Ecological Soil Screening Levels for Vanadium

Interim Final

OSWER Directive 9285.7-75

U.S. Environmental Protection Agency
Office of Solid Waste and Emergency Response
1200 Pennsylvania Avenue, N.W.
Washington, DC 20460

April 2005

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1.0 INTRODUCTION

Ecological Soil Screening Levels (Eco-SSLs) are concentrations of contaminants in soil that are protective of ecological receptors that commonly come into contact with and/or consume biota that live in or on soil. Eco-SSLs are derived separately for four groups of ecological receptors: plants, soil invertebrates, birds, and mammals. As such, these values are presumed to provide adequate protection of terrestrial ecosystems. Eco-SSLs are derived to be protective of the conservative end of the exposure and effects species distribution, and are intended to be applied at the screening stage of an ecological risk assessment. These screening levels should be used to identify the contaminants of potential concern (COPCs) that require further evaluation in the site-specific baseline ecological risk assessment that is completed according to specific guidance (U.S. EPA, 1997, 1998, and 1999). The Eco-SSLs are not designed to be used as cleanup levels and the United States (U.S.) Environmental Protection Agency (EPA) emphasizes that it would be inappropriate to adopt or modify the intended use of these Eco-SSLs as national cleanup standards.

The detailed procedures used to derive Eco-SSL values are described in separate documentation (U.S. EPA, 2003). The derivation procedures represent the collaborative effort of a multi-stakeholder group consisting of federal, state, consulting, industry, and academic participants led by the U.S. EPA, Office of Solid Waste and Emergency Response.

This document provides the Eco-SSL values for vanadium and the documentation for their derivation. This document provides guidance and is designed to communicate national policy on identifying vanadium concentrations in soil that may present an unacceptable ecological risk to terrestrial receptors. The document does not, however, substitute for EPA's statutes or regulations, nor is it a regulation itself. Thus, it does not impose legally-binding requirements on EPA, states, or the regulated community, and may not apply to a particular situation based upon the circumstances of the site. EPA may change this guidance in the future, as appropriate. EPA and state personnel may use and accept other technically sound approaches, either on their own initiative, or at the suggestion of potentially responsible parties, or other interested parties. Therefore, interested parties are free to raise questions and objections about the substance of this document and the appropriateness of the application of this document to a particular situation. EPA welcomes public comments on this document at any time and may consider such comments in future revisions of this document.

2.0 SUMMARY OF ECO-SSLs FOR VANADIUM

Vanadium (V) occurs commonly but not uniformly in the earth's crust, ranking 22nd among the elements present (WHO,1988). Elemental vanadium does not occur in nature but is contained in about 65 different minerals with patronite, roscoelite, carnotite, and vanadinite being the principal ore sources (CRC, 1994). Vanadium forms numerous and complicated compounds because of its many valence states which may range from +2 to +5, with +5 being the principle oxidation state (Lagerkvist et al., 1986). Vanadium can form both cationic and anionic salts (API, 1985).

Vanadium is mainly used in ferrous metallurgy where 75-85% of all vanadium produced is used as an alloy additive in making special steels. Alloys of vanadium with non-ferrous metals are widely used in the atomic industry, aircraft construction, and space technology. Vanadium is also used as a target material for x-rays and as a chemical catalyst (Alloway, 1990; WHO, 1988). Vanadium is present in coal, crude oil, naturally occurring petroleum hydrocarbons, and all fuel oils where it remains in the residue after the more volatile fractions have been distilled (http://toxnet.nlm.nih.gov).

Major sources of environmental contamination of vanadium result from the combustion of fossil fuels, the burning of coal wastes, the disposal of coal waste and fly ash, and releases from metallurgical works and smelters (NRCC, 1980; WHO, 1988; Alloway, 1990). Vanadium also enters the environment from natural sources such as continental dust, marine aerosols, and volcanic emissions (http://toxnet.nlm.nih.gov).

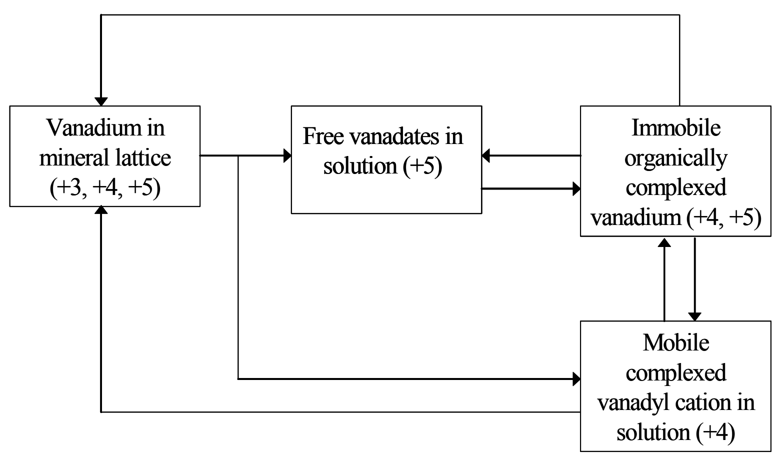


Figure 2.1 Vanadium Pools in Soil (from Alloway, 1990)

Vanadium is found in rocks and soil in the relatively insoluble trivalent form, and can also be present in the pentavalent form as vanadates of Cu, Zn, Pb, U, ferric iron, Mn, Ca, or K (API, 1985). Weathering decomposes parent rock and increases vanadium availability in soils (CCME, 1996). The vanadium pools in soils are depicted in Figure 2.1. Jacks (1976) found that the bulk of vanadium deposited in the environment is retained in the soil, mainly in association with organic matter. The mobility of vanadium in soils is affected by pH. Vanadium is fairly mobile in neutral or alkaline soils relative to other metals, but its mobility decreases in acidic soils. In the presence of humic acids, mobile metavanadate anions can be converted to the immobile vanadyl cations resulting in local accumulation. Under oxidizing, unsaturated conditions some mobility is observed, but under reducing, saturated conditions vanadium is immobile. The pentavalent cation is considerably more soluble than the trivalent cation, is readily dissolved by groundwater, and can be transported over long distances.

If released into water, vanadium is expected to exist primarily in the tetravalent and pentavalent forms. Both species are known to bind strongly to mineral or biogenic surfaces by adsorption or complexing. The chemical formulas of the vanadyl species most commonly reported in water are VO(2+) and VO(OH)(1+), and the vanadate species are H2VO4(1-) and HVO4(2-) (http://toxnet.nlm.nih.gov). Soluble vanadium present in soil appears to be easily taken up by the roots of plants usually in the tetravalent or pentavalent form (NRCC, 1980). Evidence suggests a difference in absorption between these two forms with the tetravalent (vanadyl) form being more rapidly absorbed into the roots of plants (Hopkins et al., 1977).

The Eco-SSL values derived to date for vanadium are summarized in Table 2.1.

Table 2.1 Vanadium Eco-SSLs (mg/kg dry weight in soil)

Plants	Soil Invertebrates	Wildlife	
		Avian	Mammalian
NA	NA	7.8	280
NA = Not Available. Data were insufficient to derive an Eco-SSL.			

Eco-SSL values for vanadium were derived for avian and mammalian wildlife. Eco-SSL values for vanadium could not be derived for plants or soil invertebrates as data were insufficient. The Eco-SSLs range from 7.8 mg/kg dry weight (dw) for avian wildlife to 280 mg/kg dw for mammalian wildlife. The Eco-SSL for avian wildlife is lower than the reported range of background soil concentrations in eastern and western U.S. soils (Figure 2.2). Background concentrations of many metals in U.S. soils are described in Attachment 1-4 of the Eco-SSL guidance (U.S. EPA, 2003).

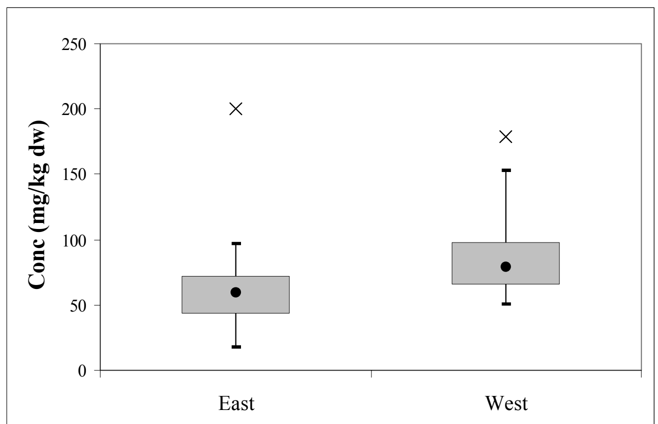
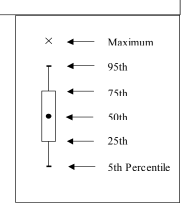


Figure 2.2 Typical Background Concentrations of Vanadium in U.S. Soils



3.0 ECO-SSL FOR TERRESTRIAL PLANTS

Of the papers identified from the literature search process, 73 were selected for acquisition for further review. Of those papers acquired, two papers met all 11 Study Acceptance Criteria (U.S. EPA 2003; Attachment 3-1). Each of these papers was reviewed and the studies were scored according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 3-2). Two studies within one paper received an Evaluation Score greater than ten. These studies are summarized in Table 3.1. At least three studies are required to derive an Eco-SSL (U.S. EPA, 2003; Attachment 3-2). Therefore, an Eco-SSL for plants could not be calculated for vanadium.

Table 3.1 Plant Toxicity Data - Vanadium

Reference	IP Number	Study ID	Test Organism		Soil pH	OM%	Bio-availability Score	ERE	Tox Parameter	Tox Value (Soil Conc mg/kg dw)	Total Evaluation Score	Eligible for Eco-SSL Derivation?	Used for Eco-SSL?
Kaplan et al., 1990	3295	a	Broccoli	*Brassica oleracea*	6.5	1.1	2	GRO	LOAEC	100	15	Y	N
Kaplan et al., 1990	3295	b	Broccoli	*Brassica oleracea*	6.5	1.9	2	GRO	NOAEC	100	15	Y	N

ERE = Ecologically relevant endpoint
GRO = Growth
LOAEC = Lowest observed adverse effect concentration
N = No
NOAEC = No observed adverse effect concentration

OM = Organic matter content
Y = Yes
Bioavailability Score described in *Guidance for Developing Eco-SSLs* (U.S. EPA, 2003)
Total Evaluation Score described in *Guidance for Developing Eco-SSLs* (U.S. EPA, 2003)

4.0 ECO-SSL FOR SOIL INVERTEBRATES

Of the papers identified from the literature search process, six were acquired for further review. Of those acquired, none met all 11 Study Acceptance Criteria (U.S. EPA, 2003; Attachment 3-1). A soil invertebrate Eco-SSL could not be derived for vanadium.

5.0 ECO-SSL FOR AVIAN WILDLIFE

The derivation of the Eco-SSL for avian wildlife was completed in two steps. First, the toxicity reference value (TRV) was derived according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-5). Second, the Eco-SSL (soil concentration) was back-calculated for each of three surrogate species based on the wildlife exposure model and the TRV (U.S. EPA, 2003).

5.1 Avian TRV

The literature search completed according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-2) identified 916 papers with possible toxicity data for either avian or mammalian species. Of these papers, 834 were rejected for use as described in Section 7.5. Of the remaining papers, 36 contained data for avian test species. These papers were reviewed and data were extracted and scored according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-3 and 4-4). The results of the data extraction and review are summarized in Table 5.1. The complete results are included as Appendix 5-1.

Within the 36 reviewed papers, there were 132 results for biochemical (BIO), behavioral (BEH), physiology (PHY), pathology (PTH), reproduction (REP), growth (GRO), and survival (MOR) effects that had a Data Evaluation Score of >65 (sufficient to derive the TRV) (U.S. EPA 2003; Attachment 4-5). These data are plotted in Figure 5.1 and correspond directly with the data presented in Table 5.1. The no-observed adverse effect (NOAEL) values for growth and reproduction are used to calculate a geometric mean NOAEL. This result is examined in relationship to the lowest bounded lowest-observed adverse effect level (LOAEL) for reproduction, growth and survival to derive the TRV according to procedures in the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-5).

A geometric mean of the NOAEL values for growth and reproduction was calculated at 1.19 mg vanadium/kg bw/day. However, this geometric mean NOAEL is higher than the lowest bounded LOAEL for growth, reproduction or survival. The TRV is equal to 0.344 mg vanadium/kg bw/day which is the highest bounded NOAEL lower than the lowest bounded LOAEL for reproduction, growth or survival.

5.2 Estimation of Dose and Calculation of the Avian Eco-SSL

Three separate Eco-SSL values were calculated for avian wildlife, one each for three surrogate species representing different trophic groups. The avian Eco-SSLs for vanadium were calculated according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-5) and are summarized in Table 5.2.

Table 5.1 Avian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)
Vanadium

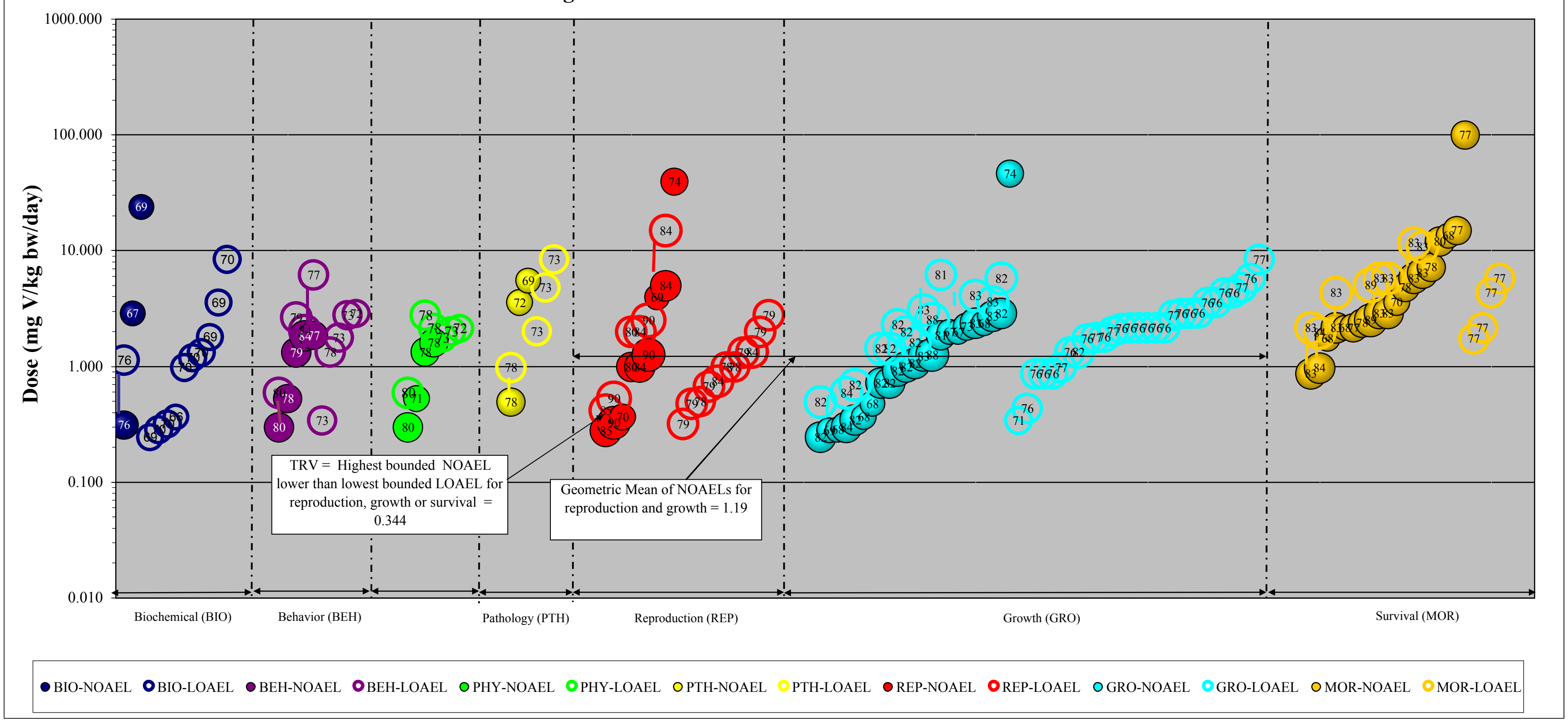
Result #	Reference	Ref No.	Test Organism	# of Conc/ Doses	Method of Analyses	Route of Exposure	Exposure Duration	Duration Units	Age	Age Units	Lifestage	Sex	Effect Type	Effect Measure	Response Site	NOAEL Dose (mg/kg bw/day)	LOAEL Dose (mg/kg bw/day)	Data Evaluation Score
	Biochemical (BIO)																	
1	White and Dieter, 1978	6727	Duck (*Anas platyrhynchos*)	4	M	FD	3	w	1	yr	AD	M	CHM	CHOL	BL	0.309	1.13	76
2	Hill, 1990	5736	Chicken (*Gallus domesticus*)	2	U	FD	18	d	1	d	JV	F	CHM	GLTH	KI	2.84		67
3	Hill, 1990	8125	Chicken (*Gallus domesticus*)	4	U	FD	19	d	1	d	JV	F	CHM	CHLR	SR	23.8		69
4	Phillips et al, 1982	6412	Chicken (*Gallus domesticus*)	4	U	FD	15	mo	1	d	JV	F	ENZ	NKAT	KI		0.244	69
5	Nielsen et al, 1980	15690	Chicken (*Gallus domesticus*)	2	U	FD	32	d	1	d	JV	M	CHM	HMCT	BL		0.284	70
6	Benabdeljelil and Jensen, 1989	5843	Chicken (*Gallus domesticus*)	2	U	FD	8	w	25	w	SM	F	CHM	GBCM	EG		0.319	70
7	Benabdeljelil and Jensen, 1989	5843	Chicken (*Gallus domesticus*)	2	U	FD	6	w	72	w	AD	F	CHM	GBCM	EG		0.366	66
8	Blalock and Hill, 1987	5927	Chicken (*Gallus domesticus*)	4	U	FD	2	w	1	d	JV	F	CHM	HMGL	BL		0.968	70
9	Kubena et al, 1986	6041	Chicken (*Gallus domesticus*)	3	U	FD	28	d	1	d	JV	M	CHM	NACO	SR		1.18	70
10	Bressman, et al., 2002	25961	Chicken (*Gallus domesticus*)	4	U	FD	56	d	32	w	SM	F	CHM	GBCM	EX		1.31	70
11	Hill, 1990	8125	Chicken (*Gallus domesticus*)	2	U	FD	19	d	1	d	JV	F	CHM	CHLR	SR		1.78	69
12	Hill, 1994	5453	Chicken (*Gallus domesticus*)	2	U	FD	21	d	1	d	JV	M	CHM	PCON	SR		3.55	69
13	Hafez and Kratzer 1976	6876	Chicken (*Gallus domesticus*)	2	U	FD	8	w	1	d	JV	M	CHM	LIPD	PL		8.36	70
	Behavior (BEH)																	
14	Cervantes and Jensen, 1986	6085	Chicken (*Gallus domesticus*)	4	U	FD	4	w	1	d	JV	M	FDB	FCNS	WO	0.295	0.589	80
15	Sell et al, 1986	6469	Chicken (*Gallus domesticus*)	3	M	FD	4	w	25	w	SM	F	FDB	FCNS	WO	0.524		78
16	Bressman, et al., 2002	25961	Chicken (*Gallus domesticus*)	4	U	FD	56	d	32	w	SM	F	FDB	FCNS	WO	1.31	2.62	79
17	Sell et al, 1982	8577	Chicken (*Gallus domesticus*)	4	M	FD	4	w	41	w	SM	F	FDB	FCNS	WO	1.82	2.01	84
18	Benabdeljelil and Jensen, 1990	5749	Chicken (*Gallus domesticus*)	4	U	FD	4	w	43	w	SM	F	FDB	FCNS	WO	1.84	6.13	77
19	Summers and Moran, 1972	7051	Chicken (*Gallus domesticus*)	2	U	FD	3	w	NR	NR	JV	NR	FDB	FCNS	WO		0.339	73
20	Toussant and Latshaw, 1994	5456	Chicken (*Gallus domesticus*)	2	M	FD	14	d	25	w	SM	F	FDB	FCNS	WO		1.33	78
21	Hill, 1990	5736	Chicken (*Gallus domesticus*)	2	U	FD	18	d	1	d	JV	F	FDB	FCNS	WO		1.77	73
22	Ousterhout and Berg, 1981	6508	Chicken (*Gallus domesticus*)	2	U	FD	7	w	40-60	w	SM	F	FDB	FDNG	WO		2.75	73
23	Hill, 1990	5734	Chicken (*Gallus domesticus*)	2	U	FD	19	d	1	d	JV	F	FDB	FCNS	WO		2.84	72
	Physiology (PHY)																	
24	Cervantes and Jensen, 1986	6085	Chicken (*Gallus domesticus*)	2	U	FD	4	w	1	d	JV	M	PHY	FDCV	WO	0.295	0.589	80
25	Sell et al, 1986	6469	Chicken (*Gallus domesticus*)	3	M	FD	4	w	25	w	SM	F	PHY	GPHY	EG	0.524		71
26	Romoser,et al, 1961	3740	Chicken (*Gallus domesticus*)	4	U	FD	21	d	9	d	JV	M	PHY	FDCV	WO	1.32	2.75	78
27	Romoser,et al, 1961	3740	Chicken (*Gallus domesticus*)	6	U	FD	21	d	7	d	JV	M	PHY	FDCV	WO	1.59	2.12	78
28	Hill, 1990	5736	Chicken (*Gallus domesticus*)	2	U	FD	18	d	1	d	JV	F	PHY	FDCV	WO		1.77	73
29	Cupo and Donaldson, 1987	5971	Chicken (*Gallus domesticus*)	2	U	FD	21	d	1	d	JV	M	PHY	FDCV	WO		2.00	73
30	Romoser,et al, 1961	3740	Chicken (*Gallus domesticus*)	7	U	FD	21	d	11	d	JV	M	PHY	FDCV	WO		2.12	72
	Pathology (PTH)																	
31	Phillips et al, 1982	6412	Chicken (*Gallus domesticus*)	4	U	FD	15	d	1	d	JV	F	HIS	GHIS	KI	0.489	0.977	78
32	Hill, 1994	5453	Chicken (*Gallus domesticus*)	2	U	FD	21	d	1	d	JV	M	ORW	SMIX	HE	3.55		72
33	Kubena and Phillips 1982	6388	Chicken (*Gallus domesticus*)	5	UX	FD	20	w	29	w	SM	F	HIS	GHIS	WO	5.45		69
34	Cupo and Donaldson, 1987	5971	Chicken (*Gallus domesticus*)	2	U	FD	21	d	1	d	JV	M	ORW	ORWT	FP		2.00	73
35	Kubena et al, 1985	6192	Chicken (*Gallus domesticus*)	2	U	FD	28	d	1	d	JV	M	ORW	ORWT	LI		4.76	73
36	Hafez and Kratzer 1976	6876	Chicken (*Gallus domesticus*)	2	U	FD	8	w	1	d	JV	M	ORW	ORWT	LI		8.36	73
	Reproduction (REP)																	
37	Sell et al, 1982	8577	Chicken (*Gallus domesticus*)	4	U	FD	7	d	41	w	LB	F	EGG	EQUA	EG	0.275	0.413	85
38	Sell et al, 1986	6469	Chicken (*Gallus domesticus*)	3	M	FD	4	w	25	w	LB	F	EGG	EQUA	EG	0.325	0.524	90
39	Benabdeljelil and Jensen, 1989	5843	Chicken (*Gallus domesticus*)	2	U	FD	6	w	72	w	LB	F	EGG	EGWT	EG	0.366		70
40	Ousterhout and Berg, 1981	6508	Chicken (*Gallus domesticus*)	3	U	FD	4	w	40	w	LB	F	EGG	EQUA	EG	0.988	1.98	80
41	Ousterhout and Berg, 1981	6508	Chicken (*Gallus domesticus*)	3	U	FD	4	w	35-40	w	LB	F	EGG	EQUA	EG	0.988	1.98	84
42	Kubena and Phillips 1982	6388	Chicken (*Gallus domesticus*)	5	UX	FD	84	d	29	w	LB	F	REP	TPRD	WO	1.25	2.50	90
43	Ousterhout and Berg, 1981	6508	Chicken (*Gallus domesticus*)	4	U	FD	4	w	50	w	LB	F	EGG	EQUA	EG	3.95		69
44	Hafez and Kratzer 1976	6848	Chicken (*Gallus domesticus*)	3	U	FD	1	mo	28	w	LB	F	REP	PROG	WO	4.94	14.8	84
45	Hafez and Kratzer 1976	6848	Japanese Quail (*Coturnix japonica*)	5	U	FD	1	mo	NR	NR	LB	F	REP	PROG	WO	39.0		74
46	Benabdeljelil and Jensen, 1989	5843	Chicken (*Gallus domesticus*)	2	U	FD	8	w	25	w	LB	F	EGG	EQUA	EG		0.319	79
47	Jensen and Maurice, 1980	9749	Chicken (*Gallus domesticus*)	2	U	FD	6	w	NR	NR	LB	F	EGG	EQUA	EG		0.475	79
48	Jensen and Maurice, 1980	9749	Chicken (*Gallus domesticus*)	3	U	FD	4	w	NR	NR	LB	F	REP	EQUA	EG		0.494	78
49	Benabdeljelil and Jensen, 1990	5749	Chicken (*Gallus domesticus*)	4	U	FD	2	w	43	w	LB	F	EGG	EQUA	EG		0.669	79
50	Sell et al, 1982	8577	Chicken (*Gallus domesticus*)	4	M	FD	7	d	41	w	LB	F	EGG	EQUA	EG		0.740	84
51	Jensen and Maurice, 1980	9749	Chicken (*Gallus domesticus*)	2	U	FD	4	w	NR	NR	LB	F	EGG	EQUA	EG		0.988	78
52	Ousterhout and Berg, 1981	6508	Chicken (*Gallus domesticus*)	3	U	FD	4	w	35-40	w	LB	F	EGG	EQUA	EG		0.988	78
53	Bressman, et al., 2002	25961	Chicken (*Gallus domesticus*)	4	U	FD	14	d	32	w	LB	F	EGG	ESQU	EG		1.31	79
54	Toussant and Latshaw, 1994	5456	Chicken (*Gallus domesticus*)	2	M	FD	9	d	25	w	LB	F	REP	PROG	WO		1.33	84
55	Ousterhout and Berg, 1981	6508	Chicken (*Gallus domesticus*)	3	U	FD	4	w	48	w	LB	F	EGG	EGWT	EG		1.98	79

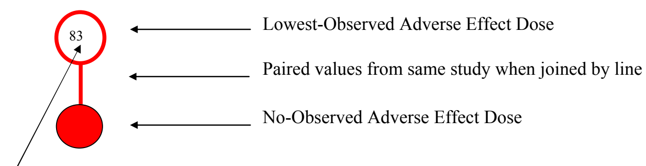
Result #	Reference	Ref No.	Test Organism	# of Conc/ Doses	Method of Analyses	Route of Exposure	Exposure Duration	Duration Units	Age	Age Units	Lifestage	Sex	Effect Type	Effect Measure	Response Site	NOAEL Dose (mg/kg bw/day)	LOAEL Dose (mg/kg bw/day)	Data Evaluation Score
56	Ousterhout and Berg, 1981	6508	Chicken (*Gallus domesticus*)	2	U	FD	7	w	40-60	w	LB	F	REP	TPRD	WO		2.75	79
Growth (GRO)																		
57	Phillips et al, 1982	6412	Chicken (*Gallus domesticus*)	4	U	FD	25	w	1	d	JV	F	GRO	BDWT	WO	0.244	0.489	82
58	Cervantes and Jensen, 1986	6085	Chicken (*Gallus domesticus*)	2	U	FD	4	w	1	d	JV	M	GRO	BDWT	WO	0.279		69
59	Nielsen et al, 1980	15690	Chicken (*Gallus domesticus*)	2	U	FD	4	w	1	d	JV	M	GRO	BDWT	WO	0.284		68
60	Cervantes and Jensen, 1986	6085	Chicken (*Gallus domesticus*)	4	U	FD	4	w	1	d	JV	M	GRO	BDWT	WO	0.295	0.589	84
61	Hill 1979	397	Chicken (*Gallus domesticus*)	4	U	FD	5	w	1	d	JV	F	GRO	BDWT	WO	0.344	0.688	82
62	Benabdeljelil and Jensen, 1989	5843	Chicken (*Gallus domesticus*)	2	U	FD	8	w	25	w	SM	F	GRO	BDWT	WO	0.366		68
63	Jensen and Maurice, 1980	9749	Chicken (*Gallus domesticus*)	2	U	FD	6	w	NR	NR	SM	F	GRO	BDWT	WO	0.475		68
64	Hill, 1990	8125	Chicken (*Gallus domesticus*)	4	U	FD	19	d	1	d	JV	F	GRO	BDWT	WO	0.711	1.42	82
65	Hill, 1990	8125	Chicken (*Gallus domesticus*)	4	U	FD	19	d	1	d	JV	F	GRO	BDWT	WO	0.711	1.42	82
66	Hathcock et al., 1964	14512	Chicken (*Gallus domesticus*)	3	U	FD	14	d	1	d	JV	NR	GRO	BDWT	WO	0.904	2.26	82
67	Ousterhout and Berg, 1981	6508	Chicken (*Gallus domesticus*)	3	U	FD	4	w	35-40	w	SM	F	GRO	BDWT	WO	0.988	1.98	82
68	Romoser,et al, 1961	3740	Chicken (*Gallus domesticus*)	6	U	FD	21	d	7	d	JV	M	GRO	BDWT	WO	1.050	1.59	82
69	Qureshi et al, 1999	5079	Chicken (*Gallus domesticus*)	4	U	FD	14	d	1	d	JV	B	GRO	BDWT	WO	1.22	3.05	83
70	Kubena and Phillips 1982	6388	Chicken (*Gallus domesticus*)	5	UX	FD	56	d	29	w	SM	F	GRO	BDWT	WO	1.26	2.51	88
71	Benabdeljelil and Jensen, 1990	5749	Chicken (*Gallus domesticus*)	4	U	FD	4	w	43	w	SM	F	GRO	BDWT	WO	1.84	6.13	81
72	Ousterhout and Berg, 1981	6508	Chicken (*Gallus domesticus*)	3	U	FD	4	w	40	w	SM	F	GRO	BDWT	WO	1.98		67
73	Ousterhout and Berg, 1981	6508	Chicken (*Gallus domesticus*)	3	U	FD	4	w	40	w	SM	F	GRO	BDWT	WO	1.98		67
74	Sell et al, 1982	8577	Chicken (*Gallus domesticus*)	4	M	FD	4	w	41	w	SM	F	GRO	BDWT	WO	2.20		73
75	Nelson et al, 1962	14516	Chicken (*Gallus domesticus*)	5	U	FD	4	w	NR	NR	JV	M	GRO	BDWT	WO	2.34	4.08	83
76	Kubena et al, 1986	6041	Chicken (*Gallus domesticus*)	3	U	FD	28	d	1	d	JV	M	GRO	BDWT	WO	2.36		68
77	Nelson et al, 1962	14516	Chicken (*Gallus domesticus*)	10	U	FD	4	w	NR	NR	JV	M	GRO	BDWT	WO	2.68	3.58	83
78	Hafez and Kratzer 1976	8663	Chicken (*Gallus domesticus*)	4	U	FD	4	w	1	d	JV	M	GRO	BDWT	WO	2.87	5.74	82
79	Hafez and Kratzer 1976	6848	Japanese Quail (*Coturnix japonica*)	5	U	FD	4	w	1	d	JV	M	GRO	BDWT	WO	46.1		74
80	Summers and Moran, 1972	7051	Chicken (*Gallus domesticus*)	2	U	FD	3	w	NR	NR	JV	NR	GRO	BDWT	WO		0.339	71
81	Hill, 1974	92	Chicken (*Gallus domesticus*)	6	U	FD	2	w	1	d	JV	B	GRO	BDWT	WO		0.429	76
82	Berg and Lawrence, 1971	9290	Chicken (*Gallus domesticus*)	3	U	FD	2	w	NR	NR	JV	M	GRO	BDWT	WO		0.859	76
83	Berg and Lawrence, 1971	9290	Chicken (*Gallus domesticus*)	3	U	FD	2	w	NR	NR	JV	M	GRO	BDWT	WO		0.859	76
84	Berg and Lawrence, 1971	9290	Chicken (*Gallus domesticus*)	3	U	FD	2	w	NR	NR	JV	M	GRO	BDWT	WO		0.859	76
85	Blalock and Hill, 1987	5927	Chicken (*Gallus domesticus*)	4	U	FD	3	w	1	d	JV	F	GRO	BDWT	WO		0.968	77
86	Romoser,et al, 1961	3740	Chicken (*Gallus domesticus*)	4	U	FD	21	d	9	d	JV	M	GRO	BDWT	WO		1.32	76
87	Toussant and Latshaw, 1994	5456	Chicken (*Gallus domesticus*)	2	M	FD	14	d	25	w	SM	F	GRO	BDWT	WO		1.33	82
88	Hill, 1979	1370	Chicken (*Gallus domesticus*)	2	U	FD	2	w	1	d	JV	B	GRO	BDWT	WO		1.72	76
89	Hill, 1990	5736	Chicken (*Gallus domesticus*)	2	U	FD	18	d	1	d	JV	F	GRO	BDWT	WO		1.77	77
90	Hill, 1990	8125	Chicken (*Gallus domesticus*)	2	U	FD	19	d	1	d	JV	F	GRO	BDWT	WO		1.78	76
91	Cupo and Donaldson, 1987	5971	Chicken (*Gallus domesticus*)	2	U	FD	21	d	1	d	JV	M	GRO	BDWT	WO		2.00	77
92	Romoser,et al, 1961	3740	Chicken (*Gallus domesticus*)	7	U	FD	21	d	11	d	JV	M	GRO	BDWT	WO		2.12	76
93	Hill, 1990	5736	Chicken (*Gallus domesticus*)	2	U	FD	18	d	1	d	JV	F	GRO	BDWT	WO		2.13	76
94	Hill, 1979	1370	Chicken (*Gallus domesticus*)	2	U	FD	2	w	1	d	JV	B	GRO	BDWT	WO		2.15	76
95	Hathcock et al., 1964	14512	Chicken (*Gallus domesticus*)	2	U	FD	14	d	1	d	JV	NR	GRO	BDWT	WO		2.15	76
96	Hill, 1980	395	Chicken (*Gallus domesticus*)	2	U	FD	1	w	1	d	JV	F	GRO	BDWT	WO		2.15	76
97	Hill, 1974	92	Chicken (*Gallus domesticus*)	3	U	FD	2	w	1	d	JV	F	GRO	BDWT	WO		2.15	76
98	Ousterhout and Berg, 1981	6508	Chicken (*Gallus domesticus*)	2	U	FD	7	w	40-60	w	SM	F	GRO	BDWT	WO		2.75	77
99	Hill, 1990	5734	Chicken (*Gallus domesticus*)	2	U	FD	19	d	1	d	JV	F	GRO	BDWT	WO		2.84	76
100	Hafez and Kratzer 1976	8663	Chicken (*Gallus domesticus*)	4	U	FD	4	w	1	d	JV	M	GRO	BDWT	WO		2.87	76
101	Hafez and Kratzer 1976	8663	Chicken (*Gallus domesticus*)	3	U	FD	4	w	1	d	JV	M	GRO	BDWT	WO		2.87	76
102	Hill, 1994	5453	Chicken (*Gallus domesticus*)	2	U	FD	21	d	1	d	JV	M	GRO	BDWT	WO		3.55	76
103	Hill, 1992	8028	Chicken (*Gallus domesticus*)	2	U	FD	19	d	1	d	JV	NR	GRO	BDWT	WO		3.55	76
104	Hathcock et al., 1964	14512	Chicken (*Gallus domesticus*)	2	U	FD	14	d	1	d	JV	NR	GRO	BDWT	WO		4.29	76
105	Burt et al, 1991	5295	Chicken (*Gallus domesticus*)	2	U	FD	14	d	1	d	JV	NR	GRO	BDWT	WO		4.29	76
106	Kubena et al, 1985	6192	Chicken (*Gallus domesticus*)	2	U	FD	14	d	1	d	JV	M	GRO	BDWT	WO		4.76	77
107	Hafez and Kratzer 1976	8663	Chicken (*Gallus domesticus*)	3	U	FD	4	w	1	d	JV	M	GRO	BDWT	WO		5.74	76
108	Hafez and Kratzer 1976	6876	Chicken (*Gallus domesticus*)	2	U	FD	8	w	1	d	JV	M	GRO	BDWT	WO		8.36	77
Survival (MOR)																		
109	Hathcock et al., 1964	14512	Chicken (*Gallus domesticus*)	3	U	FD	14	d	1	d	JV	NR	MOR	MORT	WO	0.859	2.15	83
110	Blalock and Hill, 1987	5927	Chicken (*Gallus domesticus*)	4	U	FD	3	w	1	d	JV	F	MOR	MORT	WO	0.962	1.92	84
111	Hill, 1979	1370	Chicken (*Gallus domesticus*)	2	U	FD	2	w	1	d	JV	B	MOR	MORT	WO	1.72		68
112	Hill, 1974	92	Chicken (*Gallus domesticus*)	3	U	FD	5	w	1	d	JV	B	MOR	MORT	WO	2.15	4.294	83
113	Hill, 1979	1370	Chicken (*Gallus domesticus*)	2	U	FD	2	w	1	d	JV	B	MOR	MORT	WO	2.15		68

Result #	Reference	Ref No.	Test Organism	# of Conc/ Doses	Method of Analyses	Route of Exposure	Exposure Duration	Duration Units	Age	Age Units	Lifestage	Sex	Effect Type	Effect Measure	Response Site	NOAEL Dose (mg/kg bw/day)	LOAEL Dose (mg/kg bw/day)	Data Evaluation Score
114	Hill, 1974	92	Chicken (*Gallus domesticus*)	6	U	FD	5	w	1	d	JV	F	MOR	MORT	WO	2.15		77
115	Kubena et al, 1986	6041	Chicken (*Gallus domesticus*)	3	U	FD	28	d	1	d	JV	M	MOR	MORT	WO	2.36		78
116	Kubena and Phillips 1982	6388	Chicken (*Gallus domesticus*)	5	UX	FD	84	d	29	w	SM	F	MOR	MORT	WO	2.50	4.99	89
117	Hafez and Kratzer 1976	8663	Chicken (*Gallus domesticus*)	3	U	FD	4	w	1	d	JV	M	MOR	MORT	WO	2.87	5.74	83
118	Hafez and Kratzer 1976	8663	Chicken (*Gallus domesticus*)	4	U	FD	4	w	1	d	JV	M	MOR	MORT	WO	2.87	5.74	83
119	Hill, 1994	5453	Chicken (*Gallus domesticus*)	2	U	FD	21	d	1	d	JV	M	MOR	MORT	WO	3.55		70
120	Kubena et al, 1985	6192	Chicken (*Gallus domesticus*)	2	U	FD	28	d	1	d	JV	M	MOR	MORT	WO	4.76		78
121	Hafez and Kratzer 1976	8663	Chicken (*Gallus domesticus*)	4	U	FD	4	w	1	d	JV	M	MOR	MORT	WO	5.74	11.5	83
122	Romoser,et al, 1961	3740	Chicken (*Gallus domesticus*)	7	U	FD	21	d	11	d	JV	M	MOR	MORT	WO	6.37	10.6	83
123	Qureshi et al, 1999	5079	Chicken (*Gallus domesticus*)	4	U	FD	14	d	1	d	JV	B	MOR	MORT	WO	7.15		78
124	White and Dieter, 1978	6727	Duck (*Anas platyrhynchos*)	4	M	FD	12	w	1	yr	AD	B	MOR	MORT	WO	12.0		80
125	Van Vleet et al, 1981	80	Duck (*Anas sp.)*	2	U	FD	15	d	1	d	JV	M	MOR	MORT	WO	13.4		68
126	Hafez and Kratzer 1976	6848	Chicken (*Gallus domesticus*)	3	U	FD	1	mo	28	w	JV	F	MOR	MORT	WO	14.8		77
127	Hafez and Kratzer 1976	6848	Japanese Quail (*Coturnix japonica*)	5	U	FD	4	w	1	d	JV	M	MOR	MORT	WO	98.7		77
128	Berg and Lawrence, 1971	9290	Chicken (*Gallus domesticus*)	2	U	FD	2	w	NR	NR	JV	M	MOR	MORT	WO		1.72	77
129	Hathcock et al., 1964	14512	Chicken (*Gallus domesticus*)	2	U	FD	14	d	1	d	JV	NR	MOR	MORT	WO		2.15	77
130	Hathcock et al., 1964	14512	Chicken (*Gallus domesticus*)	2	U	FD	14	d	1	d	JV	NR	MOR	MORT	WO		4.29	77
131	Hafez and Kratzer 1976	8663	Chicken (*Gallus domesticus*)	3	U	FD	4	w	1	d	JV	M	MOR	MORT	WO		5.74	77

ACHE = acetylcholinesterase; ACTV = general activity levels; AD = adult; ALWT = albumin weight; B = both; BDWT = body weight changes; BEH = behavior; BL = blood; BR = brain; CALC = calcium; CHOL = cholesterol; CHLR = ; d = days; EG = egg; EQUA = egg quality; EGWT = egg weight; ENZ = enzyme changes; ESQU = eggshell quality; EX = excrement; F = female; FCNS = food consumption; FD = food; FDB = feeding behavior; FDCV = food conversion efficiency; FDNG = ; FP = ; GBCM = general biochemical; GGRO = general growth changes; GHIS = general histology; GPHY = general physiology; GRO = growth; GLPX = gluathione peroxidase; GLTH = glutathione; HE = heart; HMCT = hematocrit; HMGL = hemoglobin; JV = juvenile; KI = kidney; LB = laying bird; LI = liver; LIPD = lipid; LOAEL = lowest observed adverse effect level; M = male; M = measured; MOR = mortality, MORT = mortality; NACO = ; NKAT = ; NOAEL = no observed adverse effect level; NR = Not reported; ORW = organ weight changes; ORWT = organ weight; PCON = phosphate concentration; PL = plasma; PROG = progeny counts; REP = reproduction; SM = sexually mature; SMIX = relative to body weight; SR = serum; SURV = survival; TPRD = total production; U = unmeasured; UX = measured but results not reported; w = weeks;
WO = whole organism; yr = years

Figure 5.1 Avian TRV Derivation for Vanadium





Wildlife TRV Derivation Process

1) There are at least three results available for two test species within the growth, reproduction, and mortality effect groups. There are enough data to derive a TRV.

2) There are three NOAEL results available within the growth and reproduction effect groups for calculation of a geometric mean.

3) The geometric mean is equal to 1.19 mg vanadium /kg bw/d but is higher than the lowest bounded LOAEL for results within the reproduction, growth, and survival effect groups.

4) The avian wildlife TRV for vanadium is equal to 0.344 mg vanadium/kg bw/day which is the highest bounded LOAEL lower than the lowest bounded LOAEL for results within reproduction, growth and survival effect groups.

Table 5.2 Calculation of the Avian Eco-SSLs for Vanadium						
Surrogate Receptor Group	**TRV for Vanadium (mg dw/kg bw/d) [1]**	**Food Ingestion Rate (FIR)[2] (kg dw/kg bw/d)**	**Soil Ingestion as Proportion of Diet (P_s)[2]**	**Concentration of Vanadium in Biota Type (i)[2,3] (B_i) (mg/kg dw)**	**Vanadium in Diet of Prey [4] (C_{diet})**	**Eco-SSL (mg/kg dw)[5]**
Avian herbivore (dove)	0.344	0.190	0.139	B_i = 0.00485 * $Soil_j$ where i = plants	NA	13
Avian ground insectivore (woodcock)	0.344	0.214	0.164	B_i = 0.042 * $Soil_j$ where i = earthworms	NA	7.8
Avian carnivore (hawk)	0.344	0.035	0.057	B_i = C_{diet} * 0.0123 where i = mammals	C_{diet} = 0.042 * $Soil_j$	140

[1] The process for derivation of wildlife TRVs is described in Attachment 4-5 of U.S. EPA (2003).
[2] Parameters (FIR, P_s, B_i values, regressions) are provided in U.S. EPA (2003) Attachment 4-1 (revised February 2005).
[3] B_i = Concentration in biota type (i) which represents 100% of the diet for the respective receptor.
[4] C_{diet} = Concentration in the diet of small mammals consumed by predatory species (hawk).
[5] HQ = FIR * ($Soil_j$ * P_s + B_i) / TRV) solved for HQ=1 where $Soil_j$ = Eco-SSL (Equation 4-2; U.S. EPA, 2003).
NA = Not Applicable

6.0 ECO-SSL FOR MAMMALIAN WILDLIFE

The derivation of the Eco-SSL for mammalian wildlife was completed in two steps. First the TRV was derived according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-5). Second, the Eco-SSL (soil concentration) was back-calculated for each of three mammalian surrogate species based on the wildlife exposure model and the TRV (U.S. EPA, 2003).

6.1 Mammalian TRV

The literature search was completed according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-2) and identified 916 papers with possible toxicity data for vanadium for either avian or mammalian test species. Of these studies, 834 were rejected for use as described in Section 7.5. Of the remaining papers, 48 contained data for mammalian test species. These papers were reviewed and the data were extracted and scored according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-3 and 4-4). The results of the data extraction and review are summarized in Table 6.1. The complete results are provided in Appendix 6-1.

Within the 48 papers, there were 101 results for biochemical (BIO), behavioral (BEH), physiology (PHY), pathology (PTH), reproduction (REP), growth (GRO), and survival (MOR) endpoints that had a total Data Evaluation Score >65 (sufficient to derive the TRV) (U.S. EPA 2003; Attachment 4-3). These data are plotted in Figure 6.1 and correspond directly with the data presented in Table 6.1. The NOAEL values for growth and reproduction are used to calculate a geometric mean NOAEL. This result is examined in relationship to the lowest bounded LOAEL for reproduction, growth and survival to derive the TRV according to procedures in the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-4).

Table 6.1 Mammalian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)
Vanadium

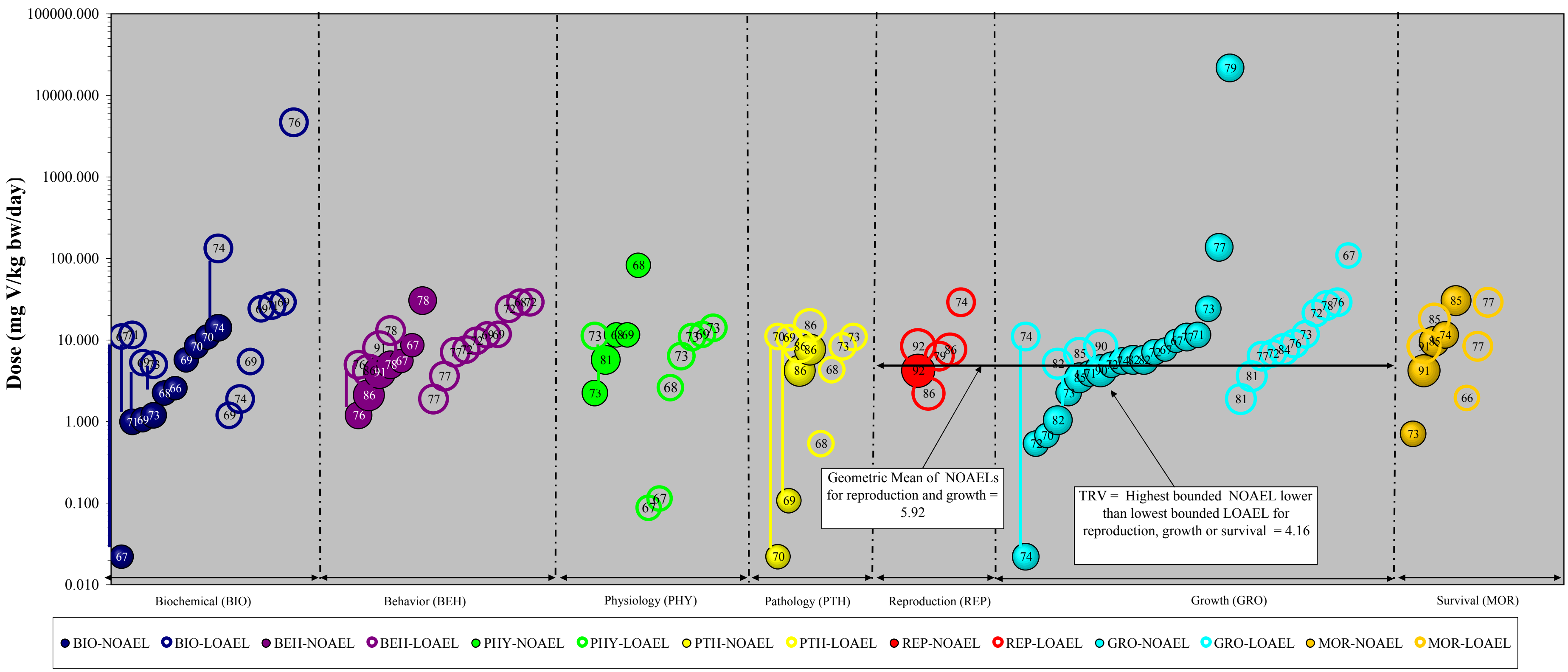
Result #	Reference	Ref No.	Test Organism	# of Conc/ Doses	Method of Analyses	Route of Exposure	Exposure Duration	Duration Units	Age	Age Units	Lifestage	Sex	Effect Type	Effect Measure	Response Site	NOAEL Dose (mg/kg bw/day)	LOAEL Dose (mg/kg bw/day)	Total
Biochemical (BIO)																		
1	Mravcova et al, 1989	17942	Rat (*Rattus norvegicus*)	3	U	DR	3	mo	21	d	JV	M	CHM	HMGL	BL	0.0220	11.0	67
2	Jadhav and Jandhyala, 1983	17758	Rat (*Rattus norvegicus*)	3	U	DR	6	w	NR	NR	JV	M	ENZ	NKAT	KI	0.978	11.4	71
3	Domingo et al, 1985	17806	Rat (*Rattus norvegicus*)	4	U	DR	3	mo	NR	NR	JV	M	CHM	PRTL	PL	1.05	5.26	69
4	Zaporowska, 1994	17668	Rat (*Rattus norvegicus*)	5	U	DR	4	w	2	mo	JV	M	CHM	ASCA	KI	1.18	4.93	73
5	Bogden et al, 1982	17431	Rat (*Rattus norvegicus*)	3	U	FD	2	w	NR	NR	JV	F	ENZ	NKAT	BR	2.23		68
6	MacDonald et al, 1988	17908	Guinea Pig (*Cavia porcellus*)	2	U	DR	20	d	NR	NR	JV	M	CHM	NACO	BL	2.55		66
7	Hansard, et al, 1978	14511	Sheep (*Ovis aries*)	4	UX	FD	84	d	NR	NR	JV	M	CHM	HMGL	WO	5.69		69
8	Van Vleet et al, 1981	149	Pig (*Sus scrofa*)	2	U	FD	10	w	NR	NR	JV	M	ENZ	GLPX	BL	8.33		70
9	Susic and Kentera, 1986	17849	Rat (*Rattus norvegicus*)	2	U	FD	2	mo	NR	NR	JV	M	CHM	HMCT	BL	10.8		70
10	Susic and Kentera, 1987	17911	Rat (*Rattus norvegicus*)	3	U	FD	24	w	3-3.5	mo	JV	M	CHM	HMCT	BL	14.0	131	74
11	Zaporowska et al, 1993	17421	Rat (*Rattus norvegicus*)	3	U	DR	4	w	2	mo	JV	M	CHM	RBCE	BL		1.18	69
12	Sharma et al, 1986	17331	Mouse (*Mus musculus*)	4	U	DR	30	d	NR	NR	JV	M	HRM	NORE	HY		1.88	74
13	Schroeder, 1968	15506	Rat (*Rattus norvegicus*)	2	U	DR	738	d	21-23	d	JV	B	CHM	CHOL	SR		5.44	69
14	Meryervitch et al. 1987	17283	Rat (*Rattus norvegicus*)	2	U	DR	3	w	NR	NR	JV	M	CHM	GCHM	LI		24	69
15	Mountain et al, 1953	14517	Rat (*Rattus norvegicus*)	3	U	FD	76	d	NR	NR	JV	M	CHM	GBCM	HA		26.4	71
16	Zaporowska and Wasilewski, 1989	17933	Rat (*Rattus norvegicus*)	2	U	DR	4	w	2	mo	JV	M	CHM	RBCE	BL		29.0	69
17	Higashino et al, 1983	17448	Rat (*Rattus norvegicus*)	3	M	FD	2	w	NR	NR	JV	F	CHM	NACO	PL		4612	76
Behavior (BEH)																		
18	Zaporowska et al, 1993	17421	Rat (*Rattus norvegicus*)	3	U	DR	4	w	2	mo	JV	M	FDB	WCON	WO	1.18	4.93	76
19	Sanchez et al, 1991	17465	Mouse (*Mus musculus*)	5	U	GV	9	d	NR	NR	GE	F	FDB	FCNS	WO	2.08	4.16	86
20	Hansard, et al, 1978	14511	Sheep (*Ovis aries*)	4	UX	FD	2	w	NR	NR	JV	M	FDB	FCNS	WO	4.00	8.00	91
21	Zaporowska, 1994	17668	Rat (*Rattus norvegicus*)	5	U	DR	4	w	2	mo	JV	M	FDB	FCNS	WO	4.93	13.0	78
22	Hansard et al, 1982	17677	Sheep (*Ovis aries*)	3	U	FD	90	d	NR	NR	JV	M	FDB	FCNS	WO	5.46		67
23	Parker and Sharma, 1978	17515	Rat (*Rattus norvegicus*)	3	U	DR	3	mo	1	mo	JV	NR	FDB	FCNS	WO	8.54		67
24	Paternain et al, 1990	17487	Mouse (*Mus musculus*)	4	U	GV	9	d	NR	NR	GE	F	FDB	FCNS	WO	30.2		78
25	Franke and Moxon 1937	14508	Rat (*Rattus norvegicus*)	2	U	FD	100	d	28	d	JV	M	FDB	FCNS	WO		1.88	77
26	Franke and Moxon 1937	14508	Rat (*Rattus norvegicus*)	2	U	FD	100	d	28	d	JV	M	FDB	FCNS	WO		3.58	77
27	Adachi et al, 2000	17205	Rat (*Rattus norvegicus*)	2	U	FD	5	d	6	w	JV	F	FDB	FCNS	WO		7.06	77
28	Dai et al, 1995	17357	Rat (*Rattus norvegicus*)	2	U	DR	1	w	NR	NR	JV	M	FDB	FCNS	WO		7.64	72
29	Dai et al, 1995	17357	Rat (*Rattus norvegicus*)	2	U	DR	8	w	NR	NR	JV	M	FDB	WCON	WO		9.68	72
30	Cadene et al, 1996	17292	Rat (*Rattus norvegicus*)	2	U	DR	6	mo	NR	NR	JV	M	FDB	WCON	WO		11.6	69
31	Zaporowska and Scibior, 1999	17224	Rat (*Rattus norvegicus*)	2	U	DR	4	w	2	mo	JV	M	FDB	FCNS	WO		11.6	69
32	Meryervitch et al. 1987	17283	Rat (*Rattus norvegicus*)	2	U	DR	3	w	NR	NR	JV	M	FDB	WCON	WO		24	72
33	Ganguli et al, 1994	17379	Rat (*Rattus norvegicus*)	2	U	DR	10	d	NR	NR	GE	F	FDB	WCON	WO		28.7	68
34	Zaporowska and Wasilewski, 1989	17933	Rat (*Rattus norvegicus*)	2	U	DR	2	w	2	mo	JV	M	FDB	WCON	WO		29.0	72
Physiology (PHY)																		
35	Domingo et al, 1985	17806	Rat (*Rattus norvegicus*)	4	U	DR	2	w	NR	NR	JV	M	PHY	EXCR	KI	2.23	11.1	73
36	Hansard, et al, 1978	14511	Sheep (*Ovis aries*)	4	UX	FD	84	d	NR	NR	JV	M	PHY	FDCV	WO	5.69		81
37	Jadhav and Jandhyala, 1983	17758	Rat (*Rattus norvegicus*)	3	U	DR	6	w	NR	NR	JV	M	PHY	BLPR	WO	11.4		68
38	Cadene et al, 1996	17292	Rat (*Rattus norvegicus*)	2	U	DR	6	mo	NR	NR	JV	M	PHY	GPHY	HE	11.6		69
39	Hamel and Duckworth, 1995	17336	Rat (*Rattus norvegicus*)	2	U	FD	14	d	39-41	d	JV	M	PHY	GPHY	LI	81.5		68
40	Carmignani et al, 1996	17328	Rabbit (*Oryctolagus cuniculus*)	2	U	DR	12	mo	3	mo	JV	M	PHY	BDVL	WO		0.0867	67
41	Boscolo, et al, 1994	17375	Rat (*Rattus norvegicus*)	2	U	DR	180	d	NR	NR	JV	M	PHY	BLPR	WO		0.113	67
42	MacDonald et al, 1988	17908	Guinea Pig (*Cavia porcellus*)	2	U	DR	14	d	NR	NR	JV	M	PHY	EXCR	KI		2.58	68
43	Elfant and Keen, 1987	17263	Rat (*Rattus norvegicus*)	2	U	FD	3	w	NR	NR	GE	F	PHY	GPHY	LI		6.26	73
44	Susic and Kentera, 1986	17849	Rat (*Rattus norvegicus*)	2	U	FD	2	mo	NR	NR	JV	M	PHY	BLPR	WO		10.8	73
45	Zaporowska and Scibior, 1999	17224	Rat (*Rattus norvegicus*)	2	U	DR	4	w	2	mo	JV	M	PHY	FDCV	WO		11.6	69
46	Susic and Kentera, 1987	17911	Rat (*Rattus norvegicus*)	3	U	FD	24	w	3-3.5	mo	JV	M	PHY	GPHY	WO		14.0	73
Pathology (PTH)																		
47	Mravcova et al, 1989	17942	Rat (*Rattus norvegicus*)	3	U	DR	3	mo	21	d	JV	M	ORW	ORWT	SP	0.0220	11.0	70
48	Mravcova et al, 1993	17400	Rat (*Rattus norvegicus*)	3	U	DR	6	mo	NR	NR	NR	B	ORW	ORWT	SP	0.106	10.6	69
49	Sanchez et al, 1991	17465	Mouse (*Mus musculus*)	5	U	GV	12	d	NR	NR	GE	F	ORW	SMIX	KI	4.16	8.31	86
50	Paternain et al, 1990	17487	Mouse (*Mus musculus*)	4	U	GV	9	d	NR	NR	GE	F	ORW	ORWT	LI	7.55	15.1	86
51	Schroeder et al, 1970	252	Rat (*Rattus norvegicus*)	2	U	DR	1202	d	21	d	JV	M	ORW	ORWT	HE		0.534	68
52	Mravcova et al, 1993	17400	Mouse (*Mus musculus*)	2	U	GV	6	w	NR	NR	NR	B	ORW	ORWT	SP		4.29	68
53	Van Vleet et al, 1981	149	Pig (*Sus scrofa*)	2	U	FD	10	w	NR	NR	JV	M	HIS	GLSN	HE		8.33	73
54	Susic and Kentera, 1986	17849	Rat (*Rattus norvegicus*)	2	U	FD	2	mo	NR	NR	JV	M	ORW	SMIX	HE		10.8	73
Reproduction (REP)																		
55	Sanchez et al, 1991	17465	Mouse (*Mus musculus*)	5	U	GV	12	d	NR	NR	GE	F	REP	ODVP	WO	4.16	8.31	92
56	Domingo et al, 1986	17864	Rat (*Rattus norvegicus*)	4	U	OR	36	d	NR	NR	GE	F	REP	PRWT	WO		2.18	86
57	Elfant and Keen, 1987	17263	Rat (*Rattus norvegicus*)	2	U	FD	3	w	NR	NR	GE	F	REP	PROG	WO		6.26	79

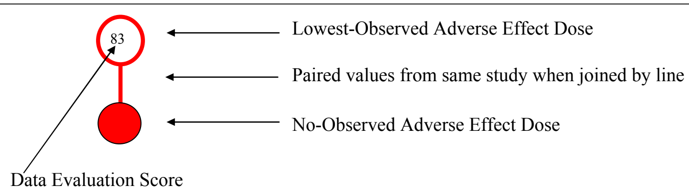
Table 6.1 Mammalian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)
Vanadium

Result #	Reference	Ref No.	Test Organism	# of Conc/ Doses	Method of Analyses	Route of Exposure	Exposure Duration	Duration Units	Age	Age Units	Lifestage	Sex	Effect Type	Effect Measure	Response Site	NOAEL Dose (mg/kg bw/day)	LOAEL Dose (mg/kg bw/day)	Total
58	Paternain et al, 1990	17487	Mouse (*Mus musculus*)	4	U	GV	9	d	NR	NR	GE	F	REP	RSEM	WO		7.55	86
59	Ganguli et al, 1994	17379	Rat (*Rattus norvegicus*)	2	U	DR	10	d	NR	NR	GE	F	REP	PROG	WO		28.7	74
	Growth (GRO)																	
60	Mravcova et al, 1989	17942	Rat (*Rattus norvegicus*)	3	U	DR	8	w	21	d	JV	M	GRO	BDWT	WO	0.0220	11.0	74
61	Schroeder et al, 1970	252	Rat (*Rattus norvegicus*)	2	U	DR	519	d	21	d	JV	B	GRO	BDWT	WO	0.534		72
62	Schroeder and Mitchener, 1975	1858	Mouse (*Mus musculus*)	2	U	DR	520	d	19-20	d	JV	M	GRO	BDWT	WO	0.674		70
63	Daniel and Lillie, 1938	14507	Rat (*Rattus norvegicus*)	6	U	FD	10	w	3-4	w	JV	B	GRO	BDWT	WO	1.03	5.11	82
64	Bogden et al, 1982	17431	Rat (*Rattus norvegicus*)	3	U	FD	2	w	NR	NR	JV	F	GRO	BDWT	WO	2.23		73
65	Sanchez et al, 1998	17276	Rat (*Rattus norvegicus*)	4	U	GV	3	w	NR	NR	JV	M	GRO	BDWT	WO	3.43	6.85	85
66	Domingo et al, 1985	17806	Rat (*Rattus norvegicus*)	4	U	DR	3	mo	NR	NR	JV	M	GRO	BDWT	WO	3.84		71
67	Sanchez et al, 1991	17465	Mouse (*Mus musculus*)	5	U	GV	9	d	NR	NR	GE	F	GRO	BDWT	WO	4.16	8.31	90
68	Zaporowska et al, 1993	17421	Rat (*Rattus norvegicus*)	3	U	DR	4	w	2	mo	JV	M	GRO	BDWT	WO	4.93		72
69	Hansard et al, 1982	17677	Sheep (*Ovis aries*)	3	U	FD	90	d	NR	NR	JV	M	GRO	BDWT	WO	5.46		74
70	Hansard, et al, 1978	14511	Sheep (*Ovis aries*)	4	UX	FD	84	d	NR	NR	JV	M	GRO	BDWT	WO	5.69		82
71	Hansard, et al, 1978	14511	Sheep (*Ovis aries*)	4	UX	FD	84	d	NR	NR	JV	M	GRO	BDWT	WO	5.69		82
72	Adachi et al, 2000	17205	Rat (*Rattus norvegicus*)	2	U	FD	1	w	6	w	JV	F	GRO	BDWT	WO	7.06		72
73	Dai et al, 1995	17357	Rat (*Rattus norvegicus*)	2	U	DR	12	w	NR	NR	JV	F	GRO	BDWT	WO	7.64		67
74	Dai et al, 1995	17357	Rat (*Rattus norvegicus*)	2	U	DR	12	w	NR	NR	JV	M	GRO	BDWT	WO	9.68		67
75	Susic and Kentera, 1986	17849	Rat (*Rattus norvegicus*)	2	U	FD	2	mo	NR	NR	JV	M	GRO	BDWT	WO	10.8		77
76	Cadene et al, 1996	17292	Rat (*Rattus norvegicus*)	2	U	DR	6	mo	NR	NR	JV	M	GRO	BDWT	WO	11.6		71
77	Meryervitch et al. 1987	17283	Rat (*Rattus norvegicus*)	2	U	DR	3	w	NR	NR	JV	M	GRO	BDWT	WO	24		73
78	Susic and Kentera, 1987	17911	Rat (*Rattus norvegicus*)	3	U	FD	24	w	3-3.5	mo	JV	M	GRO	BDWT	WO	136		77
79	Higashino et al, 1983	17448	Rat (*Rattus norvegicus*)	3	M	FD	2	w	NR	NR	JV	F	GRO	BDWT	WO	21695		79
80	Franke and Moxon 1937	14508	Rat (*Rattus norvegicus*)	2	U	FD	100	d	28	d	JV	B	GRO	BDWT	WO		1.88	81
81	Franke and Moxon 1937	14508	Rat (*Rattus norvegicus*)	2	U	FD	100	d	28	d	JV	B	GRO	BDWT	WO		3.58	81
82	Elfant and Keen, 1987	17263	Rat (*Rattus norvegicus*)	2	U	FD	3	w	NR	NR	GE	F	GRO	BDWT	WO		6.26	77
83	Challiss et al, 1987	17284	Rat (*Rattus norvegicus*)	2	U	DR	14	d	NR	NR	JV	M	GRO	BDWT	WO		6.82	72
84	Paternain et al, 1990	17487	Mouse (*Mus musculus*)	4	U	GV	9	d	NR	NR	GE	F	GRO	BDWT	WO		7.55	84
85	Van Vleet et al, 1981	149	Pig (*Sus scrofa*)	2	U	FD	3	w	NR	NR	JV	M	GRO	BDWT	WO		9.03	76
86	Zaporowska and Scibior, 1999	17224	Rat (*Rattus norvegicus*)	2	U	DR	4	w	2	mo	JV	M	GRO	BDWT	WO		11.6	73
87	Bhanot et al, 1994	17688	Rat (*Rattus norvegicus*)	2	U	DR	6	w	3	w	JV	M	GRO	BDWT	WO		21.2	72
88	Mountain et al, 1953	14517	Rat (*Rattus norvegicus*)	3	U	FD	76	d	NR	NR	JV	M	GRO	BDWT	WO		26.4	78
89	Zaporowska and Wasilewski, 1989	17933	Rat (*Rattus norvegicus*)	2	U	DR	8	w	2	mo	JV	M	GRO	BDWT	WO		29.0	76
90	Ramanadham et al, 1989	17927	Rat (*Rattus norvegicus*)	2	U	DR	10	w	NR	NR	JV	M	GRO	BDWT	WO		108	67
	Survival (MOR)																	
91	Schroeder and Mitchener, 1975	1858	Mouse (*Mus musculus*)	2	U	DR	520	d	19-20	d	JV	M	MOR	LFSP	WO	0.701		73
92	Sanchez et al, 1991	17465	Mouse (*Mus musculus*)	5	U	GV	12	d	NR	NR	GE	F	MOR	GMOR	WO	4.16	8.31	91
93	Daniel and Lillie, 1938	14507	Rat (*Rattus norvegicus*)	6	U	FD	10	w	3-4	w	JV	B	MOR	MORT	WO	9.6	17.9	85
94	Cadene et al, 1996	17292	Rat (*Rattus norvegicus*)	2	U	DR	6	mo	NR	NR	JV	M	MOR	MORT	WO	11.6		74
95	Paternain et al, 1990	17487	Mouse (*Mus musculus*)	4	U	GV	9	d	NR	NR	GE	F	MOR	MORT	WO	30.2		85
96	Kasibhatla and Rai, 1993	17381	Rabbit (*Oryctolagus cuniculus*)	4	U	DR	171	d	NR	NR	AD	NR	MOR	SURV	WO		1.93	66
97	Van Vleet et al, 1981	149	Pig (*Sus scrofa*)	2	U	FD	10	w	NR	NR	JV	M	MOR	MORT	WO		8.33	77
98	Zaporowska and Wasilewski, 1989	17933	Rat (*Rattus norvegicus*)	2	U	DR	4	w	2	mo	JV	M	MOR	MORT	WO		29.0	77

ACHE = acetylcholinesterase; ACTP = accuracy of learned behavior; ACTV = activity, general; AD = adult; AR = adrenal; ASAT = aspartate aminotransferase; ASCA = ; B = both; BDVL = blood volume; BDWT = body weight changes; BEH = behavior; BL = blood; BLPR = blood pressure; BR = brain; bw = body weight; CHM = chemical changes; CHOL = cholesterol; d - day; DOPA = dopamine; DR = Drinking water; ENZ = enyzme level changes; EXCR = excretion; F = female; FCNS = food consumption; FD = food; FDB = feeding behavior; FDCV = food converson efficiency; GBCM = general biochemical changes; GE = gestation; GENZ = general enzyme changes; GHIS = general histology; GLPX = glutathione peroxidase; GLSN = gross lesions; GMOR = general mortality; GPHY = general pysiology changes; GRO = growth; GRS = gross body weight changes; GV = gavage; HA = hair; HE = heart; HIS = histological changes; HMCT = hematocrit; HMGL = hemoglobin; HRM = hormone changes; JV = juvenile; kg = kilograms; KI = kidney; L = liter; LI = liver; LOAEL = lowest observed adverse effect level; mo = months; M = male; M = measured; MOR = effects on mortality and survival; MORT = mortality; NOAEL = No Observed Advese Effect Level; NR = Not reported; OR = other oral; ORW = organ weight changes; ORWT = organ weight changes; PHY = physiology; PORP = porphyrin; PROG = progeny numbers/counts; PRWT = progeny weight; PTH = pathology; PY = progeny; RBCE = red blood cell count; REP = reproduction; RPRT = respiratory rate; RSEM = resorbed embryo; SM = sexually mature; SMIX = weight relative to body weight; SP = spleen; SR = serum; SURV = survival; TE = testes; TEWT = testes weight; TRII = tridothyronine; TRYP = tryptophan; U = unmeasured; UR = urine; USTR = ultrastructural changes; UX = measured but values not reported; w = weeks; WCON = water consumption; WO = whole organism; yr = year.

Figure 6.1 Mammalian TRV Derivation for Vanadium





Wildlife TRV Derivation Process

1) There are at least three results available for two test species within the growth, reproduction, and mortality effect groups. There are enough data to derive a TRV.

2) There are three NOAEL results available within the growth and reproduction effect groups for calculation of a geometric mean.

3) The geometric mean is equal to 5.92 mg vanadium/kg bw/d but is higher than the lowest bounded LOAEL for results within the reproduction, growth, and survival effect groups.

4) The mammalian wildlife TRV is equal to 4.16 mg vanadium/kg bw/day which is the highest bounded NOAEL lower than the lowest bounded LOAEL for reproduction, growth or survival.

A geometric mean of the NOAEL values for growth and reproduction was calculated at 5.92 mg vanadium/kg bw/day. However, this geometric mean NOAEL is higher than the lowest bounded LOAEL for growth, reproduction or survival. The TRV is equal to 4.16 mg vanadium/kg bw/day which is the highest bounded NOAEL lower than the lowest bounded LOAEL for reproduction, growth or survival.

6.2 Estimation of Dose and Calculation of the Mammalian Eco-SSL

Three separate Eco-SSL values were calculated for mammalian wildlife, one each for three surrogate species representing different trophic groups. The mammalian Eco-SSLs for vanadium are calculated according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-5) and are summarized in Table 6.2

Table 6.2 Calculation of the Mammalian Eco-SSLs for Vanadium

Surrogate Receptor Group	TRV for Vanadium (mg dw/kg bw/d) [1]	Food Ingestion Rate (FIR)[2] (kg dw/kg bw/d)	Soil Ingestion as Proportion of Diet (P_s)[2]	Concentration of Vanadium in Biota Type (i)[2,3] (B_i) (mg/kg dw)	Vanadium in Diet of Prey [4] (C_{diet})	Eco-SSL (mg/kg dw)[5]
Mammalian herbivore (vole)	4.16	0.0875	0.032	B_i = 0.00485 * $Soil_j$ where i = plants	NA	1300
Mammalian ground insectivore (shrew)	4.16	0.209	0.030	B_i = 0.042 * $Soil_j$ where i = earthworms	NA	280
Mammalian carnivore (weasel)	4.16	0.130	0.043	B_i = C_{diet} * 0.0123 where i = mammals	C_{diet} = 0.042 * $Soil_j$	580

[1] The process for derivation of wildlife TRVs is described in Attachment 4-5 of U.S. EPA (2003).
[2] Parameters (FIR, P_s, B_i values, regressions) are provided in U.S. EPA (2003) Attachment 4-1 (revised February 2005).
[3] B_i = Concentration in biota type (i) which represents 100% of the diet for the respective receptor.
[4] C_{diet} = Concentration in the diet of small mammals consumed by predatory species (weasel).
[5] HQ = FIR * ($Soil_j$ * P_s + B_i) / TRV) solved for HQ=1 where $Soil_j$ = Eco-SSL (Equation 4-2; U.S. EPA, 2003).
NA = Not Applicable

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7.5 References Rejected for Use in Derivation of Wildlife TRVs

These references were reviewed and rejected for use in derivation of the Eco-SSL. The definition of the codes describing the basis for rejection is provided at the end of the reference sections.

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Diss the biochemistry of transition metals: copper, vanadium, and iron. *738101 ORDER NO: AAD81-03507*

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CP newer trace elements - vanadium (v) and arsenic (as) : deficiencyand possible metabolic roles. .| au. *<Document Title>Trace Element Metabolism in Man and Animals - 3*

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Diss studies on the role of protein-tyrosine phosphorylation in growth factor signal transduction. *01138624 ORDER NO: AAD91-01789*

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Literature Rejection Categories		
Rejection Criteria	**Description**	**Receptor**
ABSTRACT (Abstract)	Abstracts of journal publications or conference presentations.	Wildlife Plants and Soil Invertebrates
ACUTE STUDIES (Acu)	Single oral dose or exposure duration of three days or less.	Wildlife
AIR POLLUTION (Air P)	Studies describing the results for air pollution studies.	Wildlife Plants and Soil Invertebrates
ALTERED RECEPTOR (Alt)	Studies that describe the effects of the contaminant on surgically-altered or chemically-modified receptors (e.g., right nephrectomy, left renal artery ligature, hormone implant, etc.).	Wildlife
AQUATIC STUDIES (Aquatic)	Studies that investigate toxicity in aquatic organisms.	Wildlife Plants and Soil Invertebrates
ANATOMICAL STUDIES (Anat)	Studies of anatomy. Instance where the contaminant is used in physical studies (e.g., silver nitrate staining for histology).	Wildlife
BACTERIA (Bact)	Studies on bacteria or susceptibility to bacterial infection.	Wildlife Plants and Soil Invertebrates
BIOACCUMULATION SURVEY (Bio Acc)	Studies reporting the measurement of the concentration of the contaminant in tissues.	Wildlife Plants and Soil Invertebrates
BIOLOGICAL PRODUCT (BioP)	Studies of biological toxicants, including venoms, fungal toxins, *Bacillus thuringiensis*, other plant, animal, or microbial extracts or toxins.	Wildlife Plants and Soil Invertebrates
BIOMARKER (Biom)	Studies reporting results for a biomarker having no reported association with an adverse effect and an exposure dose (or concentration).	Wildlife
CARCINOGENICITY STUDIES (Carcin)	Studies that report data only for carcinogenic endpoints such as tumor induction. Papers that report systemic toxicity data are retained for coding of appropriate endpoints.	Wildlife Plants and Soil Invertebrates
CHEMICAL METHODS (Chem Meth)	Studies reporting methods for determination of contaminants, purification of chemicals, etc. Studies describing the preparation and analysis of the contaminant in the tissues of the receptor.	Wildlife Plants and Soil Invertebrates
CONFERENCE PROCEEDINGS (CP)	Studies reported in conference and symposium proceedings.	Wildlife Plants and Soil Invertebrates
DEAD (Dead)	Studies reporting results for dead organisms. Studies reporting field mortalities with necropsy data where it is not possible to establish the dose to the organism.	Wildlife Plants and Soil Invertebrates
DISSERTATIONS (Diss)	Dissertations are excluded. However, dissertations are flagged for possible future use.	Wildlife
DRUG (Drug)	Studies reporting results for testing of drug and therapeutic effects and side-effects. Therapeutic drugs include vitamins and minerals. Studies of some minerals may be included if there is potential for adverse effects.	Wildlife Plants and Soil Invertebrates
DUPLICATE DATA (Dup)	Studies reporting results that are duplicated in a separate publication. The publication with the earlier year is used.	Wildlife Plants and Soil Invertebrates

Literature Rejection Categories		
Rejection Criteria	**Description**	**Receptor**
ECOLOGICAL INTERACTIONS (Ecol)	Studies of ecological processes that do not investigate effects of contaminant exposure (e.g., studies of “silver” fox natural history; studies on ferrets identified in iron search).	Wildlife Plants and Soil Invertebrates
EFFLUENT (Effl)	Studies reporting effects of effluent, sewage, or polluted runoff.	Wildlife Plants and Soil Invertebrates
ECOLOGICALLY RELEVANT ENDPOINT (ERE)	Studies reporting a result for endpoints considered as ecologically relevant but is not used for deriving Eco-SSLs (e.g., behavior, mortality).	Plants and Soil Invertebrates
CONTAMINANT FATE/METABOLISM (Fate)	Studies reporting what happens to the contaminant, rather than what happens to the organism. Studies describing the intermediary metabolism of the contaminant (e.g., radioactive tracer studies) without description of adverse effects.	Wildlife Plants and Soil Invertebrates
FOREIGN LANGUAGE (FL)	Studies in languages other than English.	Wildlife Plants and Soil Invertebrates
FOOD STUDIES (Food)	Food science studies conducted to improve production of food for human consumption.	Wildlife
FUNGUS (Fungus)	Studies on fungus.	Wildlife Plants and Soil Invertebrates
GENE (Gene)	Studies of genotoxicity (chromosomal aberrations and mutagenicity).	Wildlife Plants and Soil Invertebrates
HUMAN HEALTH (HHE)	Studies with human subjects.	Wildlife Plants and Soil Invertebrates
IMMUNOLOGY (IMM)	Studies on the effects of contaminants on immunological endpoints.	Wildlife Plants and Soil Invertebrates
INVERTEBRATE (Invert)	Studies that investigate the effects of contaminants on terrestrial invertebrates are excluded.	Wildlife
IN VITRO (In Vit)	*In vitro* studies, including exposure of cell cultures, excised tissues and/or excised organs.	Wildlife Plants and Soil Invertebrates
LEAD SHOT (Lead shot)	Studies administering lead shot as the exposure form. These studies are labeled separately for possible later retrieval and review.	Wildlife
MEDIA (Media)	Authors must report that the study was conducted using natural or artificial soil. Studies conducted in pore water or any other aqueous phase (e.g., hydroponic solution), filter paper, petri dishes, manure, organic or histosoils (e.g., peat muck, humus), are not considered suitable for use in defining soil screening levels.	Plants and Soil Invertebrates
METHODS (Meth)	Studies reporting methods or methods development without usable toxicity test results for specific endpoints.	Wildlife Plants and Soil Invertebrates
MINERAL REQUIREMENTS (Mineral)	Studies examining the minerals required for better production of animals for human consumption, unless there is potential for adverse effects.	Wildlife
MIXTURE (Mix)	Studies that report data for combinations of single toxicants (e.g. cadmium and copper) are excluded. Exposure in a field setting from contaminated natural soils or waste application to soil may be coded as Field Survey.	Wildlife Plants and Soil Invertebrates

Literature Rejection Categories		
Rejection Criteria	**Description**	**Receptor**
MODELING (Model)	Studies reporting the use of existing data for modeling, i.e., no new organism toxicity data are reported. Studies which extrapolate effects based on known relationships between parameters and adverse effects.	Wildlife Plants and Soil Invertebrates
NO CONTAMINANT OF CONCERN (No COC)	Studies that do not examine the toxicity of Eco-SSL contaminants of concern.	Wildlife Plants and Soil Invertebrates
NO CONTROL (No Control)	Studies which lack a control or which have a control that is classified as invalid for derivation of TRVs.	Wildlife Plants and Soil Invertebrates
NO DATA (No Data)	Studies for which results are stated in text but no data is provided. Also refers to studies with insufficient data where results are reported for only one organism per exposure concentration or dose (wildlife).	Wildlife Plants and Soil Invertebrates
NO DOSE or CONC (No Dose)	Studies with no usable dose or concentration reported, or an insufficient number of doses/concentrations are used based on Eco-SSL SOPs. These are usually identified after examination of full paper. This includes studies which examine effects after exposure to contaminant ceases. This also includes studies where offspring are exposed in utero and/or lactation by doses to parents and then after weaning to similar concentrations as their parents. Dose cannot be determined.	Wildlife Plants and Soil Invertebrates
NO DURATION (No Dur)	Studies with no exposure duration. These are usually identified after examination of full paper.	Wildlife Plants and Soil Invertebrates
NO EFFECT (No Efct)	Studies with no relevant effect evaluated in a biological test species or data not reported for effect discussed.	Wildlife Plants and Soil Invertebrates
NO ORAL (No Oral)	Studies using non-oral routes of contaminant administration including intraperitoneal injection, other injection, inhalation, and dermal exposures.	Wildlife
NO ORGANISM (No Org) or NO SPECIES	Studies that do not examine or test a viable organism (also see in vitro rejection category).	Wildlife Plants and Soil Invertebrates
NOT AVAILABLE (Not Avail)	Papers that could not be located. Citation from electronic searches may be incorrect or the source is not readily available.	Wildlife Plants and Soil Invertebrates
NOT PRIMARY (Not Prim)	Papers that are not the original compilation and/or publication of the experimental data.	Wildlife Plants and Soil Invertebrates
NO TOXICANT (No Tox)	No toxicant used. Publications often report responses to changes in water or soil chemistry variables, e.g., pH or temperature. Such publications are not included.	Wildlife Plants and Soil Invertebrates
NO TOX DATA (No Tox Data)	Studies where toxicant used but no results reported that had a negative impact (plants and soil invertebrates).	Plants and Soil Invertebrates
NUTRIENT (Nutrient)	Nutrition studies reporting no concentration related negative impact.	Plants and Soil Invertebrates
NUTRIENT DEFICIENCY (Nut def)	Studies of the effects of nutrient deficiencies. Nutritional deficient diet is identified by the author. If reviewer is uncertain then the administrator should be consulted. Effects associated with added nutrients are coded.	Wildlife
NUTRITION (Nut)	Studies examining the best or minimum level of a chemical in the diet for improvement of health or maintenance of animals in captivity.	Wildlife
OTHER AMBIENT CONDITIONS (OAC)	Studies which examine other ambient conditions: pH, salinity, DO, UV, radiation, etc.	Wildlife Plants and Soil Invertebrates

Literature Rejection Categories		
Rejection Criteria	**Description**	**Receptor**
OIL (Oil)	Studies which examine the effects of oil and petroleum products.	Wildlife Plants and Soil Invertebrates
OM, pH (OM, pH)	Organic matter content of the test soil must be reported by the authors, but may be presented in one of the following ways; total organic carbon (TOC), particulate organic carbon (POC), organic carbon (OC), coarse particulate organic matter (CPOM), particulate organic matter (POM), ash free dry weight of soil, ash free dry mass of soil, percent organic matter, percent peat, loss on ignition (LOI), organic matter content (OMC). With the exception of studies on non-ionizing substances, the study must report the pH of the soil, and the soil pH should be within the range of $4 and #8.5. Studies that do not report pH or report pH outside this range are rejected.	Plants and Soil Invertebrates
ORGANIC METAL (Org Met)	Studies which examine the effects of organic metals. This includes tetraethyl lead, triethyl lead, chromium picolinate, phenylarsonic acid, roxarsone, 3-nitro-4-phenylarsonic acid,, zinc phosphide, monomethylarsonic acid (MMA), dimethylarsinic acid (DMA), trimethylarsine oxide (TMAO), or arsenobetaine (AsBe) and other organo metallic fungicides. Metal acetates and methionines are not rejected and are evaluated.	Wildlife
LEAD BEHAVIOR OR HIGH DOSE MODELS (Pb Behav)	There are a high number of studies in the literature that expose rats or mice to high concentrations of lead in drinking water (0.1, 1 to 2% solutions) and then observe behavior in offspring, and/or pathology changes in the brain of the exposed dam and/or the progeny. Only a representative subset of these studies were coded. Behavior studies examining complex behavior (learned tasks) were also not coded.	Wildlife
PHYSIOLOGY STUDIES (Phys)	Physiology studies where adverse effects are not associated with exposure to contaminants of concern.	Wildlife
PLANT (Plant)	Studies of terrestrial plants are excluded.	Wildlife
PRIMATE (Prim)	Primate studies are excluded.	Wildlife
PUBL AS (Publ as)	The author states that the information in this report has been published in another source. Data are recorded from only one source. The secondary citation is noted as Publ As.	Wildlife Plants and Soil Invertebrates
QSAR (QSAR)	Derivation of Quantitative Structure-Activity Relationships (QSAR) is a form of modeling. QSAR publications are rejected if raw toxicity data are not reported or if the toxicity data are published elsewhere as original data.	Wildlife Plants and Soil Invertebrates
REGULATIONS (Reg)	Regulations and related publications that are not a primary source of data.	Wildlife Plants and Soil Invertebrates
REVIEW (Rev)	Studies in which the data reported in the article are not primary data from research conducted by the author. The publication is a compilation of data published elsewhere. These publications are reviewed manually to identify other relevant literature.	Wildlife Plants and Soil Invertebrates

Literature Rejection Categories		
Rejection Criteria	**Description**	**Receptor**
SEDIMENT CONC (Sed)	Studies in which the only exposure concentration/dose reported is for the level of a toxicant in sediment.	Wildlife Plants and Soil Invertebrates
SCORE (Score)	Papers in which all studies had data evaluation scores at or lower then the acceptable cut-off (#10 of 18) for plants and soil invertebrates).	Plants and Soil Invertebrates
SEDIMENT CONC (Sed)	Studies in which the only exposure concentration/dose reported is for the level of a toxicant in sediment.	Wildlife Plants and Soil Invertebrates
SLUDGE	Studies on the effects of ingestion of soils amended with sewage sludge.	Wildlife Plants and Soil Invertebrates
SOIL CONC (Soil)	Studies in which the only exposure concentration/dose reported is for the level of a toxicant in soil.	Wildlife
SPECIES	Studies in which the species of concern was not a terrestrial invertebrate or plant or mammal or bird.	Plants and Soil Invertebrates Wildlife
STRESSOR (QAC)	Studies examining the interaction of a stressor (e.g., radiation, heat, etc.) and the contaminant, where the effect of the contaminant alone cannot be isolated.	Wildlife Plants and Soil Invertebrates
SURVEY (Surv)	Studies reporting the toxicity of a contaminant in the field over a period of time. Often neither a duration nor an exposure concentration is reported.	Wildlife Plants and Soil Invertebrates
REPTILE OR AMPHIBIAN (Herp)	Studies on reptiles and amphibians. These papers flagged for possible later review.	Wildlife Plants and Soil Invertebrates
UNRELATED (Unrel)	Studies that are unrelated to contaminant exposure and response and/or the receptor groups of interest.	Wildlife
WATER QUALITY STUDY (Wqual)	Studies of water quality.	Wildlife Plants and Soil Invertebrates
YEAST (Yeast)	Studies of yeast.	Wildlife Plants and Soil Invertebrates

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Appendix 5-1

Avian Toxicity Data Extracted and Reviewed for Wildlife Toxicity Reference Value (TRV) - Vanadium

April 2005

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Appendix 5.1 Avian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)
Vanadium

Ref			Exposure																					Effects						Conversion to mg/kg bw/day				Result		Data Evaluation Score										
Result #	Ref N.	Reference	Chemical Form	MW%	Test Species	Phase #	# of Conc/ Doses	Conc/ Doses	Conc/Dose Units	Wet Weight Reported?	Percent Moisture	Application Frequency	Method of Analyses	Route of Exposure	Exposure Duration	Duration Units	Age	Age Units	Lifestage	Sex	Control Type	Test Location	Endpoint Number	General Effect Group	Effect Type	Effect Measure	Response Site	Study NOAEL	Study LOAEL	Body Weight Reported?	Body Weight in kg	Ingestion Rate Reported?	Ingestion Rate in kg/day or L/day	NOAEL Dose (mg/kg/day)	LOAEL Dose (mg/kg/day)	Data Source	Dose Route	Test Concentrations	Chemical form	Dose Quantification	Endpoint	Dose Range	Statistical Power	Exposure Duration	Test Conditions	Total
Biochemical																																														
1	6727	White and Dieter, 1978	Vanadyl sulfate	100	Duck (*Anas platyrhynchos*)	1	4	0/2.84/10.36/110	mg/kg diet	Y		ADL	M	FD	3	w	1	yr	AD	M	V	Lab	3	BIO	CHM	CHOL	BL	2.84	10.4	Y	1.17	Y	0.121	0.309	1.13	10	10	10	10	7	1	8	10	6	4	76
2	5736	Hill, 1990	Sodium metavanadate	100	Chicken (*Gallus domesticus*)	1	2	0/40	mg/kg diet	NR		ADL	U	FD	18	d	1	d	JV	F	C	Lab	4	BIO	CHM	GLTH	KI	40.0		N	0.564	N	0.04009	2.84		10	10	5	10	5	1	4	8	10	4	67
3	8125	Hill, 1990	Ammonium vanadate	100	Chicken (*Gallus domesticus*)	2	4	0/10/20/30	mg/kg diet	NR		ADL	U	FD	19	d	1	d	JV	F	C	Lab	2	BIO	CHM	CHLR	SR	30.0		N	0.000564	N	0.00045	23.8		10	10	5	10	5	1	4	10	10	4	69
4	6412	Phillips et al, 1982	Calcium orthovanadate	17	Chicken (*Gallus domesticus*)	1	4	0/25/50/100	mg/kg diet	N		ADL	U	FD	15	mo	1	d	JV	F	C	Lab	3	BIO	ENZ	NKAT	KI		25.0	N	1.042	N	0.05978		0.244	10	10	5	10	5	1	4	10	10	4	69
5	15690	Nielsen et al, 1980	Ammonium metavandate	100	Chicken (*Gallus domesticus*)	1	2	0/5	ug/g diet	N		NR	U	FD	32	d	1	d	JV	M	C	Lab	2	BIO	CHM	HMCT	BL		5.0	Y	1.07	N	0.06082		0.284	10	10	5	10	6	1	4	10	10	4	70
6	5843	Benabdeljelil and Jensen, 1989	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	2	2	0/5	mg/kg diet	N		ADL	U	FD	8	w	25	w	SM	F	C	Lab	4	BIO	CHM	GBCM	EG		5.0	N	1.6	Y	0.102		0.319	10	10	5	10	6	1	4	10	10	4	70
7	5843	Benabdeljelil and Jensen, 1989	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	2	2	0/5	mg/kg diet	N		ADL	U	FD	6	w	72	w	AD	F	C	Lab	4	BIO	CHM	GBCM	EG		5.0	N	1.6	Y	0.117		0.366	10	10	5	10	6	1	4	10	6	4	66
8	5927	Blalock and Hill, 1987	Vanadyl chloride	100	Chicken (*Gallus domesticus*)	1	4	0/10/20/40	mg/kg diet	N		NR	U	FD	2	w	1	d	JV	F	C	Lab	3	BIO	CHM	HMGL	BL		10.0	Y	0.233	N	0.02255		0.968	10	10	5	10	6	1	4	10	10	4	70
9	6041	Kubena et al, 1986	Calcium orthovanadate	100	Chicken (*Gallus domesticus*)	1	3	0/12.5/25.0	mg/kg diet	NR		ADL	U	FD	28	d	1	d	JV	M	C	Lab	5	BIO	CHM	NACO	SR		12.5	Y	0.2496	N	0.02358		1.18	10	10	5	10	6	1	4	10	10	4	70
10	25961	Bressman, et al., 2002	Ammonium Metavanadate	100	Chicken (*Gallus domesticus*)	1	4	0/20/40/60	mg/kg diet	NR		ADL	U	FD	56	d	32	w	SM	F	C	Lab	4	BIO	CHM	GBCM	EX		20.0	N	1.6	Y	0.1049		1.31	10	10	5	10	6	1	4	10	10	4	70
11	8125	Hill, 1990	Sodium metavanadate	100	Chicken (*Gallus domesticus*)	1	2	0/25	mg/kg diet	NR		ADL	U	FD	19	d	1	d	JV	F	C	Lab	2	BIO	CHM	CHLR	SR		25.0	N	0.564	N	0.04009		1.78	10	10	5	10	5	1	4	10	10	4	69
12	5453	Hill, 1994	Ammoinium metavanadate	100	Chicken (*Gallus domesticus*)	1	2	0/50	mg/kg diet	NR		EOD	U	FD	21	d	1	d	JV	M	C	Lab	2	BIO	CHM	PCON	SR		50.0	N	0.564	N	0.04009		3.55	10	10	5	10	5	1	4	10	10	4	69
13	6876	Hafez and Kratzer 1976	Ammonium vanadate	100	Chicken (*Gallus domesticus*)	1	2	0/100	mg/kg diet	N		ADL	U	FD	8	w	1	d	JV	M	C	Lab	3	BIO	CHM	LIPD	PL		100	Y	0.3543	N	0.02962		8.36	10	10	5	10	6	1	4	10	10	4	70
Behavior																																														
14	6085	Cervantes and Jensen, 1986	Ammonium vanadate	100	Chicken (*Gallus domesticus*)	1	4	0/5/10/20	mg/kg diet	N		ADL	U	FD	4	w	1	d	JV	M	C	Lab	2	BEH	FDB	FCNS	WO	5.0	10.0	Y	0.65	Y	0.03829	0.295	0.589	10	10	5	10	7	4	10	10	10	4	80
15	6469	Sell et al, 1986	Dicalcium phosphate	100	Chicken (*Gallus domesticus*)	1	3	0/4.6/7.4	mg/kg diet	N		ADL	M	FD	4	w	25	w	SM	F	C	Lab	2	BEH	FDB	FCNS	WO	7.40		N	1.6	Y	0.1132	0.524		10	10	10	10	6	4	4	10	10	4	78
16	25961	Bressman, et al., 2002	Ammonium Metavanadate	100	Chicken (*Gallus domesticus*)	1	4	0/20/40/60	mg/kg diet	NR		ADL	U	FD	56	d	32	w	SM	F	C	Lab	1	BEH	FDB	FCNS	WO	20.0	40.0	N	1.6	Y	0.1049	1.31	2.62	10	10	5	10	6	4	10	10	10	4	79
17	8577	Sell et al, 1982	Ammonium vanadate	100	Chicken (*Gallus domesticus*)	1	4	0/10.2/27.5/30.4	mg/kg diet	NR		NR	M	FD	4	w	41	w	SM	F	C	Lab	1	BEH	FDB	FCNS	WO	27.5	30.4	N	1.6	Y	0.106	1.82	2.01	10	10	10	10	6	4	10	10	10	4	84
18	5749	Benabdeljelil and Jensen, 1990	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	1	4	0/10/30/100	mg/kg diet	N		ADL	U	FD	4	w	43	w	SM	F	C	Lab	2	BEH	FDB	FCNS	WO	30.0	100	N	1.6	Y	0.098	1.84	6.13	10	10	5	10	6	4	8	10	10	4	77
19	7051	Summers and Moran, 1972	Vanadium	100	Chicken (*Gallus domesticus*)	1	2	0/10	mg/kg diet	NR		NR	U	FD	3	w	NR	NR	JV	NR	C	Lab	3	BEH	FDB	FCNS	WO		10.0	N	0.564	Y	0.0191		0.339	10	10	5	10	6	4	4	10	10	4	73
20	5456	Toussant and Latshaw, 1994	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	1	2	0/18.6	mg/kg diet	NR		ADL	M	FD	14	d	25	w	SM	F	C	Lab	2	BEH	FDB	FCNS	WO		18.6	N	1.6	Y	0.114		1.33	10	10	10	10	6	4	4	10	10	4	78
21	5736	Hill, 1990	Sodium metavanadate	100	Chicken (*Gallus domesticus*)	1	2	0/40	mg/kg diet	NR		ADL	U	FD	18	d	1	d	JV	F	C	Lab	2	BEH	FDB	FCNS	WO		40.0	N	0.564	Y	0.025		1.77	10	10	5	10	6	4	4	10	10	4	73
22	6508	Ousterhout and Berg, 1981	Ammonium vanadate	100	Chicken (*Gallus domesticus*)	1	2	0/40	mg/kg diet	N		NR	U	FD	7	w	40-60	w	SM	F	C	Lab	2	BEH	FDB	FDNG	WO		40.0	N	1.6	Y	0.11		2.75	10	10	5	10	6	4	4	10	10	4	73
23	5734	Hill, 1990	Sodium vanadate	100	Chicken (*Gallus domesticus*)	1	2	0/40	mg/kg diet	NR		ADL	U	FD	19	d	1	d	JV	F	M	Lab	2	BEH	FDB	FCNS	WO		40.0	N	0.564	N	0.04009		2.84	10	10	5	10	5	4	4	10	10	4	72
Physiology																																														
24	6085	Cervantes and Jensen, 1986	Ammonium vanadate	100	Chicken (*Gallus domesticus*)	4	4	0/5/10/20	mg/kg diet	N		ADL	U	FD	4	w	1	d	JV	M	C	Lab	4	PHY	PHY	FDCV	WO	5.0	10.0	Y	0.65	Y	0.03829	0.295	0.589	10	10	5	10	7	4	10	10	10	4	80
25	6469	Sell et al, 1986	Dicalcium phosphate	100	Chicken (*Gallus domesticus*)	1	3	0/4.6/7.4	mg/kg diet	N		ADL	M	FD	4	w	25	w	SM	F	C	Lab	3	PHY	PHY	GPHY	EG	7.40		N	1.6	Y	0.1132	0.524		10	10	10	10	6	4	4	3	10	4	71
26	3740	Romoser,et al, 1961	Calcium vanadate	100	Chicken (*Gallus domesticus*)	3	4	0/23/48/55	mg/kg diet	NR		ADL	U	FD	21	d	9	d	JV	M	C	Lab	2	PHY	PHY	FDCV	WO	23.0	48.0	N	1.042	N	0.05978	1.32	2.75	10	10	5	10	5	4	10	10	10	4	78
27	3740	Romoser,et al, 1961	Calcium vanadate	100	Chicken (*Gallus domesticus*)	2	6	0/10/15/20/30/40	mg/kg diet	NR		ADL	U	FD	21	d	7	d	JV	M	C	Lab	2	PHY	PHY	FDCV	WO	30.0	40.0	N	1.3	N	0.06904	1.59	2.12	10	10	5	10	5	4	10	10	10	4	78
28	5736	Hill, 1990	Sodium metavanadate	100	Chicken (*Gallus domesticus*)	1	2	0/40	mg/kg diet	NR		ADL	U	FD	18	d	1	d	JV	F	C	Lab	3	PHY	PHY	FDCV	WO		40.0	N	0.564	Y	0.025		1.77	10	10	5	10	6	4	4	10	10	4	73
29	5971	Cupo and Donaldson, 1987	Sodium vanadate	100	Chicken (*Gallus domesticus*)	1	2	0/20	mg/kg diet	NR		ADL	U	FD	21	d	1	d	JV	M	C	Lab	2	PHY	PHY	FDCV	WO		20.0	Y	0.213	N	0.02127		2.00	10	10	5	10	6	4	4	10	10	4	73
30	3740	Romoser,et al, 1961	Calcium vanadate	100	Chicken (*Gallus domesticus*)	1	7	0/40/60/120/200/400/600	mg/kg diet	NR		ADL	U	FD	21	d	11	d	JV	M	C	Lab	3	PHY	PHY	FDCV	WO		40.0	N	1.3	N	0.06904		2.12	10	10	5	10	5	4	4	10	10	4	72
Pathology																																														
31	6412	Phillips et al, 1982	Calcium orthovanadate	17	Chicken (*Gallus domesticus*)	1	4	0/25/50/100	mg/kg diet	N		ADL	U	FD	15	d	1	d	JV	F	C	Lab	2	PTH	HIS	GHIS	KI	50.0	100	N	1.042	N	0.05978	0.489	0.977	10	10	5	10	5	4	10	10	10	4	78
32	5453	Hill, 1994	Ammoinium metavanadate	100	Chicken (*Gallus domesticus*)	1	2	0/50	mg/kg diet	NR		EOD	U	FD	21	d	1	d	JV	M	C	Lab	3	PTH	ORW	SMIX	HE	50.0		N	0.564	N	0.04009	3.55		10	10	5	10	5	4	4	10	10	4	72
33	6388	Kubena and Phillips 1982	Calcium orthovanadate	100	Chicken (*Gallus domesticus*)	1	5	0/12.5/25/50/100	mg/kg diet	N		ADL	UX	FD	20	w	29	w	SM	F	C	Lab	3	PTH	HIS	GHIS	WO	100		Y	1.206	N	0.06575	5.45		10	10	10	10	6	4	4	1	10	4	69
34	5971	Cupo and Donaldson, 1987	Sodium vanadate	100	Chicken (*Gallus domesticus*)	1	2	0/20	mg/kg diet	NR		ADL	U	FD	21	d	1	d	JV	M	C	Lab	3	PTH	ORW	ORWT	FP		20.0	Y	0.213	N	0.02127		2.00	10	10	5	10	6	4	4	10	10	4	73
35	6192	Kubena et al, 1985	Calcium orthovanadate	100	Chicken (*Gallus domesticus*)	1	2	0/50	mg/kg diet	N		ADL	U	FD	28	d	1	d	JV	M	C	Lab	4	PTH	ORW	ORWT	LI		50.0	Y	0.24345	N	0.0232		4.76	10	10	5	10	6	4	4	10	10	4	73
36	6876	Hafez and Kratzer 1976	Ammonium vanadate	100	Chicken (*Gallus domesticus*)	1	2	0/100	mg/kg diet	N		ADL	U	FD	8	w	1	d	JV	M	C	Lab	2	PTH	ORW	ORWT	LI		100	Y	0.3543	N	0.02962		8.36	10	10	5	10	6	4	4	10	10	4	73
Reproduction																																														
37	8577	Sell et al, 1982	Ammonium vanadate	100	Chicken (*Gallus domesticus*)	2	4	0/2/4/6/7.9	mg/kg diet	NR		NR	U	FD	7	d	41	w	LB	F	C	Lab	2	REP	EGG	EQUA	EG	4.0	6.0	N	1.6	Y	0.11	0.275	0.413	10	10	5	10	6	10	10	10	10	4	85
38	6469	Sell et al, 1986	Dicalcium phosphate	100	Chicken (*Gallus domesticus*)	1	3	0/4.6/7.4	mg/kg diet	N		ADL	M	FD	4	w	25	w	LB	F	C	Lab	1	REP	EGG	EQUA	EG	4.60	7.40	N	1.6	Y	0.1132	0.325	0.524	10	10	10	10	6	10	10	10	10	4	90
39	5843	Benabdeljelil and Jensen, 1989	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	1	2	0/5	mg/kg diet	N		ADL	U	FD	6	w	72	w	LB	F	C	Lab	3	REP	EGG	EGWT	EG	5.0		N	1.6	Y	0.117	0.366		10	10	5	10	6	10	4	1	10	4	70
40	6508	Ousterhout and Berg, 1981	Vanadate chloride	100	Chicken (*Gallus domesticus*)	5	3	0/20/40	mg/kg diet	N		NR	U	FD	4	w	40	w	LB	F	C	Lab	2	REP	EGG	EQUA	EG	20.0	40.0	N	1.6	N	0.07903	0.988	1.98	10	10	5	10	5	10	10	10	6	4	80
41	6508	Ousterhout and Berg, 1981	Vanadyl sulfate	100	Chicken (*Gallus domesticus*)	6	3	0/20/40	mg/kg diet	N		NR	U	FD	4	w	40	w	SM	F	C	Lab	2	REP	REP	EQUA	EG	20.0	40.0	N	1.6	N	0.07903	0.988	1.98	10	10	5	10	5	10	10	10	10	4	84
42	6388	Kubena and Phillips 1982	Calcium orthovanadate	100	Chicken (*Gallus domesticus*)	1	5	0/12.5/25/50/100	mg/kg diet	N		ADL	UX	FD	84	d	29	w	LB	F	C	Lab	5	REP	REP	TPRD	WO	25.0	50.0	Y	1.554	N	0.07755	1.25	2.50	10	10	10	10	6	10	10	10	10	4	90
43	6508	Ousterhout and Berg, 1981	Ammonium vanadate	100	Chicken (*Gallus domesticus*)	4	4	0/20/40/80	mg/kg diet	N		NR	U	FD	4	w	50	w	LB	F	C	Lab	1	REP	EGG	EQUA	EG	80.0		N	1.6	N	0.07903	3.95		10	10	5	10	5	10	4	1	10	4	69
44	6848	Hafez and Kratzer 1976	Ammonium vanadate	100	Chicken (*Gallus domesticus*)	1	3	0/100/300	mg/kg diet	N		ADL	U	FD	1	mo	28	w	LB	F	C	Lab	1	REP	REP	PROG	WO	100	300	N	1.6	N	0.07903	4.94	14.8	10	10	5	10	5	10	10	10	10	4	84
45	6848	Hafez and Kratzer 1976	Ammonium vanadate	100	Japanese Quail (*Coturnix japonica*)	2	5	0/50/100/200/300	mg/kg diet	N		ADL	U	FD	1	mo	NR	NR	LB	F	C	Lab	1	REP	REP	PROG	WO	300		N	0.1	N	0.013	39.0		10	10	5	10	5	10	4	6	10	4	74
46	5843	Benabdeljelil and Jensen, 1989	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	2	2	0/5	mg/kg diet	N		ADL	U	FD	8	w	25	w	LB	F	C	Lab	3	REP	EGG	EQUA	EG		5.0	N	1.6	Y	0.102		0.319	10	10	5	10	6	10	4	10	10	4	79
47	9749	Jensen and Maurice, 1980	Ammonium vanadate	100	Chicken (*Gallus domesticus*)	3	2	0/10	mg/kg diet	N		ADL	U	FD	6	w	NR	NR	LB	F	C	Lab	1	REP	EGG	EQUA	EG		10.0	Y	1.791	N	0.08505		0.475	10	10	5	10	6	10	4	10	10	4	79
48	9749	Jensen and Maurice, 1980	Ammonium vanadate	100	Chicken (*Gallus domesticus*)	1	3	0/10/20	mg/kg diet	N		ADL	U	FD	4	w	NR	NR	LB	F	C	Lab	1	REP	REP	EQUA	EG		10.0	N	1.6	N	0.07903		0.494	10	10	5	10	5	10	4	10	10	4	78
49	5749	Benabdeljelil and Jensen, 1990	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	1	4	0/10/30/100	mg/kg diet	N		ADL	U	FD	2	w	43	w	LB	F	C	Lab	3	REP	EGG	EQUA	EG		10.0	N	1.6	Y	0.107		0.669	10	10	5	10	6	10	4	10	10	4	79
50	8577	Sell et al, 1982	Ammonium vanadate	100	Chicken (*Gallus domesticus*)	1	4	0/10.2/27.5/30.4	mg/kg diet	NR		NR	M	FD	7	d	41	w	LB	F	C	Lab	3	REP	EGG	EQUA	EG		10.2	N	1.6	Y	0.116		0.740	10	10	10	10	6	10	4	10	10	4	84

Appendix 5.1 Avian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)
Vanadium
Page 2 of 3

Ref			Exposure																					Effects						Conversion to mg/kg bw/day				Result		Data Evaluation Score										
Result #	Ref N.	Reference	Chemical Form	MW%	Test Species	Phase #	# of Conc/ Doses	Conc/ Doses	Conc/Dose Units	Wet Weight Reported?	Percent Moisture	Application Frequency	Method of Analyses	Route of Exposure	Exposure Duration	Duration Units	Age	Age Units	Lifestage	Sex	Control Type	Test Location	Ednpoint Number	General Effect Group	Effect Type	Effect Measure	Response Site	Study NOAEL	Study LOAEL	Body Weight Reported?	Body Weight in kg	Ingestion Rate Reported?	Ingestion Rate in kg/day or L/day	NOAEL Dose (mg/kg/day)	LOAEL Dose (mg/kg/day)	Data Source	Dose Route	Test Concentrations	Chemical form	Dose Quantification	Endpoint	Dose Range	Statistical Power	Exposure Duration	Test Conditions	Total
51	9749	Jensen and Maurice, 1980	Ammonium vanadate	100	Chicken (*Gallus domesticus*)	2	2	0/20	mg/kg diet	N		ADL	U	FD	4	w	NR	NR	LB	F	C	Lab	1	REP	EGG	EQUA	EG		20.0	N	1.6	N	0.07903		0.988	10	10	5	10	5	10	4	10	10	4	78
52	6508	Ousterhout and Berg, 1981	Ammonium vanadate	100	Chicken (*Gallus domesticus*)	3	3	0/20/40	mg/kg diet	N		NR	U	FD	4	w	35-40	w	LB	F	C	Lab	2	REP	EGG	EQUA	EG		20.0	N	1.6	N	0.07903		0.988	10	10	5	10	5	10	4	10	10	4	78
53	25961	Bressman, et al., 2002	Ammonium Metavanadate	100	Chicken (*Gallus domesticus*)	1	4	0/20/40/60	mg/kg diet	NR		ADL	U	FD	14	d	32	w	LB	F	C	Lab	3	REP	EGG	ESQU	EG		20.0	N	1.6	Y	0.1049		1.31	10	10	5	10	6	10	4	10	10	4	79
54	5456	Toussant and Latshaw, 1994	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	1	2	0/18.6	mg/kg diet	NR		ADL	M	FD	9	d	25	w	LB	F	C	Lab	3	REP	REP	PROG	WO		18.6	N	1.6	Y	0.114		1.33	10	10	10	10	6	10	4	10	10	4	84
55	6508	Ousterhout and Berg, 1981	Ammonium vanadate	100	Chicken (*Gallus domesticus*)	2	3	0/40/80	mg/kg diet	N		NR	U	FD	4	w	48	w	LB	F	C	Lab	1	REP	EGG	EGWT	EG		40.0	Y	1.6	N	0.07903		1.98	10	10	5	10	6	10	4	10	10	4	79
56	6508	Ousterhout and Berg, 1981	Ammonium vanadate	100	Chicken (*Gallus domesticus*)	1	2	0/40	mg/kg diet	N		NR	U	FD	7	w	40-60	w	LB	F	C	Lab	3	REP	REP	TPRD	WO		40.0	N	1.6	Y	0.11		2.75	10	10	5	10	6	10	4	10	10	4	79
Growth																																														
57	6412	Phillips et al, 1982	Calcium orthovanadate	17	Chicken (*Gallus domesticus*)	1	4	0/25/50/100	mg/kg diet	N		ADL	U	FD	25	w	1	d	JV	F	C	Lab	1	GRO	GRO	BDWT	WO	25.0	50.0	N	1.042	N	0.05978	0.244	0.489	10	10	5	10	5	8	10	10	10	4	82
58	6085	Cervantes and Jensen, 1986	Ammonium vanadate	100	Chicken (*Gallus domesticus*)	2	2	0/5	mg/kg diet	N		ADL	U	FD	4	w	1	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	5.0		Y	0.687	Y	0.03839	0.279		10	10	5	10	7	8	4	1	10	4	69
59	15690	Nielsen et al, 1980	Ammonium metavandate	100	Chicken (*Gallus domesticus*)	1	2	0/5	ug/g diet	N		NR	U	FD	4	w	1	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	5.0		Y	1.07	N	0.06082	0.284		10	10	5	10	6	8	4	1	10	4	68
60	6085	Cervantes and Jensen, 1986	Ammonium vanadate	100	Chicken (*Gallus domesticus*)	1	4	0/5/10/20	mg/kg diet	N		ADL	U	FD	4	w	1	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	5.0	10.0	Y	0.65	Y	0.03829	0.295	0.589	10	10	5	10	7	8	10	10	10	4	84
61	397	Hill 1979	Sodium metavanadate	100	Chicken (*Gallus domesticus*)	3	4	0/3/6/12	mg/kg diet	N		ADL	U	FD	5	w	1	d	JV	F	C	NR	1	GRO	GRO	BDWT	WO	6.0	12.0	N	1.042	N	0.05978	0.344	0.688	10	10	5	10	5	8	10	10	10	4	82
62	5843	Benabdeljelil and Jensen, 1989	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	2	2	0/5	mg/kg diet	N		ADL	U	FD	8	w	25	w	SM	F	C	Lab	1	GRO	GRO	BDWT	WO	5.0		N	1.6	Y	0.102	0.366		10	10	5	10	6	8	4	1	10	4	68
63	9749	Jensen and Maurice, 1980	NH4VO3	100	Chicken (*Gallus domesticus*)	3	2	0/10	mg/kg diet	N		ADL	U	FD	6	w	NR	NR	SM	F	C	Lab	2	GRO	GRO	BDWT	WO	10.0		Y	1.791	N	0.08505	0.475		10	10	5	10	6	8	4	1	10	4	68
64	8125	Hill, 1990	Ammonium vanadate	100	Chicken (*Gallus domesticus*)	2	4	0/10/20/30	mg/kg diet	NR		ADL	U	FD	19	d	1	d	JV	F	C	Lab	1	GRO	GRO	BDWT	WO	10.0	20.0	N	0.564	N	0.04009	0.711	1.42	10	10	5	10	5	8	10	10	10	4	82
65	8125	Hill, 1990	Ammonium vanadate	100	Chicken (*Gallus domesticus*)	3	4	0/10/20/40	mg/kg diet	NR		ADL	U	FD	19	d	1	d	JV	F	C	Lab	1	GRO	GRO	BDWT	WO	10.0	20.0	N	0.564	N	0.04009	0.711	1.42	10	10	5	10	5	8	10	10	10	4	82
66	14512	Hathcock et al., 1964	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	1	3	0/10/25	mg/kg diet	Y		ADL	U	FD	14	d	1	d	JV	NR	C	Lab	2	GRO	GRO	BDWT	WO	10	25	N	0.328	N	0.02817	0.904	2.26	10	10	5	10	5	8	10	10	10	4	82
67	6508	Ousterhout and Berg, 1981	Ammonium vanadate	100	Chicken (*Gallus domesticus*)	3	3	0/20/40	mg/kg diet	N		NR	U	FD	4	w	35-40	w	SM	F	C	Lab	1	GRO	GRO	BDWT	WO	20.0	40.0	N	1.6	N	0.07903	0.988	1.98	10	10	5	10	5	8	10	10	10	4	82
68	3740	Romoser,et al, 1961	Calcium vanadate	100	Chicken (*Gallus domesticus*)	2	6	0/10/15/20/30/40	mg/kg diet	NR		ADL	U	FD	21	d	7	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	20.0	30.0	N	1.3	N	0.06904	1.050	1.59	10	10	5	10	5	8	10	10	10	4	82
69	5079	Qureshi et al, 1999	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	1	4	0/10/25/50	mg/kg diet	N		ADL	U	FD	14	d	1	d	JV	B	C	Lab	1	GRO	GRO	BDWT	WO	10.0	25.0	Y	0.12	N	0.01464	1.22	3.05	10	10	5	10	6	8	10	10	10	4	83
70	6388	Kubena and Phillips 1982	Calcium orthovanadate	100	Chicken (*Gallus domesticus*)	1	5	0/12.5/25/50/100	mg/kg diet	N		ADL	UX	FD	56	d	29	w	SM	F	C	Lab	1	GRO	GRO	BDWT	WO	25.0	50.0	Y	1.526	N	0.07663	1.26	2.51	10	10	10	10	6	8	10	10	10	4	88
71	5749	Benabdeljelil and Jensen, 1990	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	1	4	0/10/30/100	mg/kg diet	N		ADL	U	FD	4	w	43	w	SM	F	C	Lab	1	GRO	GRO	BDWT	WO	30.0	100	N	1.6	Y	0.098	1.84	6.13	10	10	5	10	6	8	8	10	10	4	81
72	6508	Ousterhout and Berg, 1981	Vanadyl dichloride	100	Chicken (*Gallus domesticus*)	5	3	0/20/40	mg/kg diet	N		NR	U	FD	4	w	40	w	SM	F	C	Lab	1	GRO	GRO	BDWT	WO	40.0		N	1.6	N	0.07903	1.98		10	10	5	10	5	8	4	1	10	4	67
73	6508	Ousterhout and Berg, 1981	Vanadyl sulfate	100	Chicken (*Gallus domesticus*)	6	3	0/20/40	mg/kg diet	N		NR	U	FD	4	w	40	w	SM	F	C	Lab	1	GRO	GRO	BDWT	WO	40.0		N	1.6	N	0.07903	1.98		10	10	5	10	5	8	4	1	10	4	67
74	8577	Sell et al, 1982	Ammonium vanadate	100	Chicken (*Gallus domesticus*)	1	4	0/10.2/27.5/30.4	mg/kg diet	NR		NR	M	FD	4	w	41	w	SM	F	C	Lab	2	GRO	GRO	BDWT	WO	30.4		N	1.6	Y	0.116	2.20		10	10	10	10	6	8	4	1	10	4	73
75	14516	Nelson et al, 1962	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	2	5	0/17/27/47/87	mg/kg diet	NR		ADL	U	FD	4	w	NR	NR	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	27	47	Y	0.319	N	0.02766	2.34	4.07	10	10	5	10	6	8	10	10	10	4	83
76	6041	Kubena et al, 1986	Calcium orthovanadate	100	Chicken (*Gallus domesticus*)	1	3	0/12.5/25.0	mg/kg diet	N		ADL	U	FD	28	d	1	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	25.0		Y	0.25035	N	0.02363	2.36		10	10	5	10	6	8	4	1	10	4	68
77	14516	Nelson et al, 1962	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	1	10	0/14.07/17/21.14/27/35.2	mg/kg diet	NR		ADL	U	FD	4	w	NR	NR	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	35.3	47.0	Y	0.464	N	0.0353	2.68	3.58	10	10	5	10	6	8	10	10	10	4	83
78	8663	Hafez and Kratzer 1976	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	1	4	0/50/100/200	mg/kg diet	N		ADL	U	FD	4	w	1	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	50.0	100	N	1.042	N	0.05978	2.87	5.74	10	10	5	10	5	8	10	10	10	4	82
79	6848	Hafez and Kratzer 1976	Ammonium vanadate	100	Japanese Quail (*Coturnix japonica*)	3	5	0/50/100/200/300	mg/kg diet	N		ADL	U	FD	4	w	1	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	300		N	0.0618	N	0.0095	46.1		10	10	5	10	5	8	4	8	10	4	74
80	7051	Summers and Moran, 1972	Vanadium	100	Chicken (*Gallus domesticus*)	1	2	0/10	mg/kg diet	NR		NR	U	FD	3	w	NR	NR	JV	NR	C	Lab	2	GRO	GRO	BDWT	WO		10.0	N	0.564	Y	0.0191		0.339	10	10	5	4	6	8	4	10	10	4	71
81	92	Hill, 1974	Sodium Vanadate	100	Chicken (*Gallus domesticus*)	1	6	0/5/10/15/20/25	mg/kg diet	N		ADL	U	FD	2	w	1	d	JV	B	C	Lab	1	GRO	GRO	BDWT	WO		5.0	N	0.328	N	0.02817		0.429	10	10	5	10	5	8	4	10	10	4	76
82	9290	Berg and Lawrence, 1971	Vanadyl Sulfate	100	Chicken (*Gallus domesticus*)	3	3	0/10/20	mg/kg diet	NR		ADL	U	FD	2	w	NR	NR	JV	M	C	Lab	1	GRO	GRO	BDWT	WO		10.0	N	0.328	N	0.02817		0.859	10	10	5	10	5	8	4	10	10	4	76
83	9290	Berg and Lawrence, 1971	Ammonium Metavanadate	100	Chicken (*Gallus domesticus*)	2	3	0/10/20	mg/kg diet	NR		ADL	U	FD	2	w	NR	NR	JV	M	C	Lab	1	GRO	GRO	BDWT	WO		10.0	N	0.328	N	0.02817		0.859	10	10	5	10	5	8	4	10	10	4	76
84	9290	Berg and Lawrence, 1971	Vanadyl Dichloride	100	Chicken (*Gallus domesticus*)	4	3	0/10/20	mg/kg diet	NR		ADL	U	FD	2	w	NR	NR	JV	M	C	Lab	1	GRO	GRO	BDWT	WO		10.0	N	0.328	N	0.02817		0.859	10	10	5	10	5	8	4	10	10	4	76
85	5927	Blalock and Hill, 1987	Vanadyl chloride	100	Chicken (*Gallus domesticus*)	1	4	0/10/20/40	mg/kg diet	N		NR	U	FD	3	w	1	d	JV	F	C	Lab	1	GRO	GRO	BDWT	WO		10.0	Y	0.233	N	0.02255		0.968	10	10	5	10	6	8	4	10	10	4	77
86	3740	Romoser,et al, 1961	Calcium vanadate	100	Chicken (*Gallus domesticus*)	3	4	0/23/48/55	mg/kg diet	NR		ADL	U	FD	21	d	9	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO		23.0	N	1.042	N	0.05978		1.32	10	10	5	10	5	8	4	10	10	4	76
87	5456	Toussant and Latshaw, 1994	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	1	2	0/18.6	mg/kg diet	NR		ADL	M	FD	14	d	25	w	SM	F	C	Lab	1	GRO	GRO	BDWT	WO		18.6	N	1.6	Y	0.114		1.33	10	10	10	10	6	8	4	10	10	4	82
88	1370	Hill, 1979	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	1	2	0/20	mg/kg diet	N		ADL	U	FD	2	w	1	d	JV	B	C	Lab	1	GRO	GRO	BDWT	WO		20	N	0.328	N	0.02817		1.72	10	10	5	10	5	8	4	10	10	4	76
89	5736	Hill, 1990	Sodium metavanadate	100	Chicken (*Gallus domesticus*)	1	2	0/40	mg/kg diet	NR		ADL	U	FD	18	d	1	d	JV	F	C	Lab	1	GRO	GRO	BDWT	WO		40.0	N	0.564	Y	0.025		1.77	10	10	5	10	6	8	4	10	10	4	77
90	8125	Hill, 1990	Sodium metavanadate	100	Chicken (*Gallus domesticus*)	1	2	0/25	mg/kg diet	NR		ADL	U	FD	19	d	1	d	JV	F	C	Lab	1	GRO	GRO	BDWT	WO		25.0	N	0.564	N	0.04009		1.78	10	10	5	10	5	8	4	10	10	4	76
91	5971	Cupo and Donaldson, 1987	Sodium vanadate	100	Chicken (*Gallus domesticus*)	1	2	0/20	mg/kg diet	NR		ADL	U	FD	21	d	1	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO		20.0	Y	0.213	N	0.02127		2.00	10	10	5	10	6	8	4	10	10	4	77
92	3740	Romoser,et al, 1961	Calcium vanadate	100	Chicken (*Gallus domesticus*)	1	7	0/40/60/120/200/400/600	mg/kg diet	NR		ADL	U	FD	21	d	11	d	JV	M	C	Lab	2	GRO	GRO	BDWT	WO		40.0	N	1.3	N	0.06904		2.12	10	10	5	10	5	8	4	10	10	4	76
93	5736	Hill, 1990	Sodium metavanadate	100	Chicken (*Gallus domesticus*)	2	2	0/30	mg/kg diet	NR		ADL	U	FD	18	d	1	d	JV	F	C	Lab	1	GRO	GRO	BDWT	WO		30.0	N	0.564	N	0.04009		2.13	10	10	5	10	5	8	4	10	10	4	76
94	1370	Hill, 1979	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	2	2	0/25	mg/kg diet	N		ADL	U	FD	2	w	1	d	JV	B	C	Lab	1	GRO	GRO	BDWT	WO		25	N	0.328	N	0.02817		2.15	10	10	5	10	5	8	4	10	10	4	76
95	14512	Hathcock et al., 1964	Vanadyl Sulfate	100	Chicken (*Gallus domesticus*)	2	2	0/25	mg/kg diet	NR		ADL	U	FD	14	d	1	d	JV	NR	C	Lab	2	GRO	GRO	BDWT	WO		25	N	0.328	N	0.02817		2.15	10	10	5	10	5	8	4	10	10	4	76
96	395	Hill, 1980	Sodium Vanadate	100	Chicken (*Gallus domesticus*)	1	2	0/25	mg/kg diet	NR		NR	U	FD	1	w	1	d	JV	F	C	Lab	1	GRO	GRO	BDWT	WO		25.0	N	0.328	N	0.02817		2.15	10	10	5	10	5	8	4	10	10	4	76
97	92	Hill, 1974	Sodium Vanadate	100	Chicken (*Gallus domesticus*)	2	3	0/25/50	mg/kg diet	N		ADL	U	FD	2	w	1	d	JV	F	C	Lab	1	GRO	GRO	BDWT	WO		25.0	N	0.328	N	0.02817		2.15	10	10	5	10	5	8	4	10	10	4	76
98	6508	Ousterhout and Berg, 1981	Ammonium vanadate	100	Chicken (*Gallus domesticus*)	1	2	0/40	mg/kg diet	N		NR	U	FD	7	w	40-60	w	SM	F	C	Lab	1	GRO	GRO	BDWT	WO		40.0	N	1.6	Y	0.11		2.75	10	10	5	10	6	8	4	10	10	4	77
99	5734	Hill, 1990	Sodium vanadate	100	Chicken (*Gallus domesticus*)	1	2	0/40	mg/kg diet	NR		ADL	U	FD	19	d	1	d	JV	F	M	Lab	1	GRO	GRO	BDWT	WO		40.0	N	0.564	N	0.04009		2.84	10	10	5	10	5	8	4	10	10	4	76
100	8663	Hafez and Kratzer 1976	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	2	4	0/50/100/200	mg/kg diet	N		ADL	U	FD	4	w	1	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO		50.0	N	1.042	N	0.05978		2.87	10	10	5	10	5	8	4	10	10	4	76
101	8663	Hafez and Kratzer 1976	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	3	3	0/50/200	mg/kg diet	N		ADL	U	FD	4	w	1	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO		50.0	N	1.041	N	0.05974		2.87	10	10	5	10	5	8	4	10	10	4	76
102	5453	Hill, 1994	Ammoinium metavanadate	100	Chicken (*Gallus domesticus*)	1	2	0/50	mg/kg diet	NR		EOD	U	FD	21	d	1	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO		50.0	N	0.564	N	0.04009		3.55	10	10	5	10	5	8	4	10	10	4	76
103	8028	Hill, 1992	Ammonium Metavanadate	100	Chicken (*Gallus domesticus*)	1	2	0/50	mg/kg diet	NR		ADL	U	FD	19	d	1	d	JV	NR	C	Lab	1	GRO	GRO	BDWT	WO		50.0	N	0.564	N	0.04009		3.55	10	10	5	10	5	8	4	10	10	4	76
104	14512	Hathcock et al., 1964	Ammonium Metavanadate	100	Chicken (*Gallus domesticus*)	3	2	0/50	mg/kg diet	NR		ADL	U	FD	14	d	1	d	JV	NR	C	Lab	2	GRO	GRO	BDWT	WO		50	N	0.328	N	0.02817		4.29	10	10	5	10	5	8	4	10	10	4	76

Appendix 5.1 Avian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)
Vanadium
Page 3 of 3

Ref			Exposure																					Effects						Conversion to mg/kg bw/day				Result		Data Evaluation Score										
Result #	Ref N.	Reference	Chemical Form	MW%	Test Species	Phase #	# of Conc/ Doses	Conc/ Doses	Conc/Dose Units	Wet Weight Reported?	Percent Moisture	Application Frequency	Method of Analyses	Route of Exposure	Exposure Duration	Duration Units	Age	Age Units	Lifestage	Sex	Control Type	Test Location	Ednpoint Number	General Effect Group	Effect Type	Effect Measure	Response Site	Study NOAEL	Study LOAEL	Body Weight Reported?	Body Weight in kg	Ingestion Rate Reported?	Ingestion Rate in kg/day or L/day	NOAEL Dose (mg/kg/day)	LOAEL Dose (mg/kg/day)	Data Source	Dose Route	Test Concentrations	Chemical form	Dose Quantification	Endpoint	Dose Range	Statistical Power	Exposure Duration	Test Conditions	Total
105	5295	Burt et al, 1991	Ammonium metavanandate	100	Chicken (*Gallus domesticus*)	1	2	0/50	mg/kg diet	N		NR	U	FD	14	d	1	d	JV	NR	C	Lab	1	GRO	GRO	BDWT	WO		50.0	N	0.328	N	0.02817		4.29	10	10	5	10	5	8	4	10	10	4	76
106	6192	Kubena et al, 1985	Calcium orthovanadate	100	Chicken (*Gallus domesticus*)	1	2	0/50	mg/kg diet	N		ADL	U	FD	14	d	1	d	JV	M	C	Lab	2	GRO	GRO	BDWT	WO		50.0	Y	0.24345	N	0.0232		4.76	10	10	5	10	6	8	4	10	10	4	77
107	8663	Hafez and Kratzer 1976	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	5	3	0/100/200	mg/kg diet	NR		ADL	U	FD	4	w	1	d	JV	M	C	Lab	2	GRO	GRO	BDWT	WO		100	N	1.04E-06	N	0.05978		5.74	10	10	5	10	5	8	4	10	10	4	76
108	6876	Hafez and Kratzer 1976	Ammonium vanadate	100	Chicken (*Gallus domesticus*)	1	2	0/100	mg/kg diet	N		ADL	U	FD	8	w	1	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO		100	Y	0.3543	N	0.02962		8.36	10	10	5	10	6	8	4	10	10	4	77
Survival																																														
109	14512	Hathcock et al., 1964	Ammonium Metavanadate	100	Chicken (*Gallus domesticus*)	1	3	0/10/25	mg/kg diet	NR		ADL	U	FD	14	d	1	d	JV	NR	C	Lab	1	MOR	MOR	MORT	WO	10	25	N	0.328	N	0.02817	0.859	2.15	10	10	5	10	5	9	10	10	10	4	83
110	5927	Blalock and Hill, 1987	Vanadyl chloride	100	Chicken (*Gallus domesticus*)	1	4	0/10/20/40	mg/kg diet	N		NR	U	FD	3	w	1	d	JV	F	C	Lab	2	MOR	MOR	MORT	WO	10.0	20.0	Y	0.237	N	0.0228	0.962	1.92	10	10	5	10	6	9	10	10	10	4	84
111	1370	Hill, 1979	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	1	2	0/20	mg/kg diet	N		ADL	U	FD	2	w	1	d	JV	B	C	Lab	2	MOR	MOR	MORT	WO	20		N	0.328	N	0.02817	1.72		10	10	5	10	5	9	4	1	10	4	68
112	92	Hill, 1974	Sodium Vanadate (NaVO3)	100	Chicken (*Gallus domesticus*)	2	3	0/25/50	mg/kg diet	N		ADL	U	FD	5	w	1	d	JV	B	C	Lab	2	MOR	MOR	MORT	WO	25.0	50.0	N	0.328	N	0.02817	2.15	4.294	10	10	5	10	5	9	10	10	10	4	83
113	1370	Hill, 1979	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	2	2	0/25	mg/kg diet	N		ADL	U	FD	2	w	1	d	JV	B	C	Lab	2	MOR	MOR	MORT	WO	25		N	0.328	N	0.02817	2.15		10	10	5	10	5	9	4	1	10	4	68
114	92	Hill, 1974	Sodium Vanadate (NaVO3)	100	Chicken (*Gallus domesticus*)	1	6	0/5/10/15/20/25	mg/kg diet	N		ADL	U	FD	5	w	1	d	JV	F	C	Lab	2	MOR	MOR	MORT	WO	25.0		N	0.328	N	0.02817	2.15		10	10	5	10	5	9	4	10	10	4	77
115	6041	Kubena et al, 1986	Calcium orthovanadate	100	Chicken (*Gallus domesticus*)	1	3	0/12.5/25.0	mg/kg diet	NR		ADL	U	FD	28	d	1	d	JV	M	C	Lab	3	MOR	MOR	MORT	WO	25.0		Y	0.25035	N	0.02363	2.36		10	10	5	10	6	9	4	10	10	4	78
116	6388	Kubena and Phillips 1982	Calcium orthovanadate	100	Chicken (*Gallus domesticus*)	1	5	0/12.5/25/50/100	mg/kg diet	N		ADL	UX	FD	84	d	29	w	SM	F	C	Lab	2	MOR	MOR	MORT	WO	50.0	100	Y	1.554	N	0.07755	2.50	4.99	10	10	10	10	6	9	10	10	10	4	89
117	8663	Hafez and Kratzer 1976	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	3	3	0/50/200	mg/kg diet	N		ADL	U	FD	4	w	1	d	JV	M	C	Lab	2	MOR	MOR	MORT	WO	50.0	200	N	1.042	N	0.05978	2.87	11.5	10	10	5	10	5	9	10	10	10	4	83
118	8663	Hafez and Kratzer 1976	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	2	4	0/50/100/200	mg/kg diet	N		ADL	U	FD	4	w	1	d	JV	M	C	Lab	2	MOR	MOR	MORT	WO	50	100.0	N	1.042	N	0.05978	2.87	5.74	10	10	5	10	5	9	10	10	10	4	83
119	5453	Hill, 1994	Ammoinium metavanadate	100	Chicken (*Gallus domesticus*)	1	2	0/50	mg/kg diet	NR		EOD	U	FD	21	d	1	d	JV	M	C	Lab	4	MOR	MOR	MORT	WO	50.0		N	0.564	N	0.04009	3.55		10	10	5	10	5	9	4	3	10	4	70
120	6192	Kubena et al, 1985	Calcium orthovanadate	100	Chicken (*Gallus domesticus*)	1	2	0/50	mg/kg diet	N		ADL	U	FD	28	d	1	d	JV	M	C	Lab	1	MOR	MOR	MORT	WO	50.0		Y	0.24345	N	0.0232	4.76		10	10	5	10	6	9	4	10	10	4	78
121	8663	Hafez and Kratzer 1976	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	1	4	0/50/100/200	mg/kg diet	N		ADL	U	FD	4	w	1	d	JV	M	C	Lab	2	MOR	MOR	MORT	WO	100	200	N	1.042	N	0.05978	5.74	11.5	10	10	5	10	5	9	10	10	10	4	83
122	3740	Romoser,et al, 1961	Calcium vanadate	100	Chicken (*Gallus domesticus*)	1	7	0/40/60/120/200/400/60(	mg/kg diet	NR		ADL	U	FD	21	d	11	d	JV	M	C	Lab	1	MOR	MOR	MORT	WO	120	200	N	1.3	N	0.06904	6.37	10.6	10	10	5	10	5	9	10	10	10	4	83
123	5079	Qureshi et al, 1999	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	1	4	0/10/25/50	mg/kg diet	N		ADL	U	FD	14	d	1	d	JV	B	C	Lab	2	MOR	MOR	MORT	WO	50.0		Y	0.076	N	0.01087	7.15		10	10	5	10	6	9	4	10	10	4	78
124	6727	White and Dieter, 1978	Vanadyl sulfate	100	Duck (*Anas platyrhynchos*)	1	4	0/2.84/10.36/110	mg/kg diet	Y		ADL	M	FD	12	w	1	yr	AD	B	V	Lab	4	MOR	MOR	MORT	WO	110		Y	1.17	Y	0.121	12.0		10	10	10	10	7	9	4	10	6	4	80
125	80	Van Vleet et al, 1981	Vanadate	100	Duck (*Anas sp.)*	1	2	0/100	mg/kg diet	N		ADL	U	FD	15	d	1	d	JV	M	C	Lab	2	MOR	MOR	MORT	WO	100		N	0.092	N	0.01231	13.4		10	10	5	10	5	9	4	1	10	4	68
126	6848	Hafez and Kratzer 1976	Ammonium vanadate	100	Chicken (*Gallus domesticus*)	1	3	0/100/300	mg/kg diet	N		ADL	U	FD	1	mo	28	w	JV	F	C	Lab	3	MOR	MOR	MORT	WO	300		N	1.6	N	0.07903	14.8		10	10	5	10	5	9	4	10	10	4	77
127	6848	Hafez and Kratzer 1976	Ammonium vanadate	100	Japanese Quail (*Coturnix japonica*)	3	5	0/50/100/200/300	mg/kg diet	N		ADL	U	FD	4	w	1	d	JV	M	C	Lab	2	MOR	MOR	MORT	WO	300		N	0.0618	N	0.0095	98.7		10	10	5	10	5	9	4	10	10	4	77
128	9290	Berg and Lawrence, 1971	Ammonium Metavanadate	100	Chicken (*Gallus domesticus*)	1	2	0/20	mg/kg diet	NR		ADL	U	FD	2	w	NR	NR	JV	M	C	Lab	1	MOR	MOR	MORT	WO		20.0	N	0.328	N	0.02817		1.72	10	10	5	10	5	9	4	10	10	4	77
129	14512	Hathcock et al., 1964	Vanadyl Sulfate	100	Chicken (*Gallus domesticus*)	2	2	0/25	mg/kg diet	NR		ADL	U	FD	14	d	1	d	JV	NR	C	Lab	1	MOR	MOR	MORT	WO		25	N	0.328	N	0.02817		2.15	10	10	5	10	5	9	4	10	10	4	77
130	14512	Hathcock et al., 1964	Ammonium Metavanadate	100	Chicken (*Gallus domesticus*)	3	2	0/50	mg/kg diet	NR		ADL	U	FD	14	d	1	d	JV	NR	C	Lab	1	MOR	MOR	MORT	WO		50	N	0.328	N	0.02817		4.29	10	10	5	10	5	9	4	10	10	4	77
131	8663	Hafez and Kratzer 1976	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	5	3	0/100/200	mg/kg diet	NR		ADL	U	FD	4	w	1	d	JV	M	C	Lab	1	MOR	MOR	MORT	WO		100	N	1.042	N	0.05978		5.74	10	10	5	10	5	9	4	10	10	4	77
Data Not Used to Derive TRV																																													
132	6085	Cervantes and Jensen, 1986	Ammonium vanadate	100	Chicken (*Gallus domesticus*)	2	2	0/5	mg/kg diet	N		ADL	U	FD	4	w	1	d	JV	M	C	Lab	2	PHY	PHY	FDCV	WO	5.0		Y	0.687	Y	0.03839	0.279		10	10	5	10	7	4	4	1	10	4	65
133	6085	Cervantes and Jensen, 1986	Ammonium vanadate	100	Chicken (*Gallus domesticus*)	2	2	0/5	mg/kg diet	N		ADL	U	FD	4	w	1	d	JV	M	C	Lab	3	BEH	FDB	FCNS	WO	5.0		Y	0.687	Y	0.03839	0.279		10	10	5	10	7	4	4	1	10	4	65
134	6085	Cervantes and Jensen, 1986	Ammonium vanadate	100	Chicken (*Gallus domesticus*)	2	2	0/5	mg/kg diet	N		ADL	U	FD	4	w	1	d	JV	M	C	Lab	3	BIO	CHM	KCON	LI	5.0		Y	0.687	Y	0.03839	0.279		10	10	5	10	7	1	4	1	10	4	65
135	5843	Benabdeljelil and Jensen, 1989	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	2	2	0/5	mg/kg diet	N		ADL	U	FD	8	w	25	w	SM	F	C	Lab	2	BEH	FDB	FCNS	WO	5.0		N	1.6	Y	0.102	0.319		10	10	5	10	6	4	4	1	10	4	64
136	7051	Summers and Moran, 1972	Vanadium	100	Chicken (*Gallus domesticus*)	1	2	0/10	mg/kg diet	NR		NR	U	FD	3	w	NR	NR	JV	NR	C	Lab	1	MOR	MOR	SURV	WO	10.0		N	0.564	Y	0.0191	0.339		10	10	5	4	6	9	4	1	10	4	63
137	7051	Summers and Moran, 1972	Vanadium	100	Chicken (*Gallus domesticus*)	1	2	0/10	mg/kg diet	NR		NR	U	FD	3	w	NR	NR	JV	NR	C	Lab	4	BIO	CHM	PCON	PL	10.0		N	0.564	Y	0.0191	0.339		10	10	5	4	6	1	4	1	10	4	55
138	5843	Benabdeljelil and Jensen, 1989	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	1	2	0/5	mg/kg diet	N		ADL	U	FD	6	w	72	w	AD	F	C	Lab	1	GRO	GRO	BDWT	WO	5.0		N	1.6	Y	0.117	0.366		10	10	5	10	6	8	4	1	6	4	64
139	5843	Benabdeljelil and Jensen, 1989	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	1	2	0/5	mg/kg diet	N		ADL	U	FD	6	w	72	w	AD	F	C	Lab	2	BEH	FDB	FCNS	WO	5.0		N	1.6	Y	0.117	0.366		10	10	5	10	6	4	4	1	6	4	60
140	8577	Sell et al, 1982	Ammonium vanadate	100	Chicken (*Gallus domesticus*)	2	4	0/2/4/6/7.9	mg/kg diet	NR		NR	U	FD	4	w	41	w	SM	F	C	Lab	1	BEH	FDB	FCNS	WO	7.90		N	1.6	Y	0.108	0.533		10	10	5	10	6	4	4	1	10	4	64
141	6085	Cervantes and Jensen, 1986	Ammonium vanadate	100	Chicken (*Gallus domesticus*)	1	4	0/5/10/20	mg/kg diet	N		ADL	U	FD	4	w	1	d	JV	M	C	Lab	3	BIO	CHM	KCON	LI	20.0		Y	0.557	Y	0.0345	1.24		10	10	5	10	7	1	4	1	10	4	62
142	6041	Kubena et al, 1986	Calcium orthovanadate	100	Chicken (*Gallus domesticus*)	1	3	0/12.5/25.0	mg/kg diet	NR		ADL	U	FD	28	d	1	d	JV	M	C	Lab	4	PTH	ORW	SMIX	LI	25.0		Y	0.25035	N	0.02363	2.36		10	10	5	10	6	4	4	1	10	4	64
143	6041	Kubena et al, 1986	Calcium orthovanadate	100	Chicken (*Gallus domesticus*)	1	3	0/12.5/25.0	mg/kg diet	NR		ADL	U	FD	28	d	1	d	JV	M	C	Lab	2	BEH	FDB	FEFF	WO	25.0		Y	0.25035	N	0.02363	2.36		10	10	5	10	6	4	4	1	10	4	64
144	5734	Hill, 1990	Sodium vanadate	100	Chicken (*Gallus domesticus*)	1	2	0/40	mg/kg diet	NR		ADL	U	FD	19	d	1	d	JV	F	M	Lab	3	BIO	CHM	GBCM	LI	40.0		N	0.564	N	0.04009	2.84		10	10	5	10	5	1	4	6	10	4	65
145	25961	Bressman, et al., 2002	Ammonium Metavanadate	100	Chicken (*Gallus domesticus*)	1	4	0/20/40/60	mg/kg diet	NR		ADL	U	FD	56	d	32	w	SM	F	C	Lab	2	PHY	PHY	FDCV	WO	60.0		N	1.6	Y	0.0894	3.35		10	10	5	10	6	4	4	1	10	4	64
146	8028	Hill, 1992	Ammonium Metavanadate	100	Chicken (*Gallus domesticus*)	1	2	0/50	mg/kg diet	NR		ADL	U	FD	20	d	1	d	JV	NR	C	Lab	2	BIO	CHM	NADP	LI	50.0		N	0.564	N	0.04009	3.55		10	10	5	10	5	1	4	3	10	4	62
147	5295	Burt et al, 1991	Ammonium metavanandate	100	Chicken (*Gallus domesticus*)	1	2	0/50	mg/kg diet	N		NR	U	FD	14	d	14	d	JV	NR	C	Lab	2	BIO	CHM	LIPD	MU	50.0		N	0.328	N	0.02817	4.29		10	10	5	10	5	1	4	3	10	4	62
148	6192	Kubena et al, 1985	Calcium orthovanadate	100	Chicken (*Gallus domesticus*)	1	2	0/50	mg/kg diet	N		ADL	U	FD	28	d	1	d	JV	M	C	Lab	5	BIO	CHM	HMGL	SR	50.0		Y	0.24345	N	0.0232	4.76		10	10	5	10	6	1	4	1	10	4	61
149	6192	Kubena et al, 1985	Calcium orthovanadate	100	Chicken (*Gallus domesticus*)	1	2	0/50	mg/kg diet	NR		ADL	U	FD	28	d	1	d	JV	M	C	Lab	3	BEH	FDB	FEFF	WO	50.0		Y	0.24345	N	0.0232	4.76		10	10	5	10	6	4	4	1	10	4	64
150	14516	Nelson et al, 1962	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	2	5	0/17/27/47/87	mg/kg diet	NR		ADL	U	FD	4	w	NR	NR	JV	M	C	Lab	1	PHY	PHY	FDCV	WO	87		Y	0.206	N	0.0208	8.79		10	10	5	10	6	4	4	1	10	4	64
151	14516	Nelson et al, 1962	Ammonium metavanadate	100	Chicken (*Gallus domesticus*)	1	10	0/14.07/17/21.14/27/35.2	mg/kg diet	NR		ADL	U	FD	4	w	NR	NR	JV	M	C	Lab	2	PHY	PHY	FDCV	WO	120.1		Y	0.235	N	0.02267	11.6		10	10	5	10	6	4	4	1	10	4	64
152	80	Van Vleet et al, 1981	Vanadate	100	Duck (*Anas sp.)*	1	2	0/100	mg/kg diet	N		ADL	U	FD	15	d	1	d	JV	M	C	Lab	1	PTH	HIS	NCRO	MT	100		N	0.092	N	0.01231	13.4		10	10	5	10	5	4	4	1	10	4	63
153	80	Van Vleet et al, 1981	Vanadate	100	Duck (*Anas sp.)*	1	2	0/100	mg/kg diet	N		ADL	U	FD	15	d	1	d	JV	M	C	Lab	3	BIO	ENZ	GLPX	BL	100		N	0.092	N	0.01231	13.4		10	10	5	10	5	1	4	3	10	4	62
154	6848	Hafez and Kratzer 1976	Ammonium vanadate	100	Chicken (*Gallus domesticus*)	1	3	0/100/300	mg/kg diet	N		ADL	U	FD	1	mo	28	w	JV	F	C	Lab	2	BIO	CHM	CHOL	YO	300		N	1.6	N	0.07903	14.8		10	10	5	10	5	1	4	1	10	4	60
155	6848	Hafez and Kratzer 1976	Ammonium vanadate	100	Japanese Quail (*Coturnix japonica*)	2	5	0/50/100/200/300	mg/kg diet	N		ADL	U	FD	1	mo	NR	NR	AD	F	C	Lab	2	BIO	CHM	CHOL	YO	300		N	0.1	N	0.013	39.0		10	10	5	10	5	1	4	1	10	4	60

Eco-SSL
Ecological Soil Screening Levels

Appendix 6-1

Mammalian Toxicity Data Extracted and Reviewed for Wildlife Toxicity Reference Value (TRV) - Vanadium

April 2005

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Ref			Exposure																				Effects						Conversion to mg/kg bw/day					Result		Data Evaluation Score										
Result #	Ref N.		Chemical Form	MW%	Test Species	Phase #	# of Conc/ Doses	Conc/ Doses	Conc/Dose Units	Wet Weight Reported?	Percent Moisture	Application Frequency	Method of Analyses	Route of Exposure	Exposure Duration	Duration Units	Age	Age Units	Lifestage	Sex	Control Type	Test Location		General Effect Group	Effect Type	Effect Measure	Response Site	Study NOAEL	Study LOAEL	Body Weight Reported?	Body Weight in kg	Ingestion Rate Reported?	Ingestion Rate in kg or L/day	NOAEL Dose (mg/kg/day)	LOAEL Dose (mg/kg/day)	Data Source	Dose Route	Test Concentrations	Chemical form	Dose Quantification	Endpoint	Dose Range	Statistical Power	Exposure Duration	Test Conditions	Total
Biochemical																																														
1	17942	Mravcova et al, 1989	Vanadium pentoxide	100	Rat (*Rattus norvegicus*)	1	3	0/0.2/100	mg/L	NR		ADL	U	DR	3	mo	21	d	JV	M	C	Lab	3	BIO	CHM	HMGL	BL	0.20	100	Y	0.35	N	0.0384854	0.0220	11.0	10	5	5	10	6	1	6	10	10	4	67
2	17758	Jadhav and Jandhyala, 1983	Vanadate	51.49	Rat (*Rattus norvegicus*)	1	3	0/1.9/22.2	mg/kg bw/d	NR		DLY	U	DR	6	w	NR	NR	JV	M	C	Lab	3	BIO	ENZ	NKAT	KI	1.90	22.2	Y	0.25	Y	0.029	0.978	11.4	10	5	5	10	10	1	6	10	10	4	71
3	17806	Domingo et al, 1985	Sodium metavanadate	100	Rat (*Rattus norvegicus*)	1	4	0/5/10/50	mg/L	NR		ADL	U	DR	3	mo	NR	NR	JV	M	C	Lab	5	BIO	CHM	PRTL	PL	10.0	50.0	Y	0.5416	N	0.0570093	1.05	5.26	10	5	5	10	6	1	8	10	10	4	69
4	17668	Zaporowska, 1994	Analytical ammonium metavanadate	100	Rat (*Rattus norvegicus*)	1	5	0/1.18/4.93/12.99/22.06	mg/kg bw/d	NR		ADL	U	DR	4	w	2	mo	JV	M	C	Lab	2	BIO	CHM	ASCA	KI	1.18	4.93	N	0.217	N	0.002502	1.18	4.93	10	5	5	10	10	1	8	10	10	4	73
5	17431	Bogden et al, 1982	Sodium metavanadate	100	Rat (*Rattus norvegicus*)	1	3	0/5/25	mg/kg diet	N		ADL	U	FD	2	w	NR	NR	JV	F	C	Lab	1	BIO	ENZ	NKAT	BR	25.0		Y	0.233	N	0.0207455	2.23		10	10	5	10	6	1	4	8	10	4	68
6	17908	MacDonald et al, 1988	Sodium orthovanadate	100	Guinea Pig (*Cavia porcellus*)	1	2	0/2.55	mg/org/d	NR		ADL	U	DR	20	d	NR	NR	JV	M	C	Lab	2	BIO	CHM	NACO	BL	25.0		Y	0.65	Y	0.06718	2.55		10	5	5	10	7	1	4	10	10	4	66
7	14511	Hansard, et al, 1978	Ammonium vanadate	100	Sheep (*Ovis aries*)	1	4	0/10/100/200	mg/kg diet	NR		DLY	UX	FD	84	d	NR	NR	JV	M	C	Lab	4	BIO	CHM	HMGL	WO	200		Y	54.5	Y	1.55	5.69		10	10	10	10	7	1	4	1	6	10	69
8	149	Van Vleet et al, 1981	Ammonium metavanadate	100	Pig (*Sus scrofa*)	1	2	0/200	mg/kg diet	N		ADL	U	FD	10	w	NR	NR	JV	M	C	Lab	4	BIO	ENZ	GLPX	BL	200		Y	16.6	N	0.6916487	8.33		10	10	5	10	6	1	4	10	10	4	70
9	17849	Susic and Kentera, 1986	Ammonium vanadate	43.55	Rat (*Rattus norvegicus*)	1	2	0/300	mg/kg diet	N		NR	U	FD	2	mo	NR	NR	JV	M	C	Lab	4	BIO	CHM	HMCT	BL	300		Y	0.358	N	0.029529	10.8		10	10	5	10	6	1	4	10	10	4	70
10	17911	Susic and Kentera, 1987	Sodium vanadate	100	Rat (*Rattus norvegicus*)	1	3	0/5/47	mg/org/d	NR		ADL	U	FD	24	w	3-3.5	mo	JV	M	C	Lab	3	BIO	CHM	HMCT	BL	5.0	47.0	Y	0.358	N	0.029529	14.0	131	10	10	5	10	6	1	8	10	10	4	74
11	17421	Zaporowska et al, 1993	Ammonium metavanadate	100	Rat (*Rattus norvegicus*)	1	3	0/1.18/4.93	mg/kg bw/d	NR		NR	U	DR	4	w	2	mo	JV	M	C	Lab	3	BIO	CHM	RBCE	BL		1.18	Y	0.25383	Y	1.763E-05		1.18	10	5	5	10	10	1	4	10	10	4	69
12	17331	Sharma et al, 1986	Sodium orthovanadate	100	Mouse (*Mus musculus*)	1	4	0/1.88/7.07/17.24	mg/kg bw/d	N		ADL	U	DR	30	d	NR	NR	JV	M	C	Lab	1	BIO	HRM	NORE	HY		1.88	Y	0.027	N	0.0038359		1.88	10	5	10	10	10	1	4	10	10	4	74
13	15506	Schroeder, 1968	Vanadyl sulfate	100	Rat (*Rattus norvegicus*)	1	2	0/5.444	mg/kg bw/d	NR		ADL	U	DR	738	d	21-23	d	JV	B	C	Lab	1	BIO	CHM	CHOL	SR		5.44	N	0.51	N	0.0268903		5.44	10	5	5	10	10	1	4	10	10	4	69
14	17283	Meryervitch et al. 1987	Sodium metavanadate	100	Rat (*Rattus norvegicus*)	1	2	0/24	mg/kg bw/d	NR		ADL	U	DR	3	w	NR	NR	JV	M	C	Lab	2	BIO	CHM	GCHM	LI		24	Y	0.2714	Y	0.03257		24	10	5	5	10	10	1	4	10	10	4	69
15	14517	Mountain et al, 1953	Vanadium Pentoxide	100	Rat (*Rattus norvegicus*)	1	3	0/10.33/18.88	mg/org/d	NR		ADL	U	FD	76	d	NR	NR	JV	M	C	Lab	3	BIO	CHM	GBCM	HA		10.3	Y	0.392	Y	0.0183		26.4	10	10	5	10	7	1	4	10	10	4	71
16	17933	Zaporowska and Wasilewski, 1989	Ammonium metavanadate	100	Rat (*Rattus norvegicus*)	1	2	0/29	mg/kg bw/d	NR		NR	U	DR	4	w	2	mo	JV	M	C	Lab	4	BIO	CHM	RBCE	BL		29.0	Y	0.250	Y	1.51E-05		29.0	10	5	5	10	10	1	4	10	10	4	69
17	17448	Higashino et al, 1983	Sodium metavanadate	100	Rat (*Rattus norvegicus*)	1	3	0/4612/21695	mg/kg bw/d	NR		NR	M	FD	2	w	NR	NR	JV	F	C	Lab	1	BIO	CHM	NACO	PL		4612	Y	0.2349	N	0.0208844		4612	10	10	10	10	7	1	4	10	10	4	76
Behavior																																														
18	17421	Zaporowska et al, 1993	Ammonium metavanadate	100	Rat (*Rattus norvegicus*)	1	3	0/1.18/4.93	mg/kg bw/d	NR		NR	U	DR	4	w	2	mo	JV	M	C	Lab	1	BEH	FDB	WCON	WO	1.18	4.93	Y	0.25785	Y	1.763E-05	1.18	4.93	10	5	5	10	10	4	8	10	10	4	76
19	17465	Sanchez et al, 1991	Sodium orthovanadate	27.7	Mouse (*Mus musculus*)	1	5	0/7.5/15/30/60	mg/kg bw/d	N		DLY	U	GV	9	d	NR	NR	GE	F	C	Lab	2	BEH	FDB	FCNS	WO	7.50	15.0	Y	0.0355	N	0.004	2.08	4.16	10	8	10	10	10	4	10	10	10	4	86
20	14511	Hansard, et al, 1978	Ammonium vanadate	100	Sheep (*Ovis aries*)	1	4	0/10/100/200	mg/kg diet	N		DLY	UX	FD	2	w	NR	NR	JV	M	C	Lab	2	BEH	FDB	FCNS	WO	100	200	Y	38.75	Y	1.55	4.00	8.00	10	10	10	10	7	4	10	10	10	10	91
21	17668	Zaporowska, 1994	Analytical ammonium metavanadate	100	Rat (*Rattus norvegicus*)	1	5	0/1.18/4.93/12.99/22.06	mg/kg bw/d	NR		ADL	U	DR	4	w	2	mo	JV	M	C	Lab	1	BEH	FDB	FCNS	WO	4.93	12.99	N	0.217	N	0.002502	4.93	13.0	10	5	5	10	10	4	10	10	10	4	78
22	17677	Hansard et al, 1982	Ammonium metavanadate	100	Sheep (*Ovis aries*)	1	3	0/50/200	mg/kg diet	NR		ADL	U	FD	90	d	NR	NR	JV	M	C	Lab	2	BEH	FDB	FCNS	WO	200		Y	51.28	Y	1.4	5.46		10	10	5	10	7	4	4	3	10	4	67
23	17515	Parker and Sharma, 1978	Vanadyl sulfate or Sodium orthovanadate	100	Rat (*Rattus norvegicus*)	1	3	0/854/8540	ug/kg bw/d	NR		NR	U	DR	3	mo	1	mo	JV	NR	C	Lab	2	BEH	FDB	FCNS	WO	8540		Y	0.45	Y	0.3795556	8.54		10	5	5	10	7	4	4	8	10	4	67
24	17487	Paternain et al, 1990	Vanadyl sulfate pentahydrate	20.13	Mouse (*Mus musculus*)	1	4	0/37.5/75/150	mg/kg bw/d	N		DLY	U	GV	9	d	NR	NR	GE	F	C	Lab	3	BEH	FDB	FCNS	WO	150		Y	0.0045	Y	0.0052185	30.2		10	8	10	10	10	4	4	8	10	4	78
25	14508	Franke and Moxon 1937	Sodium metavanadate	100	Rat (*Rattus norvegicus*)	1	2	0/1.88	mg/kg bw/d	N		DLY	U	FD	100	d	28	d	JV	M	C	Lab	2	BEH	FDB	FCNS	WO		1.88	Y	0.2528	Y	0.0105		1.88	10	10	5	10	10	4	4	10	10	4	77
26	14508	Franke and Moxon 1937	Sodium vanadate	100	Rat (*Rattus norvegicus*)	2	2	0/3.58	mg/kg bw/d	N		DLY	U	FD	100	d	28	d	JV	M	C	Lab	2	BEH	FDB	FCNS	WO		3.58	Y	0.151	Y	0.00775		3.58	10	10	5	10	10	4	4	10	10	4	77
27	17205	Adachi et al, 2000	Sodium metavanadate	100	Rat (*Rattus norvegicus*)	1	2	0/7060	ug/kg bw/d	NR		ADL	U	FD	5	d	6	w	JV	F	C	Lab	2	BEH	FDB	FCNS	WO		7060	Y	0.142	Y	0.01		7.06	10	10	5	10	10	4	4	10	10	4	77
28	17357	Dai et al, 1995	Vanadyl sulfate hydrate	100	Rat (*Rattus norvegicus*)	2	2	0/7.64	mg/kg bw/d	NR		ADL	U	DR	1	w	NR	NR	JV	M	C	Lab	2	BEH	FDB	FCNS	WO		7.64	Y	0.55	N	0.0578045		7.64	10	5	5	10	10	4	4	10	10	4	72
29	17357	Dai et al, 1995	Ammonium metavanadate	100	Rat (*Rattus norvegicus*)	1	2	0/9.68	mg/kg bw/d	NR		ADL	U	DR	8	w	NR	NR	JV	M	C	Lab	2	BEH	FDB	WCON	WO		9.68	Y	0.52	N	0.0549589		9.68	10	5	5	10	10	4	4	10	10	4	72
30	17292	Cadene et al, 1996	Vanadyl sulfate pentahydrate	20.14	Rat (*Rattus norvegicus*)	1	2	0/0.75	mg/ml	NR		ADL	U	DR	6	mo	NR	NR	JV	M	C	Lab	2	BEH	FDB	WCON	WO		0.75	Y	0.4196	Y	0.0321		11.6	10	5	5	10	7	4	4	10	10	4	69
31	17224	Zaporowska and Scibior, 1999	Ammonium metavanadate	100	Rat (*Rattus norvegicus*)	1	2	0/11.6	mg/kg bw/d	NR		ADL	U	DR	4	w	2	mo	JV	M	C	Lab	2	BEH	FDB	FCNS	WO		11.6	Y	0.260	Y	0.01961		11.6	10	5	5	10	7	4	4	10	10	4	69
32	17283	Meryervitch et al. 1987	Sodium metavanadate	100	Rat (*Rattus norvegicus*)	1	2	0/24	mg/kg bw/d	NR		ADL	U	DR	3	w	NR	NR	JV	M	C	Lab	2	BEH	FDB	WCON	WO		24	Y	0.2714	Y	0.03257		24	10	5	5	10	10	4	4	10	10	4	72
33	17379	Ganguli et al, 1994	Sodium orthovanadate	100	Rat (*Rattus norvegicus*)	1	2	0/0.25	mg/ml	NR		DLY	U	DR	10	d	NR	NR	GE	F	C	Lab	2	BEH	FDB	WCON	WO		0.250	Y	0.23	N	0.0263749		28.7	10	5	5	10	6	4	4	10	10	4	68
34	17933	Zaporowska and Wasilewski, 1989	Ammonium metavanadate	100	Rat (*Rattus norvegicus*)	1	2	0/29	mg/kg bw/d	NR		NR	U	DR	2	w	2	mo	JV	M	C	Lab	3	BEH	FDB	WCON	WO		29.0	Y	0.225	Y	1.425E-05		29.0	10	5	5	10	10	4	4	10	10	4	72
Physiology																																														
35	17806	Domingo et al, 1985	Sodium metavanadate	100	Rat (*Rattus norvegicus*)	1	4	0/5/10/50	mg/L	NR		ADL	U	DR	2	w	NR	NR	JV	M	C	Lab	3	PHY	PHY	EXCR	KI	10.0	50.0	Y	0.1868	Y	0.04164	2.23	11.1	10	5	5	10	7	4	8	10	10	4	73
36	14511	Hansard, et al, 1978	Ammonium vanadate	100	Sheep (*Ovis aries*)	1	4	0/10/100/200	mg/kg diet	NR		DLY	UX	FD	84	d	NR	NR	JV	M	C	Lab	3	PHY	PHY	FDCV	WO	200		Y	54.5	Y	1.55	5.69		10	10	10	10	7	4	4	6	10	10	81
37	17758	Jadhav and Jandhyala, 1983	Vanadate	51.49	Rat (*Rattus norvegicus*)	1	3	0/1.9/22.2	mg/kg bw/d	NR		DLY	U	DR	6	w	NR	NR	JV	M	C	Lab	1	PHY	PHY	BLPR	WO	22.2		Y	0.25	Y	0.029	11.4		10	5	5	10	10	4	4	6	10	4	68
38	17292	Cadene et al, 1996	Vanadyl sulfate pentahydrate	20.14	Rat (*Rattus norvegicus*)	1	2	0/0.75	mg/ml	NR		ADL	U	DR	6	mo	NR	NR	JV	M	C	Lab	3	PHY	PHY	GPHY	HE	0.75		Y	0.4196	Y	0.0321	11.6		10	5	5	10	7	4	4	10	10	4	69
39	17336	Hamel and Duckworth, 1995	Sodium orthovanadate	100	Rat (*Rattus norvegicus*)	1	2	0/81.5	mg/kg bw/d	NR		ADL	U	FD	14	d	39-41	d	JV	M	C	Lab	1	PHY	PHY	GPHY	LI	81.5		N	0.14	N	0.0136482	81.5		10	10	5	10	10	4	4	1	10	4	68
40	17328	Carmignani et al, 1996	Sodium metavanadate	100	Rabbit (*Oryctolagus cuniculus*)	1	2	0/1	mg/L	NR		NR	U	DR	12	mo	3	mo	JV	M	C	Lab	1	PHY	PHY	BDVL	WO		1.0	N	3.76	N	0.3260651		0.08672	10	5	5	10	5	4	4	10	10	4	67
41	17375	Boscolo, et al, 1994	Sodium metavanadate	100	Rat (*Rattus norvegicus*)	1	2	0/1	ug/g	NR		NR	U	DR	180	d	NR	NR	JV	M	C	Lab	1	PHY	PHY	BLPR	WO		1.0	N	0.267	N	0.0301644		0.11298	10	5	5	10	5	4	4	10	10	4	67
42	17908	MacDonald et al, 1988	Sodium orthovanadate	100	Guinea Pig (*Cavia porcellus*)	1	2	0/2.55	mg/org/d	NR		ADL	U	DR	14	d	NR	NR	JV	M	C	Lab	1	PHY	PHY	EXCR	KI		25.0	Y	0.65	Y	0.06718		2.55	10	5	5	10	7	4	4	10	10	4	69
43	17263	Elfant and Keen, 1987	Sodium metavanadate	100	Rat (*Rattus norvegicus*)	2	2	0/75	ug/g diet	NR		ADL	U	FD	3	w	NR	NR	GE	F	C	Lab	3	PHY	PHY	GPHY	LI		75	Y	0.334	N	0.0278918		6.26	10	10	5	10	6	4	4	10	10	4	73
44	17849	Susic and Kentera, 1986	Ammonium vanadate	43.55	Rat (*Rattus norvegicus*)	1	2	0/300	mg/kg diet	NR		NR	U	FD	2	mo	NR	NR	JV	M	C	Lab	1	PHY	PHY	BLPR	WO		300	Y	0.358	N	0.029529		10.8	10	10	5	10	6	4	4	10	10	4	73
45	17224	Zaporowska and Scibior, 1999	Ammonium metavanadate	100	Rat (*Rattus norvegicus*)	1	2	0/11.6	mg/kg bw/d	NR		ADL	U	DR	4	w	2	mo	JV	M	C	Lab	3	PHY	PHY	FDCV	WO		11.6	Y	0.260	Y	0.01961		11.6	10	5	5	10	7	4	4	10	10	4	69
46	17911	Susic and Kentera, 1987	Sodium vanadate	100	Rat (*Rattus norvegicus*)	1	3	0/5/47	mg/org/d	NR		ADL	U	FD	24	w	3-3.5	mo	JV	M	C	Lab	2	PHY	PHY	GPHY	WO		5.0	Y	0.358	N	0.029529		14.0	10	10	5	10	6	4	4	10	10	4	73
Pathology																																														
47	17942	Mravcova et al, 1989	Vanadium pentoxide	100	Rat (*Rattus norvegicus*)	1	3	0/0.2/100	mg/L	NR		ADL	U	DR	3	mo	21	d	JV	M	C	Lab	2	PTH	ORW	ORWT	SP	0.20	100	Y	0.35	N	0.0384854	0.0220	11.0	10	5	5	10	6	4	6	10	10	4	70
48	17400	Mravcova et al, 1993	Vanadium oxide	100	Rat (*Rattus norvegicus*)	1	3	0/1/100	mg/L	NR		NR	U	DR	6	mo	NR	NR	NR	B	C	Lab	1	PTH	ORW	ORWT	SP	1.0	100	N	0.5	N	0.0530528	0.106	10.6	10	5	5	10	5	4	6	10	10	4	69
49	17465	Sanchez et al, 1991	Sodium orthovanadate	27.7	Mouse (*Mus musculus*)	1	5	0/7.5/15/30/60	mg/kg bw/d	N		DLY	U	GV	12	d	NR	NR	GE	F	C	Lab	3	PTH	ORW	SMIX	KI	15.0	30.0	Y	0.0471	N	0.006	4.16	8.31	10	8	10	10	10	4	10	10	10	4	86
50	17487	Paternain et al, 1990	Vanadyl sulfate pentahydrate	20.13	Mouse (*Mus musculus*)	1	4	0/37.5/75/150	mg/kg bw/d	N		DLY	U	GV	9	d	NR	NR	GE	F	C	Lab	4	PTH	ORW	ORWT	LI	37.5	75.0	Y	0.0043	Y	0.0054171	7.55	15.1	10	8	10	10	10	4	10	10	10	4	86
51	252	Schroeder et al, 1970	Vanadyl Sulfate	100	Rat (*Rattus norvegicus*)	2	2	0/5	mg/L	NR		ADL	U	DR	1202	d	21	d	JV	B	C	Lab	1	PTH	ORW	ORWT	HE		5	Y	0.4728	N	0.0504481		0.534	10	5	5	10	6	4	4	10	10	4	68
52	17400	Mravcova et al, 1993	Vanadium oxide	100	Mouse (*Mus musculus*)	2	2	0/4.29	mg/kg bw/d	NR		X per w	U	GV	6	w	NR	NR	NR	B	C	Lab	1	PTH	ORW	ORWT	SP		4.29	N	0.0375	N	0.0046218		4.29	10	8	10	10	10	4	4	10	3	4	68
53	149	Van Vleet et al, 1981	Ammonium metavanadate	100	Pig (*Sus scrofa*)	1	2	0/200	mg/kg diet	N		ADL	U	FD	10	w	NR	NR	JV	M	C	Lab	3	PTH	HIS	GLSN	HE		200	Y	16.6	N	0.6916487		8.33	10	10	5	10	6	4	4	10	10	4	73
54	17849	Susic and Kentera, 1986	Ammonium vanadate	43.55	Rat (*Rattus norvegicus*)	1	2	0/300	mg/kg diet	NR		NR	U	FD	2	mo	NR	NR	JV	M	C	Lab	3	PTH	ORW	SMIX	HE		300	Y	0.358	N	0.029529		10.8	10	10	5	10	6	4	4	10	10	4	73

Ref			Exposure																					Effects						Conversion to mg/kg bw/day				Result		Data Evaluation Score										
Result #	Ref N.		Chemical Form	MW%	Test Species	Phase #	# of Conc/ Doses	Conc/ Doses	Conc/Dose Units	Wet Weight Reported?	Percent Moisture	Application Frequency	Method of Analyses	Route of Exposure	Exposure Duration	Duration Units	Age	Age Units	Lifestage	Sex	Control Type	Test Location		General Effect Group	Effect Type	Effect Measure	Response Site	Study NOAEL	Study LOAEL	Body Weight Reported?	Body Weight in kg	Ingestion Rate Reported?	Ingestion Rate in kg or L/day	NOAEL Dose (mg/kg/day)	LOAEL Dose (mg/kg/day)	Data Source	Dose Route	Test Concentrations	Chemical form	Dose Quantification	Endpoint	Dose Range	Statistical Power	Exposure Duration	Test Conditions	Total
Reproduction																																														
55	17465	Sanchez et al, 1991	Sodium orthovanadate	27.7	Mouse (*Mus musculus*)	1	5	0/7.5/15/30/60	mg/kg bw/d	N		DLY	U	GV	12	d	NR	NR	GE	F	C	Lab	4	REP	REP	ODVP	WO	15.0	30.0	Y	0.0471	N	0.006	4.16	8.31	10	8	10	10	10	10	10	10	10	4	92
56	17864	Domingo et al, 1986	Sodium metavanadate	43.55	Rat (*Rattus norvegicus*)	1	4	0/5/10/20	mg/kg bw/d	N		DLY	U	OR	36	d	NR	NR	GE	F	C	Lab	1	REP	REP	PRWT	WO		5.0	Y	0.28	N	0.024128		2.18	10	8	10	10	10	10	4	10	10	4	86
57	17263	Elfant and Keen, 1987	Sodium metavanadate	100	Rat (*Rattus norvegicus*)	2	2	0/75	ug/g diet	NR		ADL	U	FD	3	w	NR	NR	GE	F	C	Lab	2	REP	REP	PROG	WO		75	Y	0.334	N	0.0278918		6.26	10	10	5	10	6	10	4	10	10	4	79
58	17487	Paternain et al, 1990	Vanadyl sulfate pentahydrate	20.13	Mouse (*Mus musculus*)	1	4	0/37.5/75/150	mg/kg bw/d	N		DLY	U	GV	9	d	NR	NR	GE	F	C	Lab	5	REP	REP	RSEM	WO		37.5	Y	0.0042	Y	0.0053013		7.55	10	8	10	10	10	10	4	10	10	4	86
59	17379	Ganguli et al, 1994	Sodium orthovanadate	100	Rat (*Rattus norvegicus*)	1	2	0/0.25	mg/ml	NR		DLY	U	DR	10	d	NR	NR	GE	F	C	Lab	3	REP	REP	PROG	WO		0.250	Y	0.23	N	0.0263749		28.7	10	5	5	10	6	10	4	10	10	4	74
Growth																																														
60	17942	Mravcova et al, 1989	Vanadium pentoxide	100	Rat (*Rattus norvegicus*)	1	3	0/0.2/100	mg/L	NR		ADL	U	DR	8	w	21	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	0.20	100	Y	0.35	N	0.0384854	0.0220	11.0	10	5	5	10	6	8	6	10	10	4	74
61	252	Schroeder et al, 1970	Vanadyl Sulfate	100	Rat (*Rattus norvegicus*)	1	2	0/5	mg/L	NR		ADL	U	DR	519	d	21	d	JV	B	C	Lab	1	GRO	GRO	BDWT	WO	5.0		Y	0.4728	N	0.0504481	0.534		10	5	5	10	6	8	4	10	10	4	72
62	1858	Schroeder and Mitchener, 1975	Vanadyl sulfate	100	Mouse (*Mus musculus*)	1	2	0/5	mg/L	NR		NR	U	DR	520	d	19-20	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	5.0		Y	0.0455	N	0.0061354	0.674		10	5	5	10	6	8	4	8	10	4	70
63	14507	Daniel and Lillie, 1938	Sodium metavanadate	100	Rat (*Rattus norvegicus*)	1	6	0/0.444/1.03/5.11/9.78/19.0	mg/kg bw/d	NR		ADL	U	FD	10	w	3-4	w	JV	B	C	Lab	1	GRO	GRO	BDWT	WO	1.03	5.11	Y	0.242	Y	0.0214019	1.03	5.11	10	10	5	10	7	8	8	10	10	4	82
64	17431	Bogden et al, 1982	Sodium metavanadate	100	Rat (*Rattus norvegicus*)	1	3	0/5/25	mg/kg diet	N		ADL	U	FD	2	w	NR	NR	JV	F	C	Lab	2	GRO	GRO	BDWT	WO	25.0		Y	0.233	N	0.0207455	2.23		10	10	5	10	6	8	4	6	10	4	73
65	17276	Sanchez et al, 1998	Sodium metavanadate	41.78	Rat (*Rattus norvegicus*)	1	4	0/4.1/8.2/16.4	mg/kg bw/d	NR		DLY	U	GV	3	w	NR	NR	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	8.20	16.4	Y	0.4468	N	0.0354283	3.43	6.85	10	8	5	10	10	8	10	10	10	4	85
66	17806	Domingo et al, 1985	Sodium metavanadate	100	Rat (*Rattus norvegicus*)	1	4	0/5/10/50	mg/L	NR		ADL	U	DR	3	mo	NR	NR	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	50.0		Y	0.5416	Y	0.04164	3.84		10	5	5	10	7	8	4	8	10	4	71
67	17465	Sanchez et al, 1991	Sodium orthovanadate	27.7	Mouse (*Mus musculus*)	1	5	0/7.5/15/30/60	mg/kg bw/d	N		DLY	U	GV	9	d	NR	NR	GE	F	C	Lab	1	GRO	GRO	BDWT	WO	15.0	30.0	Y	0.0428	N	0.00515	4.16	8.31	10	8	10	10	10	8	10	10	10	4	90
68	17421	Zaporowska et al, 1993	Ammonium metavanadate	100	Rat (*Rattus norvegicus*)	1	3	0/1.18/4.93	mg/kg bw/d	NR		NR	U	DR	4	w	2	mo	JV	M	C	Lab	2	GRO	GRO	BDWT	WO	4.93		Y	0.25785	Y	1.763E-05	4.93		10	5	5	10	10	8	4	6	10	4	72
69	17677	Hansard et al, 1982	Ammonium metavanadate	100	Sheep (*Ovis aries*)	1	3	0/50/200	mg/kg diet	NR		ADL	U	FD	90	d	NR	NR	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	200		Y	51.28	Y	1.4	5.46		10	10	5	10	7	8	4	6	10	4	74
70	14511	Hansard, et al, 1978	Ammonium vanadate	100	Sheep (*Ovis aries*)	1	4	0/10/100/200	mg/kg diet	N		DLY	UX	FD	84	d	NR	NR	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	200		Y	54.5	Y	1.55	5.69		10	10	10	10	7	8	4	3	10	10	82
71	14511	Hansard, et al, 1978	Ammonium vanadate	100	Sheep (*Ovis aries*)	1	4	0/10/100/200	mg/kg diet	N		DLY	UX	FD	84	d	NR	NR	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	200		Y	54.5	Y	1.55	5.69		10	10	10	10	7	8	4	3	10	10	82
72	17205	Adachi et al, 2000	Sodium metavanadate	100	Rat (*Rattus norvegicus*)	1	2	0/7060	ug/kg bw/d	NR		ADL	U	FD	1	w	6	w	JV	F	C	Lab	1	GRO	GRO	BDWT	WO	7060		Y	0.145	Y	0.0105	7.06		10	10	5	10	10	8	4	1	10	4	72
73	17357	Dai et al, 1995	Vanadyl sulfate hydrate	100	Rat (*Rattus norvegicus*)	2	2	0/7.64	mg/kg bw/d	NR		ADL	U	DR	12	w	NR	NR	JV	F	C	Lab	1	GRO	GRO	BDWT	WO	7.64		Y	0.55	N	0.0578045	7.64		10	5	5	10	10	8	4	1	10	4	67
74	17357	Dai et al, 1995	Ammonium metavanadate	100	Rat (*Rattus norvegicus*)	1	2	0/9.68	mg/kg bw/d	NR		ADL	U	DR	12	w	NR	NR	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	9.68		Y	0.52	N	0.0549589	9.68		10	5	5	10	10	8	4	1	10	4	67
75	17849	Susic and Kentera, 1986	Ammonium vanadate	43.55	Rat (*Rattus norvegicus*)	1	2	0/300	mg/kg diet	NR		NR	U	FD	2	mo	NR	NR	JV	M	C	Lab	2	GRO	GRO	BDWT	WO	300		Y	0.358	N	0.029529	10.8		10	10	5	10	6	8	4	10	10	4	77
76	17292	Cadene et al, 1996	Vanadyl sulfate pentahydrate	20.14	Rat (*Rattus norvegicus*)	1	2	0/0.75	mg/ml	NR		ADL	U	DR	6	mo	NR	NR	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	0.75		Y	0.4196	Y	0.0321	11.6		10	5	5	10	7	8	4	8	10	4	71
77	17283	Meryervitch et al. 1987	Sodium metavanadate	100	Rat (*Rattus norvegicus*)	1	2	0/24	mg/kg bw/d	NR		ADL	U	DR	3	w	NR	NR	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	24		Y	0.2714	Y	0.03257	24		10	5	5	10	10	8	4	3	10	4	73
78	17911	Susic and Kentera, 1987	Sodium vanadate	100	Rat (*Rattus norvegicus*)	1	3	0/5/47	mg/org/d	NR		ADL	U	FD	24	w	3-3.5	mo	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	47.0		Y	0.345	N	0.0286447	136		10	10	5	10	6	8	4	10	10	4	77
79	17448	Higashino et al, 1983	Sodium metavanadate	100	Rat (*Rattus norvegicus*)	1	3	0/4612/21695	mg/kg bw/d	NR		NR	M	FD	2	w	NR	NR	JV	F	C	Lab	2	GRO	GRO	BDWT	WO	21695		Y	0.2349	N	0.0208844	21695		10	10	10	10	7	8	4	6	10	4	79
80	14508	Franke and Moxon 1937	Sodium metavanadate	100	Rat (*Rattus norvegicus*)	1	2	0/1.88	mg/kg bw/d	N		DLY	U	FD	100	d	28	d	JV	B	C	Lab	1	GRO	GRO	BDWT	WO		1.88	Y	0.2528	Y	0.0105		1.88	10	10	5	10	10	8	4	10	10	4	81
81	14508	Franke and Moxon 1937	Sodium vanadate	100	Rat (*Rattus norvegicus*)	2	2	0/3.58	mg/kg bw/d	N		DLY	U	FD	100	d	28	d	JV	B	C	Lab	1	GRO	GRO	BDWT	WO		3.58	Y	0.151	Y	0.00775		3.58	10	10	5	10	10	8	4	10	10	4	81
82	17263	Elfant and Keen, 1987	Sodium metavanadate	100	Rat (*Rattus norvegicus*)	2	2	0/75	ug/g diet	NR		ADL	U	FD	3	w	NR	NR	GE	F	C	Lab	1	GRO	GRO	BDWT	WO		75	Y	0.334	N	0.0278918		6.26	10	10	5	10	6	8	4	10	10	4	77
83	17284	Challiss et al, 1987	Sodium orthovanadate	27.7	Rat (*Rattus norvegicus*)	1	2	0/5	mg/org/d	NR		ADL	U	DR	14	d	NR	NR	JV	M	C	Lab	1	GRO	GRO	BDWT	WO		5.0	Y	0.2032	N	0.0235921		6.82	10	5	5	10	6	8	4	10	10	4	72
84	17487	Paternain et al, 1990	Vanadyl sulfate pentahydrate	20.13	Mouse (*Mus musculus*)	1	4	0/37.5/75/150	mg/kg bw/d	N		DLY	U	GV	9	d	NR	NR	GE	F	C	Lab	2	GRO	GRO	BDWT	WO		37.5	Y	0.0042	Y	0.0053013		7.55	10	8	10	10	10	8	4	10	10	4	84
85	149	Van Vleet et al, 1981	Ammonium metavanadate	100	Pig (*Sus scrofa*)	1	2	0/200	mg/kg diet	N		ADL	U	FD	3	w	NR	NR	JV	M	C	Lab	1	GRO	GRO	BDWT	WO		200	N	10.6	N	0.4783636		9.03	10	10	5	10	5	8	4	10	10	4	76
86	17224	Zaporowska and Scibior, 1999	Ammonium metavanadate	100	Rat (*Rattus norvegicus*)	1	2	0/11.6	mg/kg bw/d	NR		ADL	U	DR	4	w	2	mo	JV	M	C	Lab	1	GRO	GRO	BDWT	WO		11.6	Y	0.260	Y	0.01961		11.6	10	5	5	10	7	8	4	10	10	4	73
87	17688	Bhanot et al, 1994	Vanadyl sulfate	25.59	Rat (*Rattus norvegicus*)	1	2	0/0.75	mg/ml	NR		ADL	U	DR	3	w	6	w	JV	M	C	Lab	2	GRO	GRO	BDWT	WO		0.750	Y	0.334	N	0.0368984		21.2	10	5	5	10	6	8	4	10	10	4	72
88	14517	Mountain et al, 1953	Vanadium Pentoxide	100	Rat (*Rattus norvegicus*)	1	3	0/10.33/18.88	mg/org/d	NR		ADL	U	FD	76	d	NR	NR	JV	M	C	Lab	1	GRO	GRO	BDWT	WO		10.3	Y	0.392	Y	0.0183		26.4	10	10	5	10	7	8	4	10	10	4	78
89	17933	Zaporowska and Wasilewski, 1989	Ammonium metavanadate	100	Rat (*Rattus norvegicus*)	1	2	0/29	mg/kg bw/d	NR		NR	U	DR	8	w	2	mo	JV	M	C	Lab	2	GRO	GRO	BDWT	WO		29.0	Y	0.270	Y	1.386E-05		29.0	10	5	5	10	10	8	4	10	10	4	76
90	17927	Ramanadham et al, 1989	Vanadyl sulfate trihydrate	100	Rat (*Rattus norvegicus*)	1	2	0/1	mg/ml	NR		ADL	U	DR	10	w	NR	NR	JV	M	C	Lab	1	GRO	GRO	BDWT	WO		1.0	Y	0.413	N	0.0446674		108	10	5	5	5	6	8	4	10	10	4	67
Survival																																														
91	1858	Schroeder and Mitchener, 1975	Vanadyl sulfate	100	Mouse (*Mus musculus*)	1	2	0/5	mg/L	NR		NR	U	DR	520	d	19-20	d	JV	M	C	Lab	3	MOR	MOR	LFSP	WO	5.0		Y	0.031	N	0.0043437	0.701		10	5	5	10	6	9	4	10	10	4	73
92	17465	Sanchez et al, 1991	Sodium orthovanadate	27.7	Mouse (*Mus musculus*)	1	5	0/7.5/15/30/60	mg/kg bw/d	N		DLY	U	GV	12	d	NR	NR	GE	F	C	Lab	5	MOR	MOR	GMOR	WO	15.0	30	Y	0.0471	N	0.006	4.16	8.31	10	8	10	10	10	9	10	10	10	4	91
93	14507	Daniel and Lillie, 1938	Sodium metavanadate	100	Rat (*Rattus norvegicus*)	1	6	0/0.444/1.03/5.11/9.78/19.0	mg/kg bw/d	NR		ADL	U	FD	10	w	3-4	w	JV	B	C	Lab	2	MOR	MOR	MORT	WO	9.6	17.9	Y	0.157	Y	0.0149964	9.6	17.9	10	10	5	10	7	9	10	10	10	4	85
94	17292	Cadene et al, 1996	Vanadyl sulfate pentahydrate	20.14	Rat (*Rattus norvegicus*)	1	2	0/0.75	mg/ml	NR		ADL	U	DR	6	mo	NR	NR	JV	M	C	Lab	4	MOR	MOR	MORT	WO	0.75		Y	0.4196	Y	0.0321	11.6		10	5	5	10	7	9	4	10	10	4	74
95	17487	Paternain et al, 1990	Vanadyl sulfate pentahydrate	20.13	Mouse (*Mus musculus*)	1	4	0/37.5/75/150	mg/kg bw/d	N		DLY	U	GV	9	d	NR	NR	GE	F	C	Lab	1	MOR	MOR	MORT	WO	150		Y	0.0045	Y	0.0052185	30.2		10	8	10	10	10	9	4	10	10	4	85
96	17381	Kasibhatla and Rai, 1993	Metavanadate	100	Rabbit (*Oryctolagus cuniculus*)	1	2	0/20	mg/L	NR		ADL	U	DR	171	d	NR	NR	AD	NR	C	Lab	3	MOR	MOR	SURV	WO		20.0	Y	1.259	N	0.1218031		1.93	10	5	5	10	6	9	4	10	3	4	66
97	149	Van Vleet et al, 1981	Ammonium metavanadate	100	Pig (*Sus scrofa*)	1	2	0/200	mg/kg diet	N		ADL	U	FD	10	w	NR	NR	JV	M	C	Lab	2	MOR	MOR	MORT	WO		200	N	16.6	N	0.6916487		8.33	10	10	5	10	5	9	4	10	10	4	77
98	17933	Zaporowska and Wasilewski, 1989	Ammonium metavanadate	100	Rat (*Rattus norvegicus*)	1	2	0/29	mg/kg bw/d	NR		NR	U	DR	4	w	2	mo	JV	M	C	Lab	1	MOR	MOR	MORT	WO		29.0	Y	0.270	Y	1.51E-05		29.0	10	5	5	10	10	9	4	10	10	4	77
Data Not Used to Derive TRV																																														
99	252	Schroeder et al, 1970	Vanadyl Sulfate	100	Rat (*Rattus norvegicus*)	1	2	0/5	mg/L	NR		ADL	U	DR	901	d	21	d	JV	B	C	Lab	2	MOR	MOR	TDTH	WO	5.0		Y	0.4728	N	0.0504481	0.534		10	5	5	10	6	9	4	1	10	4	64
100	757	Mercado and Bibby 1973	Vanadic acid, Ammonium salt	100	Rat (*Rattus norvegicus*)	1	2	0/5	mg/L	N		ADL	U	DR	50	d	23	d	JV	M	C	Lab	2	PHY	PHY	GPHY	TH	5.0		N	0.267	N	0.0301644	0.565		10	5	5	10	5	4	4	1	10	4	58
101	757	Mercado and Bibby 1973	Vanadic acid, Ammonium salt	100	Rat (*Rattus norvegicus*)	1	2	0/5	mg/L	N		ADL	U	DR	50	d	23	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	5.0		N	0.267	N	0.0301644	0.565		10	5	5	10	5	8	4	1	10	4	62
102	20979	Kanisawa and Schroeder, 1967	Vanadyl sulfate	100	Mouse (*Mus musculus*)	1	2	0/5	mg/L	NR		NR	U	DR	518	d	20-22	d	JV	B	C	Lab	2	PTH	GRS	BDWT	WO	5.0		N	0.0375	N	0.0051554	0.687		10	5	5	10	5	4	4	1	10	4	58
103	20979	Kanisawa and Schroeder, 1967	Vanadyl sulfate	100	Mouse (*Mus musculus*)	1	2	0/5	mg/L	NR		NR	U	DR	518	d	20-22	d	JV	B	C	Lab	3	PTH	HIS	GHIS	MT	5.0		N	0.0375	N	0.0051554	0.687		10	5	5	10	5	4	4	1	10	4	58
104	20979	Kanisawa and Schroeder, 1967	Vanadyl sulfate	100	Mouse (*Mus musculus*)	1	2	0/5	mg/L	NR		NR	U	DR	24	mo	20-22	d	JV	B	C	Lab	1	MOR	MOR	MORT	WO	5.0		N	0.0375	N	0.0051554	0.687		10	5	5	10	5	9	4	1	10	4	63
105	1858	Schroeder and Mitchener, 1975	Vanadyl sulfate	100	Mouse (*Mus musculus*)	1	2	0/5	mg/L	NR		NR	U	DR	520	d	19-20	d	JV	B	C	Lab	3	PTH	HIS	EDMA	WO	5.0		Y	0.031	N	0.0043437	0.701		10	5	5	10	6	4	4	1	10	4	59
106	14508	Franke and Moxon 1937	Sodium metavanadate	100	Rat (*Rattus norvegicus*)	1	2	0/1.88	mg/kg bw/d	N		DLY	U	FD	100	d	28	d	JV	B	C	Lab	3	BIO	CHM	HMGL	BL	1.88		Y	0.2528	Y	0.0105	1.88		10	10	5	10	10	1	4	1	10	4	65
107	17920	Kowalska 1988	Sodium metavanadate	100	Rat (*Rattus norvegicus*)	1	2	0/20	mg/L	N		ADL	U	DR	21	d	3	mo	GE	F	C	Lab	1	REP	REP	OTHR	PY	20.0		N	0.297	N	0.0331983	2.24		10	5	5	10	5	10	4	1	10	4	64
108	14508	Franke and Moxon 1937	Sodium vanadate	100	Rat (*Rattus norvegicus*)	2	2	0/3.58	mg/kg bw/d	N		DLY	U	FD	100	d	28	d	JV	M	C	Lab	3	BIO	CHM	HMGL	BL	3.58		Y	0.151	Y	0.00775	3.58		10	10	5	10	10	1	4	1	10	4	65

Ref			Exposure																				Effects						Conversion to mg/kg bw/day					Result		Data Evaluation Score										
Result #	Ref N.		Chemical Form	MW%	Test Species	Phase #	# of Conc/ Doses	Conc/ Doses	Conc/Dose Units	Wet Weight Reported?	Percent Moisture	Application Frequency	Method of Analyses	Route of Exposure	Exposure Duration	Duration Units	Age	Age Units	Lifestage	Sex	Control Type	Test Location		General Effect Group	Effect Type	Effect Measure	Response Site	Study NOAEL	Study LOAEL	Body Weight Reported?	Body Weight in kg	Ingestion Rate Reported?	Ingestion Rate in kg or L/day	NOAEL Dose (mg/kg/day)	LOAEL Dose (mg/kg/day)	Data Source	Dose Route	Test Concentrations	Chemical form	Dose Quantification	Endpoint	Dose Range	Statistical Power	Exposure Duration	Test Conditions	Total
109	17806	Domingo et al, 1985	Sodium metavanadate	100	Rat (*Rattus norvegicus*)	1	4	0/5/10/50	mg/L	NR		ADL	U	DR	3	mo	NR	NR	JV	M	C	Lab	2	BEH	FDB	WCON	WO	50.0		Y	0.5416	Y	0.04164	3.84		10	5	5	10	7	4	4	3	10	4	62
110	17806	Domingo et al, 1985	Sodium metavanadate	100	Rat (*Rattus norvegicus*)	1	4	0/5/10/50	mg/L	NR		ADL	U	DR	3	mo	NR	NR	JV	M	C	Lab	4	PTH	ORW	ORWT	LI	50.0		Y	0.5416	Y	0.04164	3.84		10	5	5	10	7	4	4	3	10	4	62
111	17943	Mravcova and Puzanova, 1989	Vanadyl sulfate	100	Rat (*Rattus norvegicus*)	2	2	0/50	mg/L	NR		ADL	U	DR	2	mo	21	d	JV	B	C	Lab	2	PTH	HIS	GHIS	BO	50.0		Y	0.375	N	0.0409509	5.46		10	5	5	10	6	4	4	1	10	4	59
112	17943	Mravcova and Puzanova, 1989	Vanadyl sulfate	100	Rat (*Rattus norvegicus*)	2	2	0/50	mg/L	NR		ADL	U	DR	2	mo	21	d	JV	B	C	Lab	1	GRO	GRO	BDWT	WO	50.0		Y	0.375	N	0.0409509	5.46		10	5	5	10	6	8	4	1	10	4	63
113	17943	Mravcova and Puzanova, 1989	Vanadium pentoxide	100	Rat (*Rattus norvegicus*)	1	2	0/50	mg/L	NR		ADL	U	DR	2	mo	21	d	LC	B	C	Lab	1	GRO	GRO	BDWT	WO	50.0		Y	0.33	N	0.0365004	5.53		10	5	5	10	6	8	4	1	10	4	63
114	17943	Mravcova and Puzanova, 1989	Vanadium pentoxide	100	Rat (*Rattus norvegicus*)	1	2	0/50	mg/L	NR		ADL	U	DR	2	mo	21	d	JV	B	C	Lab	2	PTH	HIS	GHIS	BO	50.0		Y	0.33	N	0.0365004	5.53		10	5	5	10	6	4	4	1	10	4	59
115	17943	Mravcova and Puzanova, 1989	Vanadium pentoxide	100	Rat (*Rattus norvegicus*)	1	2	0/50	mg/L	NR		ADL	U	DR	2	mo	21	d	JV	B	C	Lab	2	PTH	HIS	GHIS	BO	50.0		Y	0.33	N	0.0365004	5.53		10	5	5	10	6	4	4	1	10	4	59
116	17357	Dai et al, 1995	Vanadyl sulfate hydrate	100	Rat (*Rattus norvegicus*)	2	2	0/7.64	mg/kg bw/d	NR		ADL	U	DR	12	w	NR	NR	JV	M	C	Lab	3	BIO	CHM	HMCT	BL	7.64		Y	0.55	N	0.0578045	7.64		10	5	5	10	10	1	4	1	10	4	60
117	17515	Parker and Sharma, 1978	Vanadyl sulfate or Sodium orthovanadate	100	Rat (*Rattus norvegicus*)	1	3	0/854/8540	ug/kg bw/d	NR		NR	U	DR	3	mo	1	mo	JV	NR	C	Lab	1	GRO	GRO	BDWT	WO	8540		Y	0.45	Y	0.3795556	8.54		10	5	5	10	7	8	4	1	10	4	64
118	17357	Dai et al, 1995	Ammonium metavanadate	100	Rat (*Rattus norvegicus*)	1	2	0/9.68	mg/kg bw/d	NR		ADL	U	DR	12	w	NR	NR	JV	M	C	Lab	3	BIO	CHM	HMCT	BL	9.68		Y	0.52	N	0.0549589	9.68		10	5	5	10	10	1	4	1	10	4	60
119	17758	Jadhav and Jandhyala, 1983	Vanadate	51.49	Rat (*Rattus norvegicus*)	1	3	0/1.9/22.2	mg/kg bw/d	NR		DLY	U	DR	6	w	NR	NR	JV	M	C	Lab	2	BEH	FDB	WCON	WO	22.2		Y	0.25	Y	0.029	11.4		10	5	5	10	10	4	4	3	10	4	65
120	17224	Zaporowska and Scibior, 1999	Ammonium metavanadate	100	Rat (*Rattus norvegicus*)	1	2	0/11.6	mg/kg bw/d	NR		ADL	U	DR	4	w	2	mo	JV	M	C	Lab	3	BIO	ENZ	ALPH	BL	11.6		Y	0.260	Y	0.01961	11.6		10	5	5	10	7	1	4	3	10	4	59
121	17688	Bhanot et al, 1994	Vanadyl sulfate	25.59	Rat (*Rattus norvegicus*)	1	2	0/0.75	mg/ml	NR		ADL	U	DR	3	w	6	w	JV	M	C	Lab	1	PHY	PHY	BLPR	WO	0.750		Y	0.334	N	0.0368984	21.2		10	5	5	10	6	4	4	1	10	4	59
122	14517	Mountain et al, 1953	Vanadium Pentoxide	100	Rat (*Rattus norvegicus*)	1	3	0/10.33/18.88	mg/org/d	NR		ADL	U	FD	76	d	NR	NR	JV	M	C	Lab	2	BEH	FDB	FCNS	WO	18.9		Y	0.348	Y	0.0188	54.3		10	10	5	10	7	4	4	1	10	4	65
123	17927	Ramanadham et al, 1989	Vanadyl sulfate trihydrate	100	Rat (*Rattus norvegicus*)	1	2	0/1	mg/ml	NR		ADL	U	DR	10	w	NR	NR	JV	M	C	Lab	5	BEH	FDB	WCON	WO	1.0		Y	0.413	N	0.0446674	108		10	5	5	5	6	4	4	1	10	4	54
124	17328	Carmignani et al, 1996	Sodium metavanadate	100	Rabbit (*Oryctolagus cuniculus*)	1	2	0/1	mg/L	NR		NR	U	DR	12	mo	3	mo	JV	M	C	Lab	2	BIO	HRM	DOPA	PL		1.0	N	3.76	N	0.3260651		0.08672	10	5	5	10	5	1	4	10	10	4	64
125	17375	Boscolo, et al, 1994	Sodium metavanadate	100	Rat (*Rattus norvegicus*)	1	2	0/1	ug/g	NR		NR	U	DR	180	d	NR	NR	JV	M	C	Lab	2	BIO	HRM	GHRM	PL		1.0	N	0.267	N	0.0301644		0.11298	10	5	5	10	5	1	4	10	10	4	64
126	17455	Carmignani et al, 1992	Sodium vanadate	100	Rat (*Rattus norvegicus*)	1	3	0/10/40	mg/L	NR		DLY	U	DR	7	mo	21	d	JV	M	C	Lab	1	BIO	ENZ	GENZ	UR		10.0	N	0.267	N	0.0301644		1.13	10	5	5	10	5	1	4	10	10	4	64
127	17381	Kasibhatla and Rai, 1993	Metavanadate	100	Rabbit (*Oryctolagus cuniculus*)	1	2	0/20	mg/L	NR		ADL	U	DR	45	d	NR	NR	AD	NR	C	Lab	2	PTH	GRS	BDWT	WO		20.0	Y	1.337	N	0.1285741		1.92	10	5	5	10	6	4	4	10	3	4	61
128	17381	Kasibhatla and Rai, 1993	Metavanadate	100	Rabbit (*Oryctolagus cuniculus*)	1	2	0/20	mg/L	NR		ADL	U	DR	59	d	NR	NR	AD	NR	C	Lab	1	BIO	CHM	RBCE	BL		20.0	Y	1.32	N	0.1271018		1.93	10	5	5	10	6	1	4	10	3	4	58
129	14514	Mascitelli-Coriandoli and Cittero, 1959	Vanadium	100	Rat (*Rattus norvegicus*)	1	3	0/0.01/0.05	% in diet	NR		NR	U	FD	7	d	NR	NR	JV	NR	C	Lab	1	BIO	CHM	CHOL	LI		0.010	Y	0.12	N	0.0120239		10.0	10	10	5	4	6	1	4	10	10	4	64
130	17688	Bhanot et al, 1994	Vanadyl sulfate	25.59	Rat (*Rattus norvegicus*)	1	2	0/0.75	mg/ml	NR		ADL	U	DR	3	w	6	w	JV	M	C	Lab	3	BIO	HRM	GHRM	PL		0.750	Y	0.334	N	0.0368984		21.2	10	5	5	10	6	1	4	10	10	4	65
131	17379	Ganguli et al, 1994	Sodium orthovanadate	100	Rat (*Rattus norvegicus*)	1	2	0/0.25	mg/ml	NR		DLY	U	DR	10	d	NR	NR	GE	F	C	Lab	4	BIO	CHM	GLUC	BL		0.250	Y	0.23	N	0.02637		28.7	10	5	5	10	6	1	4	10	10	4	65
132	17927	Ramanadham et al, 1989	Vanadyl sulfate trihydrate	100	Rat (*Rattus norvegicus*)	1	2	0/1	mg/ml	NR		ADL	U	DR	10	w	NR	NR	JV	M	C	Lab	2	PTH	ORW	ORWT	HE		1.0	Y	0.413	N	0.0446674		108	10	5	5	5	6	4	4	10	10	4	63
133	17927	Ramanadham et al, 1989	Vanadyl sulfate trihydrate	100	Rat (*Rattus norvegicus*)	1	2	0/1	mg/ml	NR		ADL	U	DR	10	w	NR	NR	JV	M	C	Lab	4	PHY	PHY	BLPR	WO		1.0	Y	0.413	N	0.0446674		108	10	5	5	5	6	4	4	10	10	4	63
134	17927	Ramanadham et al, 1989	Vanadyl sulfate trihydrate	100	Rat (*Rattus norvegicus*)	1	2	0/1	mg/ml	NR		ADL	U	DR	10	w	NR	NR	JV	M	C	Lab	3	BIO	CHM	GLUC	PL		1.0	Y	0.413	N	0.0446674		108	10	5	5	5	6	1	4	10	10	4	60

All abbreviations and definitions are used in coding stuides are available from Attachment 4-3 of the Eco-SSL *guidance* (U.S. EPA 2003).