodromidae	*Thanatus rubicellus*	
Pisauridae	*Dolomedes sp.*	
Pisauridae	*Dolomedes triton*	
Pisauridae	*Pisaurina mira*	
Salticidae	*Eris marginata*	
Salticidae	*Eris sp.*	
Salticidae	*Evarcha hoyi*	
Salticidae	*Habrocestum pulex*	
Salticidae	*Hentzia mitrata*	
Salticidae	*Marpissa pikei*	
Salticidae	*Metaphidippus protervus*	
Salticidae	*Neon nellii*	
Salticidae	*Phidippus audax*	
Salticidae	*Phidippus sp.*	
Salticidae	*Phidippus whitmanii*	
Salticidae	*sp.*	
Salticidae	*Thiodina sylvana*	
Salticidae	*Zygoballus nervosus*	
Tetragnathidae	*Leucauge venusta*	
Tetragnathidae	*Pachygnatha autumnalis*	
Tetragnathidae	*Pachynatha furcillata*	
Tetragnathidae	*Tetragnatha elongata*	
Tetragnathidae	*Tetragnatha laborisoa*	
Tetragnathidae	*Tetragnatha sp.*	
Tetragnathidae	*Tetragnatha straminea*	
Tetragnathidae	*Tetragnatha unk1*	
Tetragnathidae	*Tetragnatha versicolor*	
Theridiidae	*Achaearanea globosa*	
Theridiidae	*Achaearanea porteri*	
Theridiidae	*Achaearanea rupicola*	
Theridiidae	*Achaearnea tepidariorum*	
Theridiidae	*Dipoena nigra*	
Theridiidae	*Enoplognatha marmorata*	
Theridiidae	*sp.*	
Theridiidae	*Steatoda americana*	
Theridiidae	*Theridion sp.*	
Theridiidae	*Thymoites sp.*	
Thomisidae	*Misumenops sp.*	

Thomisidae	*Xysticus bicuspis*	
Thomisidae	*Xysticus elegans*	
Thomisidae	*Xysticus ferox*	
Thomisidae	*Xysticus sp.*	
Thomisidae	*Xysticus unk.*	

Class: Bivalvia
Order: Unionoida

Family	Scientific Name	Common Name
Unionidae	*Cyclonaias tuberculata*	Purple wartyback
Unionidae	*Eliptio dilitata*	Spike
Unionidae	*Lampsilis fasciola*	Wavy ray lampmussel
Unionidae	*Lampsilis ovata*	Pocketbook
Unionidae	*Lasmigona subviridis*	Green floater
Unionidae	*Tritigonia verrucossa*	Pistol grip

Class: Bivalvia
Order: Veneroida

Family	Scientific Name	Common Name
Corbiculidae	*Corbicula fluminea*	Asian clam

Class Branchipoda
Order Cladocera

Specimen not identified beyond order.

Class: Chilopoda
Order: Scolopendro

Family	Scientific Name	Common Name
Cryptopidae	*Scolocryptops sexspinosus*	Centipede

Class: Diplopoda
Order: Julida

Family	Scientific Name	Common Name
Julidae	*Ophyiulus pilosus*	Millipede

Class: Diplopoda
Order Polydesmida

Family	Scientific Name	Common Name
Xystodesmidae	*Gyalostethus monticolens*	Millipede
Xystodesmidae	*Nannaria ericacea*	Millipede

Class: Gastropoda
Order: Architaenioglossa

Family	Scientific Name	Common Name
Vivaparidae	*Campeloma decisum*	Aquatic snail

Class: Gastropoda
Order: Basommatophora

Family	Scientific Name	Common Name
Ancylidae	*Ferrissia rivularis*	Aquatic snail
Planorbidae	*Helisoma anceps*	Aquatic snail
Physidae	*Physella gyrina*	Aquatic snail

Class: Gastropoda
Order: Neotaenioglossa

Family	Scientific Name	Common Name
Pleuroceridae	*Leptoxis dilatata*	Aquatic snail

Class: Insecta
Order: Coleoptera

Family	Scientific Name	Common Name
Cantharidae	*sp.*	Soldier beetle
Carabidae	*Agonum sp.*	Ground beetle
Carabidae	*Amphasia interstitialis*	Ground beetle
Carabidae	*Apenes lucidula*	Ground beetle
Carabidae	*Arisodactylus nigerrimus*	Ground beetle
Carabidae	*Chlaenius aestivus*	Ground beetle
Carabidae	*Chlaenius emarginatus*	Ground beetle
Carabidae	*Chlaenius impunctifrons*	Ground beetle
Carabidae	*Chlaenius nemoralis*	Ground beetle
Carabidae	*Clivina bipustulata*	Ground beetle
Carabidae	*Cyclotrachelus iuveuis*	Ground beetle
Carabidae	*Dicaelus dilatatus*	Ground beetle
Carabidae	*Dicaelus elongatus*	Ground beetle
Carabidae	*Dicaelus teter*	Ground beetle
Carabidae	*Lebia grandis*	Ground beetle
Carabidae	*Lebia viridis*	Ground beetle
Carabidae	*Oligthopus parmatus*	Ground beetle
Carabidae	*Poecilus sp.*	Ground beetle
Carabidae	*Pterostichus mutus*	Ground beetle
Carabidae	*Pterostichus sp.*	Ground beetle
Carabidae	*Pterostichus trinarius*	Ground beetle

Carabidae	*Rhadine caudata*	Ground beetle
Carabidae	*Scarites subterraneus*	Ground beetle
Carabidae	*Sphaeroderus stenostomus*	Ground beetle
Chrysomelidae	*Stenispa metallica*	Leaf beetle
Endomychidae	*Aphorista vittata*	Handsome fungus beetle
Lampyridae	*sp.*	Firefly
Lucanidae	*sp.*	Stag beetle
Meloidae	*Meloe angusticollis*	Blister beetle
Psephenidae	*sp.*	Water-penny beetle
Scarabaeidae	*Copris minutus*	Scarab beetle
Scarabaeidae	*Euphoria inda*	Scarab beetle
Scarabaeidae	*Phyllophaga sp.*	Scarab beetle
Staphylinidae	*Geodromicus brunneus*	Rove beetle
Staphylinidae	*Olophrum obtectum*	Rove beetle
Staphylinidae	*Pinophilus laticeps*	Rove beetle
Staphylinidae	*Platydraeus sp.*	Rove beetle

Class: Insecta
Order: Collembola

Family	**Scientific Name**	**Common Name**
Entomobryidae	*sp.*	Springtail
Hypogastruidae	*sp.*	Springtail
Sminthuridae	*sp.*	Springtail

Class: Insecta
Order: Diptera

Family	**Scientific Name**	**Common Name**
Acroceridae	*sp.*	Small-headed fly
Anthomyiidae	*sp.*	Anthomyiid fly
Asilidae	*sp.*	Robber fly
Blephariceridae	*sp.*	Net-winged midge
Cecidomyiidae	*sp.*	Gall gnat
Chironomidae	*sp.*	Midge
Chloropidae	*sp.*	Frit fly
Culicidae	*sp.*	Mosquito
Curtonotidae	*sp.*	Curtonotid fly
Dolichopodidae	*sp.*	Long-legged fly
Drosophilidae	*sp.*	Pomace fly
Empididae	*sp.*	Dance fly
Lauxaniidae	*sp.*	Lauxaniid fly
Muscidae	*sp.*	Muscid fly
Mycetophilidae	*sp.*	Fungus gnat
Phoridae	*sp.*	Humpbacked fly
Ptychopteridae	*sp.*	Phantom crane fly

Rhagionidae	*sp.*	Snipe fly
Scathophagidae	*sp.*	Scathophagid fly
Sciaridae	*sp.*	Dark-winged fungus gnat
Sepsidae	*sp.*	Scavenger fly
Simuliidae	*sp.*	Black fly
Syrphidae	*sp.*	Syrphid fly
Tabanidae	*sp.*	Deer fly
Tachinidae	*sp.*	Tachinid fly
Tephritidae	*sp.*	Fruit fly
Tipulidae	*sp.*	Crane fly
Xylophagidae	*sp.*	Xylophagid fly

Class: Insecta
Order: Ephemeroptera

Specimen not identified beyond order.

Class: Insecta
Order: Heteroptera

Family	**Scientific Name**	**Common Name**
Belostomatidae	*Belostoma fluminea*	Giant water bug
Lygalidae	*Cryphula trimaculata*	Seed bug
Miridae	*Lopidea robiniae*	Leaf bug
Pentatomidae	*Dendrocoris humeralis*	Stink bug
Psyllidae	*sp.*	Stink bug

Class: Insecta
Order: Homoptera

Family	***Scientific Name***	**Common Name**
Aphididae	*sp.*	Aphid
Cicadellidae	*sp.*	Leaf hopper

Class: Insecta
Order: Hymenoptera

Family	**Scientific Name**	**Common Name**
Braconidae	*sp.*	Brachonid
Chalcidoidea	*sp.*	Chalsid
Colletidae	*sp.*	Colletid bee
Formicidae	*Ambylopone pallipes*	Ponerinae (Ant)
Formicidae	*Campanotus sp.*	Formicinae (Ant)
Formicidae	*Formica sp.*	Formicinae (Ant)
Formicidae	*sp.*	Formicinae (Ant)
Formicidae	*sp.*	Myrmicinae (Ant)

Halictidae	*sp.*	Halictid bee
Ichneumonidae	*sp.*	Ichneumon
Pergidae	*sp.*	Pergid sawfly
Proctotrupoidea	*sp.*	Proctotrupids
Sphecidae	*sp.*	Sphecid wasp
Tenthredinidae	*sp.*	Common sawfly

Class: Insecta

Order: Lepidoptera

Family	**Scientific Name**	**Common Name**
Arctiidae	*Ecpantheria scribonia*	Giant Leopard Moth
Arctiidae	*Halysidota tessellaris*	Banded tussock moth
Arctiidae	*Haploa lecontei*	Leconte's haploa
Arctiidae	*Holomelina aurantiaca*	Orange holomelina
Arctiidae	*Holomelina opella*	Tawny Holomelina
Arctiidae	*Holomelina sp.*	Holomelina
Arctiidae	*Hypoprepia miniata*	Scarlet-winged lichen moth
Arctiidae	*Pyrrharctia isabella*	Isabella tiger moth
Arctiidae	*sp.*	Tiger moth
Arctiidae	*Spilisoma virginica*	Virginian tiger moth
Geometridae	*Biston betularia cognataria*	Pepper-and-Salt Geometer
Geometridae	*Campaea perlata*	Pale Beauty
Geometridae	*Ennomos magnaria*	Maple Spanworm Moth
Geometridae	*Euchlaena amoenaria*	Deep yellow euchlaena
Geometridae	*Eulithis diversilineata*	Lesser grapevine looper moth
Geometridae	*Heliomata cycladata*	Common spring moth
Geometridae	*Heterophleps triguttaria*	Three-spotted Fillip
Geometridae	*Lambdina pellucidaria*	Yellow-headed Looper Moth
Geometridae	*Nacophora quernaria*	Oak Beauty
Geometridae	*Orthonama centrostrigaria*	Bent-line Carpet
Geometridae	*Pobole sp.*	
Geometridae	*Semiothisa promiscuata*	Promiscuous angle
Geometridae	*Synchlora aerata*	Wavy-lined Emerald
Geometridae	*Trichodezia albovittata*	White-striped black
Geometridae	*Xanthotype sp.*	Crocus geometer
Hesperidae	*Amblyscirtes vialis*	Common roadside skipper
Hesperidae	*Ancyloxypha numitor*	Least skipper
Hesperidae	*Atalopedes campestris*	Sachem
Hesperidae	*Atrytone logan*	Delaware skipper
Hesperidae	*Atrytonopsis hianna*	Dusted skipper
Hesperidae	*Epargyreus clarus*	Silver-spotted skipper
Hesperidae	*Erynnis baptisiae*	Wild indigo duskywing
Hesperidae	*Erynnis brizo*	Sleepy duskywing
Hesperidae	*Erynnis horatius*	Horace's duskywing
Hesperidae	*Erynnis icelus*	Dreamy duskywing
Hesperidae	*Erynnis juvenalis*	Juvena'ls duskywing

Hesperidae	*Euphyes vestris*	Dun skipper
Hesperidae	*Hylephila phyleus*	Fiery skipper
Hesperidae	*Lerema accius*	Clouded skipper
Hesperidae	*Nastra iherminier*	Swarthy skipper
Hesperidae	*Panaquina ocola*	Ocola skipper
Hesperidae	*Poanes hobomok*	Hobomok skipper
Hesperidae	*Poanes zabulon*	Zabulon skipper
Hesperidae	*Polites origenes*	Crossline skipper
Hesperidae	*Polites peckius*	Peck's skipper
Hesperidae	*Polites themistocles*	Tawny-edged skipper
Hesperidae	*Pompeius verna*	Little glassywing
Hesperidae	*Pyrgus communis*	Common checkered skipper
Hesperidae	*Thorybes bathyllus*	Southern cloudywing
Hesperidae	*Thorybes pylades*	Northern cloudywing
Hesperidae	*Thymelicus lineola*	European skipper
Hesperidae	*Wallengrenia egeremet*	Northern broken dash
Lasiocampidae	*Artace cribraria*	Dot-lined White
Lasiocampidae	*Malacosoma americanum*	Tent caterpillar
Lasiocampidae	*Malacosoma disstria*	Forest tent caterpillar moth
Limacodidae	*Packardia geminata*	Slug caterpillar moth
Lycaenidae	*Callophrys gryneus*	Olive hairstreak
Lycaenidae	*Callophrys niphon*	Eastern pine elfin
Lycaenidae	*Celastrina l. ladon "neglecta"*	Summer azure
Lycaenidae	*Celastrina l. ladon "violocea"*	Spring azure
Lycaenidae	*Everes comyntas*	Eastern tailed blue
Lycaenidae	*Feniseca tarquinius*	Harvester
Lycaenidae	*Lycaena Phlaeas*	American copper
Lycaenidae	*Satyrium calanus*	Banded hairstreak
Lycaenidae	*Satyrium titus*	Coral hairstreak
Lycaenidae	*Strymon melinus humuli*	Gray hairstreak
Noctuidae	*Abargrotis alternata*	Greater red dart
Noctuidae	*Acronicta americana*	American dagger moth
Noctuidae	*Acronicta inclara*	Unclear dagger moth
Noctuidae	*Acronicta lithospila*	Streaked Dagger Moth
Noctuidae	*Acronicta sp.*	Dagger moth
Noctuidae	*Agrostis venerabilis*	Venerable Dart
Noctuidae	*Anagrapha falcifera*	Celery looper moth
Noctuidae	*Caenurgina crassiuscula*	Clover Looper Moth
Noctuidae	*Caenurgina erechtea*	Forage looper moth
Noctuidae	*Cerma cerintha*	Tufted bird-dropping moth
Noctuidae	*Euparthenos nubilis*	Locust Underwing
Noctuidae	*Heliothis zea*	Corn Earworm Moth
Noctuidae	*Lacinipolia renigera*	Bristly Cutworm Moth
Noctuidae	*Lithacodia carneola*	Pink-barred lithacodia
Noctuidae	*Mocis texana*	Texas mocis
Noctuidae	*Orthodes cynica*	Cynical Quaker
Noctuidae	*Spodoptera ornithogalli*	Yellow-striped Armyworm Moth

Noctuidae	*Spodpotera frugiperda*	Fall Armyworm Moth
Noctuidae	*Xestia badinodis*	Pale-banded Dart
Noctuidae	*Xestia bicarnea*	Pink-spotted Dart
Noctuidae	*Xestia dolosa*	Greater black-letter dart
Noctuidae	*Zale galbanata*	Maple Zale
Noctuidae	*Zale metatoides*	Washed-out zale
Noctuidae	*Zanclognatha sp.*	
Notodonitidae	*Nadata gibbosa*	White-dotted prominent
Notodonitidae	*Symmerista albifrons*	White-headed prominent
Nymphalidae	*Asterocampa c. celtis*	Hackberry emperor
Nymphalidae	*Asterocampa c. clyton*	Tawny emperor
Nymphalidae	*Cercyonis pegala*	Common wood nymph
Nymphalidae	*Chlosyne nycteis*	Silvery checkerspot
Nymphalidae	*Danaus plexippus*	Monarch
Nymphalidae	*Enodia anthedon*	Northern pearly eye
Nymphalidae	*Euptoieta claudia*	Variegated fritillary
Nymphalidae	*Junonia coenia*	Common buckeye
Nymphalidae	*Libytheana carinenta*	American snout
Nymphalidae	*Limenitis arthemis astyanax*	Red-spotted purple
Nymphalidae	*Megisto cymela*	Little wood satyr
Nymphalidae	*Nymphalis antiopa*	Mourning cloak
Nymphalidae	*Phyciodes tharos*	Pearl crescent
Nymphalidae	*Polygonia comma*	Eastern comma
Nymphalidae	*Polygonia interrogationis*	Question mark
Nymphalidae	*Speyeria aphrodite*	Aphrodite fritillary
Nymphalidae	*Speyeria cybele*	Great spangled fritillary
Nymphalidae	*Speyeria idalia*	Regal fritillary
Nymphalidae	*Vanessa virginiensis*	American lady
Nymphalidae	*Vanessa atalanta*	Red admiral
Papilionidae	*Battus philenor*	Pipevine swallowtail
Papilionidae	*Papilio glaucus*	Eastern tiger swallowtail
Papilionidae	*Papilio polyxenes*	Black swallowtail
Papilionidae	*Papilio troilus*	Spicebush swallowtail
Pieridae	*Anthocharis midea*	Falcate orangetip
Pieridae	*Colias eurytheme*	Orange sulfer
Pieridae	*Colias philodice*	Clouded sulfer
Pieridae	*Eurema lisa*	Little yellow
Pieridae	*Eurema nicippi*	Sleepy orange
Pieridae	*Phoebis sennae*	Cloudless sulpher
Pieridae	*Pieris rapae*	Cabage white
Pyralidae	*Desmia funeralis*	Grape Leaffolder Moth
Pyralidae	*Desmia maculalis*	
Saturniidae	*Anisota stigma*	Spiny oakworm moth
Saturniidae	*Drycampa rubicunda*	Rosy Maple Moth
Saturniidae	*Dryocampa rubicunda*	Rosy maple moth
Sphingidae	*Ceratomia catalpae*	Catalpa Sphinx
Tortricidae	*sp.*	Tortricid moth

Yponomeutidae	*Atteva punctella*	Ailanthus Webworm Moth

Class: Insecta
Order: Neuroptera

Family	Scientific Name	Common Name
Chrysopidae	*sp.*	Green lacewing
Corydalidae	*Chauliodes sp.*	Dobsonfly
Corydalidae	*Neohermis sp.*	Dobsonfly
Corydalidae	*Nigronia sp.*	Dobsonfly
Corydalidae	*sp.*	Dobsonfly
Hemerobiidae	*sp.*	Lacewing
Sialidae	*sp.*	Alderfly

Class: Insecta
Order: Odonata

Family	Scientific Name	Common Name
Aeshnidae	*Aeshna umbrosa*	Shadow Darner
Aeshnidae	*Boyeria vinosa*	Fawn Darner
Coenagrionidae	*Argia moesta*	Powdered Dancer
Gomphidae	*Dromogomphus spinosus*	Black-shouldered Spinyleg
Gomphidae	*Ophiogomphus rupinsulenis*	Rusty Snaketail
Gomphidae	*Stylurus spiniceps*	Arrow Clubtail
Lestidae	*Lestes rectangularis*	Slender Spreadwing
Libellulidae	*Erythemis simplicicollis*	Eastern Pondhawk
Libellulidae	*Libellula pulchella*	Twelve-spotted Skimmer
Libellulidae	*Libellula semifasciata*	Painted Skimmer
Libellulidae	*Pachydiplax longipennis*	Blue Dasher
Libellulidae	*Sumpetrum vicinum*	Yellow-legged Meadowhawk
Macromiidae	*Macromia illinoisensis illinoisensis*	Illinois River Cruiser

Class: Insecta
Order: Orthoptera

Family	Scientific Name	Common Name
Blatellidae	*Parcoblatta sp.*	Cockroach
Gryllacrididae	*sp.*	Camel cricket
Mantidae	*sp.*	Mantis

Class: Insecta
Order: Plecoptera

Specimen not identified beyond order.

Class: Insecta
Order: Pscoptera

Specimen not identified beyond order.

Class: Insecta
Order: Thysanoptera

Specimen not identified beyond order.

Class: Insecta
Order: Thysanura

Family	Scientific Name	Common Name
Machilidae	*Machilis sp.*	Bristletail

Class: Insecta
Order: Trichoptera

Family	Scientific Name	Common Name
Hydropsychidae	*Cheumatopsyche sp.*	Caddisfly
Hydropsychidae	*Hydropsyche sp.*	Caddisfly
Hydropsychidae	*Potomyia sp.*	Caddisfly

Class: Insecta
Order: Trichoptera

Family	Scientific Name	Common Name
Philopotamidae	*Chimarra sp.*	Caddisfly
Psychomyiida	Lype diversa	Caddisfly

Class: Malacostraca
Order: Decapoda

Family	Species	Common Name
Cambaridae	*Cambarus sciotensis*	
Cambaridae	*Orconectes chasmodactylus*	New River cray fish
Cambaridae	*Orconectes virilis*	virile crayfish

Class: Malacostraca
Order: Isopoda

Family	Scientific Name	Common Name
Ligiidae	*Ligidium sp.*	Pill bug
Oniscidae	*Cylisticus sp.*	Pill bug
Oniscidae	*Trachelipus sp.*	Pill bug
Trichoniscidae	*Hylonisсus sp.*	Pill bug

FISH

Family	Species	Common Name
Catastomidae	*Catostomus commersoni*	white sucker
Catastomidae	*Hypentelium nigricans*	northern hogsucker
Centrarchidae	*Ambloplites rupestris*	rock bass
Centrarchidae	*Lepomis auritus*	redbreast sunfish
Centrarchidae	*Lepomis macrochirus*	bluegill
Centrarchidae	*Micropterus dolomieui*	smallmouth bass
Centrarchidae	*Micropterus punctulatus*	spotted bass
Centrarchidae	*Micropterus salmoides*	largemouth bass
Cottidae	*Cottus bairdi*	mottled sculpin
Cyprinidae	*Campostoma anomalum*	central stoneroller
Cyprinidae	*Climostomus funduloides*	rosyside dace
Cyprinidae	*Cyprinella galactura*	whitetail shiner
Cyprinidae	*Cyprinus carpio*	common carp
Cyprinidae	*Luxilus albeolus*	white shiner
Cyprinidae	*Nocomis leptocephalus*	bluehead chub
Cyprinidae	*Nocomis micropogon*	river chub
Cyprinidae	*Nocomis platyrhychus*	bigmouth chub
Cyprinidae	*Notropis hudsonius*	spottail shiner
Cyprinidae	*Notropis telescopus*	telescope shiner
Cyprinidae	*Phoxinus oreas*	mountain redbelly dace
Cyprinidae	*Pimephales notatus*	bluntnose minnow
Cyprinidae	*Rhinichthys atratulus*	blacknose dace
Esocidae	*Esox masquinongy*	muskellunge
Ictaluridae	*Noturus insignis*	margined madtom
Ictaluridae	*Pylodictis olivaris*	flathead catfish
Percichthyidae	*Morone sp.*	bass
Percidae	*Etheostoma blennioides*	greenside darter
Percidae	*Etheostoma flabellare*	fantail darter
Percidae	*Perca flavescens*	yellow perch
Percidae	*Percina caprodes*	logperch
Percidae	*Percina gymnocephala*	Appalachia darter
Percidae	*Percina roanoka*	Roanoke darter

REPTILES AND AMPHIBIANS

Family	Scientific Name	Common Name
Ambystomatidae	*Ambystoma jeffersonianum*	Jefferson salamander
Ambystomatidae	*Ambystoma maculatum*	spotted salamander
Bufonidae	*Bufo americanus*	American toad
Bufonidae	*Bufo woodhousii*	Fowler's toad
Chelydridae	*Chelydra serpentina*	snapping turtle
Colubridae	*Carphophis amoenus*	eastern worm snake
Colubridae	*Diadophis punctatus*	ringneck snake
Colubridae	*Elaphe obsoleta*	black rat snake

Colubridae	*Nerodia sipedon*	northern water snake
Colubridae	*Regina septemvittata*	queen snake
Colubridae	*Thamnophis sirtalis*	eastern garter snake
Emydidae	*Chrysemys picta*	eastern painted turtle
Hylidae	*Hyla versicolor*	gray treefrog
Plethodontidae	*Desmognathus fuscus*	northern dusky salamander
Plethodontidae	*Desmognathus quadramaculatus*	blackbelly salamander
Plethodontidae	*Eurycea cirrigera*	southern two-lined salamander
Plethodontidae	*Plethodon cinereus*	redback salamander
Plethodontidae	*Plethodon glutinosus*	slimy salamander
Plethodontidae	*Plethodon wehrlei*	Wehrle's salamander
Ranidae	*Rana sylvatica*	wood frog
Salamandridae	*Notophthalmus viridescens*	red-spotted newt

BIRDS

Family	**Scientific Name**	**Common Name**
Accipitridae	*Accipiter striatus*	sharp-shinned hawk
Accipitridae	*Buteo jamaicensis*	red-tailed hawk
Accipitridae	*Circus cyaneus*	northern harrier
Accipitridae	*Falco sparverius*	American kestrel
Alcedinidae	*Ceryle alcyon*	belted kingfisher
Anatidae	*Aix sponsa*	wood duck
Anatidae	*Anas americana*	American wigeon
Anatidae	*Anas platyrhynchos*	mallard duck
Anatidae	*Anas rubripes*	American black duck
Anatidae	*Anas strepera*	gadwall
Anatidae	*Branta canadensis*	Canada goose
Anatidae	*Bucephala albeola*	bufflehead
Anatidae	*Lophodytes cucullatus*	hoodeed merganser
Apodidae	*Chaetura pelagica*	chimney swift
Ardeidae	*Ardea herodias*	great blue heron
Ardeidae	*Butorides striatus*	green heron
Ardeidae	*Casmerodius albus*	great egret
Ardeidae	*Nycticorax nycticorax*	black-crowned night-heron
Bombycillidae	*Bombycilla cedrorum*	cedar waxwing
Cathartidae	*Cathartes aura*	turkey vulture
Cathartidae	*Coragyps atratus*	black vulture
Certhiidae	*Certhia americana*	brown creeper
Charadriidae	*Charadrius vociferus*	killdeer
Columbidae	*Columba livia*	rock dove
Columbidae	*Zenaida macroura*	mourning dove
Corvidae	*Corvus brachyrhynchos*	American crow
Corvidae	*Corvus corax*	common raven
Corvidae	*Cyanocitta cristata*	blue jay
Cuculidae	*Coccyzus americanus*	yellow-billed cuckoo
Cuculidae	*Coccyzus erythropthalmus*	black-billed cuckoo

Emberizidae	*Agelaius phoeniceus*	red-winged blackbird
Emberizidae	*Cardinalis cardinalis*	northern cardinal
Emberizidae	*Dendroica coronata*	yellow-rumped warbler
Emberizidae	*Dendroica donimica*	yellow-throated warbler
Emberizidae	*Dendroica magnolia*	magnolia warbler
Emberizidae	*Dendroica palmarum*	palm warbler
Emberizidae	*Dendroica pensylvanica*	cheastnut-sided warbler
Emberizidae	*Dendroica petechia*	yellow warbler
Emberizidae	*Dendroica pinus*	pine warbler
Emberizidae	*Dendroica striata*	blackpoll warbler
Emberizidae	*Dendroica virens*	black-throated green warbler
Emberizidae	*Geothlypis trichas*	common yellowthroat
Emberizidae	*Helmitheros vermivorus*	worm-eating warbler
Emberizidae	*Icterus galbula*	northern oriole
Emberizidae	*Icterus spurius*	orchard oriole
Emberizidae	*Junco hyemalis*	northern junco
Emberizidae	*Melospiza georgiana*	swamp sparrow
Emberizidae	*Melospiza melodia*	song sparrow
Emberizidae	*Mniotilta varia*	black-and-white warbler
Emberizidae	*Molothrus ater*	brown-headed cowbird
Emberizidae	*Oporornis formosus*	kentucky warbler
Emberizidae	*Parula americana*	northern parula
Emberizidae	*Passer domesticus*	house sparrow
Emberizidae	*Passerina cyanea*	indigo bunting
Emberizidae	*Pheucticus ludovicianus*	rose-breasted grosbeak
Emberizidae	*Pipilo erythrophthalmus*	eastern towhee
Emberizidae	*Piranga olivacea*	scarlet tanager
Emberizidae	*Pooecetes gramineus*	vesper sparrow
Emberizidae	*Quiscalus quiscula*	common grackle
Emberizidae	*Seiurus aurocapillus*	ovenbird
Emberizidae	*Seiurus motacilla*	Louisana waterthrush
Emberizidae	*Seiurus noveboracensis*	northern waterthrush
Emberizidae	*Setophaga ruticilla*	American redstart
Emberizidae	*Spizella passerina*	chipping sparrow
Emberizidae	*Spizella pusilla*	field sparrow
Emberizidae	*Sturnella magna*	eastern meadowlark
Emberizidae	*Zonotrichia albicollis*	white-throated sparrow
Fringillidae	*Carduelis tristis*	American goldfinch
Fringillidae	*Carpodacus mexicanus*	house finch
Fringillidae	*Carpodacus purpureus*	purple finch
Hirundinidae	*Hirundo rustica*	barn swallow
Hirundinidae	*Progne subis*	purple martin
Hirundinidae	*Riparia riparia*	bank swallow
Hirundinidae	*Stelgidopteryx serripennis*	rough-winged swallow
Hirundinidae	*Tachycineta bicolor*	tree swallow
Laridae	*Larus delawarensis*	ring-billed gull
Mimidae	*Dumetella carolinensis*	gray catbird

Mimidae	*Mimus polyglottos*	northern mockingbird
Muscicapidae	*Catharus guttatus*	hermit thrush
Muscicapidae	*Hylocichla mustelina*	wood thrush
Muscicapidae	*Polioptila caerulea*	blue-gray gnatcatcher
Muscicapidae	*Regulus satrapa*	golden-crowned kinglet
Muscicapidae	*Sialia sialis*	eastern bluebird
Muscicapidae	*Turdus migratorius*	American robin
Paridae	*Parus bicolor*	tufted titmouse
Paridae	*Parus carolinensis*	carolina chickadee
Phalacrocoracidae	*Phalacrocorax auritus*	double-crested cormorant
Phasianidae	*Bonasa umbellus*	ruffed grouse
Phasianidae	*Meleagris gallopavo*	wild turkey
Picidae	*Colaptes auratus*	northern flicker
Picidae	*Dryocopus pileatus*	pileated woodpecker
Picidae	*Melanerpes carolinus*	red-bellied woodpecker
Picidae	*Picoides pubescens*	downy woodpecker
Picidae	*Picoides villosus*	hairy woodpecker
Picidae	*Sphyrapicus varius*	yellow-bellied sapsucker
Podicipedidae	*Podilymbus podiceps*	pied-billed grebe
Rallidae	*Fulica americana*	American coot
Scolopacidae	*Actitis macularia*	spotted sandpiper
Scolopacidae	*Scolopax minor*	American woodcock
Sittidae	*Sitta canadensis*	red-breasted nuthatch
Sittidae	*Sitta carolinensis*	white-breasted nuthatch
Strigidae	*Otus asio*	eastern screech owl
Sturnidae	*Sturnus vulgaris*	European starling
Trochilidae	*Archilochus colubris*	ruby-throated hummingbird
Troglodytidae	*Thryothorus ludovicianus*	carolina wren
Troglodytidae	*Troglodytes aedon*	house wren
Troglodytidae	*Troglodytes troglodytes*	winter wren
Tyrannidae	*Contopus virens*	eastern pewee
Tyrannidae	*Empidonax virescens*	acadian flycatcher
Tyrannidae	*Myiarchus crinitus*	great crested flycatcher
Tyrannidae	*Sayornis phoebe*	eastern phoebe
Tyrannidae	*Sturnella magna*	eastern kingbird
Tyrannidae	*Tyrannus tyrannus*	eastern kingbird
Vireonidae	*Vireo flavifrons*	yellow-throated vireo
Vireonidae	*Vireo gilvus*	warbling vireo
Vireonidae	*Vireo griseus*	white-eyed vireo
Vireonidae	*Vireo olivaceus*	red-eyed vireo

MAMMALS

Family	**Scientific Name**	**Common Name**
Cervidae	*Odocoileus virginianus*	white-tailed deer
Diedelphidae	*Didelphis virginiana*	Virginia opossum
Dipodidae	Zapus hudsonius	meadow jumping mouse

Mephitidae	*Mephitis mephitis*	striped skunk
Muridae	Microtis pennsylvanicus	meadow vole
Muridae	Peromyscus leucopus	white-footed mouse
Procyonidae	*Procyon lotor*	common raccoon
Sciuridae	*Marmota monax*	woodchuck
Sciuridae	*Sciurus carolinensis*	eastern gray squirrel
Sciuridae	*Sciurus niger*	eastern fox squirrel
Sciuridae	*Tamias striatus*	eastern chipmunk
Soricidae	Blarina brevicauda	northern short-tailed shrew
Soricidae	Cryptotis parva	least shrew
Soricidae	Sorex fumeus	smoky shrew
Talpidae	Parascalops breweri	hairy-tailed mole

TAXA LISTS FOR THE NEW RIVER FACILITY, RAAP

PLANTS

Group Name	Family	Scientific Name
Pteridophytes		*Adiantum pedatum*
Pteridophytes		*Asplenium platyneuron*
Pteridophytes		*Asplenium rhizophyllum*
Pteridophytes		*Athyrium felix-femina*
Pteridophytes		*Botrychium virginianum*
Pteridophytes		*Deparia acrostichoides*
Pteridophytes		*Diphasiastrum digitatum*
Pteridophytes		*Diplazium pycnocarpon*
Pteridophytes		*Dryopteris carthusiana*
Pteridophytes		*Dryopteris intermedia*
Pteridophytes		*Dryopteris marginalis*
Pteridophytes		*Equisetum arvense*
Pteridophytes		*Ophioglossum engelmannii*
Pteridophytes		*Osmunda claytoniana*
Pteridophytes		*Pellaea atropurpurea*
Pteridophytes		*Phegopteris hexagonoptera*
Pteridophytes		*Polystichum acrostichoides*
Pteridophytes		*Woodsia obtusa*
Monocots	Typhaceae	*Typha latifolia*
Monocots	Sparganiaceae	*Sparganium americanum*
Monocots	Potamogetonaceae	*Potamogeton crispus*
Monocots	Potamogetonaceae	*Potamogeton foliosus*
Monocots	Poaceae	*Agropyron repens*
Monocots	Poaceae	*Agrostis gigantea*
Monocots	Poaceae	*Agrostis perennans*
Monocots	Poaceae	*Andropogon gerardii*
Monocots	Poaceae	*Andropogon ternarius*
Monocots	Poaceae	*Andropogon virginicus*
Monocots	Poaceae	*Anthoxanthum odoratum*
Monocots	Poaceae	*Aristida dichotoma var. curtisii*
Monocots	Poaceae	*Aristida oligantha*
Monocots	Poaceae	*Aristida purpurascens*
Monocots	Poaceae	*Arrhenatherum elatius*
Monocots	Poaceae	*Bouteloua curtipendula*
Monocots	Poaceae	*Bromus commutatus*
Monocots	Poaceae	*Bromus inermis*
Monocots	Poaceae	*Bromus japonicus*
Monocots	Poaceae	*Bromus nottowayanus*
Monocots	Poaceae	*Bromus pubescens*
Monocots	Poaceae	*Bromus racemosus*
Monocots	Poaceae	*Bromus sterilis*

Monocots	Poaceae	*Bromus tectorum*
Monocots	Poaceae	*Dactylis glomeratus*
Monocots	Poaceae	*Danthonia spicata*
Monocots	Poaceae	*Dichanthelium acuminatum var.*
Monocots	Poaceae	*Dichanthelium boscii*
Monocots	Poaceae	*Dichanthelium clandestinum*
Monocots	Poaceae	*Dichanthelium dichotomum var.*
Monocots	Poaceae	*Dichanthelium latifolium*
Monocots	Poaceae	*Dichanthelium laxiflorum*
Monocots	Poaceae	*Dichanthelium linearifolium*
Monocots	Poaceae	*Dichanthelium oligosanthes var.*
Monocots.	Poaceae	*Digitaria ischaemum*
Monocots	Poaceae	*Elymus hystrix*
Monocots	Poaceae	*Elymus villosus*
Monocots	Poaceae	*Elymus virginicus*
Monocots	Poaceae	*Eragrostis pectinacea*
Monocots	Poaceae	*Eragrostis spectabilis*
Monocots	Poaceae	*Festuca elatior*
Monocots	Poaceae	*Festuca obtusa*
Monocots	Poaceae	*Festuca rubra*
Monocots	Poaceae	*Glyceria striata*
Monocots	Poaceae	*Holcus lanatus*
Monocots	Poaceae	*Leersia oryzoides*
Monocots	Poaceae	*Leersia virginica*
Monocots	Poaceae	*Muhlenbergia capillaris*
Monocots	Poaceae	*Muhlenbergia schreberi*
Monocots	Poaceae	*Muhlenbergia sobolifera*
Monocots	Poaceae	*Muhlenbergia sylvatica*
Monocots	Poaceae	*Panicum anceps*
Monocots	Poaceae	*Panicum dichotomiflorum*
Monocots	Poaceae	*Panicum flexile*
Monocots	Poaceae	*Paspalum laeve*
Monocots	Poaceae	*Paspalum setaceum*
Monocots	Poaceae	*Phleum pratense*
Monocots	Poaceae	*Poa compressa*
Monocots	Poaceae	*Poa cuspidata*
Monocots	Poaceae	*Poa pratensis*
Monocots	Poaceae	*Poa sylvestris*
Monocots	Poaceae	*Poa trivialis*
Monocots	Poaceae	*Schizachyrium scoparium*
Monocots	Poaceae	*Setaria faberi*
Monocots	Poaceae	*Setaria geniculata*
Monocots	Poaceae	*Setaria glauca*
Monocots	Poaceae	*Sorghastrum nutans*
Monocots	Poaceae	*Sorghum halepense*
Monocots	Poaceae	*Sphenopholis intermedia*
Monocots	Poaceae	*Sphenopholis nitida*

Monocots	Poaceae	*Sphenopholis pensylvanica*
Monocots	Poaceae	*Sporobolus asper*
Monocots	Poaceae	*Sporobolus vaginiflorus (incl.*
Monocots	Poaceae	*Tridens flavus*
Monocots	Cyperaceae	*Carex aggregata*
Monocots	Cyperaceae	*Carex blanda*
Monocots	Cyperaceae	*Carex cephalophora*
Monocots	Cyperaceae	*Carex digitalis*
Monocots	Cyperaceae	*Carex flaccosperma*
Monocots	Cyperaceae	*Carex frankii*
Monocots	Cyperaceae	*Carex granularis*
Monocots	Cyperaceae	*Carex grisea*
Monocots	Cyperaceae	*Carex hirsutella*
Monocots	Cyperaceae	*Carex hystericina*
Monocots	Cyperaceae	*Carex interior*
Monocots	Cyperaceae	*Carex laevivaginata*
Monocots	Cyperaceae	*Carex laxiflora*
Monocots	Cyperaceae	*Carex laxiflora var. serrulata*
Monocots	Cyperaceae	*Carex lurida*
Monocots	Cyperaceae	*Carex meadii*
Monocots	Cyperaceae	*Carex mesochorea*
Monocots	Cyperaceae	*Carex muhlenbergii*
Monocots	Cyperaceae	*Carex oligocarpa*
Monocots	Cyperaceae	*Carex pelita*
Monocots	Cyperaceae	*Carex pensylvanica*
Monocots	Cyperaceae	*Carex rosea*
Monocots	Cyperaceae	*Carex schweinitzii*
Monocots	Cyperaceae	*Carex sparganioides*
Monocots	Cyperaceae	*Carex stipata*
Monocots	Cyperaceae	*Carex stricta*
Monocots	Cyperaceae	*Carex suberecta*
Monocots	Cyperaceae	*Carex tetanica*
Monocots	Cyperaceae	*Carex umbellata*
Monocots	Cyperaceae	*Carex vulpinoides*
Monocots	Cyperaceae	*Carex willdenowii*
Monocots	Cyperaceae	*Cyperus flavescens*
Monocots	Cyperaceae	*Cyperus strigosus*
Monocots	Cyperaceae	*Eleocharis engelmannii*
Monocots	Cyperaceae	*Eleocharis erythropoda*
Monocots	Cyperaceae	*Eleocharis obtusa*
Monocots	Cyperaceae	*Schoenoplectus pungens*
Monocots	Cyperaceae	*Schoenoplectus validus*
Monocots	Cyperaceae	*Scirpus atrovirens*
Monocots	Cyperaceae	*Scirpus cyperinus*
Monocots	Cyperaceae	*Scirpus pendulus*
Monocots	Cyperaceae	*Trichophorum planifolium*
Monocots	Araceae	*Acorus calamus*

Monocots	Araceae	*Arisaema triphyllum*
Monocots	Lemnaceae	*Lemna sp.*
Monocots	Lemnaceae	*Wolffia brasiliensis*
Monocots	Juncaceae	*Juncus brachycephalus*
Monocots	Juncaceae	*Juncus dudleyi*
Monocots	Juncaceae	*Juncus effusus*
Monocots	Juncaceae	*Juncus tenuis*
Monocots	Juncaceae	*Luzula bulbosa*
Monocots	Liliaceae	*Allium cernuum*
Monocots	Liliaceae	*Allium vineale*
Monocots	Liliaceae	*Asparagus officinalis*
Monocots	Liliaceae	*Lilium superbum? (vegetative)*
Monocots	Liliaceae	*Polygonatum biflorum*
Monocots	Liliaceae	*Smilacina racemosa*
Monocots	Liliaceae	*Smilax herbacea*
Monocots	Liliaceae	*Smilax pulverulenta*
Monocots	Liliaceae	*Smilax rotundifolia*
Monocots	Liliaceae	*Smilax tamnoides*
Monocots	Liliaceae	*Trillium grandiflorum*
Monocots	Liliaceae	*Uvularia perfoliata*
Monocots	Liliaceae	*Uvularia puberula*
Monocots	Amaryllidaceae	*Hypoxis hirsuta*
Monocots	Iridaceae	*Sisyrinchium angustifolium*
Monocots	Iridaceae	*Sisyrinchium atlanticum*
Monocots	Orchidaceae	*Aplectrum hyemale*
Monocots	Orchidaceae	*Goodyera pubescens*
Monocots	Orchidaceae	*Habenaria lacera*
Monocots	Orchidaceae	*Liparis lilifolia*
Monocots	Orchidaceae	*Liparis loeselii*
Monocots	Orchidaceae	*Orchis spectabilis*
Monocots	Orchidaceae	*Spiranthes gracilis*
Monocots	Orchidaceae	*Spiranthes lucida*
Dicots	Urticaceae	*Boehmeria cylindrica*
Dicots	Urticaceae	*Laportea canadensis*
Dicots	Urticaceae	*Parietaria pensylvanica*
Dicots	Aristolochiaceae	*Aristolochia macrophylla*
Dicots	Aristolochiaceae	*Aristolochia serpentaria*
Dicots	Aristolochiaceae	*Asarum canadense*
Dicots	Polygonaceae	*Polygonum hydropiper*
Dicots	Polygonaceae	*Polygonum scandens*
Dicots	Polygonaceae	*Polygonum virginianum*
Dicots	Polygonaceae	*Rumex acetosella*
Dicots	Polygonaceae	*Rumex obtusifolius*
Dicots	Phytolaccaceae	*Phytolacca americana*
Dicots	Caryophyllaceae	*Arenaria serpyllifolia*
Dicots	Caryophyllaceae	*Cerastium fontanum*
Dicots	Caryophyllaceae	*Cerastium glomeratum*

Dicots	Caryophyllaceae	*Dianthus armeria*
Dicots	Caryophyllaceae	*Holosteum umbellatum*
Dicots	Caryophyllaceae	*Silene virginica*
Dicots	Caryophyllaceae	*Stellaria graminea*
Dicots	Caryophyllaceae	*Stellaria media*
Dicots	Caryophyllaceae	*Stellaria pubera*
Dicots	Ranunculaceae	*Aconitum uncinatum*
Dicots	Ranunculaceae	*Anemone lancifolia*
Dicots	Ranunculaceae	*Anemone virginiana*
Dicots	Ranunculaceae	*Cimicifuga racemosa*
Dicots	Ranunculaceae	*Clematis virginiana*
Dicots	Ranunculaceae	*Hepatica americana*
Dicots	Ranunculaceae	*Ranunculus abortivus*
Dicots	Ranunculaceae	*Ranunculus alleghiensis*
Dicots	Ranunculaceae	*Ranunculus bulbosus*
Dicots	Ranunculaceae	*Ranunculus fascicularis?*
Dicots	Ranunculaceae	*Ranunculus recurvatus*
Dicots	Ranunculaceae	*Thalictrum dioicum*
Dicots	Ranunculaceae	*Thalictrum revolutum*
Dicots	Ranunculaceae	*Thalictrum thalictroides*
Dicots	Berberidaceae	*Caulophyllum thalictroides*
Dicots	Berberidaceae	*Podophyllum peltatum*
Dicots	Fumariaceae	*Corydalis flavula*
Dicots	Papaveraceae	*Sanguinaria canadensis*
Dicots	Brassicaceae	*Alliaria petiolata*
Dicots	Brassicaceae	*Arabis canadensis*
Dicots	Brassicaceae	*Barbarea vulgaris*
Dicots	Brassicaceae	*Capsella bursa-pastoris*
Dicots	Brassicaceae	*Cardamine hirsuta*
Dicots	Brassicaceae	*Dentaria laciniata*
Dicots	Brassicaceae	*Draba verna*
Dicots	Brassicaceae	*Lepidium campestre*
Dicots	Brassicaceae	*Lepidium virginicum*
Dicots	Brassicaceae	*Nasturtium officinale*
Dicots	Brassicaceae	*Rorippa palustris*
Dicots	Crassulaceae	*Sedum ternatum*
Dicots	Saxifragaceae	*Heuchera americana*
Dicots	Rosaceae	*Agrimonia pubescens*
Dicots	Rosaceae	*Agrimonia rostellata*
Dicots	Rosaceae	*Fragaria virginiana*
Dicots	Rosaceae	*Geum canadense*
Dicots	Rosaceae	*Potentilla canadensis*
Dicots	Rosaceae	*Potentilla recta*
Dicots	Rosaceae	*Potentilla simplex*
Dicots	Rosaceae	*Rubus argutus*
Dicots	Rosaceae	*Rubus flagellaris*
Dicots	Rosaceae	*Rubus occidentalis*

Dicots	Rosaceae	*Rubus phoenicolasius*
Dicots	Fabaceae	*Amphicarpa bracteata*
Dicots	Fabaceae	*Cassia marilandica*
Dicots	Fabaceae	*Desmodium glutinosum*
Dicots	Fabaceae	*Desmodium marilandicum*
Dicots	Fabaceae	*Desmodium nudiflorum*
Dicots	Fabaceae	*Desmodium paniculatum*
Dicots	Fabaceae	*Desmodium perplexum*
Dicots	Fabaceae	*Desmodium rotundifolium*
Dicots	Fabaceae	*Galactia volubilis*
Dicots	Fabaceae	*Kummerowia stipulacea*
Dicots	Fabaceae	*Kummerowia striata*
Dicots	Fabaceae	*Lespedeza cuneata*
Dicots	Fabaceae	*Lespedeza procumbens*
Dicots	Fabaceae	*Lespedeza repens*
Dicots	Fabaceae	*Lespedeza violacea*
Dicots	Fabaceae	*Lespedeza virginica*
Dicots	Fabaceae	*Medicago lupulina*
Dicots	Fabaceae	*Stylosanthes biflora*
Dicots	Fabaceae	*Trifolium campestre*
Dicots	Fabaceae	*Trifolium pratense*
Dicots	Fabaceae	*Vicia angustifolia*
Dicots	Fabaceae	*Vicia caroliniana*
Dicots	Geraniaceae	*Geranium columbinum*
Dicots	Geraniaceae	*Geranium maculatum*
Dicots	Oxalidaceae	*Oxalis dillenii*
Dicots	Oxalidaceae	*Oxalis stricta*
Dicots	Oxalidaceae	*Oxalis violacea*
Dicots	Linaceae	*Linum medium var. texanum*
Dicots	Linaceae	*Linum sulcatum*
Dicots	Linaceae	*Linum virginianum*
Dicots	Polygalaceae	*Polygala senega*
Dicots	Polygalaceae	*Polygala verticillata*
Dicots	Euphorbiaceae	*Acalypha rhomboidea*
Dicots	Euphorbiaceae	*Euphorbia corollata*
Dicots	Euphorbiaceae	*Euphorbia maculata*
Dicots	Euphorbiaceae	*Euphorbia nutans*
Dicots	Callitrichaceae	*Callitriche heterophylla*
Dicots	Anacardiaceae	*Toxicodendron radicans*
Dicots	Celastraceae	*Celastrus orbiculatus*
Dicots	Balsaminaceae	*Impatiens capensis*
Dicots	Vitaceae	*Parthenocissus quinquifolius*
Dicots	Vitaceae	*Vitis aestivalis var. argentea*
Dicots	Vitaceae	*Vitis vulpina*
Dicots	Clusiaceae	*Hypericum gentianoides*
Dicots	Clusiaceae	*Hypericum mutilum*
Dicots	Clusiaceae	*Hypericum perforatum*

Dicots	Clusiaceae	*Hypericum punctatum*
Dicots	Clusiaceae	*Hypericum stragulum*
Dicots	Violaceae	*Viola canadensis*
Dicots	Violaceae	*Viola cucullata*
Dicots	Violaceae	*Viola hirsutella*
Dicots	Violaceae	*Viola palmata*
Dicots	Violaceae	*Viola rafinesquii*
Dicots	Violaceae	*Viola sororia*
Dicots	Violaceae	*Viola striata*
Dicots	Lythraceae	*Cuphea viscosissima*
Dicots	Onagraceae	*Circaea lutetiana*
Dicots	Onagraceae	*Epilobium coloratum*
Dicots	Onagraceae	*Ludwigia alternifolia*
Dicots	Onagraceae	*Ludwigia palustris*
Dicots	Araliaceae	*Panax quinquifolius*
Dicots	Apiaceae	*Anthriscus caucalis*
Dicots	Apiaceae	*Cryptotaenia canadensis*
Dicots	Apiaceae	*Daucus carota*
Dicots	Apiaceae	*Osmorhiza claytoniana*
Dicots	Apiaceae	*Osmorhiza longistylis*
Dicots	Apiaceae	*Sanicula canadensis*
Dicots	Apiaceae	*Zizia trifoliata*
Dicots	Ericaceae	*Chimaphila maculata*
Dicots	Primulaceae	*Anagalis arvensis*
Dicots	Primulaceae	*Lysimachia lanceolata*
Dicots	Primulaceae	*Lysimachia quadrifolia*
Dicots	Primulaceae	*Samolus parviflorus*
Dicots	Gentianaceae	*Gentiana quinquifolia*
Dicots	Gentianaceae	*Sabatia angularis*
Dicots	Apocynaceae	*Apocynum cannabinum*
Dicots	Apocynaceae	*Vinca minor*
Dicots	Asclepiadaceae	*Asclepias quadrifolia*
Dicots	Asclepiadaceae	*Asclepias syriaca*
Dicots	Asclepiadaceae	*Asclepias variegata*
Dicots	Asclepiadaceae	*Asclepias verticillata*
Dicots	Asclepiadaceae	*Asclepias viridiflora*
Dicots	Convolvulaceae	*Calystegia spithamaea*
Dicots	Convolvulaceae	*Ipomoea pandurata*
Dicots	Polemoniaceae	*Phlox ovata*
Dicots	Polemoniaceae	*Polemonium reptans*
Dicots	Hydrophyllaceae	*Hydrophyllum virginianum*
Dicots	Boraginaceae	*Cynoglossum virginianum*
Dicots	Boraginaceae	*Echium vulgare*
Dicots	Boraginaceae	*Hackelia virginiana*
Dicots	Boraginaceae	*Lithospermum canescens*
Dicots	Boraginaceae	*Myosotis macrosperma*
Dicots	Boraginaceae	*Onosmodium molle var.*

Dicots	Verbenaceae	*Verbena hastata*
Dicots	Verbenaceae	*Verbena simplex*
Dicots	Verbenaceae	*Verbena urticifolia*
Dicots	Lamiaceae	*Blephilia hirsuta*
Dicots	Lamiaceae	*Collinsonia canadensis*
Dicots	Lamiaceae	*Cunila origanoides*
Dicots	Lamiaceae	*Glechoma hederacea*
Dicots	Lamiaceae	*Hedeoma pulegioides*
Dicots	Lamiaceae	*Isanthus brachiata*
Dicots	Lamiaceae	*Lycopus americanus*
Dicots	Lamiaceae	*Lycopus uniflorus*
Dicots	Lamiaceae	*Lycopus virginicus*
Dicots	Lamiaceae	*Mentha piperita*
Dicots	Lamiaceae	*Monarda fistulosa*
Dicots	Lamiaceae	*Nepeta cataria*
Dicots	Lamiaceae	*Prunella vulgaris*
Dicots	Lamiaceae	*Pycnanthemum pycnanthemoides*
Dicots	Lamiaceae	*Pycnanthemum tenuifolium*
Dicots	Lamiaceae	*Pycnanthemum verticillatum*
Dicots	Lamiaceae	*Salvia lyrata*
Dicots	Lamiaceae	*Salvia urticifolia*
Dicots	Lamiaceae	*Satureja vulgaris*
Dicots	Lamiaceae	*Scutellaria elliptica*
Dicots	Lamiaceae	*Scutellaria lateriflora*
Dicots	Lamiaceae	*Scutellaria leonardii*
Dicots	Lamiaceae	*Scutellaria nervosa*
Dicots	Lamiaceae	*Scutellaria serrata*
Dicots	Lamiaceae	*Teucrium canadense*
Dicots	Solanaceae	*Datura stramonium*
Dicots	Solanaceae	*Physalis heterophylla*
Dicots	Solanaceae	*Solanum carolinense*
Dicots	Scrophulariaceae	*Agalinis tenuifolia*
Dicots	Scrophulariaceae	*Aureolaria virginica*
Dicots	Scrophulariaceae	*Chaenorrhinum minus*
Dicots	Scrophulariaceae	*Mimulus ringens*
Dicots	Scrophulariaceae	*Penstemon laevigatus*
Dicots	Scrophulariaceae	*Scrophularia marilandica*
Dicots	Scrophulariaceae	*Verbascum blattaria*
Dicots	Scrophulariaceae	*Verbascum thapsus*
Dicots	Scrophulariaceae	*Veronica americana*
Dicots	Scrophulariaceae	*Veronica anagalis-aquatica*
Dicots	Scrophulariaceae	*Veronica arvensis*
Dicots	Scrophulariaceae	*Veronica officinalis*
Dicots	Scrophulariaceae	*Veronica serpyllifolia*
Dicots	Bignoniaceae	*Campsis radicans*
Dicots	Phrymaceae	*Phryma leptostachya*
Dicots	Plantaginaceae	*Plantago aristata*

Dicots	Plantaginaceae	*Plantago lanceolata*
Dicots	Plantaginaceae	*Plantago virginica*
Dicots	Rubiaceae	*Diodia teres*
Dicots	Rubiaceae	*Galium aparine*
Dicots	Rubiaceae	*Galium circaezans*
Dicots	Rubiaceae	*Galium latifolium*
Dicots	Rubiaceae	*Galium pedemontanum*
Dicots	Rubiaceae	*Galium pilosum*
Dicots	Rubiaceae	*Galium triflorum*
Dicots	Rubiaceae	*Galium verum*
Dicots	Rubiaceae	*Houstonia caerulea*
Dicots	Rubiaceae	*Houstonia longifolia*
Dicots	Rubiaceae	*Sherardia arvensis*
Dicots	Caprifoliaceae	*Lonicera japonica*
Dicots	Caprifoliaceae	*Triosteum aurantiacum ?*
Dicots	Dipsacaceae	*Dipsacus fullonum*
Dicots	Campanulaceae	*Campanula americana*
Dicots	Campanulaceae	*Lobelia inflata*
Dicots	Campanulaceae	*Lobelia siphilitica*
Dicots	Campanulaceae	*Lobelia spicata var. leptostachya*
Dicots	Asteraceae	*Achillea millefolium*
Dicots	Asteraceae	*Ambrosia artemisiifolia*
Dicots	Asteraceae	*Antennaria parlinii ssp. fallax*
Dicots	Asteraceae	*Antennaria parlinii ssp. parlinii*
Dicots	Asteraceae	*Antennaria plantaginifolia*
Dicots	Asteraceae	*Aster lateriflorus*
Dicots	Asteraceae	*Aster phlogifolius*
Dicots	Asteraceae	*Aster pilosus*
Dicots	Asteraceae	*Aster undulatus*
Dicots	Asteraceae	*Bidens bipinnata*
Dicots	Asteraceae	*Bidens frondosa*
Dicots	Asteraceae	*Cacalia atriplicifolia*
Dicots	Asteraceae	*Carduus acanthoides*
Dicots	Asteraceae	*Carduus nutans*
Dicots	Asteraceae	*Centaurea jacea*
Dicots	Asteraceae	*Centaurea maculosa*
Dicots	Asteraceae	*Chrysanthemum leucanthemum*
Dicots	Asteraceae	*Chrysogonum virginianum*
Dicots	Asteraceae	*Cichorium intybus*
Dicots	Asteraceae	*Cirsium arvense*
Dicots	Asteraceae	*Cirsium discolor*
Dicots	Asteraceae	*Cirsium vulgare*
Dicots	Asteraceae	*Conyza canadensis*
Dicots	Asteraceae	*Crepis capillaris*
Dicots	Asteraceae	*Erechtites hieracifolia*
Dicots	Asteraceae	*Erigeron annuus*
Dicots	Asteraceae	*Erigeron philadelphicus*

Dicots	Asteraceae	*Erigeron pulchellus*
Dicots	Asteraceae	*Erigeron strigosus*
Dicots	Asteraceae	*Eupatorium fistulosum*
Dicots	Asteraceae	*Eupatorium perfoliatum*
Dicots	Asteraceae	*Eupatorium rotundifolium var.*
Dicots	Asteraceae	*Eupatorium rugosum*
Dicots	Asteraceae	*Eupatorium serotinum*
Dicots	Asteraceae	*Gnaphalium obtusifolium*
Dicots	Asteraceae	*Helianthus microcephalus*
Dicots	Asteraceae	*Heliopsis helianthoides*
Dicots	Asteraceae	*Hieracium pilosella*
Dicots	Asteraceae	*Hieracium pratense*
Dicots	Asteraceae	*Hieracium venosum*
Dicots	Asteraceae	*Hypochaeris radicata*
Dicots	Asteraceae	*Kuhnia eupatorioides*
Dicots	Asteraceae	*Polymnia uvedalia*
Dicots	Asteraceae	*Rudbeckia fulgida*
Dicots	Asteraceae	*Rudbeckia triloba*
Dicots	Asteraceae	*Senecio anonymous*
Dicots	Asteraceae	*Senecio aureus*
Dicots	Asteraceae	*Senecio plattensis x obovatus*
Dicots	Asteraceae	*Silphium trifoliatum*
Dicots	Asteraceae	*Solidago altissima*
Dicots	Asteraceae	*Solidago arguta*
Dicots	Asteraceae	*Solidago bicolor*
Dicots	Asteraceae	*Solidago nemoralis*
Dicots	Asteraceae	*Solidago rugosa*
Dicots	Asteraceae	*Solidago ulmifolia*
Dicots	Asteraceae	*Taraxacum officinale*
Dicots	Asteraceae	*Tragopogon dubius*
Dicots	Asteraceae	*Tussilago farfara*
Dicots	Asteraceae	*Verbesina alternifolia*
Dicots	Asteraceae	*Verbesina occidentalis*
Dicots	Asteraceae	*Vernonia noveboracensis*
Trees		*Juniperus virginiana*
Trees		*Pinus echinata*
Trees		*Pinus pungens*
Trees		*Pinus rigida*
Trees		*Pinus strobus*
Trees		*Pinus taeda*
Trees		*Pinus virginiana*
Trees	Salicaceae	*Salix nigra*
Trees	Juglandaceae	*Carya cordiformis*
Trees	Juglandaceae	*Carya ovata*
Trees	Juglandaceae	*Carya tomentosa*
Trees	Juglandaceae	*Juglans nigra*
Trees	Fagaceae	*Quercus alba*

Trees	Fagaceae	*Quercus coccinea*
Trees	Fagaceae	*Quercus muhlenbergii*
Trees	Fagaceae	*Quercus rubra*
Trees	Fagaceae	*Quercus stellata*
Trees	Fagaceae	*Quercus velutina*
Trees	Ulmaceae	*Celtic occidentalis*
Trees	Ulmaceae	*Ulmus rubra*
Trees	Moraceae	*Morus rubra*
Trees	Magnoliaceae	*Liriodendron tulipifera*
Trees	Magnoliaceae	*Magnolia acuminata*
Trees	Rosaceae	*Amelanchier arborea*
Trees	Rosaceae	*Crataegus crusgali*
Trees	Rosaceae	*Crataegus flabellata*
Trees	Rosaceae	*Malus coronaria*
Trees	Rosaceae	*Malus pumilus*
Trees	Rosaceae	*Prunus serotina*
Trees	Rosaceae	*Pyrus communis*
Trees	Fabaceae	*Robinia pseudoacacia*
Trees	Simarubaceae	*Ailanthus altissima*
Trees	Aceraceae	*Acer rubrum*
Trees	Aceraceae	*Acer saccharinum*
Trees	Aceraceae	*Acer saccharum*
Trees	Hippocastanaceae	*Aesculus flava*
Trees	Cornaceae	*Cornus florida*
Trees	Cornaceae	*Nyssa sylvatica*
Trees	Oleaceae	*Fraxinus americana*
Trees	Scrophulariaceae	*Paulownia tomentosa*
Shrubs	Betulaceae	*Alnus serrulata*
Shrubs	Betulaceae	*Corylus americana*
Shrubs	Berberidaceae	*Berberia canadensis*
Shrubs	Berberidaceae	*Berberis thunbergii*
Shrubs	Lauraceae	*Lindera benzoin*
Shrubs	Saxifragaceae	*Hydrangea arborescens*
Shrubs	Rosaceae	*Prunus americana*
Shrubs	Rosaceae	*Rosa multiflora*
Shrubs	Rosaceae	*Rosa palustris*
Shrubs	Anacardiaceae	*Rhus glabra*
Shrubs	Elaeagnaceae	*Elaeagnus umbellatus*
Shrubs	Cornaceae	*Cornus amomum*
Shrubs	Ericaceae	*Gaylussacia baccata*
Shrubs	Ericaceae	*Vaccinium pallidum*
Shrubs	Ericaceae	*Vaccinium stamineum*
Shrubs	Oleaceae	*Ligustrum obtusifolium*
Shrubs	Caprifoliaceae	*Lonicera maackii*
Shrubs	Caprifoliaceae	*Lonicera morrowii*
Shrubs	Caprifoliaceae	*Symphoricarpos orbiculatus*
Shrubs	Caprifoliaceae	*Viburnum prunifolium*

INVERTEBRATES

Class: Arachnida
Order: Araneae

Family	Scientific Name	Common Name
Agelenidae	*Cicurina pallida*	
Agelenidae	*Cicurina robusta*	
Agelenidae	*Cicurina sp.*	
Agelenidae	*Coras medicinalis*	
Agelenidae	*sp.*	
Agelenidae	*Wadotes bimucronatus*	
Agelenidae	*Wadotes hybridus*	
Agelenidae	*Wadotes sp.*	
Antrodiaetidae	*Antrodiaetus unicolor*	
Anyphaenidae	*Anyphaena celer*	
Anyphaenidae	*Anyphaena fraterna*	
Araneidae	*Araneus sp.*	
Araneidae	*Araneus pratensis*	
Araneidae	*Argipe trifasciata*	
Araneidae	*Mangora gibberosa*	
Araneidae	*Mangora placida*	
Araneidae	*Micrathena gracilis*	
Araneidae	*Micrathena mitrata*	
Araneidae	*Neoscona arabesca*	
Araneidae	*Neoscona pratensis*	
Araneidae	*sp.*	
Araneidae	*Verrucosa arenata*	
Atypidae	*Sphodros niger*	
Clubionidae	*Castianeira longipalpus*	
Clubionidae	*Castianeira sp.*	
Clubionidae	*Castianeira variata*	
Clubionidae	*Clubiona abboti*	
Clubionidae	*Clubiona johnsoni*	
Gnaphosidae	*Drassodes neglectus*	
Gnaphosidae	*Drassyllus creolus*	
Gnaphosidae	*Drassyllus depressus*	
Gnaphosidae	*Drassyllus eremitis*	
Gnaphosidae	*Drassyllus fallens*	
Gnaphosidae	*Drassyllus sp.*	
Gnaphosidae	*Haplodrassus signifer*	
Gnaphosidae	*Zelotes duplex*	
Gnaphosidae	*Zelotes hentzi*	
Hahniidae	*Neoantistae agilis*	
Leptonetidae	*Leptoneta sp.*	
Linyphiidae	*Bathyphantes pallida*	

Linyphiidae	*Centromerus persoluta*	
Linyphiidae	*Centromerus cornupalpis*	
Linyphiidae	*Cornicularia sp.*	
Linyphiidae	*Grammonata inornata*	
Linyphiidae	*Lepthyphantes zebra*	
Linyphiidae	*Prolinyphia marginata*	
Linyphiidae	*sp.*	
Linyphiidae	*Stemonyphantes blauveltae*	
Linyphiidae	*Tapinopa bilineata*	
Lycosidae	*Allocosa funerea*	
Lycosidae	*Gladicosa gulosa*	
Lycosidae	*Hogna frondicola*	
Lycosidae	*Hogna fronticola*	
Lycosidae	*Hogna helluo*	
Lycosidae	*Hogna punctulata*	
Lycosidae	*Hogna rabida*	
Lycosidae	*Pardosa milvina*	
Lycosidae	*Pardosa sp.*	
Lycosidae	*Pirata insularis*	
Lycosidae	*Pirata minutus*	
Lycosidae	*Pirata sedentarius*	
Lycosidae	*Pirata sp.*	
Lycosidae	*Schizocosa avida*	
Lycosidae	*Schizocosa bilineata*	
Lycosidae	*Schizocosa duplex*	
Lycosidae	*Schizocosa ocreata*	
Lycosidae	*Schizocosa ocreate*	
Lycosidae	*Schizocosa saltatrix*	
Lycosidae	*Schizocosa sp.*	
Lycosidae	*Schizocosa unk.*	
Lycosidae	*sp.*	
Lycosidae	*Trabea aurantiaca*	
Lycosidae	*Varacosa avara*	
Mimetidae	*Ero leonina*	
Oxyopidae	*Oxyopes salticus*	
Oxyopidae	*Oxyopes salticus*	
Philodromidae	*Philodromus marxi*	
Philodromidae	*Philodromus exilis*	
Philodromidae	*Philodromus minutus*	
Philodromidae	*Philodromus sp.*	
Philodromidae	*Thanatus formicinus*	
Philodromidae	*Thanatus rubicellus*	
Philodromidae	*Tibellus duttoni*	
Pisauridae	*Dolomedes albineus*	
Pisauridae	*Dolomedes sp.*	
Pisauridae	*Dolomedes triton*	
Pisauridae	*Pisaurina mira*	

Salticidae	*Eris marginata*	
Salticidae	*Eris sp.*	
Salticidae	*Habrocestum pulex*	
Salticidae	*Marpissa pikei*	
Salticidae	*Metaphidippus galathea*	
Salticidae	*Phidippus clarus*	
Salticidae	*Phidippus sp.*	
Salticidae	*Thiodina sylvana*	
Tetragnathidae	*Leucauge venusta*	
Tetragnathidae	*Pachygnatha autumnalis*	
Tetragnathidae	*Pachygnatha tristriata*	
Tetragnathidae	*Tetragnatha elongata*	
Tetragnathidae	*Tetragnatha pallescens*	
Tetragnathidae	*Tetragnatha straminea*	
Tetragnathidae	*Tetragnatha versicolor*	
Theridiidae	*Achaearanea globosa*	
Theridiidae	*Argyrodes trigona*	
Theridiidae	*Enoplognatha marmorata*	
Theridiidae	*Steatoda americana*	
Theridiidae	*Theridion albidum*	
Theridiidae	*Thymoites marxi*	
Theridiidae	*Thymoites sp.*	
Thomisidae	*Misumena vatia*	
Thomisidae	*Misumenops sp.*	
Thomisidae	*Ozyptila monroensis*	
Thomisidae	*Tmarus angulatus*	
Thomisidae	*Xysticus bicuspis*	
Thomisidae	*Xysticus elegans*	
Thomisidae	*Xysticus ferox*	
Thomisidae	*Xysticus gulosus*	
Thomisidae	*Xysticus luctans*	
Thomisidae	*Xysticus sp.*	

Class: Diplopoda
Order: Callipodida

Family	Scientific Name	Common Name
Abacionidae	*Abacion tesselatum*	Millipede

Class: Diplopoda
Order: Julida

Family	Scientific Name	Common Name
Julidae	*Ophyiulus pilosus*	Millipede

Class: Diplopoda
Order: Polydesmida

Family	Scientific Name	Common Name
Polydesmidae	*Pseudpolydesmus collinus*	Millipede
Xystodesmidae	*Brachoria separanda calcaria*	Millipede
Xystodesmidae	*Nannari sp.*	Millipede

Class: Insecta
Order: Coleoptera

Family	Scientific Name	Common Name
Cantharidae	*sp.*	Soldier beetle
Carabidae	*Amphasia interstitialis*	Ground beetle
Carabidae	*Apenes lucidula*	Ground beetle
Carabidae	*Arisodactylus nigerrinus*	Ground beetle
Carabidae	*Chlaenius lithophilus*	Ground beetle
Carabidae	*Dicaelus politus*	Ground beetle
Carabidae	*Lebia analis*	Ground beetle
Carabidae	*Lebia atriventris*	Ground beetle
Carabidae	*Lebia fuscata*	Ground beetle
Carabidae	*Lebia solea*	Ground beetle
Carabidae	*Oligthopus parmatus*	Ground beetle
Carabidae	*Pseudauphasia senicea*	Ground beetle
Carabidae	*Scaphinutus elevatus*	Ground beetle
Carabidae	*Scarites subterraneus*	Ground beetle
Carabidae	*Sphaeroderus stenostomus*	Ground beetle
Carabidae	*Steriolophus comma*	Ground beetle
Chrysomelidae	*Chrysolina inornata*	Leaf beetle
Chrysomelidae	*Glyptoscelis pubescens*	Leaf beetle
Chrysomelidae	*sp.*	Leaf beetle
Coccinellidae	*sp.*	Ladybird beetle
Cucujidae	*sp.*	Flat bark beetle
Dytiscidae	*sp.*	Predaceous diving beetle
Elateridae	*sp.*	Click beetle
Endomychidae	*Lycoperdina ferroginea*	Handsome fungus beetle
Endomychidae	*Mycetina perpulchra*	Handsome fungus beetle
Endomychidae	*Stenotarsus hispidus*	Handsome fungus beetle
Haliplidae	*sp.*	Crawling water beetle
Lampyridae	*sp.*	Firefly
Meloidae	*Meloe angusticollis*	Blister beetle
Psephenidae	*sp.*	Water-penny beetle
Scarabaeidae	*Copris minutus*	Scarab beetle
Scarabaeidae	*Copris tullius*	Scarab beetle
Scarabaeidae	*Geotropes opacus*	Scarab beetle
Staphylinidae	*Arpedium schwarzi*	Rove beetle
Staphylinidae	*Olophrum obtectum*	Rove beetle

Class: Insecta
Order: Collembola

Family	Scientific Name	Common Name
Entomobryidae	*sp.*	Springtail
Hypogastruidae	*sp.*	Springtail
Isotomidae	*sp.*	Springtail
Sminthuridae	*sp.*	Springtail

Class: Insecta
Order: Diptera

Family	Scientific Name	Common Name
Cecidomyiidae	*sp.*	Gall gnat
Ceratopogonidae	*sp.*	Biting midge
Chironomidae	*sp.*	Midge
Drosophilidae	*sp.*	Pomace fly
Ephydridae	*sp.*	Shore fly
Heleomyzidae	*sp.*	Heleomyzid fly
Lauxaniidae	*sp.*	Lauxaniid fly
Muscidae	*sp.*	Muscid fly
Mycetophilidae	*sp.*	Fungus gnat
Otitidae	*sp.*	Picture-winged fly
Phoridae	*sp.*	Humpbacked fly
Pipunculidae	*sp.*	Big-headed fly
Sciaridae	*sp.*	Dark-winged fungus gnat
Sciomyzidae	*sp.*	Marsh fly
Simuliidae	*sp.*	Black fly
Stratiomyiidae	*sp.*	Soldier fly
Syrphidae	*sp.*	Syrphid fly
Tabanidae	*sp.*	Deer fly
Tachinidae	*sp.*	Tachinid fly
Tipulidae	*sp.*	Crane fly

Class: Insecta
Order: Ephemeroptera

Specimen not identified beyond order.

Class: Insecta
Order: Heteroptera

Family	Scientific Name	Common Name
Belostomatidae	*Belostoma fluminea*	Giant water bug
Gerridae	*Gerris argenticollis*	Water strider
Hebridae	*Merragotta sp.*	Velvet water bug
Lygalidae	*Cryphula trimaculata*	Seed bug

Lygalidae	*Cymus angustatus*	Seed bug
Lygalidae	*Melaiiocorypha bicrucis*	Seed bug
Lygalidae	*Myodocha serripes*	Seed bug
Lygalidae	*Oedancala dorsalis*	Seed bug
Lygalidae	*Phlegyas abbreviatus*	Seed bug
Lygalidae	*Pseudopachybrachius basilis*	Seed bug
Lygalidae	*Xestocoris nitens*	Seed bug
Miridae	*Lopidea robiniae*	Leaf bug
Miridae	*Megaloceraea recticornis*	Leaf bug
Pentatomidae	*Acrosternum hilare*	Stink bug
Pentatomidae	*Mosmidea lergeus*	Stink bug
Pentatomidae	*sp.*	Stink bug
Reduviidae	*Fitchia aptera*	Assassin bug
Reduviidae	*Melanolestes abdominalis*	Assassin bug
Reduviidae	*sp.*	Assassin bug

Class: Insecta
Order: Homoptera

Family	**Scientific Name**	**Common Name**
Aphididae	*sp.*	Aphid
Cicadellidae	*sp.*	Leaf hopper

Class: Insecta
Order: Hymenoptera

Family	*Scientific Name*	**Common Name**
Anthoporidae	*sp.*	Apidid bee
Apidae	*sp.*	Apidid bee
Braconidae	*sp.*	Brachonid
Chalcidoidea	*sp.*	Chalsid
Formicidae	*Campanotus sp.*	Formicinae (Ant)
Formicidae	*Crematogastor sp.*	Myrmicinae (Ant)
Formicidae	*Formica sp.*	Formicinae (Ant)
Formicidae	*sp.*	Myrmicinae (Ant)
Formicidae	*sp.*	Ponerinae (Ant)
Formicidae	*Stenamma meridionale*	Myrmicinae (Ant)
Halictidae	*sp.*	Halictid bee
Ichneumonidae	*sp.*	Ichneumon
Ichneumonidae	*sp.*	Ichneumon bee
Megachilidae	*sp.*	Leafcutting bee
Mutillidae	*sp.*	Velvet ant
Proctotrupoidea	*sp.*	Proctotrupids
Tenthredinidae	*sp.*	Common sawfly
Vespidae	*Dolichovespula maculata*	Vespinae (Vespid wasp)
Vespidae	*sp.*	Vespid wasp

Class: Insecta
Order: Isoptera

Family	Scientific Name	Common Name
Rhinotermitidae	*sp.*	

Class: Insecta
Order: Lepidoptera

Family	Scientific Name	Common Name
Arctidae	*Grammia virgo*	Virgin Tiger Moth
Arctiidae	*Cisseps fulvicollis*	Yellow-collared Scape Moth
Arctiidae	*Estigmene acrea*	Salt marsh moth
Arctiidae	*Haploa lecontei*	Leconte's haploa
Arctiidae	*Holomelina opella*	Tawny Holomelina
Arctiidae	*sp.*	Tiger moth
Geometridae	*Epimecis hortaria*	Tulip-tree beauty
Geometridae	*Eubaphe mendica*	The beggar
Geometridae	*Eutrapela clemataria*	Curve-toothed Geometer
Geometridae	*Heterophleps triguiteria*	Three-spotted fillip
Geometridae	*Metarranthis hypochraria*	Common metarranthis
Geometridae	*Nepytia canosaria*	False Hemlock Looper Moth
Geometridae	*Patalene olyzonaria puber*	Juniper geometer
Geometridae	*Scopula inductata*	Soft-lined wave
Geometridae	*Scopula limboundata*	Large lace-border
Hesperidae	*Ancyloxypha numitor*	Least skipper
Hesperidae	*Atalopedes campestris*	Sachem
Hesperidae	*Atrytone logan*	Delaware skipper
Hesperidae	*Atrytonopsis hianna*	Dusted skipper
Hesperidae	*Epargyreus clarus*	Silver-spotted skipper
Hesperidae	*Erynnis baptisiae*	Wild indigo duskywing
Hesperidae	*Erynnis brizo*	Sleepy duskywing
Hesperidae	*Erynnis icelus*	Dreamy duskywing
Hesperidae	*Erynnis juvenalis*	Juvena'ls duskywing
Hesperidae	*Euphyes vestris*	Dun skipper
Hesperidae	*Lerema accius*	Clouded skipper
Hesperidae	*Nastra iherminier*	Swarthy skipper
Hesperidae	*Panaquina ocola*	Ocola skipper
Hesperidae	*Pholisora catullus*	Common sootywing
Hesperidae	*Poanes hobomok*	Hobomok skipper
Hesperidae	*Poanes zabulon*	Zabulon skipper
Hesperidae	*Polites origenes*	Crossline skipper
Hesperidae	*Polites peckius*	Peck's skipper
Hesperidae	*Polites themistocles*	Tawny-edged skipper
Hesperidae	*Pompeius verna*	Little glassywing
Hesperidae	*Pyrgus communis*	Common checkered skipper
Hesperidae	*Thorybes bathyllus*	Southern cloudywing

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Hesperidae	*Thorybes pylades*	Northern cloudywing
Hesperidae	*Thymelicus lineola*	European skipper
Hesperidae	*Wallengrenia egeremet*	Northern broken dash
Lasiocampidae	*Malacosoma sp.*	Tent caterpillar
Limacodidae	*Packardia geminata*	Slug caterpillar moth
Lycaenidae	*Callophrys gryneus*	Olive hairstreak
Lycaenidae	*Callophrys henrici*	Henry's elfin
Lycaenidae	*Callophrys niphon*	Eastern pine elfin
Lycaenidae	*Celastrina l. ladon "neglecta"*	Summer azure
Lycaenidae	*Celastrina l. ladon "violocea"*	Spring azure
Lycaenidae	*Celastrina neglectamajor*	Appalachian azure
Lycaenidae	*Everes comyntas*	Eastern tailed blue
Lycaenidae	*Feniseca tarquinius*	Harvester
Lycaenidae	*Lycaena Phlaeas*	American copper
Lycaenidae	*Satyrium calanus*	Banded hairstreak
Lycaenidae	*Satyrium titus*	Coral hairstreak
Lycaenidae	*Strymon melinus humuli*	Gray hairstreak
Noctuidae	*Caenurgina erechtea*	Forage looper moth
Noctuidae	*Feltia jaculifera*	Dingy cutworm moth
Noctuidae	*Galgula partita*	The wedgeling
Noctuidae	*Leucania sp.*	Armyworm moth
Noctuidae	*Leucania sp.*	Wainscot sp.
Noctuidae	*Mocis texana*	Texas mocis
Noctuidae	*Panthea furcilla*	Eastern panthea
Noctuidae	*Plathypena scabra*	Green cloverworm moth
Noctuidae	*Pseudaletia unipuncta*	Armyworm moth
Noctuidae	*sp.*	Noctuid moth
Noctuidae	*Spodoptera ornithogalli*	Yellow-striped Armyworm Moth
Noctuidae	*Xestia dolosa*	Greater Black-letter Dart
Noctuidae	*Xestia elimata*	
Nymphalidae	*Asterocampa c. celtis*	Hackberry emperor
Nymphalidae	*Boloria bellona*	Meadow fritillary
Nymphalidae	*Cercyonis pegala*	Common wood nymph
Nymphalidae	*Chlosyne nycteis*	Silvery checkerspot
Nymphalidae	*Danaus plexippus*	Monarch
Nymphalidae	*Enodia anthedon*	Northern pearly eye
Nymphalidae	*Euptoieta claudia*	Variegated fritillary
Nymphalidae	*Junonia coenia*	Common buckeye
Nymphalidae	*Limenitis arthemis astyanax*	Red-spotted purple
Nymphalidae	*Megisto cymela*	Little wood satyr
Nymphalidae	*Nymphalis antiopa*	Mourning cloak
Nymphalidae	*Phyciodes tharos*	Pearl crescent
Nymphalidae	*Polygonia comma*	Eastern comma
Nymphalidae	*Polygonia interrogationis*	Question mark
Nymphalidae	*Speyeria aphrodite*	Aphrodite fritillary
Nymphalidae	*Speyeria cybele*	Great spangled fritillary
Nymphalidae	*Speyeria idalia*	Regal fritillary

Nymphalidae	*Vanessa virginiensis*	American lady
Nymphalidae	*Vanessa atalanta*	Red admiral
Nymphalidae	*Vanessa cardui*	Painted lady
Papilionidae	*Battus philenor*	Pipevine swallowtail
Papilionidae	*Papilio cresphontes*	Giant swallowtail
Papilionidae	*Papilio glaucus*	Eastern tiger swallowtail
Papilionidae	*Papilio polyxenes*	Black swallowtail
Papilionidae	*Papilio troilus*	Spicebush swallowtail
Pieridae	*Anthocharis midea*	Falcate orangetip
Pieridae	*Colias eurytheme*	Orange sulfer
Pieridae	*Colias philodice*	Clouded sulfer
Pieridae	*Eurema nicippi*	Sleepy orange
Pieridae	*Phoebis sennae*	Cloudless sulpher
Pieridae	*Pieris rapae*	Cabage white
Sphingidae	*Hemaris diffinis*	Snowberry Clearwing
Sphingidae	*Hemaris thysbe*	Hummingbird clearwing
Sphingidae	*Manduca sexta*	Carolina Sphinx
Yponomeutidae	*Atteva punctella*	Ailanthus webwom moth

Class: Insecta
Order: Neuroptera

Family	**Scientific Name**	**Common Name**
Corydalidae	*Nigronia sp.*	Dobsonfly
Hemerobiidae	*sp.*	Lacewing

Class: Insecta
Order: Odonata

Family	**Scientific Name**	**Common Name**
Aeshnidae	*Aeshna umbrosa*	Shadow Darner
Aeshnidae	*Anax junius*	Common Green Darner
Calopterygidae	*Calopteryx maculata*	Ebony Jewelwing
Calopterygidae	*Calopteryx maculata*	Ebony Jewelwing
Coenagrionidae	*Argia moesta*	Powdered Dancer
Coenagrionidae	*Agria fumipennis violacea*	Variable Dancer
Coenagrionidae	*Amphiagrion saucium*	Eastern Red Damsel
Coenagrionidae	*Argia fumipennis violacea*	Variable Dancer
Coenagrionidae	*Enallagma aspersum*	Azure Bluet
Coenagrionidae	*Enallagma civile*	Familiar Bluet
Coenagrionidae	*Enallagma signatum*	Orange Bluet
Coenagrionidae	*Ischnura hastata*	Citrine Forktail
Coenagrionidae	*Ischnura verticalis*	Eastern Forktail
Coenagrionidae	*Ishnura Hastata*	Citrine Forktail
Coenagrionidae	*Ishnura verticalis*	Eastern Forktail
Corduliida	*Epitheca cynosura*	Common Baskettail
Gomphidae	*Gomphus exilis*	Lancet Clubtail

Gomphidae	*Gomphus lividus*	Ashy Clubtail
Gomphidae	*Lanthus vernalis*	Southern Pygmy Clubtail
Lestidae	*lestes disjunctus asutralis*	Common Spreadwing
Lestidae	*Lestes disjunctus australis*	Common Spreadwing
Lestidae	*Lestes eurinus*	Amber-winged Spreadwing
Lestidae	*Lestes rectangularis*	Slender Spreadwing
Lestidae	*Lestes vigilax*	Swamp Spreadwing
Libellulidae	*Celithemis elisa*	Calico Pennant
Libellulidae	*Erythemis simplicicollis*	Eastern Pondhawk
Libellulidae	*Libellula lydia*	Common Whitetail
Libellulidae	*Libellula semifasciata*	Painted Skimmer
Libellulidae	*Pachydiplax longipennis*	Blue Dasher
Libellulidae	*Perithemis tenera*	Eastern Amberwing
Libellulidae	*Sympetrum rubicundulum*	Ruby Meadowhawk
Libellulidae	*Tramea lacerata*	Black Saddlebags
Liebellulidae	*Sympetrum rubicundulum*	Ruby Meadowhawk

Class: Insecta
Order: Orthoptera

Family	**Scientific Name**	**Common Name**
Blatellidae	*Parcoblatta sp.*	Cockroach

Class: Insecta
Order: Siphonoptera

Specimen not identified beyond order.

Class: Insecta
Order: Thysanura

Family	**Scientific Name**	**Common Name**
Machilidae	*Machilis sp.*	Bristletail

Class: Insecta
Order: Trichoptera

Family	**Scientific Name**	**Common Name**
Hydropsychidae	*Cheumatopsyche sp.*	Caddisfly
Hydropsychidae	*Hydropsyche sp.*	Caddisfly
Hydropsychidae	*Potomyia sp.*	Caddisfly
Leptoceridae	*Mystacides sp.*	Caddisfly
Limnephilidae		Caddisfly
Philopotamidae	*Chimarra sp.*	Caddisfly
Polycentropodidae	*Polycentropus sp.*	Caddisfly

Class: Malacostraca
Order: Isopoda

Family	Scientific Name	Common Name
Asellidae	*Caecidotea sp.*	Isopod
Oniscidae	*Cylisticus sp.*	Pill bug
Oniscidae	*Trachelipus sp.*	Pill bug

Class: Malacostraca
Order: Amphipoda

Family	Scientific Name	Common Name
Crangonyctidae	*Gammarus minus*	Amphipod
Crangonyctidae	*Stygobromus abditus*	Amphipod

FISH

Family	Scientific Name	Common Name
Centrarchidae	*Lepomis cyanellus*	green sunfish
Centrarchidae	*Lepomis macrochirus*	bluegill
Centrarchidae	*Lepomis macrochirus x Lepomis*	bluegill x green sunfish
Centrarchidae	*Micropterus salmoides*	largemouth bass
Cyprinidae	*Campostoma anomalum*	central stoneroller
Cyprinidae	*Cyprinus carpio*	common carp
Cyprinidae	*Nocomis leptocephalus*	bluehead chub
Cyprinidae	*Phoxinus oreas*	mountain redbelly dace
Cyprinidae	*Rhinichthys atratulus*	blacknose dace
Ictaluridae	*Noturus insignis*	margined madtom
Salmonidae	*Oncorhynchus mykiss*	rainbow trout
Salmonidae	*Salmo trutta*	brown trout

REPTILES AND AMPHIBIANS

Family	Scientific Name	Common Name
	Ambystoma jeffersonianum	Jefferson salamander
	Bufo americanus	American toad
	Bufo woodhousii	Fowler's toad
	Chelydra serpentina	snapping turtle
	Chrysemys picta	eastern painted turtle
	Coluber constrictor	northern black racer
	Desmognathus fuscus	northern dusky salamander
	Diadophis punctatus	ringneck snake
	Elaphe obsoleta	black rat snake
	Eurycea cirrigera	southern two-lined salamander
	Eurycea longicauda	longtail salamander
	Hyla versicolor	gray treefrog

	Lampropeltis triangulum	eastern milk snake
	Plethodon cinereus	redback salamander
	Plethodon glutinosus	slimy salamander
	Pseudacris crucifer	spring peeper
	Pseudacris triseriata	upland chorus frog
	Pseudotriton ruber	northern red salamander
	Rana catesbeiana	bullfrog
	Rana clamitans	green frog
	Rana sylvatica	wood frog
	Terrapene carolina	eastern box turtle
	Thamnophis sirtalis	eastern garter snake

BIRDS

Family	Scientific Name	Common name
Accipitridae	*Accipiter cooperii*	cooper's hawk
Accipitridae	*Accipiter striatus*	sharp-shinned hawk
Accipitridae	*Buteo jamaicensis*	red-tailed hawk
Accipitridae	*Buteo lagopus*	rough-legged hawk
Accipitridae	*Circus cyaneus*	northern harrier
Accipitridae	*Falco sparverius*	American kestrel
Accipitridae	*Pandion haliaetus*	osprey
Alaudidae	*Eremophila alpestris*	horned lark
Alcedinidae	*Ceryle alcyon*	belted kingfisher
Anatidae	*Aix sponsa*	wood duck
Anatidae	*Anas acuta*	northern pintail
Anatidae	*Anas crecca*	green-winged teal
Anatidae	*Anas discors*	blue-winged teal
Anatidae	*Anas platyrhynchos*	mallard duck
Anatidae	*Anas rubripes*	American black duck
Anatidae	*Anas strepera*	gadwall
Anatidae	*Aythya collaris*	ring-necked duck
Anatidae	*Bucephala albeola*	bufflehead
Anatidae	*Lophodytes cucullatus*	hoodeed merganser
Apodidae	*Chaetura pelagica*	chimney swift
Ardeidae	*Ardea herodias*	great blue heron
Ardeidae	*Butorides striatus*	green heron
Bombycillidae	*Bombycilla cedrorum*	cedar waxwing
Caprimulgidae	*Chordeiles minor*	common nighthawk
Columbidae	*Zenaida macroura*	mourning dove
Corvidae	*Corvus brachyrhynchos*	American crow
Corvidae	*Corvus corax*	common raven
Corvidae	*Cyanocitta cristata*	blue jay
Cuculidae	*Coccyzus americanus*	yellow-billed cuckoo
Cuculidae	*Coccyzus erythropthalmus*	black-billed cuckoo
Emberizidae	*Agelaius phoeniceus*	red-winged bkackbird
Emberizidae	*Agelaius phoeniceus*	red-winged blackbird

Emberizidae	*Ammodramus henslowii*	Henslow's sparrow
Emberizidae	*Ammodramus savannarum*	grasshopper sparrow
Emberizidae	*Cardinalis cardinalis*	northern cardinal
Emberizidae	*Dendroica coronata*	yellow-rumped warbler
Emberizidae	*Dendroica discolor*	prairie warbler
Emberizidae	*Dendroica fusca*	blackburnian warbler
Emberizidae	*Dendroica magnolia*	magnolia warbler
Emberizidae	*Dendroica palmarum*	palm warbler
Emberizidae	*Dendroica pensylvanica*	cheastnut-sided warbler
Emberizidae	*Dendroica pinus*	pine warbler
Emberizidae	*Dendroica virens*	black-throated green warbler
Emberizidae	*Dolichonyx oryzivorus*	bobolink
Emberizidae	*Geothlypis trichas*	common yellowthroat
Emberizidae	*Guiraca caerulea*	blue grosbeak
Emberizidae	*Icteria virens*	yellow-breasted chat
Emberizidae	*Icterus galbula*	northern oriole
Emberizidae	*Icterus spurius*	orchard oriole
Emberizidae	*Junco hyemalis*	northern junco
Emberizidae	*Melospiza georgiana*	swamp sparrow
Emberizidae	*Melospiza melodia*	song sparrow
Emberizidae	*Mniotilta varia*	black-and-white warbler
Emberizidae	*Molothrus ater*	brown-headed cowbird
Emberizidae	*Oporornis formosus*	kentucky warbler
Emberizidae	*Passerculus sandwichensis*	savannah sparrow
Emberizidae	*Passerina cyanea*	indigo bunting
Emberizidae	*Pipilo erythrophthalmus*	eastern towhee
Emberizidae	*Piranga olivacea*	scarlet tanager
Emberizidae	*Quiscalus quiscula*	common grackle
Emberizidae	*Seiurus aurocapillus*	ovenbird
Emberizidae	*Setophaga ruticilla*	American redstart
Emberizidae	*Spizella arborea*	American tree sparrow
Emberizidae	*Spizella passerina*	chipping sparrow
Emberizidae	*Spizella pusilla*	field sparrow
Emberizidae	*Sturnella magna*	eastern meadowlark
Emberizidae	*Zonotrichia albicollis*	white-throated sparrow
Fringillidae	*Carduelis tristis*	American goldfinch
Fringillidae	*Carpodacus mexicanus*	house finch
Hirundinidae	*Hirundo rustica*	barn swallow
Hirundinidae	*Stelgidopteryx serripennis*	rough-winged swallow
Hirundinidae	*Tachycineta bicolor*	tree swallow
Lanidae	*Lanius ludovicianus*	loggerhead shrike
Mimidae	*Dumetella carolinensis*	gray catbird
Mimidae	*Mimus polyglottos*	northern mockingbird
Mimidae	*Toxostoma rufum*	brown thrasher
Muscicapidae	*Catharus guttatus*	hermit thrush
Muscicapidae	*Hylocichla mustelina*	wood thrush
Muscicapidae	*Polioptila caerulea*	blue-gray gnatcatcher

Cervidae	*Odocoileus virginianus*	white-tailed deer
Diedelphidae	*Didelphis virginiana*	Virginia opossum
Dipodidae	*Zapus hudsonius*	meadow jumping mouse
Mephitidae	*Mephitis mephitis*	striped skunk
Muridae	*Microtis pennsylvanicus*	meadow vole
Muridae	*Microtis pinetorum*	woodland vole
Muridae	*Mus musculus*	house mouse
Muridae	*Peromyscus leucopus*	white-footed mouse
Muridae	*Rethrodontomys humulis*	eastern harvest mouse
Procyonidae	*Procyon lotor*	common raccoon
Sciuridae	*Marmota monax*	woodchuck
Sciuridae	*Sciurus carolinensis*	eastern gray squirrel
Sciuridae	*Sciurus niger*	eastern fox squirrel
Sciuridae	*Tamias striatus*	eastern chipmunk
Soricidae	*Blarina brevicauda*	northern short-tailed shrew
Soricidae	*Cryptotis parva*	least shrew
Talpidae	*Parascalops breweri*	hairy-tailed mole

Appendix B

Presentation of Quantitation Limits for Nondetected Chemicals

Appendix B
Presentation of Quantitation Limits for Nondetected Chemicals

Appendix B presents the range of quantitation limits for all non-detected chemicals in the Radford Ammunition Plant surface soil, surface water, and sediment. The tables also present a comparison of Region III BTAG Screening Levels to the maximum detection limit for each chemical.

Appendix B
Comparison of BTAG Screening Levels to Maximum Detection Limits for Non-detected Chemicals in Surface Soil at Radford Main Manufacturing Plant
(Concentrations in ug/kg organics; mg/kg inorganics)

Chemical	Range of Detection Limits	Region III BTAG Screening Level	Maximum Detection Limit >Screening Level?
Volatile Organics:			
Acetone	3,300	NSL	---
Benzene	100	100	No
Bromodichloromethane	200	450,000	No
Bromoform	200	NSL	---
Bromomethane	260	NSL	---
2-Butanone	4,300	NSL	---
Carbon disulfide	600	NSL	---
Carbon tetrachloride	310	<300	**Yes**
Chlorobenzene	100	100	No
Chloroethane	640	NSL	---
Chloroform	240	<300	No
Chloromethane	960	NSL	---
1,1-Dichloroethane	490	<300	**Yes**
1,2-Dichloroethane	320	870,000	No
1,2-Dichloroethene (total)	320	<300	**Yes**
1,1-Dichloroethene	270	NSL	---
1,2-Dichloropropane	530	NSL	---
cis-1,3-Dichloropropene	600	<300 [A]	**Yes**
trans-1,3-Dichloropropene	600	<300 [A]	**Yes**
Ethyl benzene	190	100	**Yes**
2-Hexanone	1,000	NSL	---
4-Methyl-2-pentanone	630	100,000	No
Methylene chloride	4,400	<300	**Yes**
Styrene	600	100	**Yes**
1,1,2,2-Tetrachloroethane	200	<300 [B]	No
Tetrachloroethene	160	<300	No
Toluene	100	100	No
1,1,1-Trichloroethane	200	<300 [C]	No
1,1,2-Trichloroethane	330	<300 [C]	**Yes**
Trichloroethene	230	<300	No
Trichlorofluoromethane	230	NSL	---
Vinyl acetate	1,000	NSL	---
Vinyl chloride	1,800	300	**Yes**
PAHs:			
Acenaphthylene	230 - 550	100	**Yes**
Anthracene	12.0 - 710	100	**Yes**
Carbazole	430 - 4,400	NSL	---
Dibenzofuran	430 - 4,400	NSL	---
2-Methylnaphthalene	430 - 4,400	NSL	---

Appendix B

Comparison of BTAG Screening Levels to Maximum Detection Limits for Non-detected Chemicals in Surface Soil at Radford Main Manufacturing Plant

(Concentrations in ug/kg organics; mg/kg inorganics)

Chemical	Range of Detection Limits	Region III BTAG Screening Level	Maximum Detection Limit >Screening Level?
Explosives:			
2,6-Dinitrotoluene	320 - 4,400	NSL	---
2,4-Dinitrotoluene	430 - 4,400	NSL	---
HMX	2,000	NSL	---
4,6-dinitro-2-Methylphenol	800 - 22,000	NSL	---
Nitrobenzene	430 - 4,400	NSL	---
RDX	1,280	NSL	---
Tetryl	2,110	NSL	---
2,4,6-Trinitrotoluene	2,000	NSL	---
Other Semivolatile Organics:			
Acrylonitrile	2,000	NSL	---
Benzoic acid	2,200 - 22,000	NSL	---
Benzyl alcohol	860 - 8,700	NSL	---
4-Bromophenyl phenyl ether	41.0 - 4,400	NSL	---
Butylbenzyl phthalate	430 - 4,400	NSL	---
4-Chloroaniline	860 - 8,700	NSL	---
bis(2-Chloroethoxy)methane	190 - 4,400	NSL	---
bis(2-Chloroethyl)ether	360 - 4,400	NSL	---
bis(2-Chloroisopropyl)ether	440	NSL	---
4-Chloro-3-methylphenol	860 - 8,700	NSL	---
2-Chloronaphthalene	240 - 4,400	NSL	---
2-Chlorophenol	55.0 - 4,400	100	**Yes**
4-Chlorophenyl phenyl ether	430 - 4,400	NSL	---
1,2-Dichlorobenzene	42.0 - 4,400	<300	**Yes**
1,3-Dichlorobenzene	42.0 - 4,400	NSL	---
1,4-Dichlorobenzene	34.0 - 4,400	<100	**Yes**
3,3'-Dichlorobenzidine	860 - 8,700	NSL	---
2,4-Dichlorophenol	65.0 - 4,400	100	**Yes**
Dimethylphthalate	63.0 - 4,400	NSL	---
2,4-Dimethylphenol	430 - 4,400	100	**Yes**
2,4-Dinitrophenol	2,200 - 22,100	100 [D]	**Yes**
1,2-Diphenylhydrazine	430 - 4,400	NSL	---
Hexachlorobenzene	80.0 - 4,400	NSL	---
Hexachlorobutadiene	430 - 4,400	NSL	---
Hexachlorocyclopentadiene	430 - 4,400	NSL	---
Hexachloroethane	430 - 4,400	NSL	---
Isophorone	430 - 4,400	NSL	---
2-Methylphenol	98.0 - 4,400	100	**Yes**
4-Methylphenol	240 - 4,400	100	**Yes**

Appendix B
Comparison of BTAG Screening Levels to Maximum Detection Limits for Non-detected Chemicals in Surface Soil at Radford Main Manufacturing Plant
(Concentrations in ug/kg organics; mg/kg inorganics)

Chemical	Range of Detection Limits	Region III BTAG Screening Level	Maximum Detection Limit >Screening Level?
2-Nitroaniline	2,200 - 22,000	NSL	---
3-Nitroaniline	2,200 - 22,000	NSL	---
4-Nitroaniline	2,200 - 22,100	NSL	---
2-Nitrophenol	430 - 4,400	100 [E]	**Yes**
4-Nitrophenol	2,200 - 22,100	100	**Yes**
n-Nitroso-di-n-propylamine	430 - 4,400	NSL	---
n-Nitrosodiphenylamine	290 - 4,400	NSL	---
di-n-Octylphthalate	230 - 4,400	NSL	---
2,2'-Oxybis(1-chloropropane)	430 - 4,400	NSL	---
Pentachlorophenol	760 - 22,000	100	**Yes**
Phenol	52.0 - 4,400	100	**Yes**
1,2,4-Trichlorobenzene	220 - 4,400	<100 [F]	**Yes**
2,4,5-Trichlorophenol	490 - 11,000	100	**Yes**
2,4,6-Trichlorophenol	61.0 - 4,400	100	**Yes**
Xylenes	780	NSL	---
Inorganics:			
Thallium	0.770 - 34.3	0.001	**Yes**

[A] Value for dichloropropene.
[B] Value for tetrachloroethane.
[C] Value for trichloroethane.
[D] Value for dinitrophenol.
[E] Value for 4-nitrophenol.
[F] Value for trichlorobenzene.
NSL= No screening level available.

Appendix B
Comparison of BTAG Screening Levels to Maximum Detection Limits for Non-detected Chemicals in Sediment at Radford Main Manufacturing Plant
(Concentrations in ug/kg organics; mg/kg inorganics)

Chemical	Range of Detection Limits	Region III BTAG Screening	Maximum Detection Limit >Screening Level?
Volatile Organics:			
Acetone	3,300	NSL	---
Benzene	100	NSL	---
Bromodichloromethane	200	NSL	---
Bromoform	200	NSL	---
Bromomethane	260	NSL	---
2-Butanone	4,300	NSL	---
Carbon disulfide	600	NSL	---
Carbon tetrachloride	310	NSL	---
Chlorobenzene	100	NSL	---
Chloroethane	640	NSL	---
Chloroform	240	NSL	---
bis(2-Chloroisopropyl)ether	440	NSL	---
Chloromethane	960	NSL	---
Dibromochloromethane	250	NSL	---
Dichlorobenzene	200	NSL	---
1,1-Dichloroethane	490	NSL	---
1,2-Dichloroethane	320	NSL	---
1,2-Dichloroethene (total)	320	NSL	---
1,1-Dichloroethene	270	NSL	---
1,2-Dichloropropane	530	NSL	---
1,3-Dichloropropane	200	NSL	---
cis-1,3-Dichloropropene	600	NSL	---
trans-1,3-Dichloropropene	600	NSL	---
1,3-Dimethylbenzene	230	NSL	---
Ethyl benzene	190	10	**Yes**
2-Hexanone	1,000	NSL	---
4-Methyl-2-pentanone	630	NSL	---
Methylene chloride	4,400	NSL	---
Styrene	600	NSL	---
1,1,2,2-Tetrachloroethane	200	NSL	---
Tetrachloroethene	160	57	**Yes**
Toluene	100	NSL	---
1,1,1-Trichloroethane	200	31 [A]	**Yes**
1,1,2-Trichloroethane	330	31 [A]	**Yes**
Trichloroethene	230	NSL	---
Trichlorofluoromethane	230	NSL	---
Vinyl acetate	1,000	NSL	---
Vinyl chloride	1,800	NSL	---
Xylenes (total)	780	40 [B]	**Yes**
PAHs:			
Anthracene	710	85.3	**Yes**

Appendix B
Comparison of BTAG Screening Levels to Maximum Detection Limits for Non-detected Chemicals in Sediment at Radford Main Manufacturing Plant
(Concentrations in ug/kg organics; mg/kg inorganics)

Chemical	Range of Detection Limits	Region III BTAG Screening	Maximum Detection Limit >Screening Level?
Benzo(a)pyrene	1,200	430	**Yes**
Benzo(b)fluoranthene	310	3,200	No
Benzo(k)fluoranthene	130	3,200 [C]	No
Dibenz(a,h)anthracene	310	63.4	**Yes**
Indeno(1,2,3-c,d)pyrene	2,400	600	**Yes**
Naphthalene	740	160	**Yes**
Explosives:			
2,4-Dinitrotoluene	1,400 - 2,500	NSL	---
2,6-Dinitrotoluene	320 - 2000	NSL	---
HMX	2,000	NSL	---
Nitrobenzene	1,140 - 1,800	NSL	---
RDX	1,280	NSL	---
Tetryl	2,110	NSL	---
Other Semivolatile Organics:			
Acrylonitrile	2,000	NSL	---
4-Bromophenyl phenyl ether	41	NSL	---
Butylbenzyl phthalate	1,800	63	**Yes**
bis(2-Chloroethoxy)methane	190	NSL	---
bis(2-Chloroethyl)ether	360	NSL	---
4-Chloro-3-methylphenol	930	NSL	---
2-Chloronaphthalene	240	NSL	---
2-Chlorophenol	55	NSL	---
1,2-Dichlorobenzene	42	35	**Yes**
1,3-Dichlorobenzene	42 - 140	NSL	---
1,4-Dichlorobenzene	34	110	No
3,3'-Dichlorobenzidine	1,600	NSL	---
2,4-Dichlorophenol	65	NSL	---
2,4-Dimethylphenol	3,000	29	**Yes**
2,4-Dinitrophenol	4,700	NSL	---
Hexachlorobenzene	80	22	**Yes**
Hexachlorobutadiene	970	11	**Yes**
Hexachlorocyclopentadiene	520	NSL	---
Hexachloroethane	1,800	NSL	---
2-Methylphenol	98	63	**Yes**
4-Methylphenol	240	670	No
4,6-dinitro-2-Methylphenol	800	NSL	---
4-Nitrophenol	3,300	NSL	---
n-Nitroso-di-n-propylamine	1,100	NSL	---
di-n-Octylphthalate	230	6,200	No
Pentachlorophenol	760	360	**Yes**
Phenol	52	420	No
1,2,4-Trichlorobenzene	220	40.0 [D]	**Yes**

Appendix B
Comparison of BTAG Screening Levels to Maximum Detection Limits for Non-detected Chemicals in Sediment at Radford Main Manufacturing Plant
(Concentrations in ug/kg organics; mg/kg inorganics)

Chemical	Range of Detection Limits	Region III BTAG Screening	Maximum Detection Limit >Screening Level?
2,4,5-Trichlorophenol	490	NSL	---
2,4,6-Trichlorophenol	61	NSL	---
Inorganics:			
Antimony	19.6	150	No
Cadmium	1.20	1.2	No
Selenium	0.449 - 40.0	NSL	---
Thallium	34.3	NSL	---

[A] Value for trichloroethane.

[B] Value for xylene.

[C] Value for benzo(b)fluoranthene.

[D] Value for trichlorobenzene.

NSL= No screening level available.

Appendix B
Comparison of BTAG Screening Levels to Maximum Detection Limits for Non-detected Chemicals in Surface Water at Radford Main Manufacturing Plant
(Concentrations in ug/L)

Chemical	Range of Detection Limits	Region III BTAG Screening Level	Maximum Detection Limit >Screening Level?
<u>New River</u>			
Volatile Organics:			
Acetone	8.00	9,000,000	No
Benzene	1.00	5,300	No
Bromodichloromethane	1.00	11,000	No
Bromoform	11.0	NSL	---
Bromomethane	14.0	NSL	---
2-Butanone	10.0	3,220,000	No
Carbon disulfide	5.00	2	**Yes**
Carbon tetrachloride	1.00	35,200	No
Chlorobenzene	1.00	50	No
Chloroethane	8.00	NSL	---
Chloroform	1.00	1,240	No
Chloromethane	1.20	NSL	---
Dibromochloromethane	1.00	11,000	No
Dichlorobenzene	2.00	NSL	---
1,1-Dichloroethane	1.00	160,000	No
1,2-Dichloroethane	1.00	20,000	No
1,2-Dichloroethene (total)	5.00	11,600	No
1,1-Dichloroethene	1.00	11,600	No
1,2-Dichloropropane	1.00	NSL	---
1,3-Dichloropropane	4.80	NSL	---
cis-1,3-Dichloropropene	5.00	244 [A]	No
trans-1,3-Dichloropropene	5.00	244 [A]	No
1,3-Dimethylbenzene	1.00	NSL	---
Ethyl benzene	1.00	32,000	No
2-Hexanone	1.00	428,000	No
4-Methyl-2-pentanone	1.40	460,000	No
Methylene chloride	1.00	11,000	No
Styrene	5.00	NSL	---
1,1,2,2-Tetrachloroethane	1.50	2,400 [B]	No
Tetrachloroethene	1.00	840	No
Toluene	1.00	17,000	No
1,1,1-Trichloroethane	1.00	9,400 [C]	No
1,1,2-Trichloroethane	1.00	9,400 [C]	No
Trichloroethene	1.00	21,900	No
Trichlorofluoromethane	1.00	11,000	No
Vinyl acetate	1.00	NSL	---
Vinyl chloride	12.0	11,600	No
Xylenes (total)	2.00	6,000 [D]	No

Appendix B
Comparison of BTAG Screening Levels to Maximum Detection Limits for Non-detected Chemicals in Surface Water at Radford Main Manufacturing Plant
(Concentrations in ug/L)

Chemical	Range of Detection Limits	Region III BTAG Screening Level	Maximum Detection Limit >Screening Level?
PAHs:			
Anthracene	5.20	0.1	**Yes**
Benz(a)anthracene	9.80	6.3	**Yes**
Benzo(a)pyrene	14.0	NSL	---
Benzo(b)fluoranthene	10.0	NSL	---
Benzo(k)fluoranthene	10.0	NSL	---
Chrysene	7.40	NSL	---
Dibenz(a,h)anthracene	12.0	NSL	---
Fluoranthene	24.0	3,980	No
Indeno(1,2,3-c,d)pyrene	21.0	NSL	---
Naphthalene	0.500	100	No
Phenanthrene	9.90	6.3	**Yes**
Pyrene	17.0	NSL	---
Explosives:			
1,3-Dinitrobenzene	0.458	1,200	No
2,4-Dinitrotoluene	0.397 - 5.80	230	No
2,6-Dinitrotoluene	0.600 - 6.70	230 [E]	No
HMX	0.533	NSL	---
Nitrobenzene	0.682 - 3.70	27,000	No
RDX	0.416	NSL	---
Tetryl	0.631	NSL	---
1,3,5-Trinitrobenzene	0.210	NSL	---
2,4,6-Trinitrotoluene	0.426	NSL	---
Other Semivolatile Organics:			
Acrylonitrile	8.40	2,600	No
4-Bromophenyl phenyl ether	22.0	NSL	---
di-n-Butylphthalate	33.0	0.3	**Yes**
Butylbenzyl phthalate	28.0	3	**Yes**
bis(2-Chloroethoxy)methane	6.80	11,000	No
bis(2-Chloroethyl)ether	0.680	NSL	---
bis(2-Chloroisopropyl)ether	5.00	NSL	---
4-Chloro-3-methylphenol	8.50	NSL	---
2-Chloronaphthalene	2.60	NSL	---
2-Chlorophenol	2.80	970	No
1,2-Dichlorobenzene	1.20	763	No
1,3-Dichlorobenzene	1.00 - 3.40	763	No
1,4-Dichlorobenzene	1.50	763	No
3,3'-Dichlorobenzidine	5.00	NSL	---
2,4-Dichlorophenol	8.40	365	No
Diethylphthalate	5.90	3	**Yes**
Dimethylphthalate	2.20	3	No

Appendix B
Comparison of BTAG Screening Levels to Maximum Detection Limits for Non-detected Chemicals in Surface Water at Radford Main Manufacturing Plant
(Concentrations in ug/L)

Chemical	Range of Detection Limits	Region III BTAG Screening Level	Maximum Detection Limit >Screening Level?
2,4-Dimethylphenol	4.40	NSL	---
2,4-Dinitrophenol	180	150 [F]	**Yes**
bis(2-Ethylhexyl)phthalate	7.70	30	No
Hexachlorobenzene	12.0	3.68	**Yes**
Hexachlorobutadiene	8.70	9.3	No
Hexachlorocyclopentadiene	54.0	5.2	**Yes**
Hexachloroethane	8.30	540	No
2-Methylphenol	3.60	NSL	---
4-Methylphenol	2.80	NSL	---
4,6-dinitro-2-Methylphenol	50.0	NSL	---
4-Nitrophenol	96.0	150	No
n-Nitroso-di-n-propylamine	6.80	NSL	---
n-Nitrosodiphenylamine	3.70	5,850	No
di-n-Octylphthalate	1.50	0.3	**Yes**
Pentachlorophenol	9.10	13	No
Phenol	2.20	79	No
1,2,4-Trichlorobenzene	2.40	50 [G]	No
2,4,5-Trichlorophenol	2.80	63	No
2,4,6-Trichlorophenol	3.60	970	No
Inorganics:			
Aluminum	141	25	**Yes**
Antimony	60.0	30	**Yes**
Arsenic	2.35	48 [H]	No
Beryllium	1.64	5.3	No
Cadmium	6.78	.53	**Yes**
Calcium	500	NSL	---
Chromium	16.8	2 [I]	**Yes**
Iron	38.1	320	No
Magnesium	500	NSL	---
Manganese	2.75	14,500	No
Mercury	0.100	0.012	**Yes**
Nickel	32.1	160	No
Potassium	375	NSL	---
Selenium	2.53	5	No
Silver	0.333	0.0001	**Yes**
Sodium	500	NSL	---
Thallium	125	40	**Yes**
Lagoon 1			
PAHs:			
Acenaphthene	0.100	520	No
Acenaphthylene	1.00	NSL	---

Appendix B
Comparison of BTAG Screening Levels to Maximum Detection Limits for Non-detected Chemicals in Surface Water at Radford Main Manufacturing Plant
(Concentrations in ug/L)

Chemical	Range of Detection Limits	Region III BTAG Screening Level	Maximum Detection Limit >Screening Level?
Anthracene	0.0500	0.1	No
Benz(a)anthracene	0.0500	6.3	No
Benzo(a)pyrene	0.0500	NSL	---
Benzo(b)fluoranthene	0.100	NSL	---
Benzo(g,h,i)perylene	0.100	NSL	---
Benzo(k)fluoranthene	0.0500	NSL	---
Carbazole	10.0	NSL	---
Chrysene	0.0500	NSL	---
Dibenz(a,h)anthracene	0.100	NSL	---
Dibenzofuran	10.0	NSL	---
Fluoranthene	0.100	3,980	No
Fluorene	0.100	430	No
Indeno(1,2,3-c,d)pyrene	0.0500	NSL	---
2-Methylnaphthalene	10.0	NSL	---
Naphthalene	0.100	100	No
Phenanthrene	0.0500	6.3	No
Pyrene	0.0500	NSL	---
Explosives:			
2,4-Dinitrotoluene	10.0	230	No
2,6-Dinitrotoluene	10.0	230 [E]	No
Nitrobenzene	10.0	27,000	No
Other Semivolatile Organics:			
Benzoic acid	50.0	NSL	---
Benzyl alcohol	20.0	460,000	No
4-Bromophenyl phenyl ether	10.0	NSL	---
Butylbenzyl phthalate	10.0	3	**Yes**
4-Chloroaniline	20.0	NSL	---
bis(2-Chloroethoxy)methane	10.0	11,000	No
bis(2-Chloroethyl)ether	10.0	NSL	---
4-Chloro-3-methylphenol	20.0	NSL	---
2-Chloronaphthalene	10.0	NSL	---
2-Chlorophenol	10.0	970	No
4-Chlorophenyl phenyl ether	10.0	NSL	---
1,2-Dichlorobenzene	10.0	763	No
1,3-Dichlorobenzene	10.0	763	No
1,4-Dichlorobenzene	10.0	763	No
3,3'-Dichlorobenzidine	20.0	NSL	---
2,4-Dichlorophenol	10.0	365	No
Dimethylphthalate	10.0	3	**Yes**
2,4-Dimethylphenol	10.0	NSL	---
2,4-Dinitrophenol	50.0	150 [F]	No

Appendix B
Comparison of BTAG Screening Levels to Maximum Detection
Limits for Non-detected Chemicals in Surface Water at Radford Main Manufacturing Plant
(Concentrations in ug/L)

Chemical	Range of Detection Limits	Region III BTAG Screening Level	Maximum Detection Limit >Screening Level?
1,2-Diphenylhydrazine	10.0	270	No
bis(2-Ethylhexyl)phthalate	10.0	30	No
Hexachlorobenzene	10.0	3.68	**Yes**
Hexachlorobutadiene	10.0	9.3	**Yes**
Hexachlorocyclopentadiene	10.0	5.2	**Yes**
Hexachloroethane	10.0	540	No
Isophorone	10.0	117,000	No
2-Methylphenol	10.0	NSL	---
4-Methylphenol	10.0	NSL	---
4,6-dinitro-2-Methylphenol	50.0	NSL	---
2-Nitroaniline	50.0	NSL	---
3-Nitroaniline	50.0	NSL	---
4-Nitroaniline	50.0	NSL	---
2-Nitrophenol	10.0	150 [J]	No
4-Nitrophenol	50.0	150	No
n-Nitroso-di-n-propylamine	10.0	NSL	---
n-Nitrosodiphenylamine	10.0	5,850	No
di-n-Octylphthalate	10.0	0.3	**Yes**
2,2'-Oxybis(1-chloropropane)	10.0	NSL	---
Pentachlorophenol	50.0	13	**Yes**
Phenol	10.0	79	No
1,2,4-Trichlorobenzene	10.0	50 [G]	No
2,4,5-Trichlorophenol	50.0	63	No
2,4,6-Trichlorophenol	10.0	970	No
Inorganics:			
Antimony	5.00	30	No
Arsenic	6.00	48 [H]	No
Beryllium	1.00	5.3	No
Cadmium	1.00	.53	**Yes**
Chromium	1.00	2 [I]	No
Cobalt	1.00	35,000	No
Copper	19.7	6.5	**Yes**
Iron	96.2	320	No
Lead	2.00	3.2	No
Manganese	19.1	14,500	No
Mercury	0.200	0.012	**Yes**
Nickel	1.00	160	No
Selenium	4.00	5	No
Silver	2.00	0.0001	**Yes**
Thallium	6.00	40	No
Vanadium	1.20	<10,000	No

Appendix B
Comparison of BTAG Screening Levels to Maximum Detection Limits for Non-detected Chemicals in Surface Water at Radford Main Manufacturing Plant
(Concentrations in ug/L)

Chemical	Range of Detection Limits	Region III BTAG Screening Level	Maximum Detection Limit >Screening Level?
<u>Lagoon 2</u>			
PAHs:			
Acenaphthene	0.100	520	No
Acenaphthylene	1.00	NSL	---
Anthracene	0.0500	0.1	No
Benz(a)anthracene	0.0500	6.3	No
Benzo(a)pyrene	0.0500	NSL	---
Benzo(b)fluoranthene	0.100	NSL	---
Benzo(g,h,i)perylene	0.100	NSL	---
Benzo(k)fluoranthene	0.0500	NSL	---
Carbazole	10.0	NSL	---
Chrysene	0.0500	NSL	---
Dibenz(a,h)anthracene	0.100	NSL	---
Dibenzofuran	10.0	NSL	---
Fluoranthene	0.100	3,980	No
Fluorene	0.100	430	No
Indeno(1,2,3-c,d)pyrene	0.0500	NSL	---
2-Methylnaphthalene	10.0	NSL	---
Naphthalene	0.100	100	No
Phenanthrene	0.0500	6.3	No
Pyrene	0.0500	NSL	---
Explosives:			
2,4-Dinitrotoluene	10.0	230	No
2,6-Dinitrotoluene	10.0	230 [E]	No
Nitrobenzene	10.0	27,000	No
Other Semivolatile Organics:			
Benzoic acid	50.0	NSL	---
Benzyl alcohol	20.0	460,000	No
4-Bromophenyl phenyl ether	10.0	NSL	---
di-n-Butylphthalate	10.0	0.3	**Yes**
Butylbenzyl phthalate	10.0	3	**Yes**
4-Chloroaniline	20.0	NSL	---
bis(2-Chloroethoxy)methane	10.0	11,000	No
bis(2-Chloroethyl)ether	10.0	NSL	---
4-Chloro-3-methylphenol	20.0	NSL	---
2-Chloronaphthalene	10.0	NSL	---
2-Chlorophenol	10.0	970	No
4-Chlorophenyl phenyl ether	10.0	NSL	---
1,2-Dichlorobenzene	10.0	763	No
1,3-Dichlorobenzene	10.0	763	No
1,4-Dichlorobenzene	10.0	763	No

Appendix B
Comparison of BTAG Screening Levels to Maximum Detection
Limits for Non-detected Chemicals in Surface Water at Radford Main Manufacturing Plant
(Concentrations in ug/L)

Chemical	Range of Detection Limits	Region III BTAG Screening Level	Maximum Detection Limit >Screening Level?
3,3'-Dichlorobenzidine	20.0	NSL	---
2,4-Dichlorophenol	10.0	365	No
Dimethylphthalate	10.0	3	**Yes**
2,4-Dimethylphenol	10.0	NSL	---
2,4-Dinitrophenol	50.0	150 [F]	No
1,2-Diphenylhydrazine	10.0	270	No
bis(2-Ethylhexyl)phthalate	10.0	30	No
Hexachlorobenzene	10.0	3.68	**Yes**
Hexachlorobutadiene	10.0	9.3	**Yes**
Hexachlorocyclopentadiene	10.0	5.2	**Yes**
Hexachloroethane	10.0	540	No
Isophorone	10.0	117,000	No
2-Methylphenol	10.0	NSL	---
4-Methylphenol	10.0	NSL	---
4,6-dinitro-2-Methylphenol	50.0	NSL	---
2-Nitroaniline	50.0	NSL	---
3-Nitroaniline	50.0	NSL	---
4-Nitroaniline	50.0	NSL	---
2-Nitrophenol	10.0	150 [J]	No
4-Nitrophenol	50.0	150	No
n-Nitroso-di-n-propylamine	10.0	NSL	---
n-Nitrosodiphenylamine	10.0	5,850	No
di-n-Octylphthalate	10.0	0.3	**Yes**
2,2'-Oxybis(1-chloropropane)	10.0	NSL	---
Pentachlorophenol	50.0	13	**Yes**
Phenol	10.0	79	No
1,2,4-Trichlorobenzene	10.0	50 [G]	No
2,4,5-Trichlorophenol	50.0	63	No
2,4,6-Trichlorophenol	10.0	970	No
Inorganics:			
Antimony	5.00	30	No
Arsenic	6.00	48 [H]	No
Beryllium	1.00	5.3	No
Cadmium	1.00	0.53	**Yes**
Chromium	1.00	2 [I]	No
Cobalt	1.00	35,000	No
Copper	7.00	6.5	**Yes**
Iron	39.5	320	No
Lead	2.00	3.2	No
Manganese	10.9	14,500	No
Mercury	0.200	0.012	**Yes**

Appendix B
Comparison of BTAG Screening Levels to Maximum Detection
Limits for Non-detected Chemicals in Surface Water at Radford Main Manufacturing Plant
(Concentrations in ug/L)

Chemical	Range of Detection Limits	Region III BTAG Screening Level	Maximum Detection Limit >Screening Level?
Nickel	1.00	160	No
Selenium	4.60	5	No
Silver	2.00	0.0001	**Yes**
Thallium	6.00	40	No
Vanadium	1.00	<10,000	No
Lagoon 3			
PAHs:			
Acenaphthene	0.100	520	No
Acenaphthylene	1.00	NSL	---
Anthracene	0.0500	0.1	No
Benz(a)anthracene	0.0500	6.3	No
Benzo(a)pyrene	0.0500	NSL	---
Benzo(b)fluoranthene	0.100	NSL	---
Benzo(g,h,i)perylene	0.100	NSL	---
Benzo(k)fluoranthene	0.0500	NSL	---
Carbazole	10.0	NSL	---
Chrysene	0.0500	NSL	---
Dibenz(a,h)anthracene	0.100	NSL	---
Dibenzofuran	10.0	NSL	---
Fluoranthene	0.100	3,980	No
Fluorene	0.100	430	No
Indeno(1,2,3-c,d)pyrene	0.0500	NSL	---
2-Methylnaphthalene	10.0	NSL	---
Naphthalene	0.100	100	No
Phenanthrene	0.0500	6.3	No
Pyrene	0.0500	NSL	---
Explosives:			
2,4-Dinitrotoluene	10.0	230	No
2,6-Dinitrotoluene	10.0	230 [E]	No
Nitrobenzene	10.0	27,000	No
Other Semivolatile Organics:			
Benzoic acid	50.0	NSL	---
Benzyl alcohol	20.0	460,000	No
4-Bromophenyl phenyl ether	10.0	NSL	---
di-n-Butylphthalate	10.0	0.3	**Yes**
Butylbenzyl phthalate	10.0	3	**Yes**
4-Chloroaniline	20.0	NSL	---
bis(2-Chloroethoxy)methane	10.0	11,000	No
bis(2-Chloroethyl)ether	10.0	NSL	---
4-Chloro-3-methylphenol	20.0	NSL	---
2-Chloronaphthalene	10.0	NSL	---

Appendix B
Comparison of BTAG Screening Levels to Maximum Detection Limits for Non-detected Chemicals in Surface Water at Radford Main Manufacturing Plant
(Concentrations in ug/L)

Chemical	Range of Detection Limits	Region III BTAG Screening Level	Maximum Detection Limit >Screening Level?
2-Chlorophenol	10.0	970	No
4-Chlorophenyl phenyl ether	10.0	NSL	---
1,2-Dichlorobenzene	10.0	763	No
1,3-Dichlorobenzene	10.0	763	No
1,4-Dichlorobenzene	10.0	763	No
3,3'-Dichlorobenzidine	20.0	NSL	---
2,4-Dichlorophenol	10.0	365	No
Dimethylphthalate	10.0	3	**Yes**
2,4-Dimethylphenol	10.0	NSL	---
2,4-Dinitrophenol	50.0	150 [F]	No
1,2-Diphenylhydrazine	10.0	270	No
bis(2-Ethylhexyl)phthalate	10.0	30	No
Hexachlorobenzene	10.0	3.68	**Yes**
Hexachlorobutadiene	10.0	9.3	**Yes**
Hexachlorocyclopentadiene	10.0	5.2	**Yes**
Hexachloroethane	10.0	540	No
Isophorone	10.0	117,000	No
2-Methylphenol	10.0	NSL	---
4-Methylphenol	10.0	NSL	---
4,6-dinitro-2-Methylphenol	50.0	NSL	---
2-Nitroaniline	50.0	NSL	---
3-Nitroaniline	50.0	NSL	---
4-Nitroaniline	50.0	NSL	---
2-Nitrophenol	10.0	150 [J]	No
4-Nitrophenol	50.0	150	No
n-Nitroso-di-n-propylamine	10.0	NSL	---
n-Nitrosodiphenylamine	10.0	5,850	No
di-n-Octylphthalate	10.0	0.3	**Yes**
2,2'-Oxybis(1-chloropropane)	10.0	NSL	---
Pentachlorophenol	50.0	13	**Yes**
Phenol	10.0	79	No
1,2,4-Trichlorobenzene	10.0	50 [G]	No
2,4,5-Trichlorophenol	50.0	63	No
2,4,6-Trichlorophenol	10.0	970	No
Inorganics:			
Antimony	5.00	30	No
Arsenic	6.00	48 [H]	No
Beryllium	1.00	5.3	No
Cadmium	1.00	.53	**Yes**
Chromium	1.00	2 [I]	No
Cobalt	1.00	35,000	No

Appendix B
Comparison of BTAG Screening Levels to Maximum Detection Limits for Non-detected Chemicals in Surface Water at Radford Main Manufacturing Plant
(Concentrations in ug/L)

Chemical	Range of Detection Limits	Region III BTAG Screening Level	Maximum Detection Limit >Screening Level?
Copper	18.6	6.5	**Yes**
Iron	70.6	320	No
Lead	2.00	3.2	No
Mercury	0.200	0.012	**Yes**
Selenium	4.00	5	No
Silver	2.00	0.0001	**Yes**
Thallium	6.00	40	No
Vanadium	1.00	<10,000	No

[A] Value for dichloropropene.
[B] Value for tetrachloroethane.
[C] Value for trichloroethane.
[D] Value for xylene.
[E] Value for 2,4-Dinitrotoluene.
[F] Value for dinitrophenol.
[G] Value for trichlorobenzene.
[H] Value for arsenic V.
[I] Value for chromium VI.
[J] Value for 4-nitrophenol.
NSL= No screening level available.

APPENDIX C

Appendix C

Comparison of On-Site and Background Detected Chemical Concentrations

Appendix C
Comparison of On-Site and Background Detected Chemical Concentrations

As discussed in the ERA, only chemicals with maximum detected concentrations below Region III BTAG Screening Levels were eliminated as COPCs. All other chemicals were identified as COPCs and were further evaluated in the ERA. However, some inorganic chemicals occurring at concentrations above the Region III BTAG Screening Levels may not be reflective of site-related contamination, but instead, may indicate widespread contamination or naturally elevated regional concentrations. Accordingly, inorganic chemicals occurring at concentrations above background concentrations were identified. This information is useful when interpreting the results of the ERA to make risk management decisions.

There were less than six samples available in the background sample data set, thus the maximum concentration of each inorganic chemical detected at the on-site location was compared to the maximum concentration of that inorganic chemical detected in the background data grouping. If the maximum concentration of the inorganic chemical detected at the on-site location exceeded the maximum background concentration of that inorganic, then that chemical was considered to occur at concentrations above those in the background samples.

Data from a total of five surface soil samples (RVFS*49, RVFS*65, RVFS*88, RVFS*90, and RVFS*113) collected in March 1992 were used as the background data for Radford background comparisons. All background samples were collected from the top six inches of surface soil to be consistent with the samples taken from site-specific locations. The range of detected background concentrations, as well as the results of the comparisons of on-site and background inorganic chemical concentrations are presented in Appendix C.

Appendix C
Summary of Chemicals Detected in On-site and Background Surface Soil
(Concentrations in µg/kg organics, mg/kg inorganics)

Chemical	Frequency of Detection[A]	Range of Detection Limits Min	Range of Detection Limits Max	Arithmetic Mean[B]	Range of Detected Values Min	Range of Detected Values Max	Background Comparison[C] Range of Background Comparisons	Background Comparison[C] Site> Background?
Organics:								
Acenaphthene	3 / 5	120	220	180	210	280	ND	---
Benz(a)anthracene	2 / 8	12.0	41.0	110	28.0	770	ND	---
Benzo(a)pyrene	2 / 8	12.0	1,200	242	40.0	68.0	ND	---
Benzo(b)fluoranthene	3 / 8	23.0	310	245	41.0	1,500	ND	---
Benzo(g,h,i)perylene	3 / 8	23.0	180	160	37.0	960	ND	---
Benzo(k)fluoranthene	4 / 8	12.0	130	84.6	21.0	440	ND	---
di-n-Butylphthalate	1 / 7	450	4,400	978	---	820	ND	---
Chrysene	3 / 8	2.00	32.0	114	21.0	810	ND	---
Dibenz(a,h)anthracene	2 / 8	23.0	310	75.4	37.0	41.0	ND	---
Diethylphthalate	1 / 8	240	4,400	832	---	68.0	ND	---
bis(2-Ethylhexyl)phthalate	3 / 8	450	4,400	2,670	2,300	7,900	ND	---
Fluoranthene	4 / 8	23.0	43.0	117	34.0	630	ND	---
Fluorene	1 / 5	23.0	55.0	23.6	---	37.0	ND	---
Indeno(1,2,3-c,d)pyrene	2 / 8	6.90	2,400	460	23.0	24.0	ND	---
Naphthalene	2 / 8	120	740	228	190	210	ND	---
Phenanthrene	3 / 8	12.0	32.0	190	48.0	1,300	ND	---
Pyrene	4 / 8	1.00	83.0	187	36.0	1,200	ND	---
Inorganics:								
Aluminum	12 / 12	---	---	42,500	13,600	110,000	6,830 - 19,100	**Yes**
Antimony	3 / 22	0.660	19.6	8.67	1.50	60.8	7.14	**Yes**
Arsenic	18 / 22	2.50	7.90	17.2	4.20	88.0	3.52 - 7.32	**Yes**
Barium	22 / 22	---	---	320	23.9	4,000	56.5 - 103	**Yes**
Beryllium	20 / 21	---	1.30	1.56	0.813	3.89	0.500 - 0.922	**Yes**
Cadmium	5 / 22	0.130	1.30	1.31	1.50	10.7	0.700	**Yes**
Calcium	12 / 12	---	---	8,000	528	42,800	3,560 - 100,000	No
Chromium	22 / 22	---	---	120	23.4	1,600	13.0 - 39.8	**Yes**
Cobalt	12 / 12	---	---	12.1	5.68	18.5	5.04 - 22.1	No
Copper	9 / 9	---	---	90.2	15.6	336	7.86 - 23.4	**Yes**
Iron	12 / 12	---	---	30,000	19,400	44,500	10,500 - 31,300	**Yes**
Lead	26 / 27	---	10.5	640	9.80	7,070	10.5 - 255	**Yes**
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Manganese	12 / 12	---	---	583	144	1,330	199 - 892	**Yes**
Mercury	10 / 22	0.0500	1.30	0.940	0.0682	17.0	0.0500	**Yes**
Nickel	22 / 22	---	---	68.0	9.08	704	11.0 - 27.4	**Yes**
Potassium	12 / 12	---	---	1,820	1,020	3,080	656 - 3,160	No
Selenium	2 / 22	0.250	5.30	0.540	0.587	0.890	0.250	**Yes**
Silver	6 / 22	0.0124	2.60	1.95	0.0212	33.0	0.589 - 1.57	**Yes**
Sodium	9 / 9	---	---	500	184	805	205 - 299	**Yes**
Vanadium	12 / 12	---	---	62.9	41.1	89.9	23.4 - 60.4	**Yes**
Zinc	12 / 12	---	---	107	34.2	214	36.1 - 345	No

[A] The frequency of detection is the number of samples in which each chemical was detected divided by the total number of samples analyzed. The variation in the total number of samples for some chemicals reflects the exclusion of R- and B-qualified data.

[B] Detected sample concentrations and one half the detection limit of non-detected samples were used to calculate the arithmetic mean for each chemical.

[C] Background samples include samples RVFS*49, RVFS*65, RVFS*88, RVFS*90, and RVFS*113. Comparisons were based on maximum detected on-site concentrations and maximum detected background concentrations.

ND = Not Detected

APPENDIX D

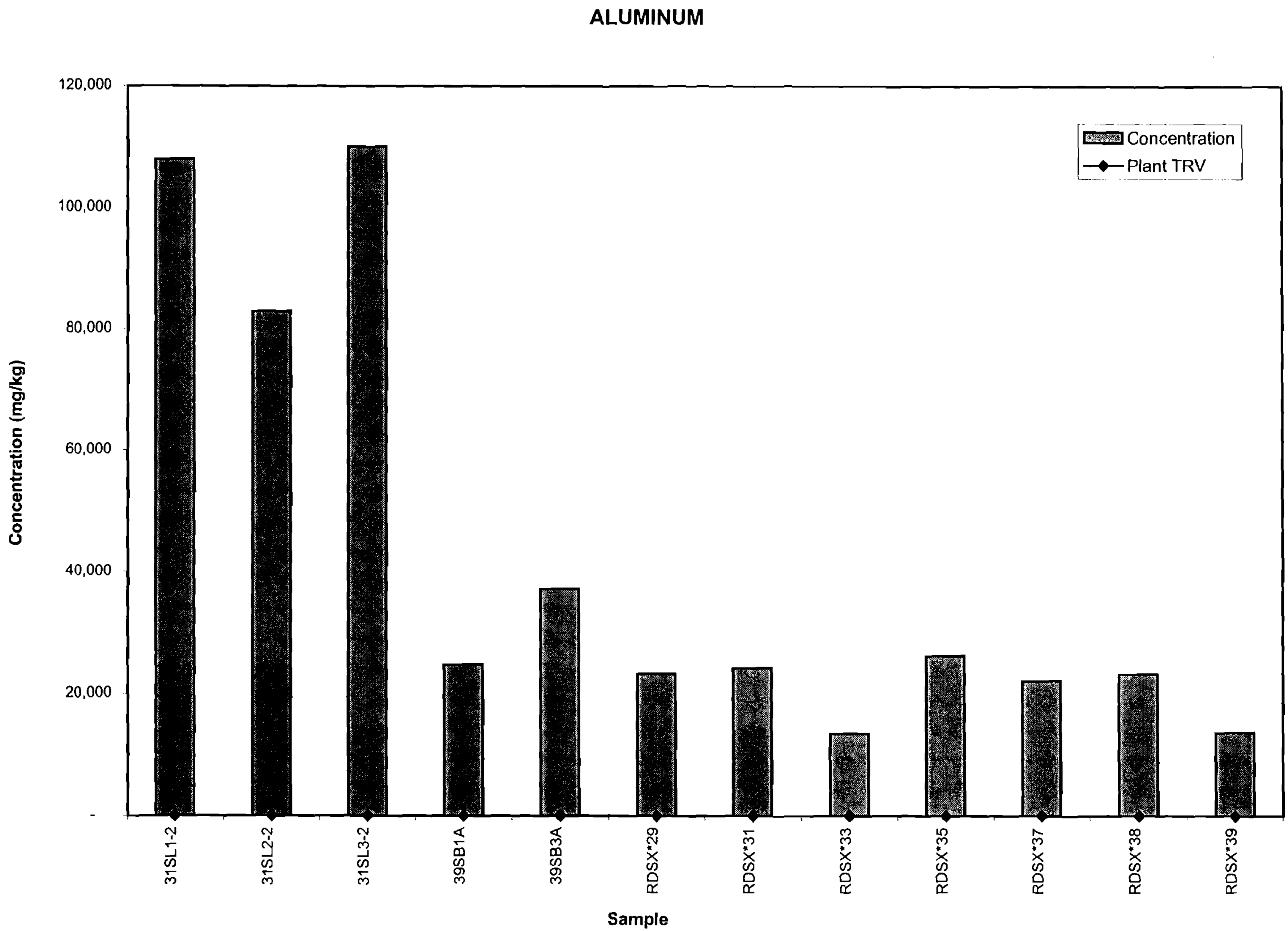
Appendix D

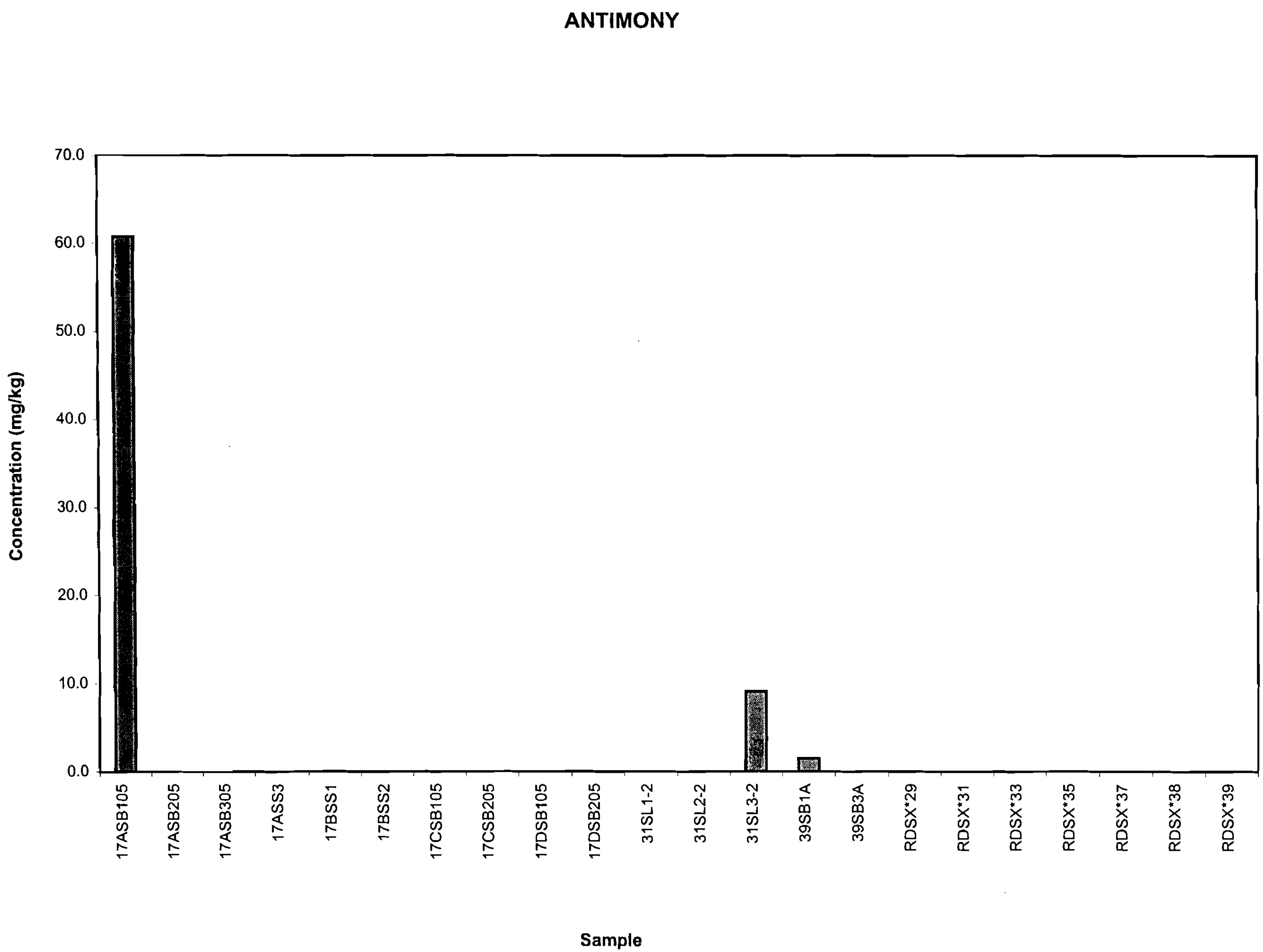
Graphical Presentation of Selected Surface Soil TRV Exceedances

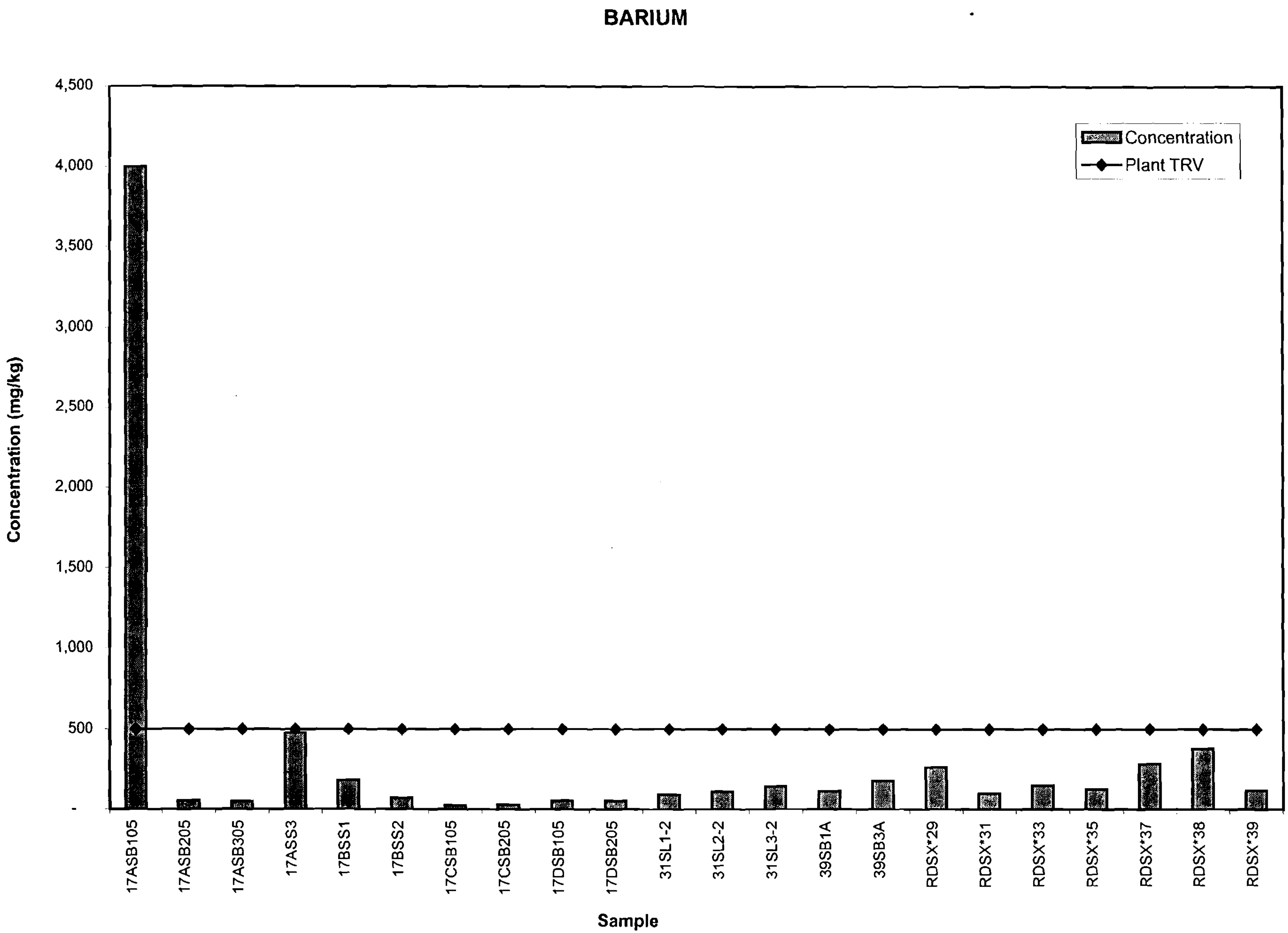
Appendix D
Graphical Presentation of Selected Surface Soil TRV Exceedances

Figures were constructed for surface soil data to illustrate the exact sampling locations where certain compounds exceeded TRVs. Samples with data rejected or blank qualified as a result of data validation are not included on any of the figures. Additionally, samples for which a given chemical was not detected appear as blank spaces on the figures.

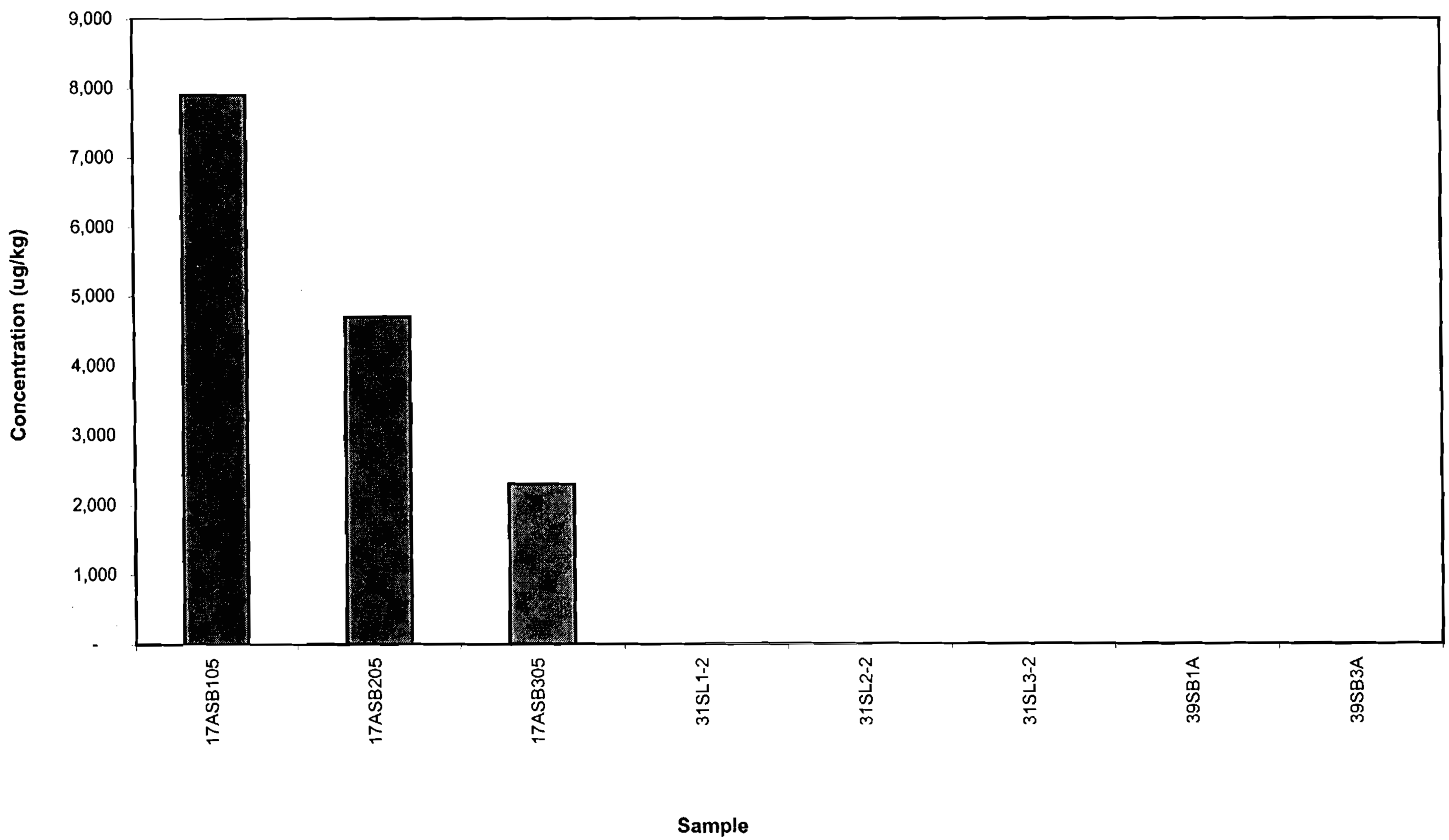
Chemicals with an EEQ greater than 5 were graphed. This includes plant EEQs (see Table 1–17), earthworm EEQs (see Table 1–18), and wildlife EEQs calculated using both surface soil and surface water concentrations (see Table 1–19, Table 1–20, Table 1–21, Table 1–24, and Table 1–25).


ALUMINUM
120,000
100,000
80,000
60,000
40,000
20,000
-
Concentration (mg/kg)
Concentration
Plant TRV
31SL1-2
31SL2-2
31SL3-2
39SB1A
39SB3A
RDSX*29
RDSX*31
RDSX*33
RDSX*35
RDSX*37
RDSX*38
RDSX*39
Sample

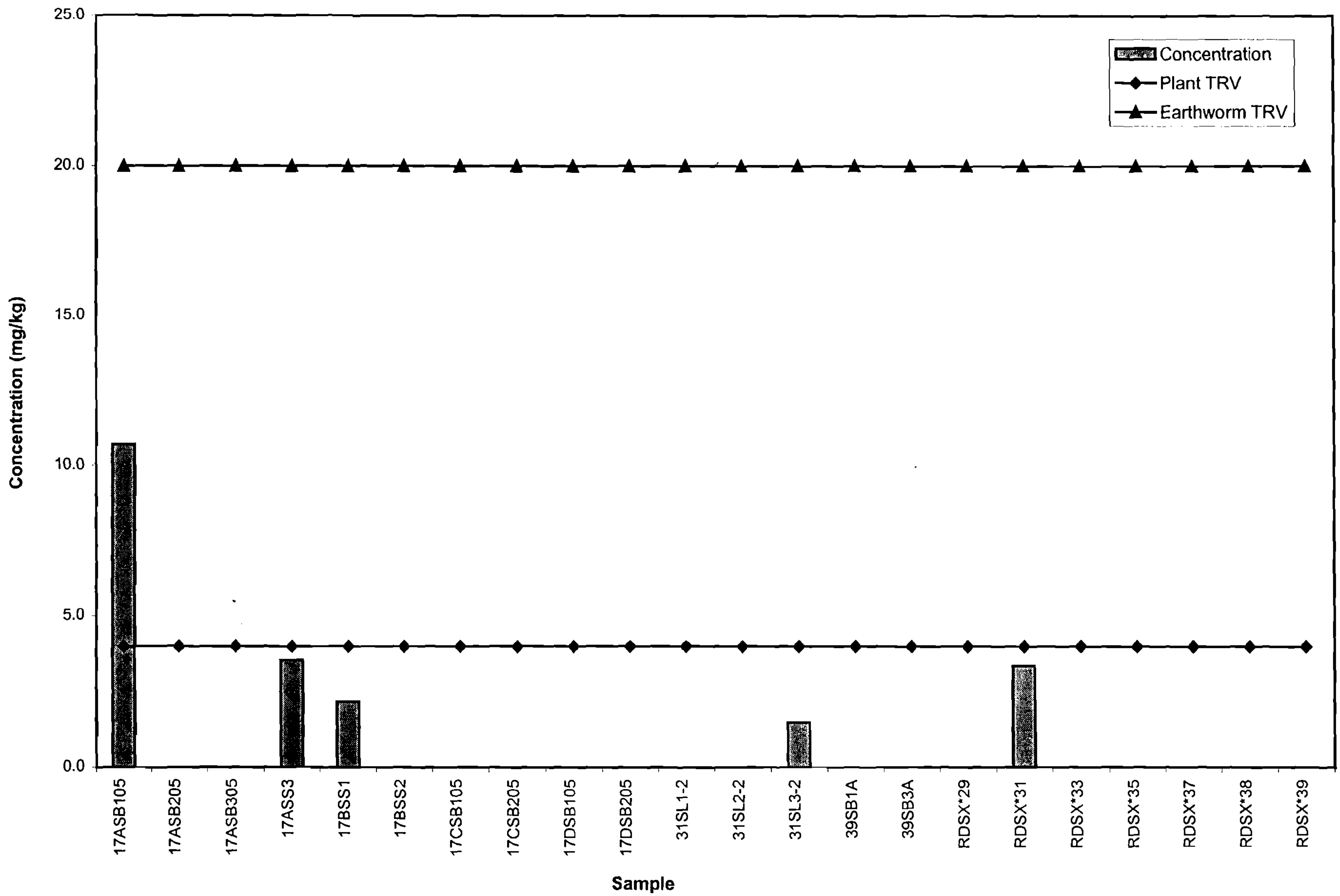

ANTIMONY
Concentration (mg/kg)
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
17ASB105
17ASB205
17ASB305
17ASS3
17BSS1
17BSS2
17CSB105
17CSB205
17DSB105
17DSB205
31SL1-2
31SL2-2
31SL3-2
39SB1A
39SB3A
RDSX*29
RDSX*31
RDSX*33
RDSX*35
RDSX*37
RDSX*38
RDSX*39
Sample


BARIUM
Concentration
Plant TRV
Concentration (mg/kg)
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
-
17ASB105
17ASB205
17ASB305
17ASS3
17BSS1
17BSS2
17CSB105
17CSB205
17DSB105
17DSB205
31SL1-2
31SL2-2
31SL3-2
39SB1A
39SB3A
RDSX*29
RDSX*31
RDSX*33
RDSX*35
RDSX*37
RDSX*38
RDSX*39
Sample

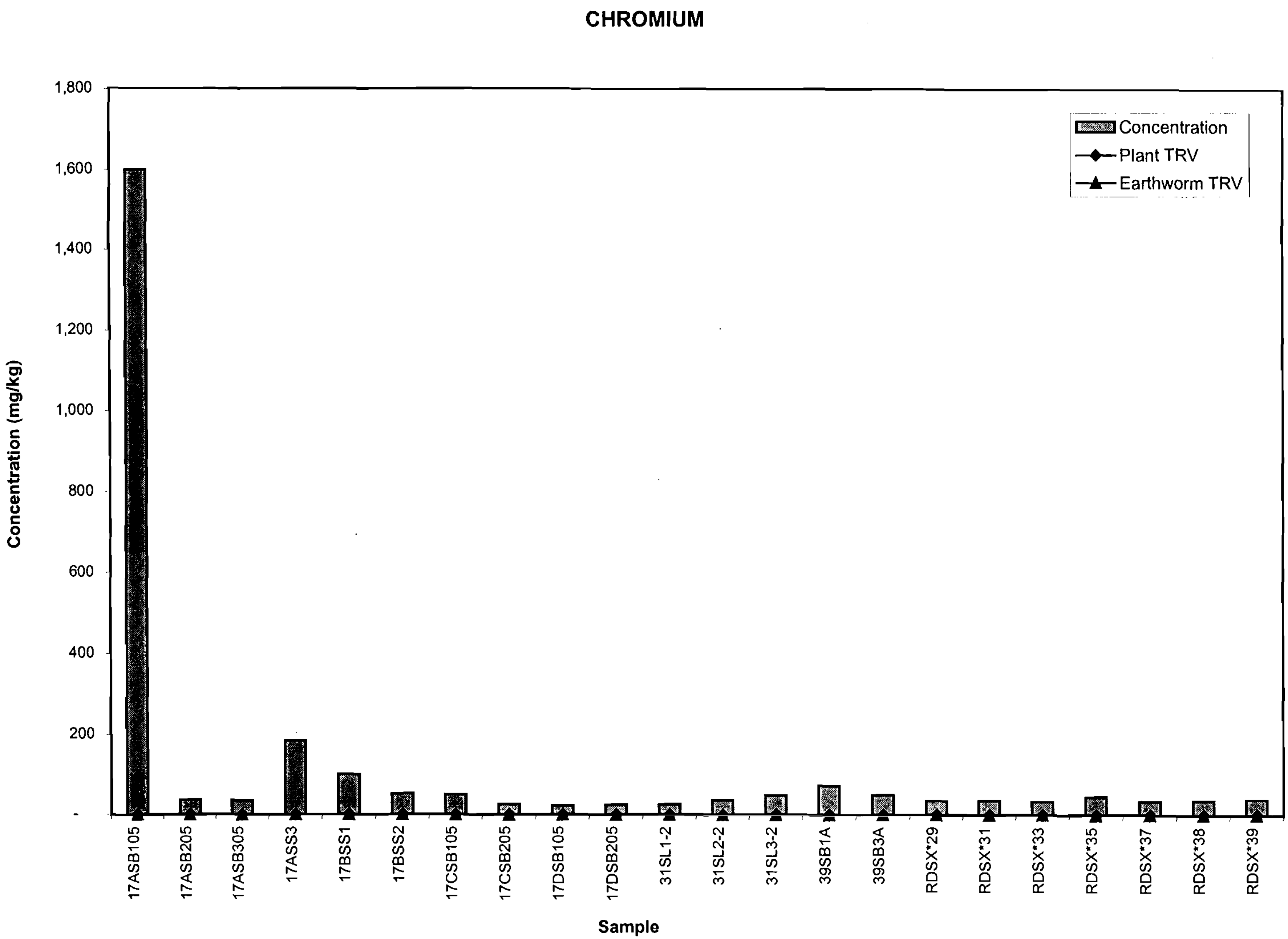
BIS(2-ETHYLHEXYL)PHTHALATE



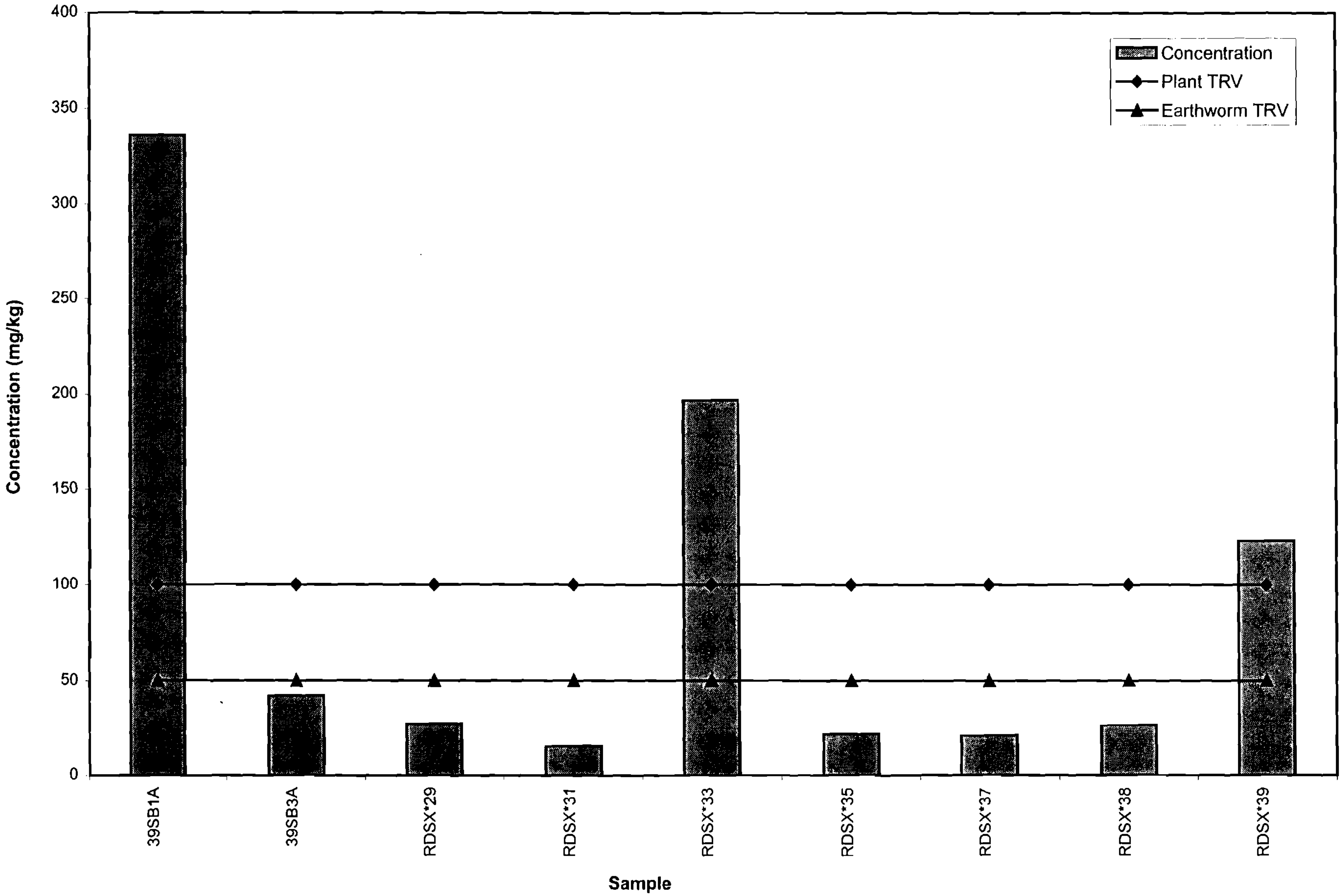
CADMIUM



Concentration
Plant TRV
Earthworm TRV
25.0
20.0
15.0
10.0
5.0
0.0
Concentration (mg/kg)
17ASB105
17ASB205
17ASB305
17ASS3
17BSS1
17BSS2
17CSB105
17CSB205
17DSB105
17DSB205
31SL1-2
31SL2-2
31SL3-2
39SB1A
39SB3A
RDSX*29
RDSX*31
RDSX*33
RDSX*35
RDSX*37
RDSX*38
RDSX*39
Sample

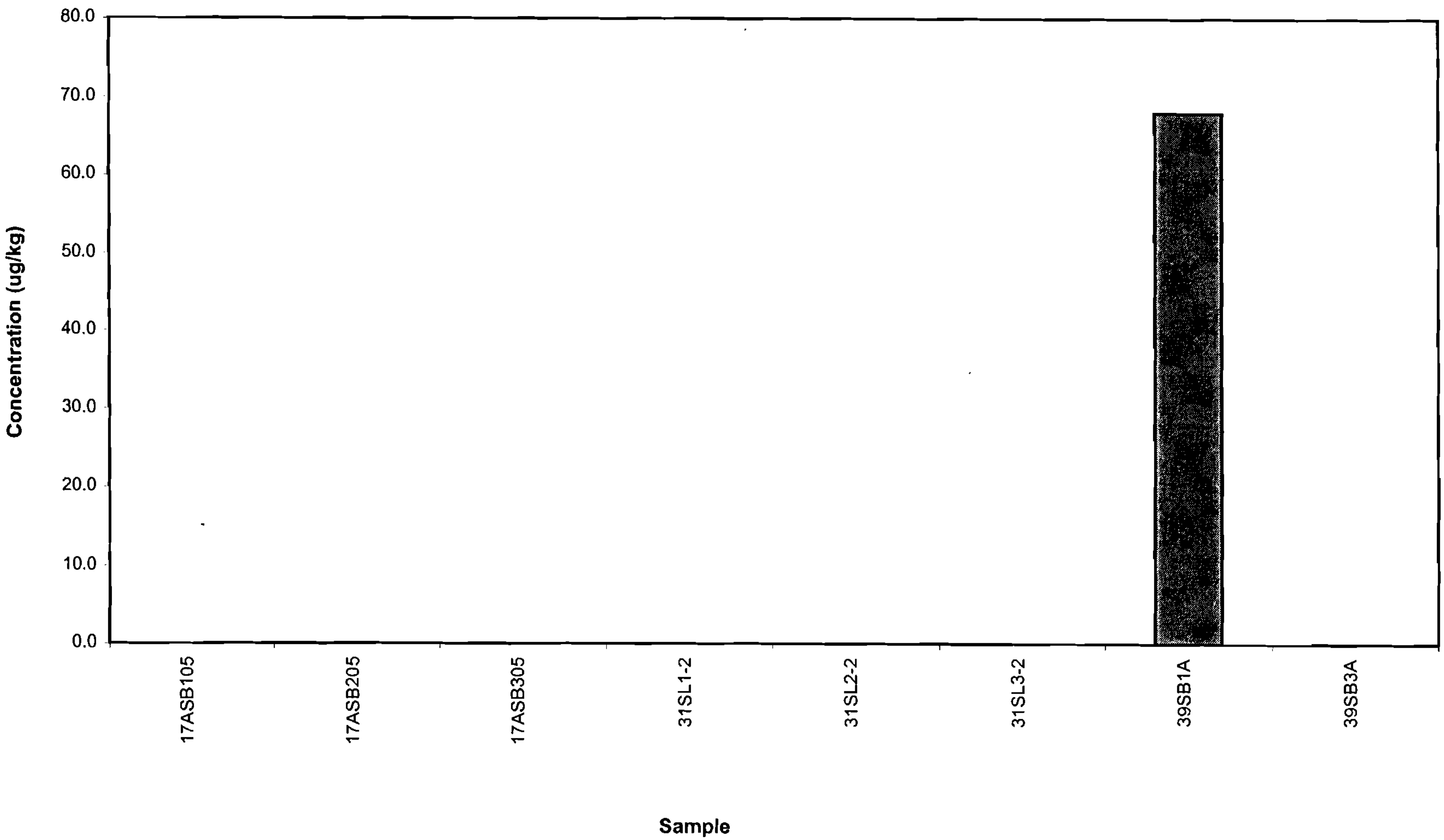

CHROMIUM
Concentration
Plant TRV
Earthworm TRV
1,800
1,600
1,400
1,200
1,000
800
600
400
200
Concentration (mg/kg)
17ASB105
17ASB205
17ASB305
17ASS3
17BSS1
17BSS2
17CSB105
17CSB205
17DSB105
17DSB205
31SL1-2
31SL2-2
31SL3-2
39SB1A
39SB3A
RDSX*29
RDSX*31
RDSX*33
RDSX*35
RDSX*37
RDSX*38
RDSX*39
Sample

COPPER

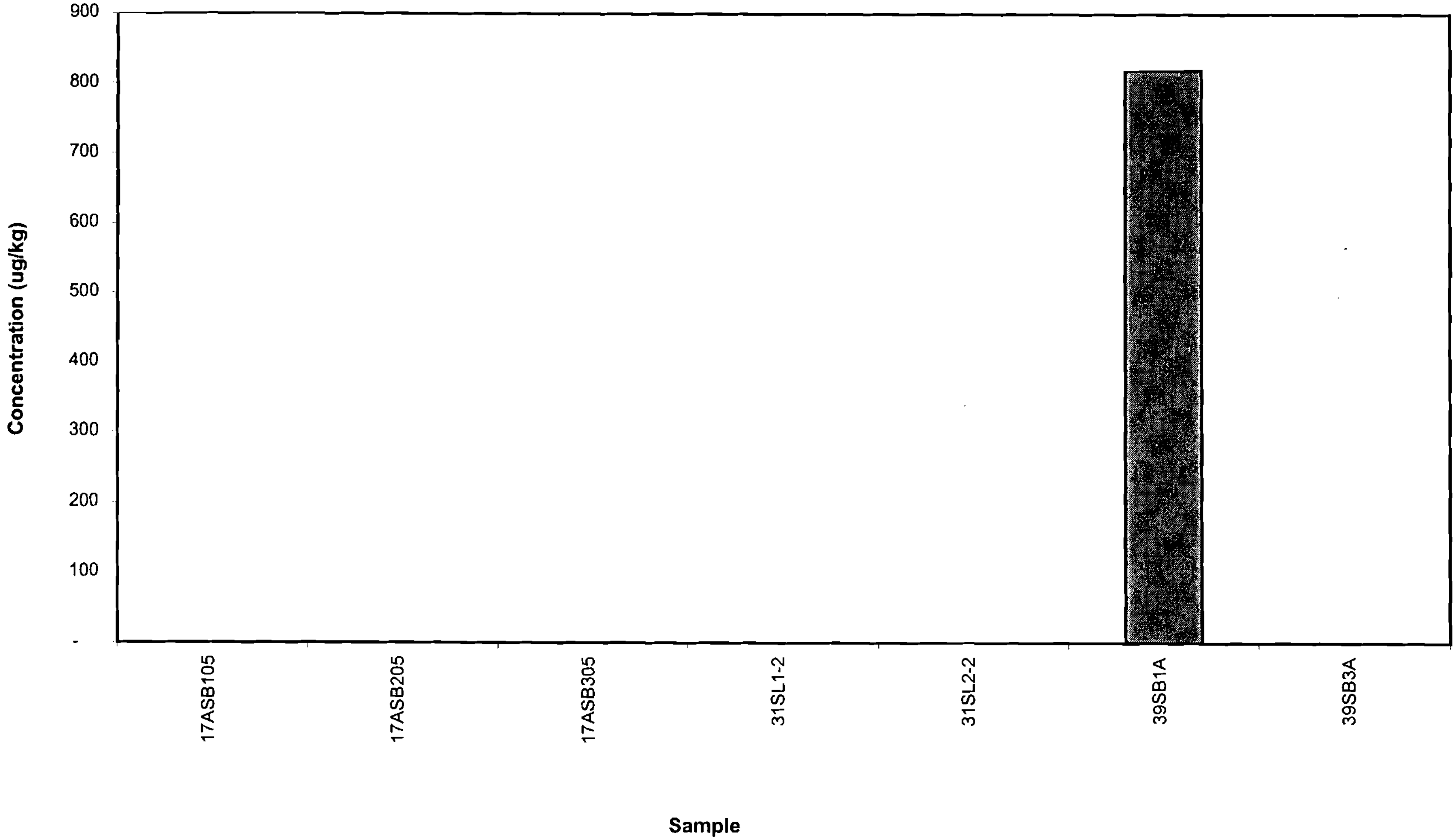


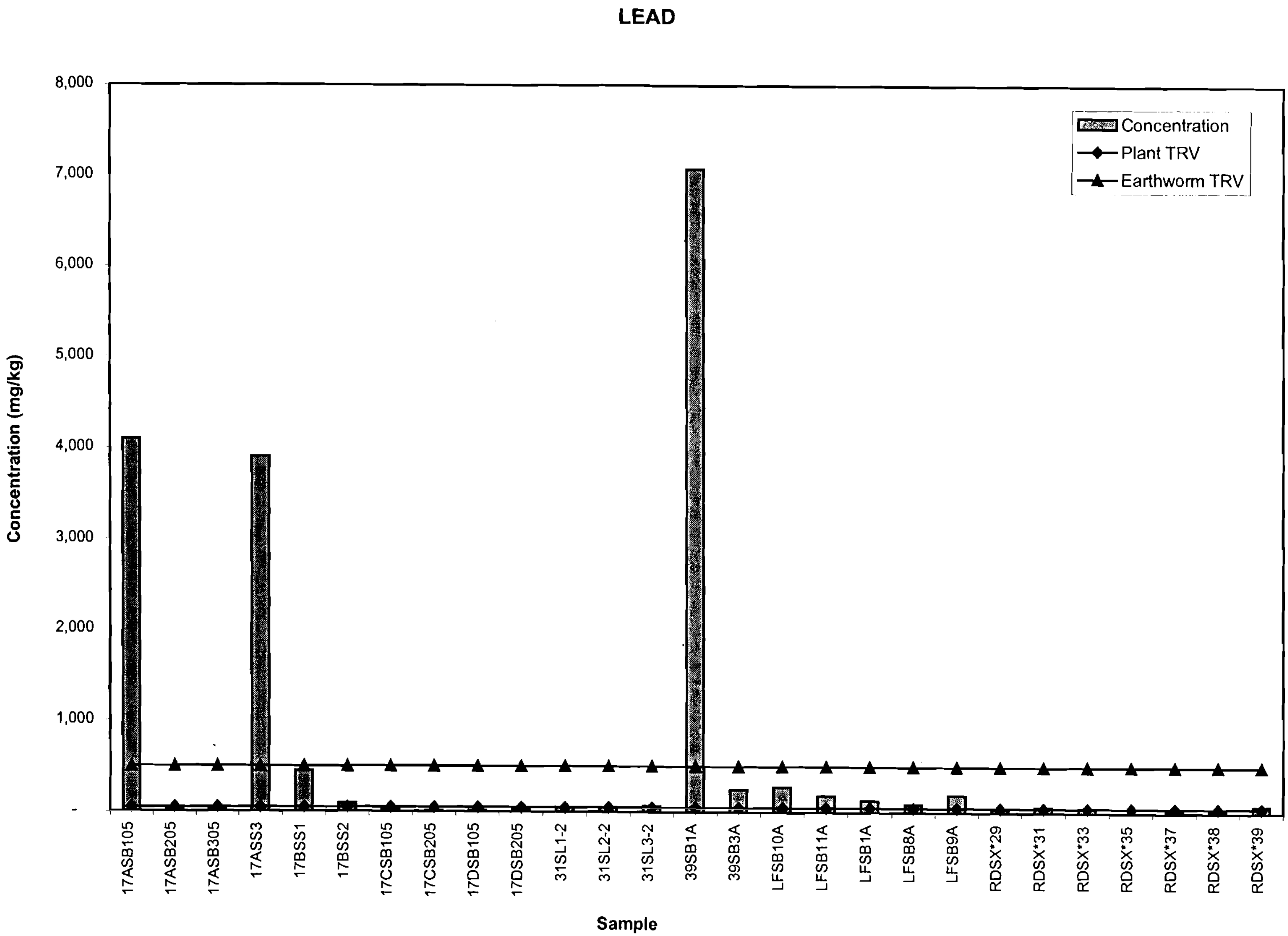
400
350
300
250
200
150
100
50
0
Concentration (mg/kg)
Concentration
Plant TRV
Earthworm TRV
39SB1A
39SB3A
RDSX*29
RDSX*31
RDSX*33
RDSX*35
RDSX*37
RDSX*38
RDSX*39
Sample

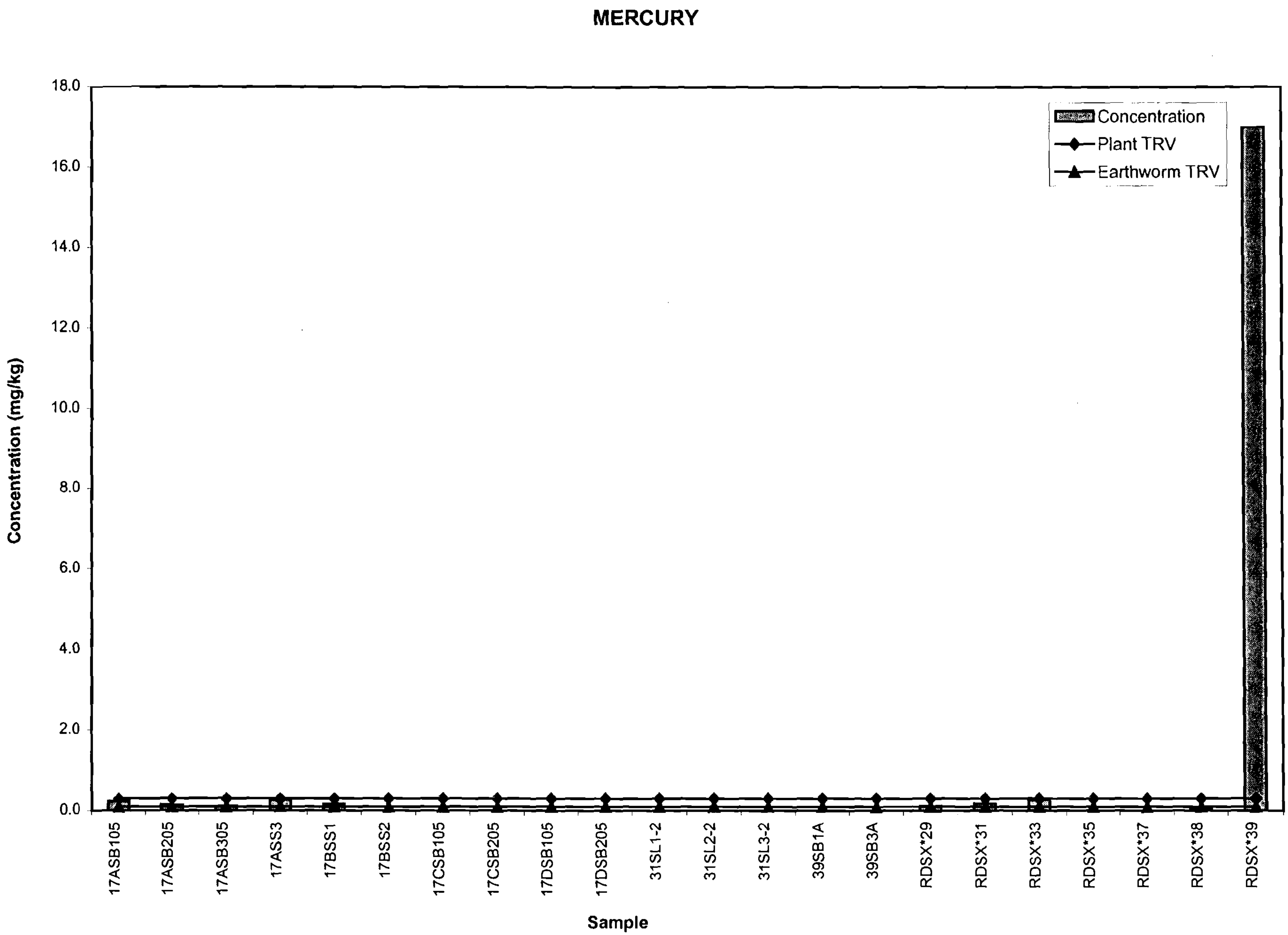
DIETHYLPHTHALATE



DI-N-BUTYLPHTHALATE

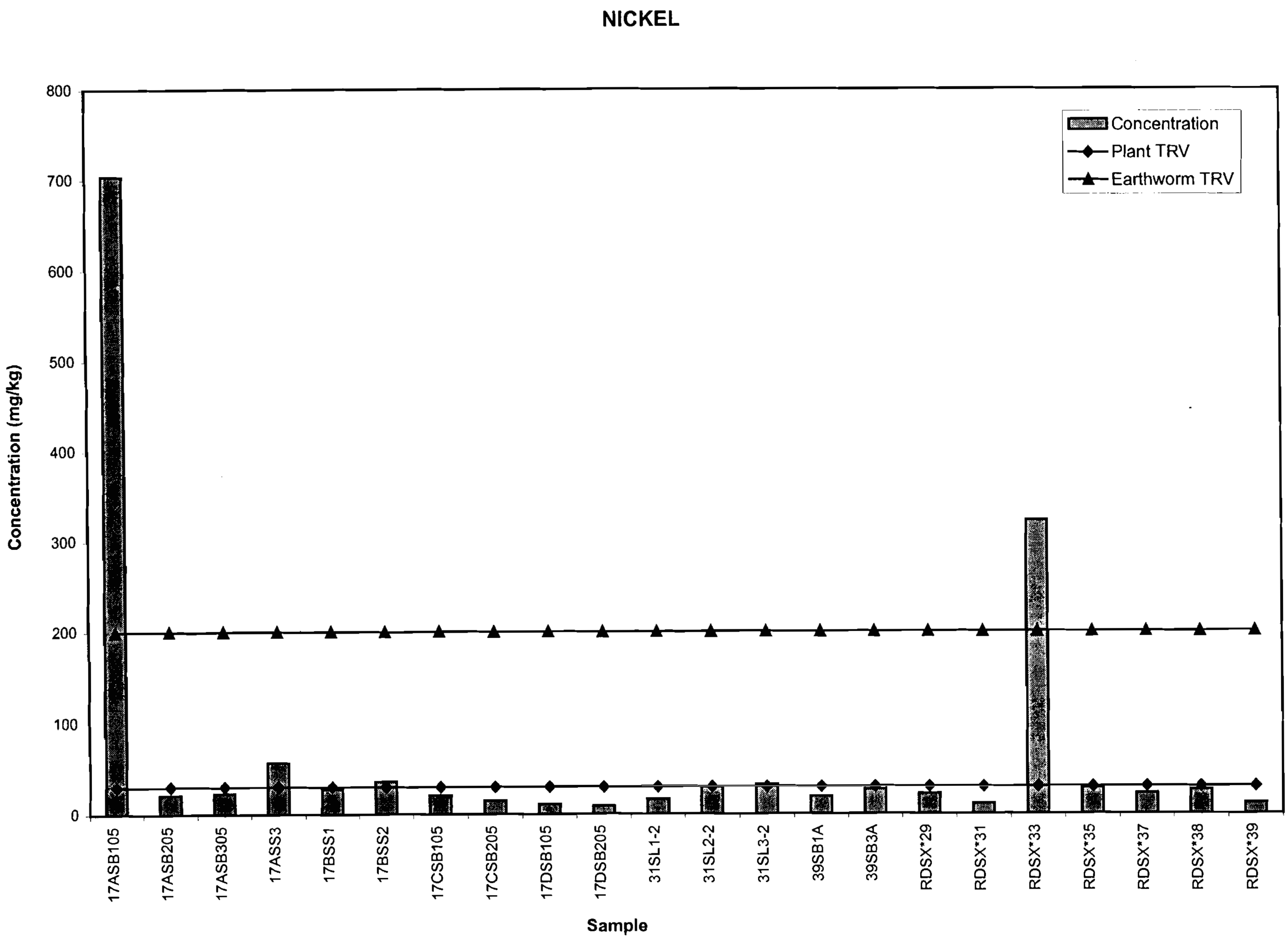


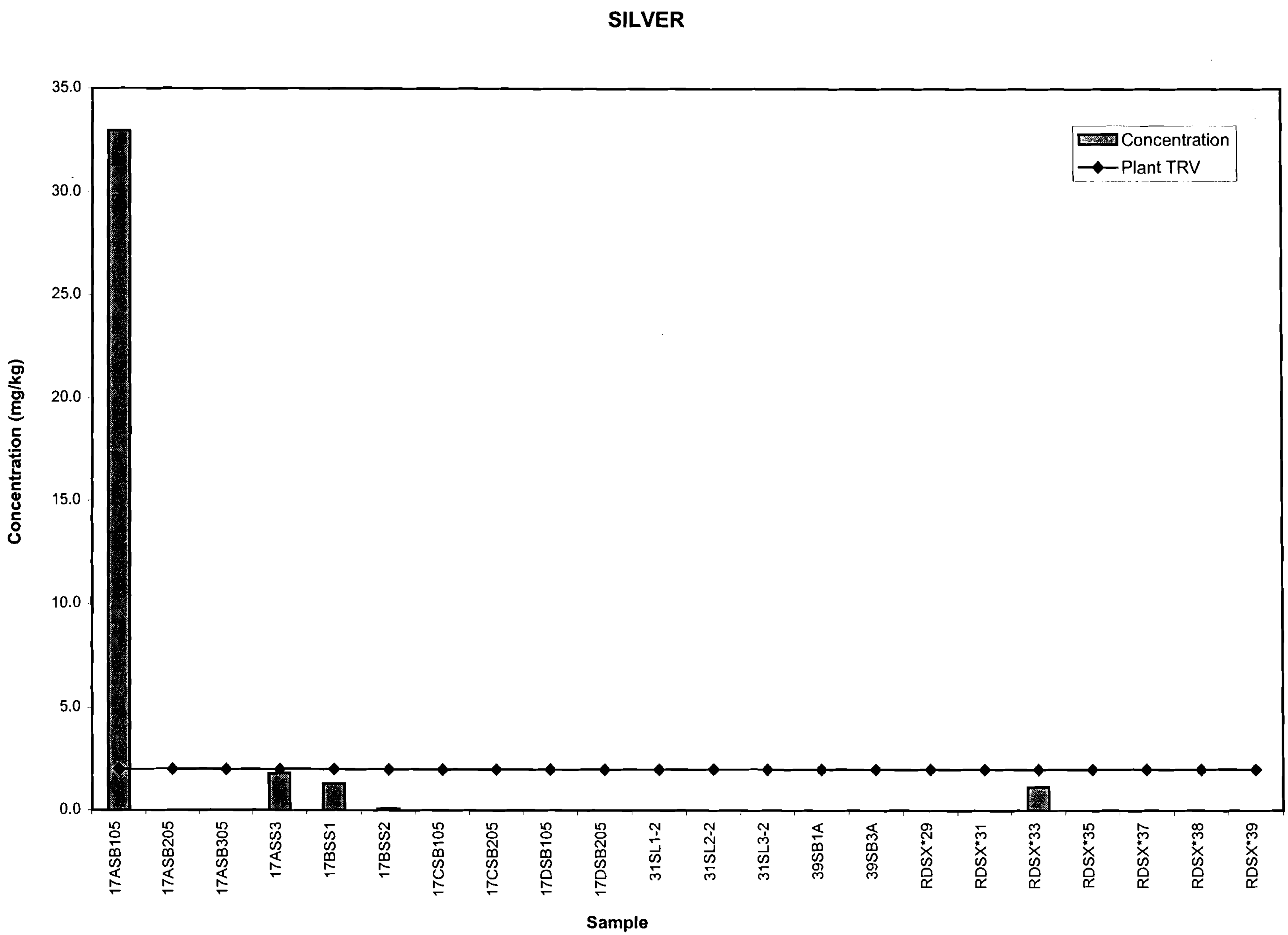

LEAD
Concentration
Plant TRV
Earthworm TRV
Concentration (mg/kg)
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
-
17ASB105
17ASB205
17ASB305
17ASS3
17BSS1
17BSS2
17CSB105
17CSB205
17DSB105
17DSB205
31SL1-2
31SL2-2
31SL3-2
39SB1A
39SB3A
LFSB10A
LFSB11A
LFSB1A
LFSB8A
LFSB9A
RDSX*29
RDSX*31
RDSX*33
RDSX*35
RDSX*37
RDSX*38
RDSX*39
Sample



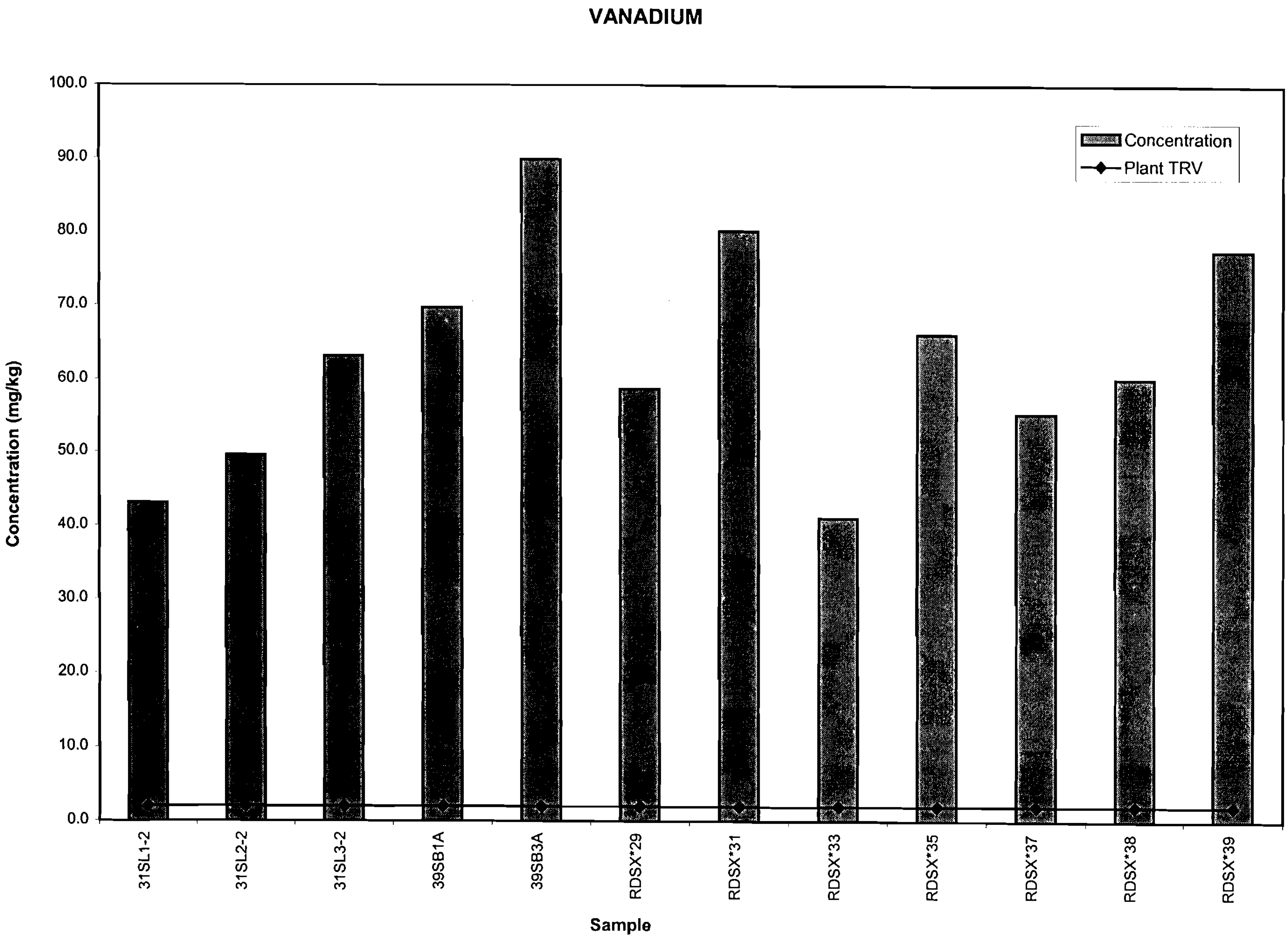
MERCURY
Concentration (mg/kg)
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Concentration
Plant TRV
Earthworm TRV
17ASB105
17ASB205
17ASB305
17ASS3
17BSS1
17BSS2
17CSB105
17CSB205
17DSB105
17DSB205
31SL1-2
31SL2-2
31SL3-2
39SB1A
39SB3A
RDSX*29
RDSX*31
RDSX*33
RDSX*35
RDSX*37
RDSX*38
RDSX*39
Sample

595

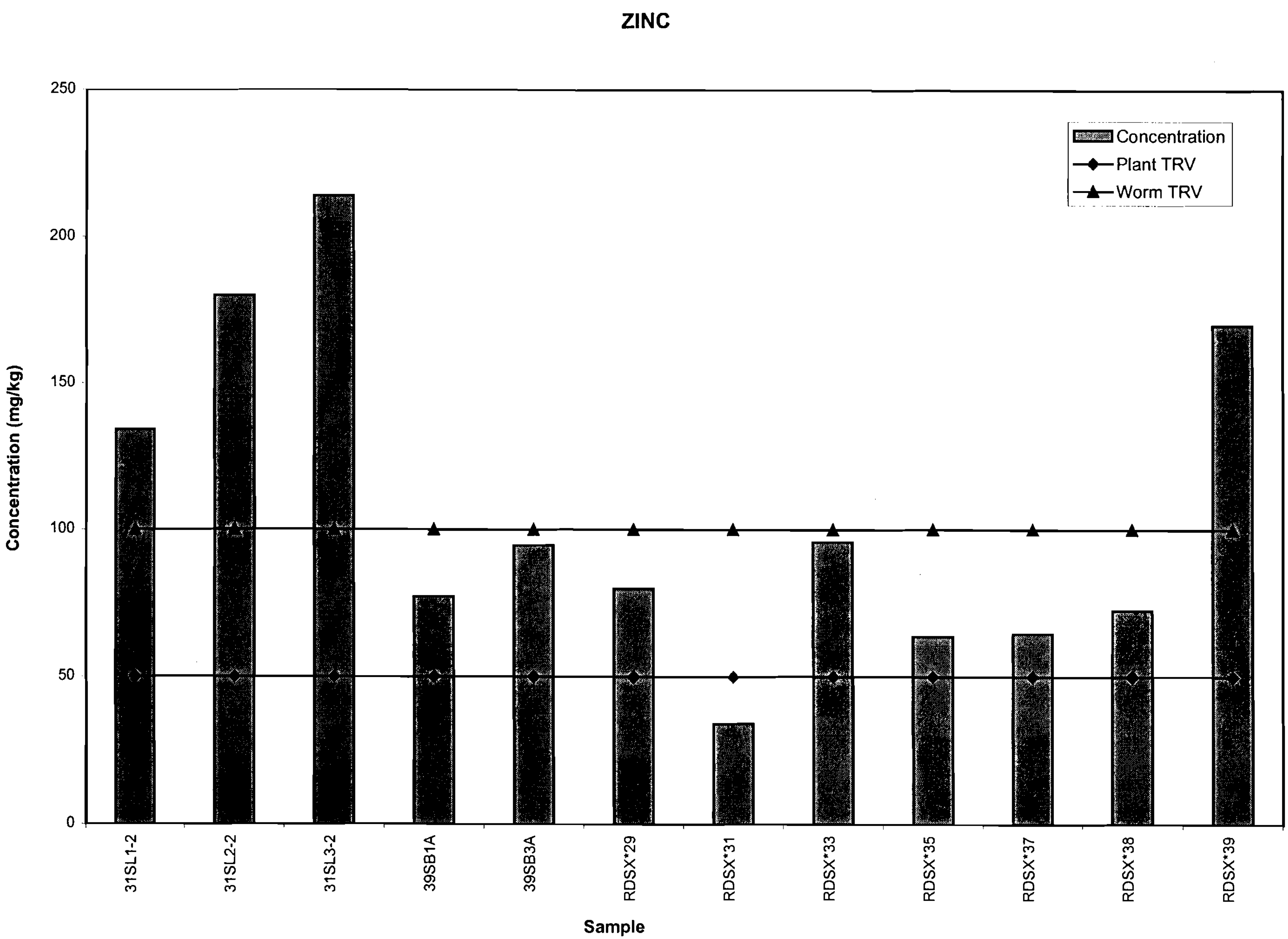

NICKEL
800
700
600
500
400
300
200
100
0
Concentration (mg/kg)
Concentration
Plant TRV
Earthworm TRV
17ASB105
17ASB205
17ASB305
17ASS3
17BSS1
17BSS2
17CSB105
17CSB205
17DSB105
17DSB205
31SL1-2
31SL2-2
31SL3-2
39SB1A
39SB3A
RDSX*29
RDSX*31
RDSX*33
RDSX*35
RDSX*37
RDSX*38
RDSX*39
Sample


SILVER
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Concentration (mg/kg)
Concentration
Plant TRV
17ASB105
17ASB205
17ASB305
17ASS3
17BSS1
17BSS2
17CSB105
17CSB205
17DSB105
17DSB205
31SL1-2
31SL2-2
31SL3-2
39SB1A
39SB3A
RDSX*29
RDSX*31
RDSX*33
RDSX*35
RDSX*37
RDSX*38
RDSX*39
Sample

297



VANADIUM
Concentration (mg/kg)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Concentration
Plant TRV
31SL1-2
31SL2-2
31SL3-2
39SB1A
39SB3A
RDSX*29
RDSX*31
RDSX*33
RDSX*35
RDSX*37
RDSX*38
RDSX*39
Sample


ZINC
Concentration
Plant TRV
Worm TRV
Concentration (mg/kg)
250
200
150
100
50
0
31SL1-2
31SL2-2
31SL3-2
39SB1A
39SB3A
RDSX*29
RDSX*31
RDSX*33
RDSX*35
RDSX*37
RDSX*38
RDSX*39
Sample

299

NDIX E

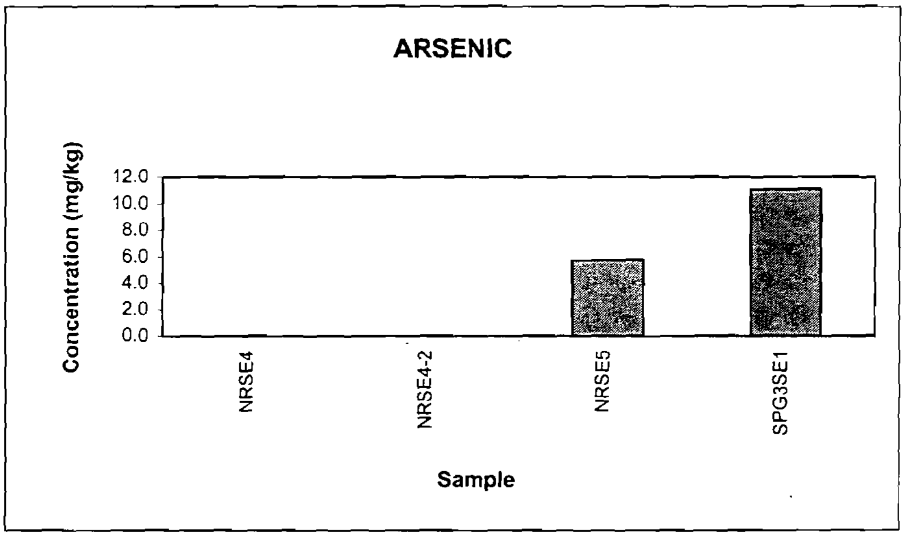
Appendix E

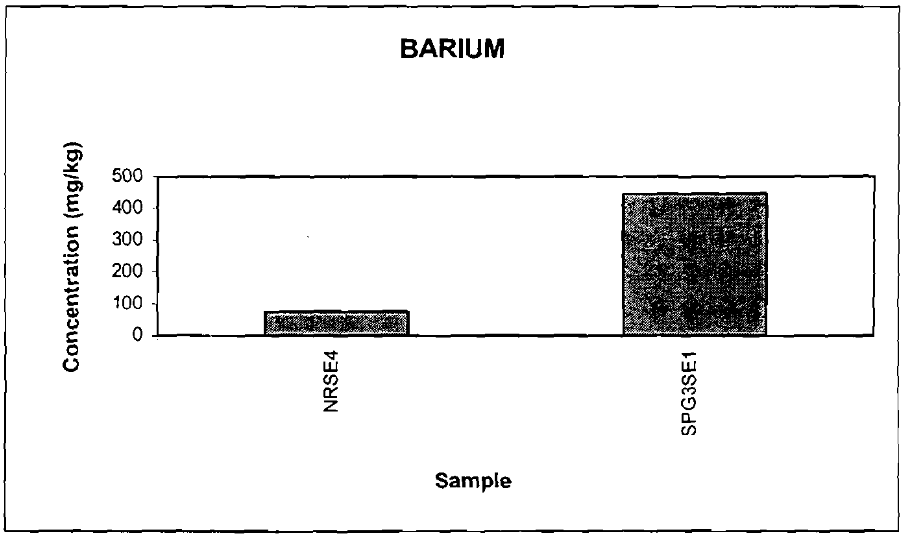
Graphical Presentation of Selected Sediment TRV Exceedances

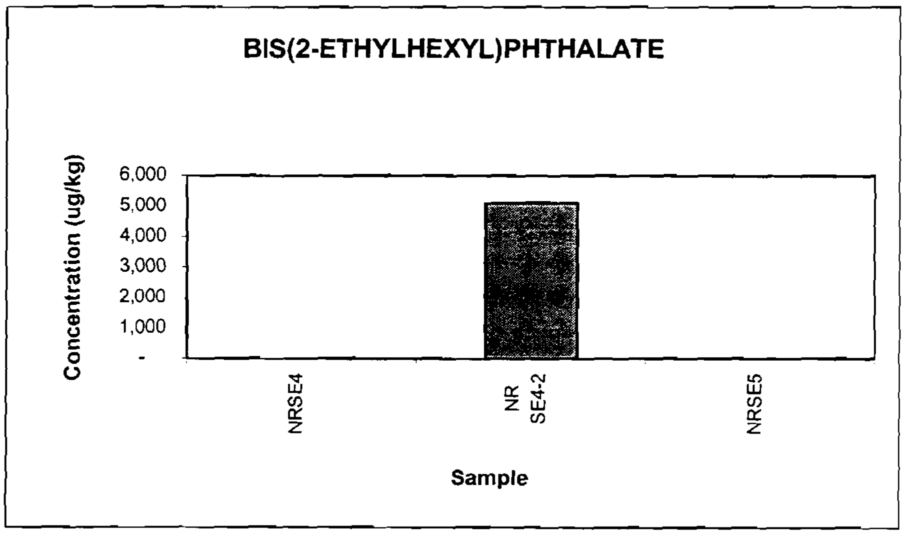
Appendix E
Graphical Presentation of Selected Sediment TRV Exceedances

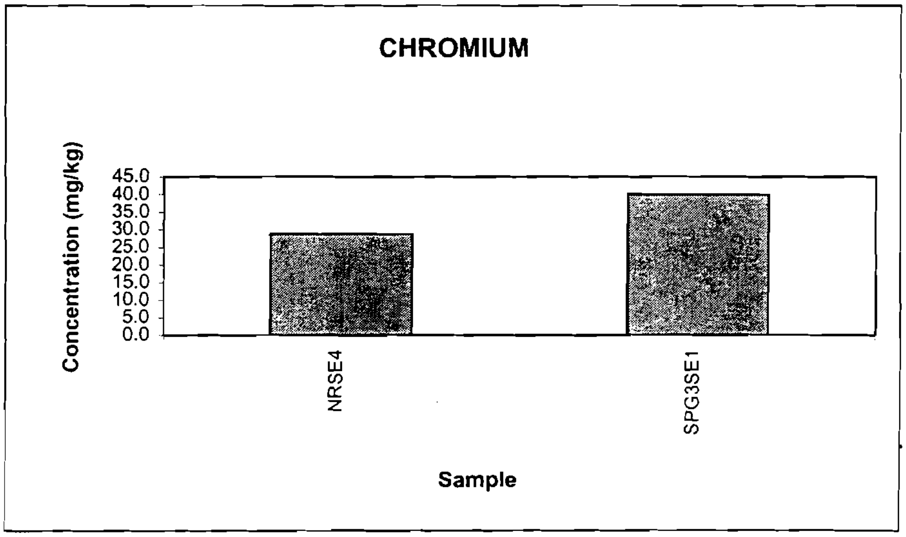
Figures were constructed for sediment data to illustrate the exact sampling locations where certain compounds exceeded TRVs. Samples with data rejected or blank qualified as a result of data validation are not included on any of the figures. Additionally, samples for which a given chemical was not detected appear as blank spaces on the figures.

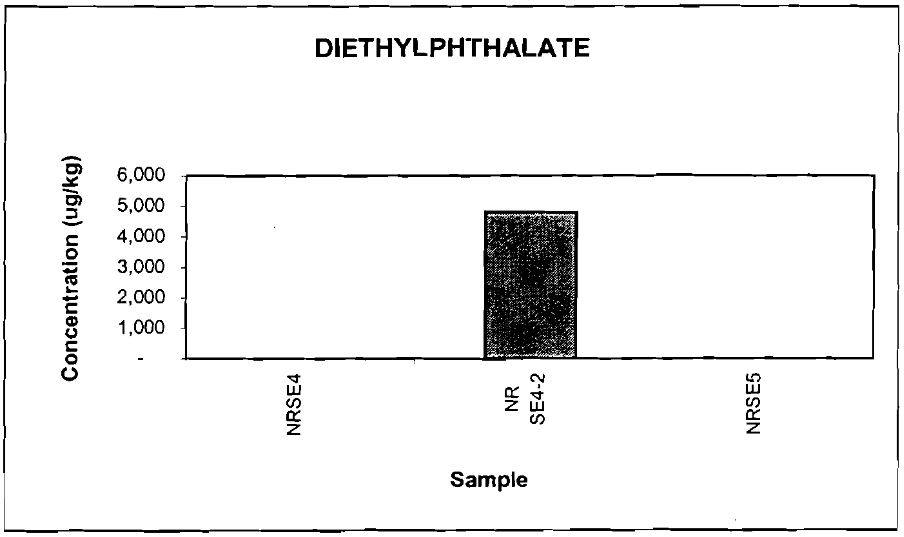
Chemicals with an EEQ greater than five were graphed. This includes sediment EEQs (see Table 1–26) and wildlife EEQs calculated using both sediment and surface water concentrations (see Table 1–22 and Table 1–23).

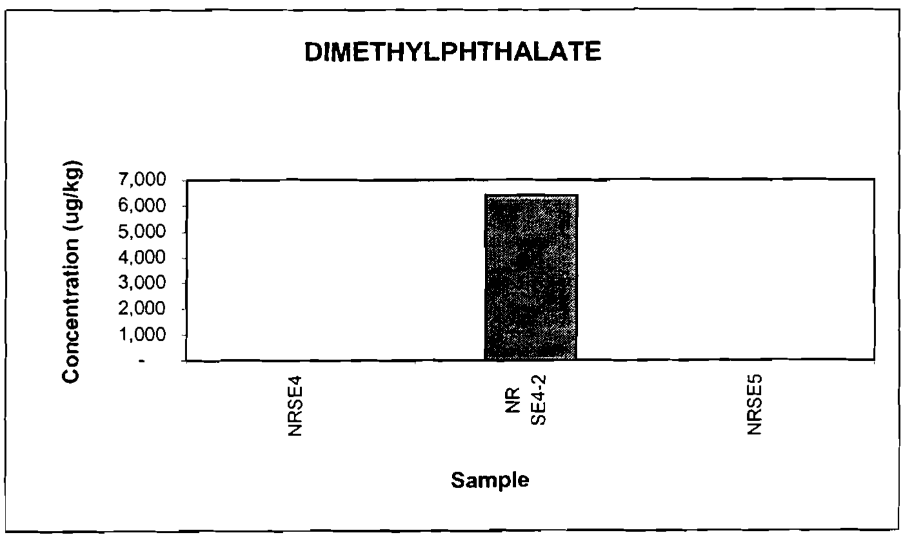

ARSENIC
Concentration (mg/kg)
12.0
10.0
8.0
6.0
4.0
2.0
0.0
NRSE4
NRSE4-2
NRSE5
SPG3SE1
Sample

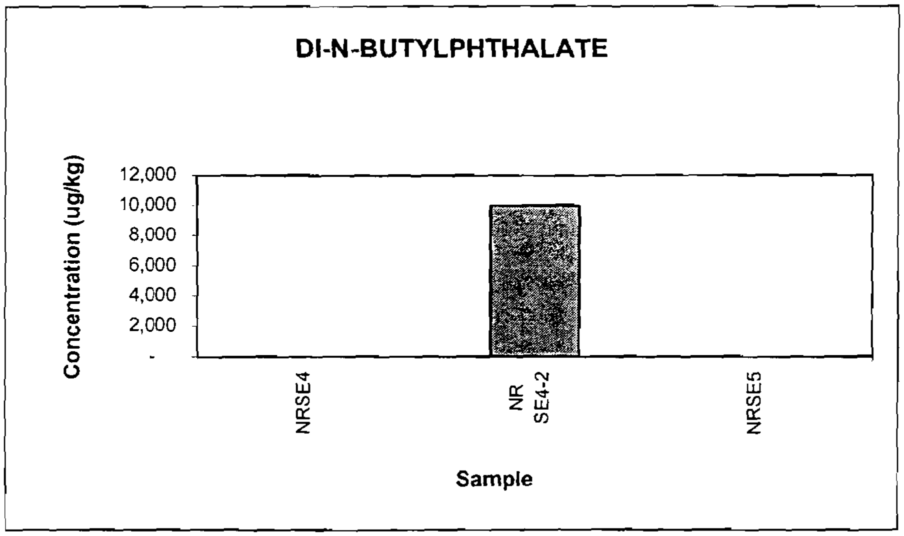

BARIUM
Concentration (mg/kg)
500
400
300
200
100
0
NRSE4
SPG3SE1
Sample

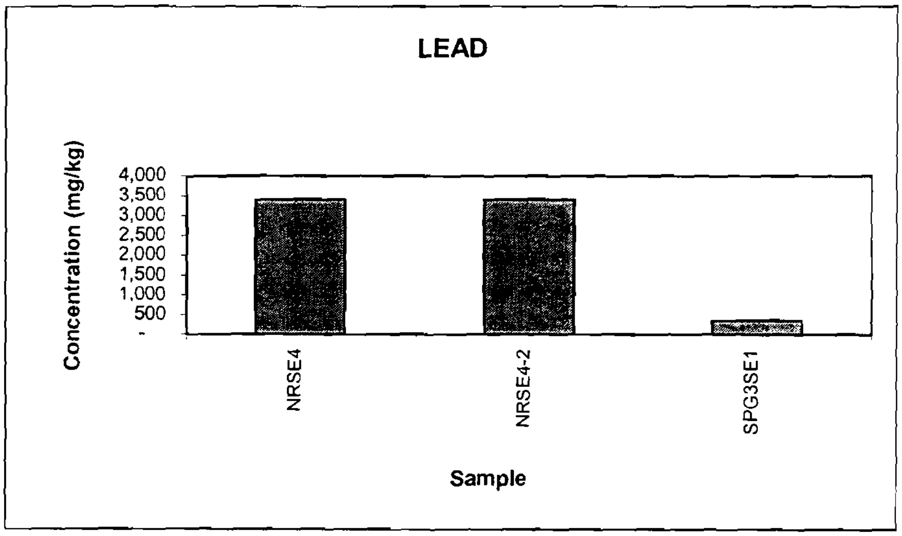

BIS(2-ETHYLHEXYL)PHTHALATE
Concentration (ug/kg)
6,000
5,000
4,000
3,000
2,000
1,000
-
NRSE4
NR SE4-2
NRSE5
Sample


CHROMIUM
Concentration (mg/kg)
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
NRSE4
SPG3SE1
Sample


DIETHYLPHTHALATE
Concentration (ug/kg)
6,000
5,000
4,000
3,000
2,000
1,000
-
NRSE4
NR SE4-2
NRSE5
Sample


DIMETHYLPHTHALATE
Concentration (ug/kg)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
-
NRSE4
NR SE4-2
NRSE5
Sample


DI-N-BUTYLPHTHALATE
Concentration (ug/kg)
12,000
10,000
8,000
6,000
4,000
2,000
-
NRSE4
NR SE4-2
NRSE5
Sample


LEAD
Concentration (mg/kg)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
-
NRSE4
NRSE4-2
SPG3SE1
Sample

APPENDIX F

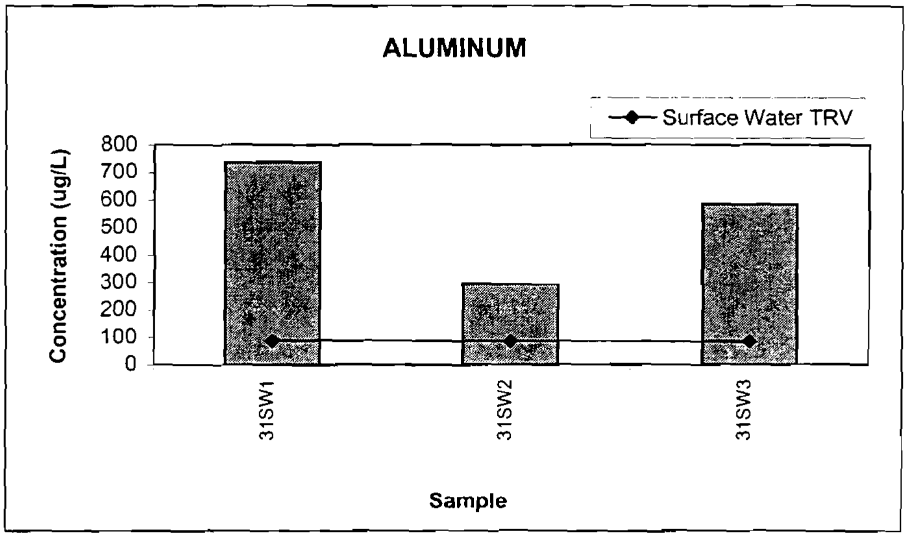
Appendix F

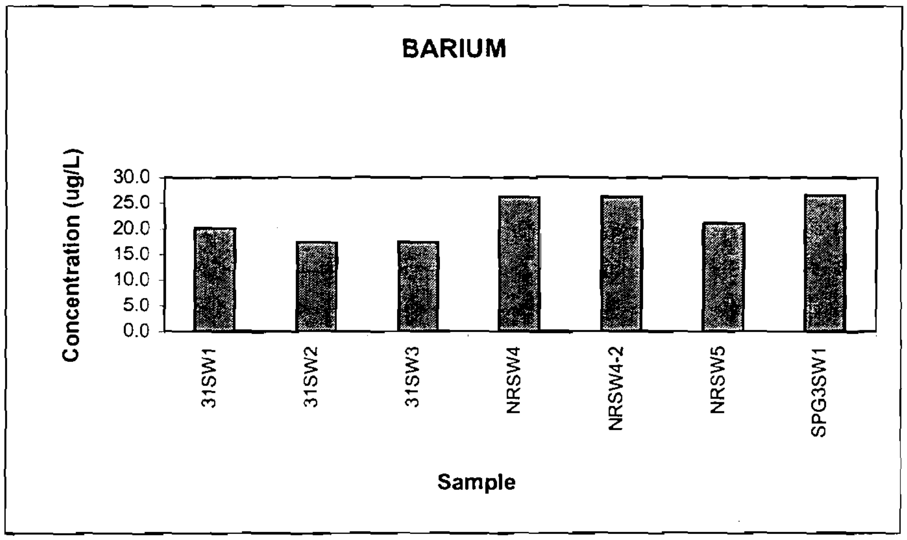
Graphical Presentation of Selected Surface Water TRV Exceedances

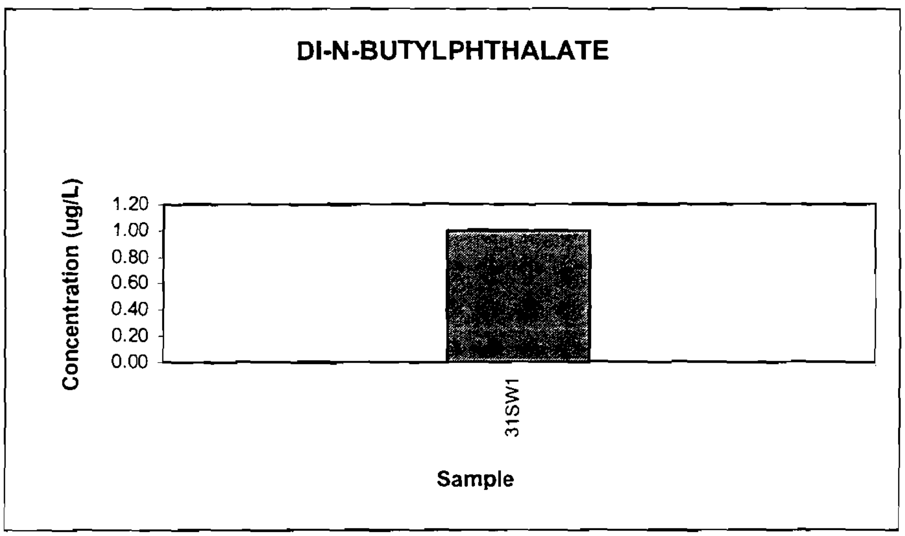
Appendix F
Graphical Presentation of Selected Surface Water TRV Exceedances

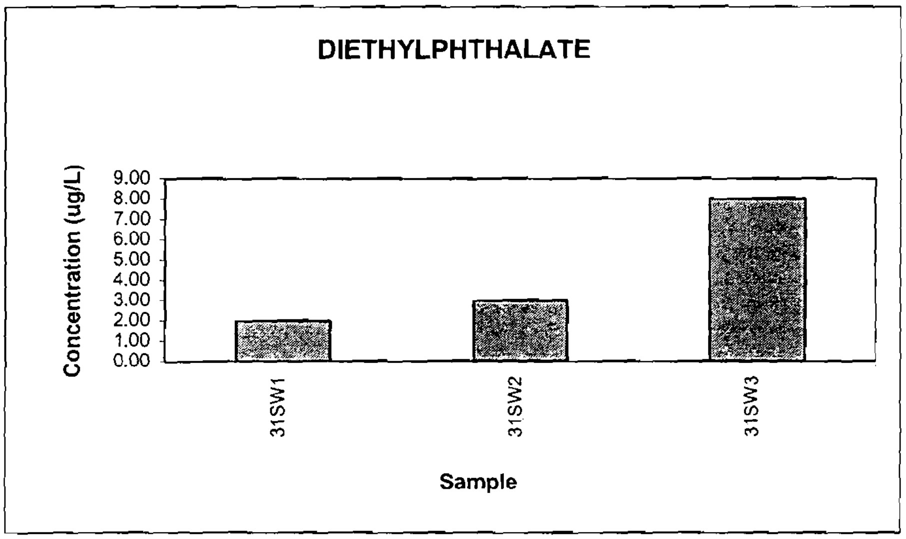
Figures were constructed for surface water data to illustrate the exact sampling locations where certain compounds exceeded TRVs. Samples with data rejected or blank qualified as a result of data validation are not included on any of the figures. Additionally, samples for which a given chemical was not detected appear as blank spaces on the figures.

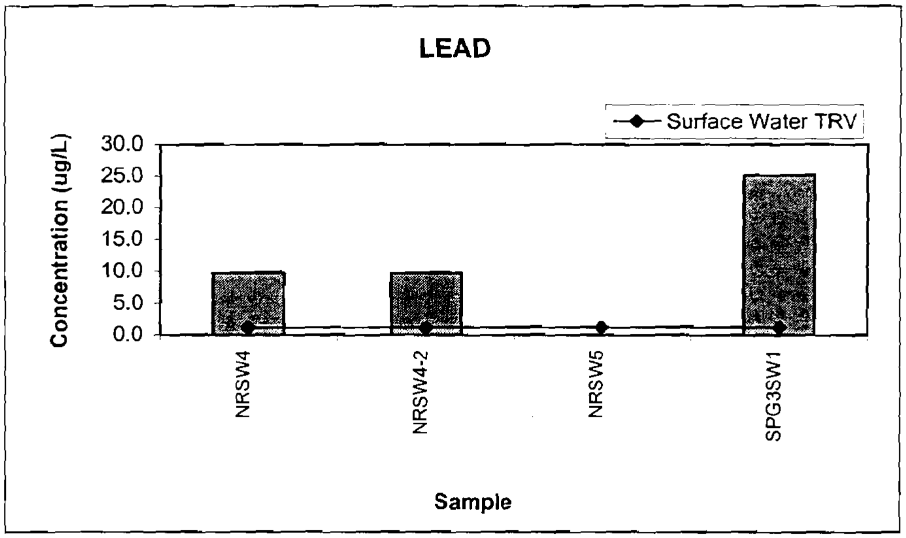
Chemicals with an EEQ greater than five were graphed. This includes surface water EEQs (see Table 1–27) and wildlife EEQs (see Table 1–19 through Table 1–25). The wildlife EEQs were calculated using surface water concentrations in conjunction with surface soil or sediment in each model.

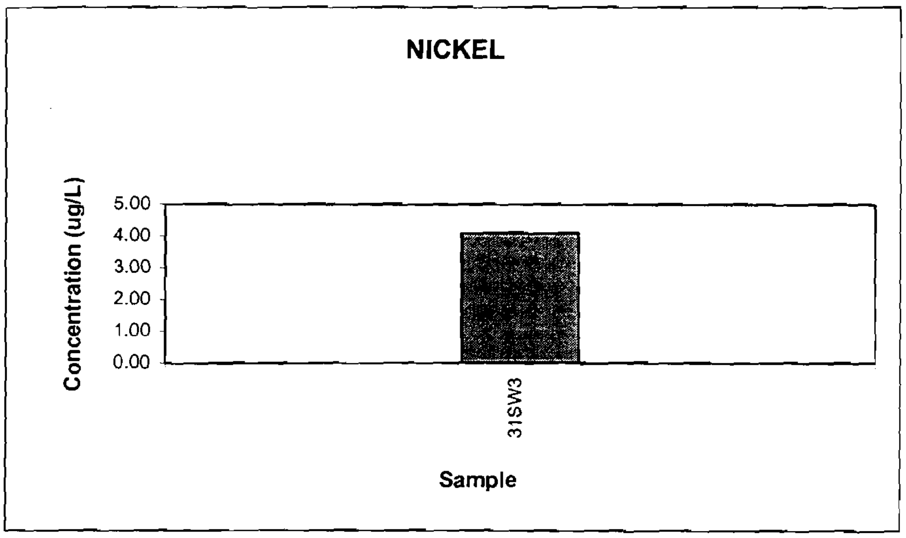

ALUMINUM
Surface Water TRV
Concentration (ug/L)
800
700
600
500
400
300
200
100
0
31SW1
31SW2
31SW3
Sample

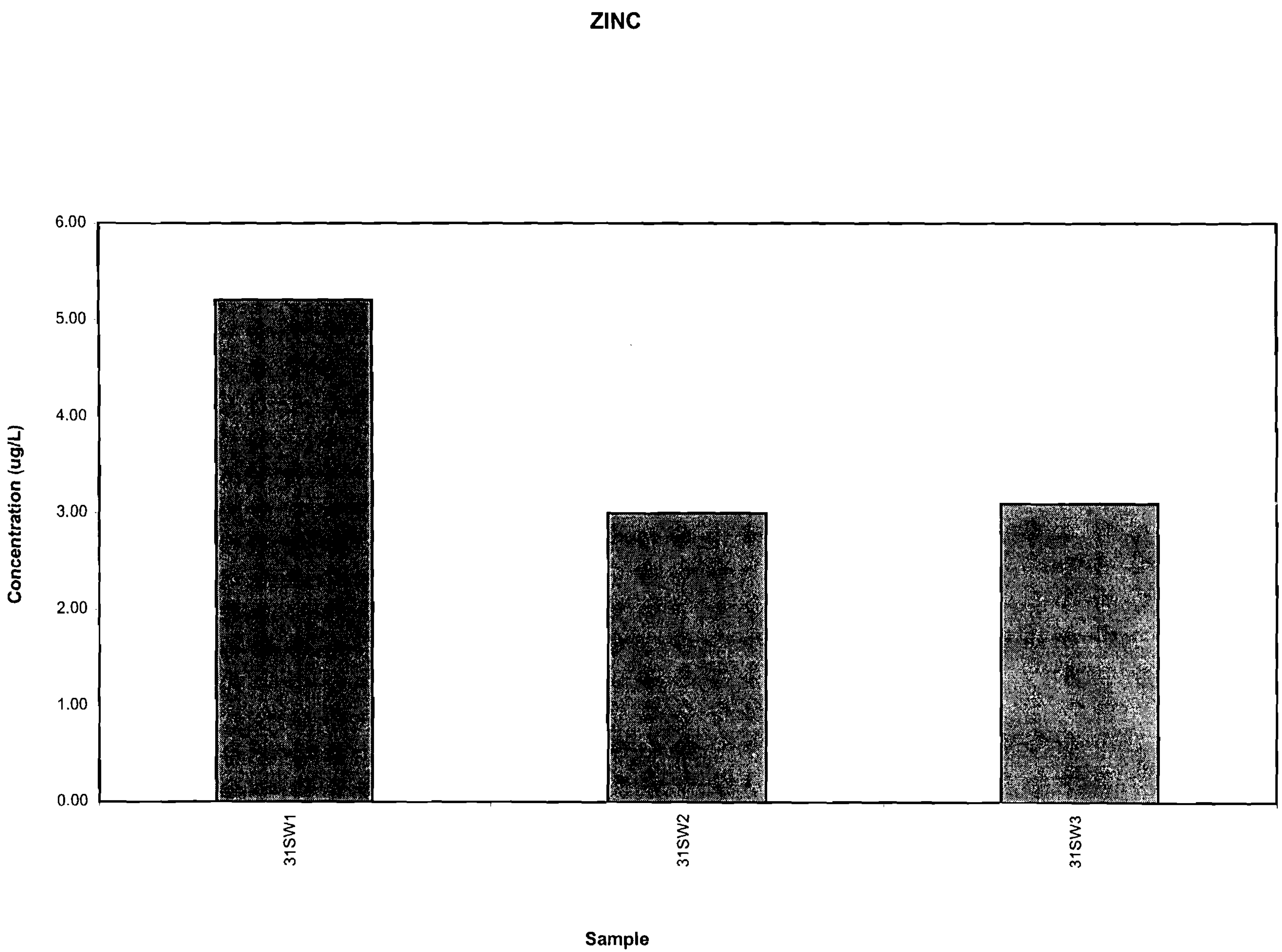

BARIUM
Concentration (ug/L)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
31SW1
31SW2
31SW3
NRSW4
NRSW4-2
NRSW5
SPG3SW1
Sample


DI-N-BUTYLPHTHALATE
Concentration (ug/L)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
31SW1
Sample


DIETHYLPHTHALATE
Concentration (ug/L)
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
31SW1
31SW2
31SW3
Sample


LEAD
Surface Water TRV
Concentration (ug/L)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
NRSW4
NRSW4-2
NRSW5
SPG3SW1
Sample


NICKEL
Concentration (ug/L)
5.00
4.00
3.00
2.00
1.00
0.00
31SW3
Sample


ZINC
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Concentration (ug/L)
31SW1
31SW2
31SW3
Sample

Screening Process

1. Set COPCs
2. Select receptors based on qualitative habitat evaluation what receptors might present that overlap the areas of contamination put a conceptual model: i.e. lines and boxes - depict possible routes movement of contamination in the environment and determine what receptors would be impacted
3. determine exposure point concentration and dose
4. review toxicological data, establish concentrations or doses that would be protective
5. risk characterization i.e. compare protective dose concentration to exposure concentrations/dose