Ecological Soil Screening Levels for Manganese

Interim Final

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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, 2005). The derivation procedures represent the collaborative effort of a multi-stakeholder group consisting of federal, state, consulting, industry, and academic participants led by what is now the U.S. EPA Office of Solid Waste and Emergency Response (OSWER).

This document provides the Eco-SSL values for manganese and the documentation for their derivation. This document provides guidance and is designed to communicate national policy on identifying manganese 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 MANGANESE

Manganese is one of the most abundant trace elements in the lithosphere and is widely distributed in the environment in over 100 minerals, including various sulfides, oxides, carbonates, silicates, phosphates, and borates (ATSDR, 1998; HSDB). The most common manganese minerals include pyrolusite (manganese dioxide), romanechite, manganite (manganese (III) oxide), and hausmannite (manganese (II, III) oxide)(ATSDR, 1998; HSDB).

The principal uses of manganese are in the manufacturing of steel and alloys (ferromanganese and copper manganese)(Budvari,1996; HSDB). Manganese compounds may also be released to the environment through their use in batteries, electrical coils, ceramics, matches, glass, dyes, fertilizers (manganese sulfate), oxidizing agents, antiseptics (potassium permanganate), catalysts (manganous acetate), pesticides (potassium permanganate), pigments (manganese sulfate), antiknock agents (methylcyclopentadienyl manganese tricarbonyl), and as animal food additives (manganese sulfate, manganese carbonate). Other important anthropogenic sources of manganese include industrial emissions, combustion of fossil fuels, and landfills (Klaassen et al., 1995; Pisarczyk, 1995; Lewis, 1997; Reidies, 1990; Ashford, 1994; ATSDR, 1998; HSDB).

Manganese compounds are important soil constituents. In soils, redox reactions affect the sorption of manganese compounds which in turn have a considerable effect on soil properties such as cation exchange (Kabata-Pendias, 1992). Background concentrations reported for many metals in U.S. soils are described in Attachment 1-4 of the Eco-SSL guidance (U.S. EPA, 2003). Typical background concentrations of manganese in U.S. soils are plotted in Figure 2.1 for both eastern and western U.S. soils.

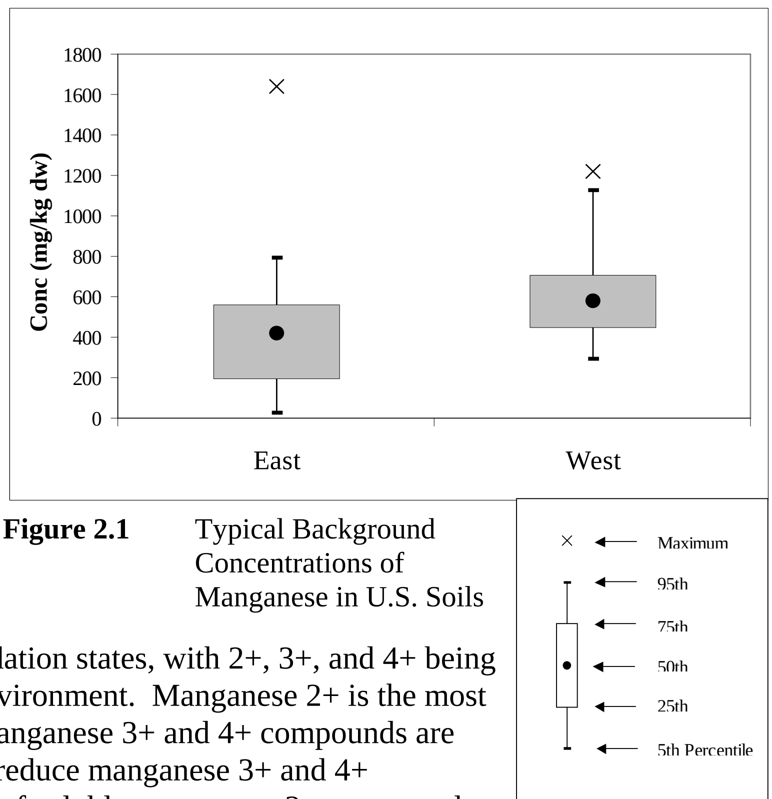


Figure 2.1 Typical Background Concentrations of Manganese in U.S. Soils

Manganese is multi-valent and can exist in the 2+, 3+, 4+, 6+, and 7+ oxidation states, with 2+, 3+, and 4+ being the dominant oxidation states in the environment. Manganese 2+ is the most stable oxidation state in water while manganese 3+ and 4+ compounds are immobile solids. Organic matter may reduce manganese 3+ and 4+ compounds, resulting in the formation of soluble manganese 2+ compounds. Insoluble manganese compounds are formed under aerobic conditions, and soluble compounds are formed under anaerobic conditions from reduction reactions by microorganisms. Soluble manganese compounds are relatively mobile and may leach into surface or ground water (Bodek et al. 1988; HSDB). Soluble manganese is released from soil through ion exchange when replaced by more strongly binding metals such as copper, zinc, or nickel (Bodek et al., 1988;

HSDB). Reducing soil pH and soil aeration increases the solubility of manganese in the soil (WHO 1981; HSDB). In soils, manganese is known to interact with a handful of other elements. Most prominently, manganese is observed to interfere with the availability of cobalt to plants from soils via a strong affinity of manganese oxides to native cobalt. Also, in acidic soils that contain a large amount of manganese, iron absorption by plants can be affected. Interactions also are known to occur between manganese and other heavy metals including cadmium, lead, zinc, and phosphorous (ATSDR, 1998; HSDB).

Manganese is an essential nutrient for both plants and animals. In animals, manganese is associated with growth, normal functioning of the central nervous system, and reproductive function. Specifically, manganese is associated with the formation of connective tissue and bone, carbohydrate and lipid metabolism, and embryonic development of the inner ear (WHO, 1981; HSDB). Manganese deficiency in animals is demonstrated by a reduced growth rate, skeletal abnormalities and abnormal reproductive function (NAP, 1980). Manganese nutritional requirements and typical concentrations in animal feed are discussed in Attachment 4-3 of the Eco-SSL guidance (U.S. EPA, 2003). High levels of manganese may produce neurotoxic responses such as hypoactivity, nervousness, tremors, and ataxia. Other reported effects include liver damage and decreased growth (Clayton and Clayton, 1981-82;1993-94; Venugopal and Luckey, 1978; HSDB).

Manganese is essential in plant nutrition for the oxidation-reduction process. Specifically, manganese participates in the oxygen-evolving system of photosynthesis and in the photosynthetic electron transport system. In the soluble form, manganese is easily taken up from soils by plants and is rapidly translocated throughout the plant. Manganese deficient plants exhibit decreased growth, interveinal chlorosis, necrotic spots on leaves, and browning of roots. Manganese toxicity is demonstrated in plants by iron chlorosis, leaf puckering, necrotic brown spots, and an uneven distribution of cholorphyll in older leaves (Kabata-Pendias, 1992).

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

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

Plants	Soil Invertebrates	Wildlife	
		Avian	Mammalian
220	450	4,300	4,000

Eco-SSL values were derived for all receptor groups. The Eco-SSL values for manganese range from 220 mg/kg dry weight (dw) for plants to 4,300 mg/kg dw for avian wildlife. The Eco-SSL for plants is less than the 5th percentile of reported background soil concentrations of manganese in western U.S. soils and less than the 50th percentile for eastern U.S. soils (Figure 2.1). The Eco-SSL for soil invertebrates is less than the 50th percentile for western U.S. soils and less than the 75th percentile for eastern U.S. soils (Figure 2.1). The Eco-SSLs for avian and mammalian wildlife are higher than reported range of background concentrations in both western and eastern U.S. soils.

3.0 ECO-SSL FOR TERRESTRIAL PLANTS

Of the papers identified from the literature search process, 407 papers were selected for acquisition for further review. Of those papers acquired, 20 met all 11 Study Acceptance Criteria (U.S. EPA, 2003; Attachment 3-1). Each of these papers were reviewed and the studies were scored according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 3-2). Six study results received an Evaluation Score greater than ten (U.S. EPA, 2003; Attachment 3-1). These studies are listed in Table 3.1.

The studies in Table 3.1 are sorted by bioavailability score. There are four studies eligible for Eco-SSL derivation. These results are used to derive the plant Eco-SSL for manganese (U.S. EPA, 2003; Attachment 3-2). The Eco-SSL is the geometric mean of the maximum acceptable toxicant concentration (MATC) values for three species under different test conditions (pH and % organic matter (OM)) and is equal to 220 mg/kg dw.

4.0 ECO-SSL FOR SOIL INVERTEBRATES

Of the papers identified from the literature search process, 18 papers were selected for acquisition for further review. Of those papers acquired, three met all 11 Study Acceptance Criteria (U.S. EPA 2003; Attachment 3-1). Each of these papers were reviewed and the studies were scored according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 3-2). Three studies received an Evaluation Score greater than ten. These studies are listed in Table 4.1 and were used to derive the soil invertebrate Eco-SSL for manganese (U.S. EPA, 2003; Attachment 3-2). The Eco-SSL is the geometric mean of the EC_{20} values for three test species under different test conditions (pH and OM%) and is equal to 450 mg/kg dw. The studies reported in Table 4.1 were completed specifically for the purpose of Eco-SSL derivation. These studies were conducted under conditions of high bioavailability and represent conservative estimates of toxicity.

Table 3.1 Plant Toxicity Data - Manganese

Reference	IP Number	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?
Reid, 1965	55992	Barley	*Hordeum vulgare*	4.6	0.78	2	GRO	MATC	71	16	Y	Y
Reid, 1965	55992	Barley	*Hordeum vulgare*	7.3	0.78	1	GRO	MATC	71	15	Y	Y
Rehab and Wallace, 1978	46710	Cotton	*Gossypium spp.*	6.6	2.4	1	GRO	MATC	707	14	Y	Y
Foy et al., 1998	11629	Nile grass	*Heroceras macrum*	4.62-5.16	0.017 - 4.24	1	GRO	MATC	707	11	Y	Y
								Geometric Mean	220			
Data Not Used to Derive Plant Eco-SSL												
Korcak, 1988	13731	Highbush Blueberry	*Vaccinium corymbosum*	4.1	1.8	2	GRO	NOAEC	1.5	16	N	N
Gonzalez and Lynch, 1999	18987	Common bean	*Phaseolus vulgaris*	5.4	1.9	2	REP	LOAEC	80	15	N	N

ERE = Ecologically relevant endpoint
GRO = Growth
LOAEC = Lowest observed adverse effect concentration
MATC = Maximum acceptable toxicant concentration. Geometric mean of NOAEC and LOAEC.
N = No
NOAEC = No observed adverse effect concentration

OM = Organic matter content
REP = Reproduction
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)

Table 4.1 Invertebrate Toxicity Data - Manganese

Reference	IP Number	Test Organism		Soil pH	OM%	Bio-availability Score	ERE	Tox Parameter	Tox Value (Soil Conc at mg/kg dw)	Total Evaluation Score	Eligible for Eco-SSL Derivation?	Used for Eco-SSL?
Kuperman et al., 2002	62344	Potworm	*Enchytraeus crypticus*	4.86 - 5.39	1.2	2	REP	EC_{20}	116	17	Y	Y
Phillips et al., 2002	62345	Springtail	*Folsomia candida*	4.56 - 5.29	1.2	2	REP	EC_{20}	1209	18	Y	Y
Simini et al., 2002	62343	Earthworm	*Eisenia fetida*	4.58 - 5.29	1.2	2	REP	EC_{20}	629	16	Y	Y
								Geometric Mean	450			

EC_{20} = Effect concentration for 20% of test population
ERE = Ecologically relevant endpoint
OM = Organic matter content
REP = Reproduction

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)

5.0 ECO-SSL FOR AVIAN WILDLIFE

The derivation of the Eco-SSL for avian wildlife was completed as two parts. 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 representing different trophic levels 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 4-1) identified 3,618 papers with possible toxicity data for either avian or mammalian species. Of these studies, 3,539 were rejected for use as described in Section 7.5. Of the remaining studies, 21 contained data for avian 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 provided as Table 5.1. The complete results are included as Appendix 5-1.

Within the reviewed papers, there are 40 results for biochemical (BIO), behavior (BEH), physiology (PHY), pathology (PTH), reproduction (REP), growth (GRO), and survival (MOR) effects that meet the Data Evaluation Score of >65 for use to derive the TRV (U.S. EPA, 2003; Attachment 4-4). These data are plotted in Figure 5.1 and correspond directly with the data presented in Table 5.1. The no-observed adverse effect level (NOAEL) results for growth and reproduction are used to calculate a geometric mean. 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 reproduction and growth was calculated at 179 mg manganese/kg bw/day. This value is lower than the lowest bounded LOAEL for reproduction, growth, or survival. Therefore, the TRV is equal to the geometric mean of the NOAEL values for reproduction and growth and is equal to 179 mg manganese/kg bw/day.

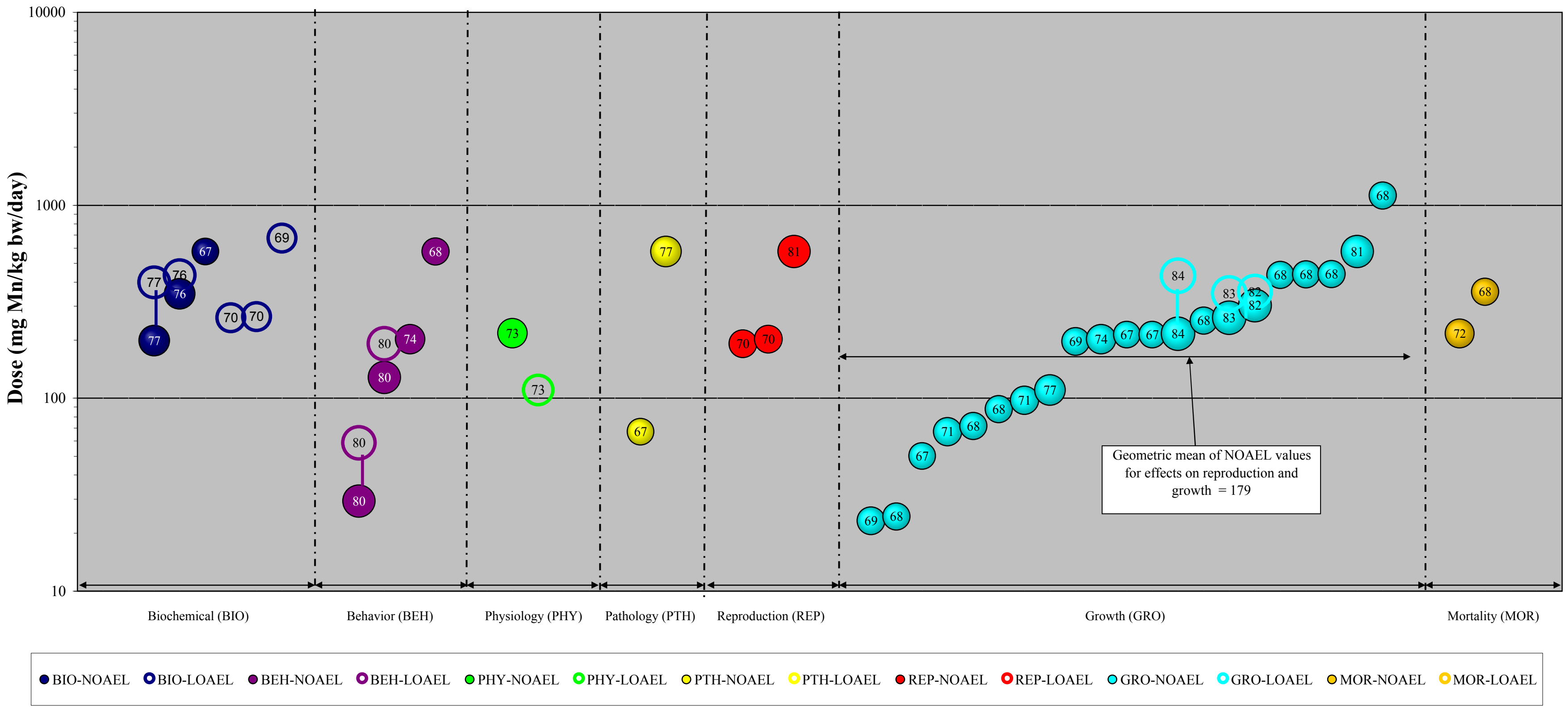
Table 5.1
Avian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)
Manganese

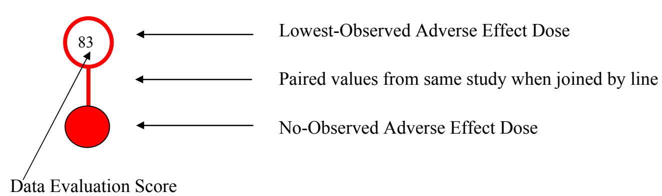
Result #	Reference	Ref No.	Test Organism	# of Conc/ Doses	Method of Analyses	Route of Exposure	Exposure Duration	Duration Units	Age	Age Units	Lifestage	Sex	Effect Type	Effect Measure	Response Site	NOAEL Dose* (mg/kg bw/day)	LOAEL Dose* (mg/kg bw/day)	Total
Biochemical (BIO)																		
1	Martinez and Diaz, 1996	5345	Chicken (*Gallus domesticus*)	4	U	FD	14	d	1	d	JV	M	CHM	HMGL	BL	199	398	77
2	Southern and Baker, 1983	6363	Chicken (*Gallus domesticus*)	4	U	FD	14	d	14	d	JV	M	CHM	HMGL	BL	347	434	76
3	Laskey and Edens, 1985	8426	Japanese quail (*Coturnix japonica*)	2	U	FD	10	w	1	d	JV	M	HRM	TSTR	SR	575		67
4	Southern and Baker, 1983	6363	Chicken (*Gallus domesticus*)	4	U	FD	14	d	7	d	JV	M	CHM	HMGL	BL		261	70
5	Southern and Baker, 1983	6363	Chicken (*Gallus domesticus*)	4	U	FD	14	d	7	d	JV	M	CHM	HMGL	BL		264	70
6	Edens and Laskey, 1990	7710	Japanese quail (*Coturnix japonica*)	2	U	FD	10	w	0	d	JV	M	CHM	GLUC	SR		674	69
Behavior (BEH)																		
7	Martinez and Diaz, 1996	5345	Chicken (*Gallus domesticus*)	4	U	FD	42	d	1	d	JV	M	FDB	FCNS	WO	29.3	58.6	80
8	Black et al., 1985	6195	Chicken (*Gallus domesticus*)	4	U	FD	3	w	1	d	JV	M	FDB	FCNS	WO	128	192	80
9	Black et al, 1984	6305	Chicken (*Gallus domesticus*)	4	U	FD	21	d	1	d	JV	M	FDB	FCNS	WO	202		74
10	Laskey and Edens, 1985	8426	Japanese quail (*Coturnix japonica*)	2	U	FD	75	d	1	d	JV	M	FDB	FCNS	WO	575		68
Physiology (PHY)																		
11	Black et al, 1984	6305	Chicken (*Gallus domesticus*)	4	U	FD	21	d	1	d	JV	M	PHY	FDCV	WO	217		73
12	Brown and Southern, 1985	6215	Chicken (*Gallus domesticus*)	2	U	FD	14	d	4	d	JV	M	PHY	FDCV	WO		110	73
Pathology (PTH)																		
13	Halpin et al, 1986	6054	Chicken (*Gallus domesticus*)	3	U	GV	14	d	8	d	JV	M	ORW	ORWT	TB	67.0		67
14	Laskey and Edens, 1985	8426	Japanese quail (*Coturnix japonica*)	2	U	FD	70	d	1	d	JV	M	ORW	ORWT	LI	575		77
Reproduction (REP)																		
15	Sazzad et al, 1994	5474	Chicken (*Gallus domesticus*)	2	U	FD	12	w	23	w	LB	F	REP	PROG	WO	191		70
16	Sazzad et al, 1994	5474	Chicken (*Gallus domesticus*)	2	U	FD	12	w	23	w	LB	F	REP	PROG	WO	202		70
17	Laskey and Edens, 1985	8426	Japanese quail (*Coturnix japonica*)	2	U	FD	75	d	1	d	JV	M	REP	TEWT	TE	575		81
Growth (GRO)																		
18	Spulkamy et al, 1976	6772	Chicken (*Gallus domesticus*)	5	U	FD	7	w	1	w	JV	M	GRO	BDWT	WO	23.1		69
19	Settle et al, 1969	7191	Chicken (*Gallus domesticus*)	3	U	FD	4	w	1	d	JV	B	GRO	BDWT	WO	24.3		68
20	Wedekind and Baker, 1990	5728	Chicken (*Gallus domesticus*)	3	U	FD	14	d	8	d	JV	M	GRO	BDWT	WO	50.2		67
21	Halpin et al, 1986	6054	Chicken (*Gallus domesticus*)	3	U	GV	14	d	8	d	JV	M	GRO	BDWT	WO	67.0		71
22	Henry et al., 1986	6087	Chicken (*Gallus domesticus*)	2	U	FD	21	d	1	d	JV	M	GRO	BDWT	WO	71.8		68
23	Baker and Halpin, 1991	5700	Chicken (*Gallus domesticus*)	2	U	FD	14	d	8	d	JV	M	GRO	BDWT	WO	87.7		68
24	De Rosa et al, 1980	44196	Chicken (*Gallus domesticus*)	2	U	FD	1	w	2	w	JV	B	GRO	BDWT	WO	97.6		71
25	Brown and Southern, 1985	6215	Chicken (*Gallus domesticus*)	2	U	FD	14	d	4	d	JV	M	GRO	BDWT	WO	110		77
26	Black et al., 1985	6195	Chicken (*Gallus domesticus*)	4	U	FD	3	w	1	d	JV	M	GRO	BDWT	WO	197		69
27	Black et al, 1984	6305	Chicken (*Gallus domesticus*)	4	U	FD	21	d	1	d	JV	M	GRO	BDWT	WO	202		74
28	Wong-Valle et al, 1989	5788	Chicken (*Gallus domesticus*)	4	U	FD	21	d	1	d	JV	M	GRO	BDWT	WO	213		67
29	Wong-Valle et al, 1989	5788	Chicken (*Gallus domesticus*)	4	U	FD	21	d	1	d	JV	M	GRO	BDWT	WO	213		67
30	Martinez and Diaz, 1996	5345	Chicken (*Gallus domesticus*)	4	U	FD	14	d	1	d	JV	M	GRO	BDWT	WO	215	431	84
31	Southern and Baker, 1983	6382	Chicken (*Gallus domesticus*)	3	U	FD	14	d	8	d	JV	M	GRO	BDWT	WO	252		68
32	Southern and Baker, 1983	6363	Chicken (*Gallus domesticus*)	4	U	FD	14	d	7	d	JV	M	GRO	BDWT	WO	261	348	83
33	Vohra and Kratzer, 1968	14404	Turkey (*Meleagris gallopavo*)	9	U	FD	21	d	NR	NR	JV	B	GRO	BDWT	WO	302	356	82
34	Southern and Baker, 1983	6363	Chicken (*Gallus domesticus*)	4	U	FD	14	d	7	d	JV	M	GRO	BDWT	WO	435		68
35	Southern and Baker, 1983	6363	Chicken (*Gallus domesticus*)	4	U	FD	14	d	7	d	JV	M	GRO	BDWT	WO	437		68
36	Southern and Baker, 1983	6363	Chicken (*Gallus domesticus*)	4	U	FD	14	d	7	d	JV	M	GRO	BDWT	WO	439		68
37	Laskey and Edens, 1985	8426	Japanese quail (*Coturnix japonica*)	2	U	FD	75	d	1	d	JV	M	GRO	BDWT	WO	575		81
38	Leeson and Summers, 1982	2196	Chicken (*Gallus domesticus*)	5	U	FD	21	d	1	d	JV	M	GRO	BDWT	WO	1120		68
Survival (MOR)																		
39	Black et al., 1984	6252	Chicken (*Gallus domesticus*)	4	U	FD	26	d	4	d	JV	B	MOR	MORT	WO	216		72
40	Vohra and Kratzer, 1968	14404	Turkey (*Meleagris gallopavo*)	9	U	FD	21	d	NR	NR	JV	B	MOR	MORT	WO	356		68

B = both; BDWT = body weight changes; BEH = behavior; BIO = biochemical; BL = blood; bw = body weight; CHM = chemical changes; d = day; DR = drinking water; ENZ = enyzme level changes; F = female; FCNS = food consumption; FD = food; FDB = feeding behavior; FDCV = food conversion efficiency; GLUC = glucose; GRO = growth; GV = gavage; HIS = histological changes; HMGL = hemoglobin; ITX = intoxication; JV = juvenile; kg = kilograms; LB = egg laying bird; LI = liver; LOAEL = lowest observed adverse effect level; mg = milligrams; 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; OTHR = Other; PHY = physiology; PROG = progeny counts/numbers; PTH = pathology; REP = reproduction; SR = serum; TB = tibia; TE = testes; TEWT = testes weight; TSTR = testosterone; U = unmeasured; UX = measured but values not reported; w = weeks; WCON = water consumption; WO = whole organism; yr = year.

*NOAEL and LOAEL values that are equal and from the same reference represent different experimental designs. These are designated with different Phase numbers in Appendix 5.1.

Figure 5.1 Avian TRV Derivation for Manganese





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 at least three NOAEL results available within the growth and reproduction effect groups for calculation of a geometric mean.

3) The geometric mean is equal to 179 mg manganese/kg bw/d and is lower than the lowest bounded LOAEL for results within the reproduction, growth, and survival (MOR) effect groups.

4) The avian wildlife TRV for manganese is equal to 179 mg manganese /kg bw/day which is the geometric mean of NOAEL values for effects on reproduction and growth.

5.2 Estimation of Dose and Calculation of the Eco-SSL

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

Table 5.2 Calculation of the Avian Eco-SSLs for Manganese

Surrogate Receptor Group	TRV for Manganese (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 Manganese in Biota Type (i)[2,3] (B_i) (mg/kg dw)	Eco-SSL (mg/kg dw)[4]
Avian herbivore (dove)	179	0.190	0.139	$B_i = 0.079 * Soil_j$ where i = plants	4300
Avian ground insectivore (woodcock)	179	0.214	0.164	$\ln(B_i) = 0.682 * \ln(Soil_j) - 0.809$ where i = earthworms	4300
Avian carnivore (hawk)	179	0.0353	0.057	$B_i = 0.0205 * Soil_j$ where i = mammals	65000

[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] $HQ = [FIR * (Soil_j * P_s + B_i)] / TRV$ solved for HQ=1 where $Soil_j$ = Eco-SSL (Equation 4-2; U.S. EPA, 2003).

6.0 ECO-SSL FOR MAMMALIAN WILDLIFE

The derivation of the Eco-SSL for mammalian wildlife was completed as two parts. 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 surrogate receptor 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 3,618 papers with possible toxicity data for manganese for either avian or mammalian species. Of these studies, 3,539 were rejected for use as described in Section 7.5. Of the remaining papers, 58 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 as Appendix 6-1.

Table 6.1 Mammalian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)
Manganese
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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	Deskin, et al, 1980	34921	Rat (*Rattus norvegicus*)	4	U	GV	24	d	1	d	JV	M	HRM	GHRM	BR	1.00	10.0	81
2	Mohamed et al, 1986	36002	Water buffalo (*Bubalus carabanensis*)	3	M	FD	90	d	13-19	mo	JV	M	CHM	CALC	SR	1.81		66
3	Bhoot et al, 1981	35470	Cattle (*Bos taurus*)	3	U	FD	66	d	1	yr	JV	F	CHM	HMGL	BL	7.05		69
4	Lipe, et al, 1999	33403	Rat (*Rattus norvegicus*)	3	U	GV	30	d	90	d	AD	M	CHM	TTAA	BR	10.0	20.0	79
5	Bonilla and Prasad, 1984	35707	Rat (*Rattus norvegicus*)	3	U	DR	8	mo	NR	NR	JV	M	HRM	NORE	BR	11.4	114	69
6	Kontur and Fechter, 1985	36045	Rat (*Rattus norvegicus*)	3	U	GV	21	d	1	d	JV	B	HRM	DOPA	BR	13.8		70
7	Lipe, et al, 1999	33403	Rat (*Rattus norvegicus*)	3	U	GV	30	d	30	d	JV	M	CHM	TTAA	BR	20.0		75
8	Cunningham et al, 1966	14461	Cattle (*Bos taurus*)	4	U	FD	100	d	10	w	JV	M	CHM	HMGL	BL	24.2	48.3	77
9	Desole, et al, 1995	33573	Rat (*Rattus norvegicus*)	4	U	GV	7	d	20	mo	AD	M	HRM	DOPA	BR	43.7	87.3	79
10	Rehnberg et al, 1980	57	Rat (*Rattus norvegicus*)	4	U	GV	20	d	1	d	JV	B	CHM	HMGL	BL	71.0	214	81
11	Laskey et al, 1985	34755	Rat (*Rattus norvegicus*)	2	U	GV	21	d	0	d	JV	M	HRM	TSTR	SR	71.0		73
12	Reid, et al, 1947	14471	Cattle (*Bos taurus*)	2	U	FD	5	mo	NR	NR	LC	F	CHM	CALC	PL	84.8		67
13	Svensson et al, 1985	34740	Rat (*Rattus norvegicus*)	2	U	GV	20	d	2	d	JV	B	CHM	CALC	SR	129		68
14	Seth et al, 1977	34791	Rat (*Rattus norvegicus*)	2	U	GV	30	d	NR	NR	LC	F	ENZ	SCDH	BR		4.17	77
15	Magour et al, 1983	34849	Rat (*Rattus norvegicus*)	2	U	DR	3	w	3	w	JV	F	CHM	PRTL	BR		6.60	69
16	Derevenco et al, 1988	1282	Rat (*Rattus norvegicus*)	3	U	FD	13	w	NR	NR	NR	M	ENZ	GENZ	BR		8.60	74
17	Hartman et al., 1955	14465	Sheep (*Ovis aries*)	3	U	FD	11	w	66-69	d	JV	B	CHM	HMGL	BL		36.7	69
18	Halacheva and Nikolova, 1975	35114	Rat (*Rattus norvegicus*)	2	U	GV	60	d	NR	NR	JV	M	CHM	ATPT	BR		75.0	77
19	Desole, et al, 1995	33573	Rat (*Rattus norvegicus*)	2	U	GV	7	d	3	mo	JV	M	HRM	DOPA	BR		87.3	77
20	Hastings and Llewellyn, 1987	34586	Hamster (*Mesocricetus auratus*)	2	U	FD	10	w	NR	NR	JV	M	CHM	CHOL	SR		120	69
21	Kristensson et al, 1986	34674	Rat (*Rattus norvegicus*)	2	U	GV	12	d	3	d	JV	M	HRM	GHRM	BR		150	77
22	Rana et. al, 1985	13236	Rat (*Rattus norvegicus*)	2	U	GV	30	d	90	d	JV	M	CHM	GLYC	LI		250	77
23	Bonilla and Diez-Ewald, 1974	35173	Rat (*Rattus norvegicus*)	2	U	DR	7	mo	NR	NR	JV	F	HRM	DOPA	BR		255	66
24	Komura and Sakamoto, 1991	33786	Mouse (*Mus musculus*)	2	U	FD	100	d	6	w	JV	M	CHM	RBCE	BL		262	71
25	Komura and Sakamoto, 1991	33786	Mouse (*Mus musculus*)	2	U	FD	100	d	6	w	JV	M	CHM	TWBC	BL		270	71
26	Komura and Sakamoto, 1991	33786	Mouse (*Mus musculus*)	2	U	FD	100	d	6	w	JV	M	CHM	RBCE	BL		284	66
27	Komura and Sakamoto, 1991	33786	Mouse (*Mus musculus*)	2	U	FD	100	d	6	w	JV	M	CHM	TWBC	BL		284	71
28	Bonilla, 1978	34677	Rat (*Rattus norvegicus*)	2	U	DR	2	mo	NR	NR	JV	M	ENZ	GENZ	BR		492	66
29	Chandra and Shukla, 1981	34922	Rat (*Rattus norvegicus*)	2	U	DR	15	d	NR	NR	JV	M	CHM	TYRO	SR		533	66
30	Bonilla, 1980	35583	Rat (*Rattus norvegicus*)	2	U	DR	1	mi	NR	NR	JV	M	ENZ	GENZ	BR		1224	66
Behavior (BEH)																		
31	Gershbein et al 1983	136	Rat (*Rattus norvegicus*)	2	U	FD	80	d	44	d	JV	M	BEH	NMVM	WO	5.89		66
32	Bhoot et al, 1981	35470	Cattle (*Bos taurus*)	3	U	FD	66	d	1	yr	JV	F	FDB	FCNS	WO	7.05		74
33	Cunningham et al, 1966	14461	Cattle (*Bos taurus*)	4	U	FD	84	d	10	w	JV	M	FDB	FCNS	WO	21.7	65.0	80
34	Black et al, 1985	35824	Sheep (*Ovis aries*)	5	U	FD	84	d	NR	NR	JV	M	FDB	FCNS	WO	59.4	119	80
35	Cunningham et al, 1966	14461	Cattle (*Bos taurus*)	4	U	FD	100	d	10	w	JV	M	FDB	FCNS	WO	73.8		74
36	Black et al, 1985	35824	Sheep (*Ovis aries*)	4	U	FD	84	d	NR	NR	JV	M	FDB	FCNS	WO	112	223	80
37	Black et al, 1985	35826	Sheep (*Ovis aries*)	4	U	FD	21	d	NR	NR	JV	M	FDB	FCNS	WO	151	226	80
38	Kontur and Fechter, 1985	34752	Rat (*Rattus norvegicus*)	4	U	DR	21	d	NR	NR	GE	F	FDB	WCON	WO	162	271	75
39	Komura and Sakamoto, 1991	33786	Mouse (*Mus musculus*)	2	U	FD	100	d	6	w	JV	M	FDB	FCNS	WO	262		67
40	Komura and Sakamoto, 1991	33786	Mouse (*Mus musculus*)	2	U	FD	100	d	6	w	JV	M	FDB	FCNS	WO	270		70
41	Komura and Sakamoto, 1991	33786	Mouse (*Mus musculus*)	2	U	FD	100	d	6	w	JV	M	FDB	FCNS	WO	284		70
42	Gaillard, et al, 1996	33511	Rat (*Rattus norvegicus*)	2	U	DR	11	w	3	w	JV	M	FDB	FCNS	WO	554		69
43	Derevenco et al, 1988	1282	Rat (*Rattus norvegicus*)	3	U	FD	13	w	NR	NR	NR	B	BEH	GBHV	WO		8.60	77
44	Bonilla, 1984	34806	Rat (*Rattus norvegicus*)	3	U	DR	1	mo	NR	NR	JV	M	BEH	ACTV	WO		11.4	68
45	Ali et al., 1981	34892	Rat (*Rattus norvegicus*)	2	U	DR	90	d	40	d	JV	M	BEH	RSPT	WO		24.3	67
46	Black et al, 1985	35826	Sheep (*Ovis aries*)	4	U	OR	7	d	NR	NR	JV	M	FDB	FCNS	WO		76.0	77
47	Nachtman et al, 1986	34669	Rat (*Rattus norvegicus*)	2	U	DR	5	w	6	w	JV	M	BEH	ACTV	WO		109	68
48	Chandra, 1983	34850	Rat (*Rattus norvegicus*)	2	U	DR	30	d	NR	NR	JV	M	BEH	AGGT	WO		114	68
49	Bonilla, 1978	34677	Rat (*Rattus norvegicus*)	2	U	DR	2	mo	NR	NR	JV	M	FDB	FCNS	WO		492	69
Physiology (PHY)																		
50	Black et al, 1985	35824	Sheep (*Ovis aries*)	5	U	FD	84	d	NR	NR	JV	M	PHY	FDCV	WO	31.6	63.2	80
51	Cunningham et al, 1966	14461	Cattle (*Bos taurus*)	4	U	FD	100	d	10	w	JV	M	PHY	FDCV	WO	73.8		74
52	Black et al, 1985	35824	Sheep (*Ovis aries*)	4	U	FD	84	d	NR	NR	JV	M	PHY	FDCV	WO	112	223	80
Pathology (PTH)																		
53	Kayongo-Male et al, 1977	34702	Pig (*Sus scrofa*)	2	M	FD	10	w	NR	NR	JV	B	HIS	GHIS	BO	1.85		68
54	Deskin et al, 1981	34921	Rat (*Rattus norvegicus*)	4	U	GV	24	d	1	d	JV	M	ORW	SMIX	BR	20.0		78
55	Rehnberg et al, 1980	57	Rat (*Rattus norvegicus*)	4	U	GV	11	d	1	d	JV	B	ORW	ORWT	BR	21.0	71.0	84
56	Svensson et al, 1985	34740	Rat (*Rattus norvegicus*)	2	U	GV	20	d	2	d	JV	M	ORW	ORWT	TB	129		71
57	Derevenco et al, 1988	1282	Rat (*Rattus norvegicus*)	3	U	FD	13	w	NR	NR	NR	M	HIS	GHIS	BR		8.60	77
58	Chandra and Imam, 1973	14460	Guinea pig (*Caviidae cavia*)	2	U	GV	30	d	NR	NR	JV	M	HIS	NCRO	IN		10.0	80
59	Wassermann and Wassermann, 1977	35046	Rat (*Rattus norvegicus*)	2	U	DR	10	d	2	mo	JV	M	HIS	GHIS	LI		22.9	67
60	Rana et. al, 1985	13236	Rat (*Rattus norvegicus*)	2	U	GV	30	d	90	d	JV	M	ORW	SMIX	LI		250	80

Table 6.1 Mammalian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)
Manganese
Page 2 of 2

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
Reproduction (REP)																		
61	Grummer, et al, 1950	14464	Pig (*Sus scrofa*)	2	U	FD	124	d	9	w	GE	F	REP	PROG	WO	2.83		71
62	Rehnberg et al, 1980	57	Rat (*Rattus norvegicus*)	4	U	GV	20	d	1	d	JV	B	REP	RHIS	TE	21.0	71.0	90
63	USDA, 1973	35143	Rat (*Rattus norvegicus*)	5	U	GV	9	d	NR	NR	GE	F	REP	PROG	WO	78.3		77
64	USDA, 1973	35143	Rabbit (*Oryctolagus cuniculus*)	5	U	GV	12	d	NR	NR	GE	F	REP	PROG	WO	112		77
65	USDA, 1973	35143	Mouse (*Mus musculus*)	5	U	GV	9	d	NR	NR	GE	F	REP	PROG	WO	125		77
66	USDA, 1973	35143	Hamster (*Mesocricetus auratus*)	5	U	GV	4	d	NR	NR	GE	F	REP	PROG	WO	136		77
67	Pappas, et al, 1997	33496	Rat (*Rattus norvegicus*)	3	U	DR	30	d	NR	NR	GE	F	REP	PRWT	WO	153	620	82
68	Kontur and Fechter, 1985	34752	Rat (*Rattus norvegicus*)	4	U	DR	21	d	NR	NR	GE	F	REP	PRWT	WO	276	415	81
69	Laskey et al, 1982	56	Rat (*Rattus norvegicus*)	4	U	FD	43	d	NR	NR	GE	F	REP	PRWT	WO	291		78
70	Leung, et al, 1982	34895	Rat (*Rattus norvegicus*)	3	U	DR	26	d	NR	NR	GE	F	REP	PRWT	WO	1069	2139	79
71	Becker and McCollum, 1938	14459	Rat (*Rattus norvegicus*)	5	U	FD	730	d	NR	NR	JV	M	REP	TEDG	TE	1996		77
72	Bataineh et al., 1998	1717	Rat (*Rattus norvegicus*)	2	U	DR	12	w	NR	NR	AD	M	REP	TEWT	TE		26.4	67
73	Laskey et al, 1985	34755	Rat (*Rattus norvegicus*)	2	U	GV	21	d	0	d	JV	M	REP	TEWT	TE		71.0	86
Growth (GRO)																		
74	Ivan and Grieve, 1975	34990	Cattle (*Bos taurus*)	2	U	FD	10	w	22-28	w	JV	M	GRO	BDWT	WO	1.30		68
75	Mohamed et al, 1986	36002	Water buffalo (*Bubalus carabanensis*)	3	M	FD	90	d	13-19	mo	JV	M	GRO	BDWT	WO	1.86		73
76	Svajgr et al., 1969	34656	Pig (*Sus scrofa*)	2	U	FD	84	d	NR	NR	JV	B	GRO	BDWT	WO	2.74		69
77	Grummer, et al, 1950	14464	Pig (*Sus scrofa*)	2	U	FD	124	d	NR	NR	JV	B	GRO	BDWT	WO	2.83		69
78	Gershbein et al 1983	136	Rat (*Rattus norvegicus*)	2	U	FD	80	d	44	d	JV	M	GRO	BDWT	WO	5.89		68
79	Bhoot et al, 1981	35470	Cattle (*Bos taurus*)	3	U	FD	66	d	1	yr	JV	F	GRO	BDWT	WO	7.05		71
80	Lee and Johnson, 1988	34504	Rat (*Rattus norvegicus*)	3	U	FD	2	w	NR	NR	JV	B	GRO	BDWT	WO	7.37		68
81	Kontur and Fechter, 1985	36045	Rat (*Rattus norvegicus*)	3	U	GV	21	d	1	d	JV	B	GRO	BDWT	WO	13.8		75
82	Leibholz et al, 1962	14468	Pig (*Sus scrofa*)	4	U	FD	10	w	2	w	JV	B	GRO	BDWT	WO	14.4	144	81
83	Lipe, et al, 1999	33403	Rat (*Rattus norvegicus*)	3	U	GV	30	d	30	d	JV	M	GRO	BDWT	WO	20.0		75
84	Deskin et al, 1981	34921	Rat (*Rattus norvegicus*)	4	U	GV	24	d	1	d	JV	M	GRO	BDWT	WO	20.0		75
85	Rehnberg et al, 1980	57	Rat (*Rattus norvegicus*)	4	U	GV	5	d	1	d	JV	B	GRO	BDWT	WO	21.0	71.0	88
86	Cunningham et al, 1966	14461	Cattle (*Bos taurus*)	4	U	FD	84	d	10	w	JV	M	GRO	BDWT	WO	21.7	65.0	84
87	Black et al, 1985	35824	Sheep (*Ovis aries*)	5	U	FD	84	d	NR	NR	JV	M	GRO	BDWT	WO	59.4	119	84
88	Laskey et al, 1985	34755	Rat (*Rattus norvegicus*)	2	U	GV	21	d	0	d	JV	M	GRO	BDWT	WO	71.0		84
89	Cunningham et al, 1966	14461	Cattle (*Bos taurus*)	4	U	FD	100	d	10	w	JV	M	GRO	BDWT	WO	73.8		69
90	USDA, 1973	35143	Rat (*Rattus norvegicus*)	5	U	GV	9	d	NR	mo	GE	F	GRO	BDWT	WO	78.3		75
91	Leibholz et al, 1962	14468	Pig (*Sus scrofa*)	6	U	FD	6	w	2	w	JV	B	GRO	BDWT	WO	86.3		68
92	Nachtman et al, 1986	34669	Rat (*Rattus norvegicus*)	2	U	DR	65	w	6	w	JV	M	GRO	BDWT	WO	102		72
93	Black et al, 1985	35824	Sheep (*Ovis aries*)	4	U	FD	84	d	NR	NR	JV	M	GRO	BDWT	WO	112	223	84
94	USDA, 1973	35143	Rabbit (*Oryctolagus cuniculus*)	5	U	GV	12	d	NR	NR	GE	F	GRO	BDWT	WO	112		75
95	USDA, 1973	35143	Mouse (*Mus musculus*)	5	U	GV	9	d	NR	NR	GE	F	GRO	BDWT	WO	125		75
96	USDA, 1973	35143	Hamster (*Mesocricetus auratus*)	5	U	GV	4	d	NR	NR	GE	F	GRO	BDWT	WO	136		75
97	Kontur and Fechter, 1985	34752	Rat (*Rattus norvegicus*)	4	U	DR	21	d	NR	NR	GE	F	GRO	BDWT	WO	162	271	79
98	Komura and Sakamoto, 1991	33786	Mouse (*Mus musculus*)	2	U	FD	100	d	6	w	JV	M	GRO	BDWT	WO	262		69
99	Komura and Sakamoto, 1991	33786	Mouse (*Mus musculus*)	2	U	FD	100	d	6	w	JV	M	GRO	BDWT	WO	270		69
100	Johnson and Kies, 1987	34574	Rat (*Rattus norvegicus*)	3	U	FD	56	d	NR	NR	JV	M	GRO	BDWT	WO	394		68
101	Gaillard, et al, 1996	33511	Rat (*Rattus norvegicus*)	2	U	DR	11	w	3	w	JV	M	GRO	BDWT	WO	554		73
102	Lipe, et al, 1999	33403	Rat (*Rattus norvegicus*)	3	U	GV	24	d	90	d	AD	M	GRO	BDWT	WO		10.0	80
103	Komura and Sakamoto, 1991	33786	Mouse (*Mus musculus*)	2	U	FD	30	d	6	w	JV	M	GRO	BDWT	WO		284	73
104	Komura and Sakamoto, 1991	33786	Mouse (*Mus musculus*)	2	U	FD	30	d	6	w	JV	M	GRO	BDWT	WO		284	78
Survival (MOR)																		
105	Rehnberg et al, 1980	57	Rat (*Rattus norvegicus*)	4	U	GV	17	d	1	d	JV	B	MOR	SURV	WO	21.0	71.0	89
106	USDA, 1973	35143	Rat (*Rattus norvegicus*)	5	U	GV	9	d	NR	NR	GE	F	MOR	SURV	WO	78.3		76
107	USDA, 1973	35143	Rabbit (*Oryctolagus cuniculus*)	5	U	GV	12	d	NR	NR	GE	F	MOR	SURV	WO	112		85
108	USDA, 1973	35143	Mouse (*Mus musculus*)	5	U	GV	9	d	NR	NR	GE	F	MOR	SURV	WO	125		85
109	USDA, 1973	35143	Hamster (*Mesocricetus auratus*)	5	U	GV	4	d	NR	NR	GE	F	MOR	SURV	WO	136		80

ACTV = activity, general; AGGT = agression; ATPT = adenosine triphosphate; B = both; BDWT = body weight changes; BEH = behavior; BIO = biochemical; BL = blood; BO = bone; BR = brain; bw = body weight; CALC = calcium; CHM = chemical changes; CHOL = cholesterol; CRKI = creatine kinase; d = day; DOPA = dopamine; DR = drinking water; ENZ = enyzme level changes; F = female; FCNS = food consumption; FD = food; FDB = feeding behavior; FDCV = food conversion efficiency; GBHV = general behavioral changes; GCHM = general biochemical changes; GE = gestation; GENZ = general enzyme changes; GGRO = general growth; GHIS = general histology; GHRM = general hormonal changes; GLYC = glycine; GRO = growth; GV = gavage; HIS = histological changes; HMGL = hemoglobin; IN = intestinal tract; ITX = intoxication; JV = juvenile; kg = kilograms; LC = lactation; LI = liver; LOAEL = lowest observed adverse effect level; mg = milligrams; mo = months; M = male; M = measured; MOR = effects on mortality and survival; NCRO = necrosis; NMVM = number of movements; NOAEL = No Observed Advese Effect Level; NORE = norephinephrine; NR = Not reported; OR = other oral; ORW = organ weight changes; ORWT = organ weight changes; OTHR = Other; PHY = physiology; PL = plasma; PROG = progeny counts/numbers; PRTL = protein, total; PRWT = progeny weight; PTH = pathology; RBCE = red blood cell count; REP = reproduction; RHIS = reproductive organ histology; RSPT = response time to stimulus; SCDH = succinate dehydrogenase; SK = skin; SM = sexually mature; SMIX = weight relative to body weight; SP = spleen; SR = serum; SURV = survival; TB = tibia; TE = testes; TEDG = testes degeneration; TEWT = testes weight; TSTR = testosterone; TTAA = amino acids, total; TWBC = white blood cell count, total; TYRO = tyrosine; U = unmeasured; UX = measured but values not reported; w = weeks; WCON = water consumption; WO = whole organism; yr = year.

*NOAEL and LOAEL values that are equal and from the same reference represent different experimental designs. These are designated with different Phase numbers in Appendix 5.1.

Within the reviewed papers there are 109 results for biochemical (BIO), behavior (BEH), physiology (PHY), pathology (PTH), reproduction (REP), growth (GRO), and survival (MOR) endpoints with a total Data Evaluation Score >65 that were used to derive the TRV (U.S. EPA 2003; Attachment 4-4). These data are plotted in Figure 6.1 and correspond directly with the data presented in Table 6.1. The NOAEL results for growth and reproduction are used to calculate a geometric mean NOAEL. This geometric mean is examined in relationship to the lowest bounded LOAEL for reproduction, growth, and survival to derive the TRV according to the Eco-SSL guidance (U.S. EPA 2003; Attachment 4-5).

A geometric mean of the NOAEL values for reproduction and growth was calculated at 51.5 mg manganese/kg bw/day. This value is lower than the lowest bounded LOAEL for reproduction, growth, or mortality results. Therefore, the TRV is equal to the geometric mean of the NOAEL values for reproduction and growth and is equal to 51.5 mg manganese/kg bw/day.

6.2 Estimation of Dose and Calculation of the Eco-SSL

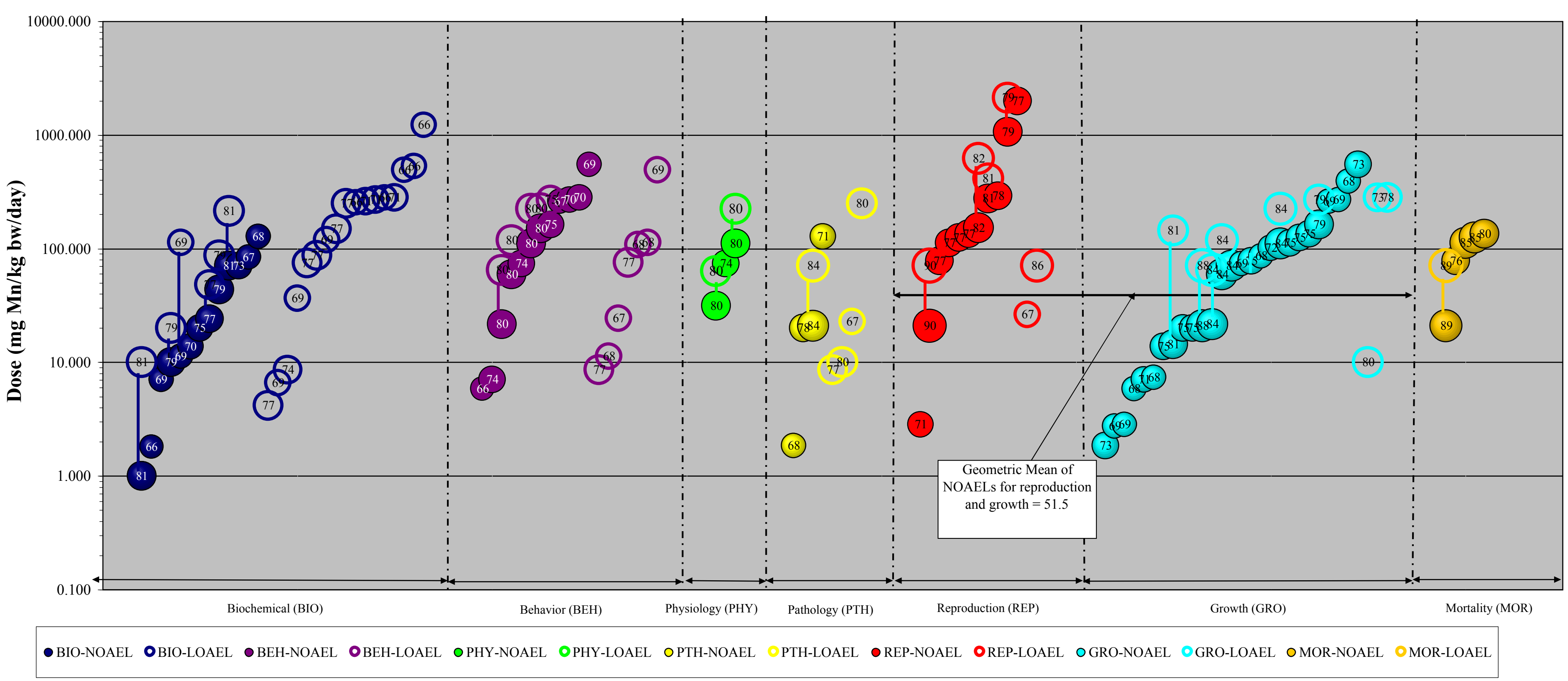
Three separate Eco-SSL values were calculated for mammalian wildlife, one for each of three surrogate receptor groups representing different trophic levels. The mammalian Eco-SSLs derived for manganese were calculated according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-5) and are summarized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

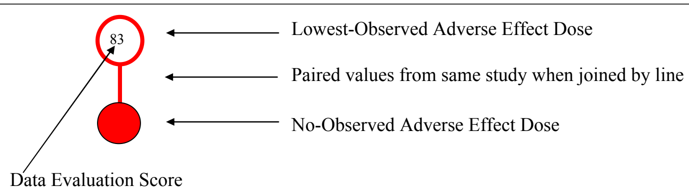
Table 6.2 Calculation of the Mammalian Eco-SSLs for Manganese

Surrogate Receptor Group	TRV for Manganese (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 Manganese in Biota Type (i)[2,3] (B_i) (mg/kg dw)	Eco-SSL (mg/kg dw)[4]
Mammalian herbivore (vole)	51.5	0.0875	0.032	$B_i = 0.079 * Soil_j$ where i = plants	5300
Mammalian ground insectivore (shrew)	51.5	0.209	0.030	$\ln(B_i) = 0.682 * \ln(Soil_j) - 0.809$ where i = earthworms	4000
Mammalian carnivore (weasel)	51.5	0.130	0.043	$B_i = 0.0205 * Soil_j$ where i = mammals	6200

[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] $HQ = [FIR * (Soil_j * P_s + B_i)] / TRV$ solved for HQ=1 where $Soil_j$ = Eco-SSL (Equation 4-2; U.S. EPA, 2003).

Figure 6.1 Mammalian TRV Derivation for Manganese





<u>Wildlife TRV Derivation Process</u>

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 51.5 mg manganese/kg bw/d and is lower than the lowest bounded LOAEL for results within the reproduction, growth, and survival (MOR) effect groups.

4) The mammalian wildlife TRV for manganese is equal to 51.5 mg Mn/kg bw/day which is the geometric mean of NOAEL values within the reproduction and growth effect groups.

7.0 REFERENCES

7.1 General Manganese References

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7.5 References Rejected for Use in Derivation of Wildlife TRV

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.

Unrel addition of calcium ions for enhancing the safety of metal-ligand chelates as magnetic resonance imaging agents and x-ray contrast agents. *PCT Int. Appl.* 10 pp.

Diss adriamycin cardiotoxicity and essential trace metal homeostasis in the in vivo rat heart (doxorubicin, cardiomyopathy, manganese, iron). *901491 ORDER NO: AAD85-26534*

In Vit 1992.*AFRRI Reports, First Quarter 1992. <NOTE> Technical Rept. AFRRI-SR92-1; AFRRI-SR92-2*

No Oral amino acid-chelated compositions and method for delivery of divalent metal cations to specific biological tissue sites. *PCT Int. Appl.* 42 pp.

Not Avail amino acid metal complexes using hydrolyzed protein as the amino acid source and methods re same. *U.S.* 11 pp.

No dose animal feed containing carboxylic acids. *PCT Int. Appl.* 36 pp.

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Mix aqueous feed additive comprising lactic acid, organic acid and chelated trace elements. *PCT Int. Appl.* 15 pp.

Diss arsenic: an analytical procedure to determine its total content in biological samples and signs of its deprivation in rats and chicks. *788794 ORDER NO: AAD82-20750*

No Oral 251.*Assessment of Toxicity of Automotive Metallic Emissions. Volume II. <NOTE> Final Rept| AU- Holbrook, D. J. | CS- North Carolina Univ.,*

FL birds and fowls fodder additive prescription and its prepn. *Faming Zhuanli Shenqing Gongkai Shuomingshu* : 10 pp.

No Oral central nervous system toxicity of manganese: mechanism of manganese concentration in the ventral mesencephalon (choroid plexus, dopamine reuptake). *01565449 ORDER NO: AAD97-20597*

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Diss chromium-nutrient interactions affecting tissue chromium, vitamin c metabolism, and cholesterol synthesis. *01135479 ORDER NO: AAD90-35204*

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Diss	diabetes teratogenicity: role of altered mineral metabolism. *1070710 ORDER NO: AAD89-10542*
Diss	effect of a direct-fed microbial on performance of single comb white leghorn chickens|. *01367290 ORDER NO: AAD94-22171*
Diss	the effect of chemical modulation of the cytochrome p-450 monooxygenase system on the activation of systemic lung toxins. *01235817 ORDER NO: AADDX-96678*
Diss	the effect of chromium depletion and streptozotocin-induced diabetes in pregnancy. *01593456 ORDER NO: AAD97-30469*
Diss	the effect of manganese on the histology and organ weights of cattle and the rat. *196716 ORDER NO: AAD00-09899*
Diss	effect of manganese oxide administration on male reproductive development and function (hormones, behavior, testes). *871743 ORDER NO: AAD85-00238*
Diss	the effect of zinc deficiency on immune function. *01173644 ORDER NO: AAD91-18419*
Diss	effects of dietary fatty acids, polyunsaturated/saturated ratios, and fat levels on growth and mineral deposition in young male rats (fatty acids). *01156306 ORDER NO: AAD91-05922*
Diss	the effects of dietary manganese deficiency on arterial glycosaminoglycan metabolism and structure in the sprague-dawley rat. *01593028 ORDER NO: AAD97-29636*
Nut def	the effects of dietary manganese deficiency on superoxide dismutase activity, lipid peroxidation and membrane stability. *881281 ORDER NO: AAD85-01790*
Diss	effects of dietary manganese on cholesterol and lipid metabolism in some avian and mammalian species. *781146 ORDER NO: AAD82-13321*
Diss	the effects of dietary sodium zeolite a on growth and mineral utilization of chickens. *01295923 ORDER NO: AAD93-17007*
Alt	*Effects of Manganese and Their Modification by Hexametaphosphate| TI-*
Nut def	effects of manganese deficiency on dietary adaptation of the exocrine pancreas in the rat (amylase, lipase, trypsin, chymotrypsin). *950860 ORDER NO: AAD13-29547*
Diss	effects of manganese on carbohydrate metabolism. *862971 ORDER NO: AAD84-24974*
Mix	electrolyte feed supplement for poultry hatchlings. *U.S.S.R. From: Izobreteniya 1992* (7): 14.
Diss	etude de l'evolution des systemes antioxydants au cours du developpement de l'insuffisance cardiaque experimentale chez le rat original title: study of antioxidant systems during the

development of experimental cardiac failure in rat (mrna, ischemia, superoxide dismutase, manganese, copper-zinc). *01476944 ORDER NO: AADAA-IC484409*

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Unrel 1974. fresh herbage. *<Document Title>Agricultural Development and Advisory Service, UK: UK,ADAS: ADAS Science Arm Annual Report 1972.* 90-91.

Diss functional assessment of manganese status (superoxide dismutase, biliary excretion). *01447018 ORDER NO: AADAA-I9527297*

Meth glucaric acid-containing formula and method for the prevention and treatment of hypercholesterolemia and cellular hyperproliferative disorders. *PCT Int. Appl.* 45 pp.

Diss heavy metal bioaccumulation in great basin submersed aquatic macrophytes. *01363274 ORDER NO: AAD94-18488*

Diss high field nmr studies of static ordering and spin-energy coupling in manganese-fluoride. *763588 ORDER NO: AAD81-26872*

Diss interactions among zinc, copper, iron, manganese, and ascorbic acid in the japanese quail (dietary supplements, toxicity, perosis, trace elements, anemia). *887582 ORDER NO: AAD85-14498*

Diss intracellular distribution of manganese and the effect of dietary manganese on rat liver arginase. *219135 ORDER NO: AAD59-01610*

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Diss kinetic modelling of iron-52/manganese-52m-citrate in brain by positron emission tomography (pet) (blood brain barrier). *01654257 ORDER NO: NOT AVAILABLE FROM UNIVERSITY MICROFILMS INT'L.*

Drug low phosphorus animal feed containing 1.alpha.-hydroxylated vitamin d compounds and method of preparing. *U.S.* 8 pp.

Diss manganese absorption: studies in humans with special reference to infant diets. *01132607 ORDER NO: NOT AVAILABLE FROM UNIVERSITY MICROFILMS INT'L.*

Diss manganese metabolism as affected by dietary calcium and phosphorus (calcium, phosphorus). *1079758 ORDER NO: AAD89-22450*

Diss manganese toxicity in the developing rat brain: the involvement of monoamine systems (catecholamines, amphetamine, neurotoxicology). *847139 ORDER NO: AAD84-14290*

Diss manganese utilization as affected by excess calcium and phosphorus. *01157849 ORDER NO: AAD91-14455*

Diss melanin binding of mptp and related substances, and manganese: possible connection with parkinsonism. *01215314 ORDER NO: NOT AVAILABLE FROM UNIVERSITY MICROFILMS INT'L.*

Diss the metabolism and toxicology of manganese. *873743 ORDER NO: NOT AVAILABLE FROM UNIVERSITY MICROFILMS INT'L.*

Diss metabolism of zinc, iron, copper and manganese of men and rats as affected by dietary protein, calcium and phosphorus. *799169 ORDER NO: AAD82-24068*

Nut def metal propionates for use as animal feed supplements. *U.S.* 6 pp. Cont.-in-part of U.S. Ser. No. 315,557, abandoned.

Nut metallic complexes of streptogramin-b, their preparation and their use in animal food. *Eur. Pat. Appl.* 12 pp.

Nut method of increasing amino acids content in grains of cereals and legumes by treatment with ammonia or urea. *Czech.* 5 pp.

Meth method to accelerate the color forming reaction between an enzyme and an indolyl derivative by adding a free radical and/or chelate to the reaction medium and its application for immunoassays and immunochromatography. *Ger. Offen.* 16 pp.

Gene methods for generating doubled haploid plants from microspores. *PCT Int. Appl.* 43 pp.

Drug methods using manganese superoxide dismutase-deficient mouse for testing compounds for use as therapeutic antioxidants. *PCT Int. Appl.* 47 pp.

Urel methylcyclopentadienyl manganese tricarbonyl teratology study in rats with attached appendices and cover letter dated 031480. *EPA/OTS; Doc #88-7900211*

Diss novel molecules useful for biological and medical applications: part i. toward the development of free radical based photoaffinity labels. part ii. new nitroxide formulations as contrast-enhancing agents for magnetic resonance imaging. part iii. mammalian brain sigma receptor specific ligands: structures and molecular mechanics calculations. *0991651 ORDER NO: AAD88-08702*

Diss nutrient availability of wheat feed screenings in broiler diet (chicken). *808758 ORDER NO: NOT AVAILABLE FROM UNIVERSITY MICROFILMS INT'L.*

Diss part i. phosphorus requirements of range beef cattle. part ii. effects of high levels of manganese supplementation on reproduction and lactation of beef cattle, and rabbits, and on the fecal excretion of calcium and phosphorus by steers. *088045 ORDER NO: NOT AVAILABLE FROM UNIVERSITY MICROFILMS INT'L.*

Diss phospholipase c (pi-plc) in adipose tissue of the ob/ob mouse. *01209355 ORDER NO: AAD92-08517|*

Diss	phosphorylase phosphatase: interconversion of active and inactive forms (manganese). *844929 ORDER NO: AAD84-12371*
Diss	the physiology of the calcium leak channel and calcium regulation in muscle and nervous tissue of the dystrophic mdx mouse (muscular dystrophy, dystrophin). *01456561 ORDER NO: AADAA-I9602450*
No Oral	plant cell preparation for stimulating fermentation and other physiological functions. *Jpn. Kokai Tokkyo Koho* : 10 pp.
Diss	pneumotoxic properties of the fuel additive methylcyclopentadienyl manganese tricarbonyl (mmt): part i. the role of the sympathetic nervous system in mmt-induced pneumotoxicity and mortality. part ii. mmt-induced pneumotoxicity and lethality which is independent of sympathetic nervous system activity. *954509 ORDER NO: AAD87-11210*
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Diss	a role for the mitochondrion in manganese toxicity. *01178926 ORDER NO: AAD91-32404*
Diss	role of copper in the phenotypic expression of scoliosis. *849880 ORDER NO: AAD84-16905*
Org Met	a segment ii teratology study on methylcyclopentadienyl managenese tricarbonyl in rats with attachment and cover letter dated 100378| so- numbers not reported) fed methylcyclopentadienylmanganesetricarbonyl (mmt), by gavage (dose levels and dosing period not reported). the authors concluded that the data did not support a conclusion that mmt was a teratogen. however, high dose levels produced high maternal and embryonal toxicity, which may have obscured potential teratogenic effects. the document summarizes this study, and no further information is available regarding experimental method or results.
Org Met	a segment ii teratology study on methylcyclopentadienyl manganese tricarbonyl in rats with cover letters dated 110579 and 100379. *EPA/OTS; Doc #88-7900211*
Meth	somatotropin-transition metal complexes as animal growth stimulants and a method for their preparation. *Eur. Pat. Appl.* 10 pp. C.
Diss	studies on the muscarinic receptors in neuroblastoma cells. *750140 ORDER NO: AAD81-14988*
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Diss	a study of membrane proteins and ion transport processes in red blood cells of the spontaneously hypertensive and wistar-kyoto rats. *938942 ORDER NO: NOT AVAILABLE FROM UNIVERSITY MICROFILMS INT'L.*
Diss	a study of the chemistry and mutagenicity of welding fume. *910380 ORDER NO: NOT AVAILABLE FROM UNIVERSITY MICROFILMS INT'L.*

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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) - Manganese

April 2007

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	5345	Martinez and Diaz, 1996	Manganese oxide	100	Chicken (*Gallus domesticus*)	1	4	0/372/744/1488	mg/kg diet	N	na	ADL	U	FD	14	d	1	d	JV	M	C	Lab	3	BIO	CHM	HMGL	BL	744	1488	Y	0.2723	Y	0.07278	199	398	10	10	5	10	7	1	10	10	10	4	77
2	6363	Southern and Baker, 1983	Manganese sulfate hydrate	100	Chicken (*Gallus domesticus*)	4	4	0/3000/4000/5000	mg/kg diet	NR	na	ADL	U	FD	14	d	14	d	JV	M	C	Lab	3	BIO	CHM	HMGL	BL	4000	5000	Y	0.318	N	0.02761	347	434	10	10	5	10	6	1	10	10	10	4	76
3	8426	Laskey and Edens, 1985	Manganese oxide	100	Japanese quail (*Coturnix japonica*)	1	2	0/575	mg/kg bw/d	NR	na	ADL	U	FD	10	w	1	d	JV	M	C	Lab	5	BIO	HRM	TSTR	SR	575		Y	0.099	Y	1.9697	575		10	10	5	10	10	1	4	3	10	4	67
4	6363	Southern and Baker, 1983	Manganese chloride tetrahydrate	100	Chicken (*Gallus domesticus*)	4	4	0/3000/4000/5000	mg/kg diet	NR	na	ADL	U	FD	14	d	7	d	JV	M	C	Lab	3	BIO	CHM	HMGL	BL		3000	Y	0.316	N	0.02749		261	10	10	5	10	6	1	4	10	10	4	70
5	6363	Southern and Baker, 1983	Manganese carbonate	100	Chicken (*Gallus domesticus*)	4	4	0/3000/4000/5000	mg/kg diet	NR	na	ADL	U	FD	14	d	7	d	JV	M	C	Lab	3	BIO	CHM	HMGL	BL		3000	Y	0.305	N	0.02687		264	10	10	5	10	6	1	4	10	10	4	70
6	7710	Edens and Laskey, 1990	Manganes oxide (Mn3O4)	100	Japanese quail (*Coturnix japonica*)	1	2	0/5000	mg/kg diet	NR	na	ADL	U	FD	10	w	0	d	JV	M	C	Lab	1	BIO	CHM	GLUC	SR		5000	N	0.09	N	0.01214		674	10	10	5	10	5	1	4	10	10	4	69
Behavior																																														
7	5345	Martinez and Diaz, 1996	Manganese oxide	100	Chicken (*Gallus domesticus*)	1	4	0/372/744/1488	mg/kg diet	N	na	ADL	U	FD	42	d	1	d	JV	M	C	Lab	2	BEH	FDB	FCNS	WO	744	1488	Y	1.8493	Y	0.07278	29.3	58.6	10	10	5	10	7	4	10	10	10	4	80
8	6195	Black et al., 1985	Manganese sulfate monohydrate	100	Chicken (*Gallus domesticus*)	1	4	0/1000/2000/3000	mg/kg diet	NR	na	ADL	U	FD	3	w	1	d	JV	M	C	Lab	3	BEH	FDB	FCNS	WO	2000	3000	Y	0.5151	Y	0.0329	128	192	10	10	5	10	7	4	10	10	10	4	80
9	6305	Black et al, 1984	Manganese oxide	100	Chicken (*Gallus domesticus*)	1	4	0/1000/2000/3000	mg/kg diet	NR	na	ADL	U	FD	21	d	1	d	JV	M	C	Lab	2	BEH	FDB	FCNS	WO	3000		Y	0.5376	Y	0.0362	202		10	10	5	10	7	4	4	10	10	4	74
10	8426	Laskey and Edens, 1985	Manganese oxide	100	Japanese quail (*Coturnix japonica*)	1	2	0/575	mg/kg bw/d	NR	na	ADL	U	FD	75	d	1	d	JV	M	C	Lab	2	BEH	FDB	FCNS	WO	575		Y	0.099	Y	1.9697	575		10	10	5	10	10	4	4	1	10	4	68
Physiology																																														
11	6305	Black et al, 1984	Manganese oxide	100	Chicken (*Gallus domesticus*)	1	4	0/1000/2000/3000	mg/kg diet	NR	na	ADL	U	FD	21	d	1	d	JV	M	C	Lab	3	PHY	PHY	FDCV	WO	3000		Y	0.5376	N	0.03886	217		10	10	5	10	6	4	4	10	10	4	73
12	6215	Brown and Southern, 1985	Manganese sulfate	100	Chicken (*Gallus domesticus*)	1	2	0/1500	mg/kg diet	N	na	ADL	U	FD	14	d	4	d	JV	M	C	Lab	2	PHY	PHY	FDCV	WO		1500	Y	0.5139	N	0.03773		110	10	10	5	10	6	4	4	10	10	4	73
Pathology																																														
13	6054	Halpin et al, 1986	Manganese sulfate hydrate	100	Chicken (*Gallus domesticus*)	1	3	0/2.6/26	mg/org/d	NR	na	2 per d	U	GV	14	d	8	d	JV	M	C	Lab	2	PTH	ORW	ORWT	TB	26		Y	0.388	N	0.03142	67.0		10	8	10	10	6	4	4	1	10	4	67
14	8426	Laskey and Edens, 1985	Manganese oxide	100	Japanese quail (*Coturnix japonica*)	1	2	0/575	mg/kg bw/d	NR	na	ADL	U	FD	70	d	1	d	JV	M	C	Lab	3	PTH	ORW	ORWT	LI	575		Y	0.099	Y	1.9697	575		10	10	5	10	10	4	4	10	10	4	77
Reproduction																																														
15	5474	Sazzad et al, 1994	Manganese oxide	100	Chicken (*Gallus domesticus*)	2	2	0/306	mg/d	NR	na	ADL	U	FD	12	w	23	w	LB	F	C	Lab	1	REP	REP	PROG	WO	306		N	1.6	Y	0.99	191		10	10	5	10	6	10	4	1	10	4	70
16	5474	Sazzad et al, 1994	Manganese oxide	100	Chicken (*Gallus domesticus*)	2	2	0/323	mg/d	NR	na	ADL	U	FD	12	w	23	w	LB	F	C	Lab	1	REP	REP	PROG	WO	323		N	1.6	Y	0.98	202		10	10	5	10	6	10	4	1	10	4	70
17	8426	Laskey and Edens, 1985	Manganese oxide	100	Japanese quail (*Coturnix japonica*)	1	2	0/575	mg/kg bw/d	NR	na	ADL	U	FD	75	d	1	d	JV	M	C	Lab	4	REP	REP	TEWT	TE	575		Y	0.099	Y	1.9697	575		10	10	5	10	10	10	4	8	10	4	81
Growth																																														
18	6772	Spulkamy et al, 1976	Manganese Sulfate	100	Chicken (*Gallus domesticus*)	1	5	0/5.85/6.61/7.44/11.64	mg/org/d	NR	na	ADL	U	FD	7	w	1	w	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	11.64		Y	0.5033	Y	0.05401	23.1		10	10	5	10	7	8	4	1	10	4	69
19	7191	Settle et al, 1969	Manganese sulfate	100	Chicken (*Gallus domesticus*)	1	3	0/220/330	mg/kg diet	NR	na	ADL	U	FD	4	w	1	d	JV	B	C	Lab	1	GRO	GRO	BDWT	WO	330		Y	0.509	N	0.0375	24.3		10	10	5	10	6	8	4	1	10	4	68
20	5728	Wedekind and Baker, 1990	Manganese sulfate monohydrate	100	Chicken (*Gallus domesticus*)	1	3	0/13.6/28.29	mg/org	NR	na	ADL	U	FD	14	d	8	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	28.29		N	0.564	N	0.04009	50.2		10	10	5	10	5	8	4	1	10	4	67
21	6054	Halpin et al, 1986	Manganese sulfate hydrate	100	Chicken (*Gallus domesticus*)	1	3	0/2.6/26	mg/org/d	NR	na	2 per d	U	GV	14	d	8	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	26		Y	0.388	N	0.03142	67.0		10	8	10	10	6	8	4	1	10	4	71
22	6087	Henry et al., 1986	Manganese sulfate hydrate	100	Chicken (*Gallus domesticus*)	1	2	0/1000	mg/kg diet	NR	na	ADL	U	FD	21	d	1	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	1000		N	0.564	Y	0.0405	71.8		10	10	5	10	6	8	4	1	10	4	68
23	5700	Baker and Halpin, 1991	Manganese sulfate monohydrate	100	Chicken (*Gallus domesticus*)	1	2	0/1000	mg/kg diet	NR	na	ADL	U	FD	14	d	8	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	1000		Y	0.309	N	0.02709	87.7		10	10	5	10	6	8	4	1	10	4	68
24	44196	De Rosa et al, 1980	Manganese	100	Chicken (*Gallus domesticus*)	1	2	0/1000	mg/kg diet	NR	na	ADL	U	FD	1	w	2	w	JV	B	C	Lab	1	GRO	GRO	BDWT	WO	1000		Y	0.2276	N	0.0222	97.6		10	10	5	4	6	8	4	10	10	4	71
25	6215	Brown and Southern, 1985	Manganese sulfate	100	Chicken (*Gallus domesticus*)	1	2	0/1500	mg/kg diet	N	na	ADL	U	FD	14	d	4	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	1500		Y	0.5139	N	0.03773	110		10	10	5	10	6	8	4	10	10	4	77
26	6195	Black et al., 1985	Manganese sulfate monohydrate	100	Chicken (*Gallus domesticus*)	1	4	0/1000/2000/3000	mg/kg diet	NR	na	ADL	U	FD	3	w	1	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	3000		Y	0.4668	Y	0.0306	197		10	10	5	10	7	8	4	1	10	4	69
27	6305	Black et al, 1984	Manganese oxide	100	Chicken (*Gallus domesticus*)	1	4	0/1000/2000/3000	mg/kg diet	NR	na	ADL	U	FD	21	d	1	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	3000		Y	0.5376	Y	0.0362	202		10	10	5	10	7	8	4	6	10	4	74
28	5788	Wong-Valle et al, 1989	Manganese sulfate hydrate	100	Chicken (*Gallus domesticus*)	2	4	0/1000/2000/3000	mg/kg diet	NR	na	ADL	U	FD	21	d	1	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	3000		N	0.564	N	0.04009	213		10	10	5	10	5	8	4	1	10	4	67
29	5788	Wong-Valle et al, 1989	Manganese oxide	100	Chicken (*Gallus domesticus*)	2	4	0/1000/2000/3000	mg/kg diet	NR	na	ADL	U	FD	21	d	1	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	3000		N	0.564	N	0.04009	213		10	10	5	10	5	8	4	1	10	4	67
30	5345	Martinez and Diaz, 1996	Manganese oxide	100	Chicken (*Gallus domesticus*)	1	4	0/372/744/1488	mg/kg diet	N	na	ADL	U	FD	14	d	1	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	744	1488	Y	0.2723	Y	0.07886	215	431	10	10	5	10	7	8	10	10	10	4	84
31	6382	Southern and Baker, 1983	Manganese sulfate hydroxide	100	Chicken (*Gallus domesticus*)	1	3	0/1500/3000	mg/kg diet	NR	na	ADL	U	FD	14	d	8	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	3000		Y	0.35	N	0.02938	252		10	10	5	10	6	8	4	1	10	4	68
32	6363	Southern and Baker, 1983	Manganese chloride tetrahydrate	100	Chicken (*Gallus domesticus*)	4	4	0/3000/4000/5000	mg/kg diet	NR	na	ADL	U	FD	14	d	7	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	3000	4000	Y	0.316	N	0.02749	261	348	10	10	5	10	6	8	10	10	10	4	83
33	14404	Vohra and Kratzer, 1968	Manganese sulfate monohydrate	100	Turkey (*Meleagris gallopavo*)	1	9	0/510/1020/2040/3000/3060/3620/4080/4800	mg/kg diet	NR	na	ADL	U	FD	21	d	NR	NR	JV	B	C	Lab	1	GRO	GRO	BDWT	WO	4080	4800	N	0.5	N	0.03706	302	356	10	10	5	10	5	8	10	10	10	4	82
34	6363	Southern and Baker, 1983	Manganese dioxide	100	Chicken (*Gallus domesticus*)	4	4	0/3000/4000/5000	mg/kg diet	NR	na	ADL	U	FD	14	d	7	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	5000		Y	0.316	N	0.02749	435		10	10	5	10	6	8	4	1	10	4	68
35	6363	Southern and Baker, 1983	Manganese sulfate hydrate	100	Chicken (*Gallus domesticus*)	4	4	0/3000/4000/5000	mg/kg diet	NR	na	ADL	U	FD	14	d	7	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	5000		Y	0.311	N	0.02721	437		10	10	5	10	6	8	4	1	10	4	68
36	6363	Southern and Baker, 1983	Manganese carbonate	100	Chicken (*Gallus domesticus*)	4	4	0/3000/4000/5000	mg/kg diet	NR	na	ADL	U	FD	14	d	7	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	5000		Y	0.308	N	0.02704	439		10	10	5	10	6	8	4	1	10	4	68
37	8426	Laskey and Edens, 1985	Manganese oxide	100	Japanese quail (*Coturnix japonica*)	1	2	0/575	mg/kg bw/d	NR	na	ADL	U	FD	75	d	1	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	575		Y	0.099	Y	1.9697	575		10	10	5	10	10	8	4	10	10	4	81
38	2196	Leeson and Summers, 1982	Manganous oxide	100	Chicken (*Gallus domesticus*)	1	5	0/110/220/440/880	mg/kg diet	NR	na	ADL	U	FD	21	d	1	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	880		N	0.564	Y	0.7178	1120		10	10	5	10	6	8	4	1	10	4	68
Survival																																														
39	6252	Black et al., 1984	Manganese	100	Chicken (*Gallus domesticus*)	1	4	0/1000/2000/4000	mg/kg diet	NR	na	ADL	U	FD	26	d	4	d	JV	B	C	Lab	2	MOR	MOR	MORT	WO	4000		N	1.042	Y	0.0563	216		10	10	5	4	6	9	4	10	10	4	72
40	14404	Vohra and Kratzer, 1968	Manganese sulfate monohydrate	100	Turkey (*Meleagris gallopavo*)	1	9	0/510/1020/2040/3000/3060/3620/4080/4800	mg/kg diet	NR	na	ADL	U	FD	21	d	NR	NR	JV	B	C	Lab	2	MOR	MOR	MORT	WO	4800		N	0.5	N	0.03706	356		10	10	5	10	5	9	4	1	10	4	68
Data Not Used to Derive TRV																																														
41	6772	Spulkamy et al, 1976	Manganese Sulfate	100	Chicken (*Gallus domesticus*)	1	5	0/5.85/6.61/7.44/11.64	mg/org/d	NR	na	ADL	U	FD	7	w	1	w	JV	M	C	Lab	3	BEH	FDB	FCNS	WO	11.64		Y	0.5033	Y	5.4E-05	23.1		10	10	5	10	7	4	4	1	10	4	65
42	6772	Spulkamy et al, 1976	Manganese Sulfate	100	Chicken (*Gallus domesticus*)	1	5	0/5.85/6.61/7.44/11.64	mg/org/d	NR	na	ADL	U	FD	7	w	1	w	JV	M	C	Lab	2	PHY	PHY	FDCV	WO	11.64		Y	0.5033	Y	5.4E-05	23.1		10	10	5	10	7	4	4	1	10	4	65
43	5345	Martinez and Diaz, 1996	Manganese oxide	100	Chicken (*Gallus domesticus*)	1	4	0/372/744/1488	mg/kg diet	N	na	ADL	U	FD	42	d	1	d	JV	M	C	Lab	4	PTH	ORW	ORWT	HE	1488		Y	1.7524	Y	0.07886	67.0		10	10	5	10	7	4	4	1	10	4	65
44	5345	Martinez and Diaz, 1996	Manganese oxide	100	Chicken (*Gallus domesticus*)	1	4	0/372/744/1488	mg/kg diet	N	na	ADL	U	FD	42	d	1	d	JV	M	C	Lab	5	PHY	PHY	FDCV	WO	1488		Y	1.7524	Y	0.07886	67.0		10	10	5	10	7	4	4	1	10	4	65
45	6087	Henry et al., 1986	Manganese sulfate hydrate	100	Chicken (*Gallus domesticus*)	1	2	0/1000	mg/kg diet	NR	na	ADL	U	FD	21	d	1	d	JV	M	C	Lab	2	BEH	FDB	FCNS	WO	1000		N	0.564	Y	0.0405	71.8		10	10	5	10	6	4	4	1	10	4	64
46	6087	Henry et al., 1986	Manganese sulfate hydrate	100	Chicken (*Gallus domesticus*)	1	2	0/1000	mg/kg diet	NR	na	ADL	U	FD	21	d	1	d	JV	M	C	Lab	4	PHY	PHY	FDCV	WO	1000		N	0.564	Y	0.0405	71.8		10	10	5	10	6	4	4	1	10	4	64
47	6087	Henry et al., 1986	Manganese sulfate hydrate	100	Chicken (*Gallus domesticus*)	1	2	0/1000	mg/kg diet	NR	na	ADL	U	FD	21	d	1	d	JV	M	C	Lab	3	PTH	ORW	SMIX	IN	1000		N	0.564	Y	0.0405	71.8		10	10	5	10	6	4	4	1	10	4	64
48	5700	Baker and Halpin, 1991	Manganese sulfate monohydrate	100	Chicken (*Gallus domesticus*)	1	2	0/1000	mg/kg diet	NR	na	ADL	U	FD	14	d	8	d	JV	M	C	Lab	3	BIO	CHM	HMGL	BL	1000		Y	0.309	N	0.02709	87.7		10	10	5	10	6	1	4	1	10	4	61

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

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
49	5700	Baker and Halpin, 1991	Manganese sulfate monohydrate	100	Chicken (*Gallus domesticus*)	1	2	0/1000	mg/kg diet	NR	na	ADL	U	FD	14	d	8	d	JV	M	C	Lab	2	PHY	PHY	FDCV	WO	1000		Y	0.309	N	0.02709	87.7		10	10	5	10	6	4	4	1	10	4	64
50	44196	De Rosa et al, 1980	Manganese	100	Chicken (*Gallus domesticus*)	1	2	0/1000	mg/kg diet	NR	na	ADL	U	FD	1	w	2	w	JV	B	C	Lab	2	BIO	ENZ	GENZ	LI	1000		Y	0.2276	N	0.0222	97.6		10	10	5	4	6	1	4	1	10	4	55
51	5728	Wedekind and Baker, 1990	Manganese sulfate monohydrate	100	Chicken (*Gallus domesticus*)	1	3	0/13.6/28.29	mg/org	NR	na	ADL	U	FD	14	d	8	d	JV	M	C	Lab	3	PHY	PHY	FDCV	WO	28.29		N	0.564	N	0.04009	50.2		10	10	5	10	5	4	4	1	10	4	63
52	5728	Wedekind and Baker, 1990	Manganese sulfate monohydrate	100	Chicken (*Gallus domesticus*)	1	3	0/13.6/28.29	mg/org	NR	na	ADL	U	FD	14	d	8	d	JV	M	C	Lab	2	PTH	ORW	ORWT	TB	28.29		N	0.564	N	0.04009	50.2		10	10	5	10	5	4	4	1	10	4	63
53	5983	Henry et al., 1987	Manganese	100	Chicken (*Gallus domesticus*)	1	4	0/1000/2000/3000	mg/kg diet	NR	na	ADL	U	FD	21	d	1	d	JV	M	C	Lab	2	BEH	FDB	FCNS	WO	3000		N	0.564	Y	0.0349	186		10	10	5	4	6	4	4	1	10	4	58
54	5983	Henry et al., 1987	Manganese	100	Chicken (*Gallus domesticus*)	1	4	0/1000/2000/3000	mg/kg diet	NR	na	ADL	U	FD	21	d	1	d	JV	M	C	Lab	3	PHY	PHY	FDCV	WO	3000		N	0.564	Y	0.0349	186		10	10	5	4	6	4	4	1	10	4	58
55	5983	Henry et al., 1987	Manganese	100	Chicken (*Gallus domesticus*)	1	4	0/1000/2000/3000	mg/kg diet	NR	na	ADL	U	FD	21	d	1	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	3000		N	0.564	Y	0.0349	186		10	10	5	4	6	8	4	1	10	4	62
56	5474	Sazzad et al, 1994	Manganese oxide	100	Chicken (*Gallus domesticus*)	2	2	0/306	mg/d	NR	na	ADL	U	FD	12	w	23	w	SM	F	C	Lab	3	BEH	FDB	FCNS	WO	306		N	1.6	Y	0.99	191		10	10	5	10	6	4	4	1	6	4	60
57	5474	Sazzad et al, 1994	Manganese oxide	100	Chicken (*Gallus domesticus*)	2	2	0/306	mg/d	NR	na	ADL	U	FD	12	w	23	w	SM	F	C	Lab	2	PHY	PHY	FDCV	WO	306		N	1.6	Y	0.99	191		10	10	5	10	6	4	4	1	6	4	60
58	6195	Black et al., 1985	Manganese sulfate monohydrate	100	Chicken (*Gallus domesticus*)	1	4	0/1000/2000/3000	mg/kg diet	NR	na	ADL	U	FD	3	w	1	d	JV	M	C	Lab	2	PHY	PHY	FDCV	WO	3000		Y	0.4668	Y	0.0306	197		10	10	5	10	7	4	4	1	10	4	65
59	5474	Sazzad et al, 1994	Manganese oxide	100	Chicken (*Gallus domesticus*)	2	2	0/323	mg/d	NR	na	ADL	U	FD	12	w	23	w	SM	F	C	Lab	3	BEH	FDB	FCNS	WO	323		N	1.6	Y	0.98	202		10	10	5	10	6	4	4	1	6	4	60
60	5474	Sazzad et al, 1994	Manganese oxide	100	Chicken (*Gallus domesticus*)	2	2	0/323	mg/d	NR	na	ADL	U	FD	12	w	23	w	SM	F	C	Lab	4	BIO	CHM	CALC	LI	323		N	1.6	Y	0.98	202		10	10	5	10	6	1	4	1	6	4	57
61	5474	Sazzad et al, 1994	Manganese oxide	100	Chicken (*Gallus domesticus*)	2	2	0/323	mg/d	NR	na	ADL	U	FD	12	w	23	w	SM	F	C	Lab	2	PHY	PHY	FDCV	WO	323		N	1.6	Y	0.98	202		10	10	5	10	6	4	4	1	6	4	60
62	5788	Wong-Valle et al, 1989	Manganese sulfate hydrate	100	Chicken (*Gallus domesticus*)	2	4	0/1000/2000/3000	mg/kg diet	NR	na	ADL	U	FD	21	d	1	d	JV	M	C	Lab	2	BEH	FDB	FCNS	WO	3000		N	0.564	N	0.04009	213		10	10	5	10	5	4	4	1	10	4	63
63	5788	Wong-Valle et al, 1989	Manganese oxide	100	Chicken (*Gallus domesticus*)	2	4	0/1000/2000/3000	mg/kg diet	NR	na	ADL	U	FD	21	d	1	d	JV	M	C	Lab	2	BEH	FDB	FCNS	WO	3000		N	0.564	N	0.04009	213		10	10	5	10	5	4	4	1	10	4	63
64	5788	Wong-Valle et al, 1989	Manganese sulfate hydrate	100	Chicken (*Gallus domesticus*)	2	4	0/1000/2000/3000	mg/kg diet	NR	na	ADL	U	FD	21	d	1	d	JV	M	C	Lab	3	PHY	PHY	FDCV	WO	3000		N	0.564	N	0.04009	213		10	10	5	10	5	4	4	1	10	4	63
65	5788	Wong-Valle et al, 1989	Manganese oxide	100	Chicken (*Gallus domesticus*)	2	4	0/1000/2000/3000	mg/kg diet	NR	na	ADL	U	FD	21	d	1	d	JV	M	C	Lab	3	PHY	PHY	FDCV	WO	3000		N	0.564	N	0.04009	213		10	10	5	10	5	4	4	1	10	4	63
66	6252	Black et al., 1984	Manganese	100	Chicken (*Gallus domesticus*)	1	4	0/1000/2000/4000	mg/kg diet	NR	na	ADL	U	FD	26	d	4	d	JV	B	C	Lab	1	GRO	GRO	BDWT	WO	4000		N	1.042	Y	0.0563	216		10	10	5	4	6	8	4	1	10	4	62
67	6252	Black et al., 1984	Manganese	100	Chicken (*Gallus domesticus*)	1	4	0/1000/2000/4000	mg/kg diet	NR	na	ADL	U	FD	26	d	4	d	JV	B	C	Lab	3	BEH	FDB	FCNS	WO	4000		N	1.042	Y	0.0563	216		10	10	5	4	6	4	4	1	10	4	58
68	6252	Black et al., 1984	Manganese	100	Chicken (*Gallus domesticus*)	1	4	0/1000/2000/4000	mg/kg diet	NR	na	ADL	U	FD	26	d	4	d	JV	B	C	Lab	4	BIO	CHM	HMGL	BL	4000		N	1.042	Y	0.0563	216		10	10	5	4	6	1	4	1	10	4	55
69	6382	Southern and Baker, 1983	Manganese sulfate hydroxide	100	Chicken (*Gallus domesticus*)	1	3	0/1500/3000	mg/kg diet	NR	na	ADL	U	FD	14	d	8	d	JV	M	C	Lab	3	BIO	CHM	HMGL	BL	3000		Y	0.35	N	0.02938	252		10	10	5	10	6	1	4	1	10	4	61
70	6382	Southern and Baker, 1983	Manganese sulfate hydroxide	100	Chicken (*Gallus domesticus*)	1	3	0/1500/3000	mg/kg diet	NR	na	ADL	U	FD	14	d	8	d	JV	M	C	Lab	2	PHY	PHY	FDCV	WO	3000		Y	0.35	N	0.02938	252		10	10	5	10	6	4	4	1	10	4	64
71	6363	Southern and Baker, 1983	Manganese dioxide	100	Chicken (*Gallus domesticus*)	4	4	0/3000/4000/5000	mg/kg diet	NR	na	ADL	U	FD	14	d	7	d	JV	M	C	Lab	3	BIO	CHM	HMGL	BL	5000		Y	0.316	N	0.02749	435		10	10	5	10	6	1	4	1	10	4	61
72	6363	Southern and Baker, 1983	Manganese dioxide	100	Chicken (*Gallus domesticus*)	4	4	0/3000/4000/5000	mg/kg diet	NR	na	ADL	U	FD	14	d	7	d	JV	M	C	Lab	2	PHY	PHY	FDCV	WO	5000		Y	0.316	N	0.02749	435		10	10	5	10	6	4	4	1	10	4	64
73	6363	Southern and Baker, 1983	Manganese sulfate hydrate	100	Chicken (*Gallus domesticus*)	4	4	0/3000/4000/5000	mg/kg diet	NR	na	ADL	U	FD	14	d	7	d	JV	M	C	Lab	2	PHY	PHY	FDCV	WO	5000		Y	0.311	N	0.02721	437		10	10	5	10	6	4	4	1	10	4	64
74	6363	Southern and Baker, 1983	Manganese carbonate	100	Chicken (*Gallus domesticus*)	4	4	0/3000/4000/5000	mg/kg diet	NR	na	ADL	U	FD	14	d	7	d	JV	M	C	Lab	2	PHY	PHY	FDCV	WO	5000		Y	0.308	N	0.02704	439		10	10	5	10	6	4	4	1	10	4	64
75	6363	Southern and Baker, 1983	Manganese chloride tetrahydrate	100	Chicken (*Gallus domesticus*)	4	4	0/3000/4000/5000	mg/kg diet	NR	na	ADL	U	FD	14	d	7	d	JV	M	C	Lab	2	PHY	PHY	FDCV	WO	5000		Y	0.29	N	0.026	448		10	10	5	10	6	4	4	1	10	4	64
76	2196	Leeson and Summers, 1982	Manganous oxide	100	Chicken (*Gallus domesticus*)	1	5	0/110/220/440/880	mg/kg diet	NR	na	ADL	U	FD	21	d	1	d	JV	M	C	Lab	2	BEH	FDB	FCNS	WO	880		N	0.564	Y	0.7178	1120		10	10	5	10	6	4	4	1	10	4	64
77	2196	Leeson and Summers, 1982	Manganous oxide	100	Chicken (*Gallus domesticus*)	1	5	0/110/220/440/880	mg/kg diet	NR	na	ADL	U	FD	21	d	1	d	JV	M	C	Lab	3	PHY	PHY	FDCV	WO	880		N	0.564	Y	0.7178	1120		10	10	5	10	6	4	4	1	10	4	64

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

*NOAEL and LOAEL values that are equal and from the same reference represent different experimental designs. These are designated with different Phase numbers.

Appendix 6-1

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

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April 2007

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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		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	34921	Deskin, et al, 1980	Manganese chloride tetrahydrate	100	Rat (*Rattus norvegicus*)	1	4	0/1/10/20	mg/kg bw/d	NR	na	DLY	U	GV	24	d	1	d	JV	M	C	Lab	2	BIO	HRM	GHRM	BR	1	10	Y	0.075	N	0.008171	1.00	10.0	10	8	10	10	10	1	8	10	10	4	81
2	36002	Mohamed et al, 1986	Manganese sulfate	100	Water buffalo (*Bubalus carabanensis*)	1	3	0/574.68/697.68	mg/org/d	NR	na	ADL	M	FD	90	d	13-19	mo	JV	M	C	NR	2	BIO	CHM	CALC	SR	679.68		Y	375.33	N	8.97686	1.81		10	10	10	10	6	1	4	1	10	4	66
3	35470	Bhoot et al, 1981	Manganese chloride	100	Cattle (*Bos taurus*)	1	3	0/100/250	mg/kg diet	NR	na	ADL	U	FD	66	d	1	yr	JV	F	C	Lab	3	BIO	CHM	HMGL	BL	250		Y	146.5	Y	4.13	7.05		10	10	5	10	7	1	4	8	10	4	69
4	33403	Lipe, et al, 1999	Manganese chloride	100	Rat (*Rattus norvegicus*)	2	3	0/10/20	mg/kg bw/d	NR	na	DLY	U	GV	30	d	90	d	AD	M	C	Lab	2	BIO	CHM	TTAA	BR	10	20	Y	0.43	N	0.03433	10.0	20.0	10	8	10	10	10	1	10	10	6	4	79
5	35707	Bonilla and Prasad, 1984	Manganese Chloride	100	Rat (*Rattus norvegicus*)	1	3	0/0.1/1.0	mg/ml	NR	na	ADL	U	DR	8	mo	NR	NR	JV	M	C	Lab	2	BIO	HRM	NORE	BR	0.1	1	Y	0.25	N	0.02843	11.4	114	10	5	5	10	6	1	8	10	10	4	69
6	36045	Kontur and Fechter, 1985	Manganese chloride tetrahydrate	100	Rat (*Rattus norvegicus*)	1	3	0/6.9/13.8	mg/kg bw/d	NR	na	DLY	U	GV	21	d	1	d	JV	B	C	Lab	2	BIO	HRM	DOPA	BR	13.8		Y	0.035	N	0.004367	13.8		10	8	10	10	10	1	4	3	10	4	70
7	33403	Lipe, et al, 1999	Manganese chloride	100	Rat (*Rattus norvegicus*)	2	3	0/10/20	mg/kg bw/d	NR	na	DLY	U	GV	30	d	30	d	JV	M	C	Lab	1	BIO	CHM	TTAA	BR	20		Y	0.2752	N	0.023787	20.0		10	8	10	10	10	1	4	8	10	4	75
8	14461	Cunningham et al, 1966	Manganese sulfate	100	Cattle (*Bos taurus*)	2	4	0/1000/2000/3000	mg/kg diet	NR	na	CON	U	FD	100	d	10	w	JV	M	C	Lab	3	BIO	CHM	HMGL	BL	1000	2000	Y	223	Y	5.39	24.2	48.3	10	10	5	10	7	1	10	10	10	4	77
9	33573	Desole et al, 1995	Manganese chloride	43.66	Rat (*Rattus norvegicus*)	2	4	0/30/100/200	mg/kg bw/d	NR	na	2 per d	U	GV	7	d	20	mo	AD	M	C	Lab	1	BIO	HRM	DOPA	BR	100	200	Y	0.7	N	0.051242	43.7	87.3	10	8	10	10	10	1	10	10	6	4	79
10	57	Rehnberg et al, 1980	Manganese oxide	100	Rat (*Rattus norvegicus*)	1	4	0/21/71/214	mg/kg bw/d	NR	na	DLY	U	GV	20	d	1	d	JV	B	C	Lab	5	BIO	CHM	HMGL	BL	71	214	Y	0.045	N	0.005369	71.0	214	10	8	10	10	10	1	8	10	10	4	81
11	34755	Laskey et al, 1985	Manganese oxide	100	Rat (*Rattus norvegicus*)	1	2	0/71	mg/kg bw/d	NR	na	DLY	U	GV	21	d	0	d	JV	M	C	Lab	3	BIO	HRM	TSTR	SR	71		Y	0.0529	N	0.006132	71.0		10	8	10	10	10	1	4	6	10	4	73
12	14471	Reid, et al, 1947	Manganese Sulfate	100	Cattle (*Bos taurus*)	1	2	0/0.36	% in diet	NR	na	ADL	U	FD	5	mo	NR	NR	LC	F	C	FieldU	1	BIO	CHM	CALC	PL	0.36		N	409	N	9.633704	84.8		10	10	5	10	5	1	4	8	10	4	67
13	34740	Svensson et al, 1985	Manganese chloride	100	Rat (*Rattus norvegicus*)	1	2	0/128.6	mg/kg bw/d	NR	na	6 per w	U	GV	20	d	2	d	JV	B	C	Lab	1	BIO	CHM	CALC	SR	128.6		N	0.267	N	0.023203	129		10	8	10	10	10	1	4	1	10	4	68
14	34791	Seth et al, 1977	Manganese chloride tetrahydrate	27.8	Rat (*Rattus norvegicus*)	1	2	0/15	mg/kg bw/d	NR	na	DLY	U	GV	30	d	NR	NR	LC	F	C	Lab	2	BIO	ENZ	SCDH	BR		15	Y	0.22	N	0.019789		4.17	10	8	10	10	10	1	4	10	10	4	77
15	34849	Magour et al, 1983	Manganese chloride tetrahydrate	100	Rat (*Rattus norvegicus*)	1	2	0/6.6	mg/kg bw/d	NR	na	ADL	U	DR	3	w	3	w	JV	F	C	Lab	1	BIO	CHM	PRTL	BR		6.6	N	0.156	N	0.018597		6.60	10	5	5	10	10	1	4	10	10	4	69
16	1282	Derevenco et al, 1988	Manganese chloride	43	Rat (*Rattus norvegicus*)	1	3	0/20/300	mg/kg bw/d	N	na	NR	U	FD	13	w	NR	NR	NR	M	C	Lab	2	BIO	ENZ	GENZ	BR		20	N	0.5	N	0.038861		8.60	10	10	5	10	10	1	4	10	10	4	74
17	14465	Hartman et al., 1955	Manganese sulfate	100	Sheep (*Ovis aries*)	1	3	0/1000/2000	mg/kg	NR	na	ADL	U	FD	11	w	66-69	d	JV	B	C	Lab	1	BIO	CHM	HMGL	BL		1000	N	34	n	1.247		36.7	10	10	5	10	5	1	4	10	10	4	69
18	35114	Halacheva and Nikolova, 1975	Manganese chloride tetrahydrate	100	Rat (*Rattus norvegicus*)	1	2	0/75	mg/kg bw/d	NR	na	EOD	U	GV	60	d	NR	NR	JV	M	C	Lab	1	BIO	CHM	ATPT	BR		75	Y	0.12	N	0.012024		75.0	10	8	10	10	10	1	4	10	10	4	77
19	33573	Desole et al, 1995	Manganese chloride	43.66	Rat (*Rattus norvegicus*)	2	2	0/200	mg/kg bw/d	NR	na	2 per d	U	GV	7	d	3	mo	JV	M	C	Lab	1	BIO	HRM	DOPA	BR		200	Y	0.35	N	0.028985		87.3	10	8	10	10	10	1	4	10	10	4	77
20	34586	Hastings and Llewellyn, 1987	Manganese sulfate	100	Hamster (*Mesocricetus auratus*)	1	2	0/1149	mg/kg diet	NR	na	ADL	U	FD	10	w	NR	NR	JV	M	C	Lab	2	BIO	CHM	CHOL	SR		1149	N	0.097	N	0.010094		120	10	10	5	10	5	1	4	10	10	4	69
21	34674	Kristensson et al, 1986	Manganese chloride	100	Rat (*Rattus norvegicus*)	1	2	0/150	mg/kg bw/d	NR	na	DLY	U	GV	12	d	3	d	JV	M	C	Lab	1	BIO	HRM	GHRM	BR		150	N	0.267	N	0.023203		150	10	8	10	10	10	1	4	10	10	4	77
22	13236	Rana et al, 1985	Manganous chloride	100	Rat (*Rattus norvegicus*)	1	2	0/0.25	g/kg bw/d	NR	na	DLY	U	GV	30	d	90	d	JV	M	C	Lab	2	BIO	CHM	GLYC	LI		0.25	Y	0.1	N	0.01035		250	10	8	10	10	10	1	4	10	10	4	77
23	35173	Bonilla and Diez-Ewald, 1974	Manganese chloride	43.66	Rat (*Rattus norvegicus*)	1	2	0/5	mg/ml	NR	na	ADL	U	DR	7	mo	NR	NR	JV	F	C	Lab	1	BIO	HRM	DOPA	BR		5	Y	0.3	Y	0.035		255	10	5	5	10	7	1	4	10	10	4	66
24	33786	Komura and Sakamoto, 1991	Manganese carbonate	100	Mouse (*Mus musculus*)	4	2	0/2	g/kg diet	NR	na	ADL	U	FD	100	d	6	w	JV	M	C	Lab	3	BIO	CHM	RBCE	BL		2	Y	0.0282	Y	0.0037		262	10	10	5	10	7	1	4	10	10	4	71
25	33786	Komura and Sakamoto, 1991	Manganese dioxide	100	Mouse (*Mus musculus*)	4	2	0/2	g/kg diet	NR	na	ADL	U	FD	100	d	6	w	JV	M	C	Lab	3	BIO	CHM	TWBC	BL		2	Y	0.0282	Y	0.0038		270	10	10	5	10	7	1	4	10	10	4	71
26	33786	Komura and Sakamoto, 1991	Manganese acetate	100	Mouse (*Mus musculus*)	4	2	0/2	g/kg diet	NR	na	ADL	U	FD	100	d	6	w	JV	M	C	Lab	3	BIO	CHM	RBCE	BL		2	Y	0.0282	Y	0.004		284	10	10	5	5	7	1	4	10	10	4	66
27	33786	Komura and Sakamoto, 1991	Manganese chloride tetrahydrate	100	Mouse (*Mus musculus*)	4	2	0/2	g/kg diet	NR	na	ADL	U	FD	100	d	6	w	JV	M	C	Lab	3	BIO	CHM	TWBC	BL		2	Y	0.0282	Y	0.004		284	10	10	5	10	7	1	4	10	10	4	71
28	34677	Bonilla, 1978	Manganese (II) chloride	43.66	Rat (*Rattus norvegicus*)	1	2	0/10	mg/ml	NR	na	ADL	U	DR	2	mo	NR	NR	JV	M	C	Lab	2	BIO	ENZ	GENZ	BR		10	Y	0.3	Y	0.0338		492	10	5	5	10	7	1	4	10	10	4	66
29	34922	Chandra and Shukla, 1981	Manganese chloride tetrahydrate	100	Rat (*Rattus norvegicus*)	1	2	0/1	mg/ml	NR	na	ADL	U	DR	15	d	NR	NR	JV	M	C	Lab	1	BIO	CHM	TYRO	SR		1	Y	0.06	Y	0.032		533	10	5	5	10	7	1	4	10	10	4	66
30	35583	Bonilla, 1980	Managese chloride	100	Rat (*Rattus norvegicus*)	1	2	0/10	mg/ml	NR	na	ADL	U	DR	1	mi	NR	NR	JV	M	C	Lab	1	BIO	ENZ	GENZ	BR		10	Y	0.25	Y	0.0306		1224	10	5	5	10	7	1	4	10	10	4	66
Behavior																																														
31	136	Gershbein et al 1983	Manganese (II) chloride	100	Rat (*Rattus norvegicus*)	1	2	0/75	mg/kg diet	N	na	ADL	U	FD	80	d	44	d	JV	M	C	Lab	1	BEH	BEH	NMVM	WO	75		Y	0.47	N	0.036934	5.89		10	10	5	10	6	4	4	3	10	4	66
32	35470	Bhoot et al, 1981	Manganese chloride	100	Cattle (*Bos taurus*)	1	3	0/100/250	mg/kg diet	NR	na	ADL	U	FD	66	d	1	yr	JV	F	C	Lab	2	BEH	FDB	FCNS	WO	250		Y	146.5	Y	4.13	7.05		10	10	5	10	7	4	4	10	10	4	74
33	14461	Cunningham et al, 1966	Manganese sulfate	100	Cattle (*Bos taurus*)	2	4	0/820/2460/4920	mg/kg diet	NR	na	ADL	U	FD	84	d	10	w	JV	M	C	Lab	2	BEH	FDB	FCNS	WO	820	2460	Y	229	Y	6.05	21.7	65.0	10	10	5	10	7	4	10	10	10	4	80
34	35824	Black et al, 1985	Manganese oxide	100	Sheep (*Ovis aries*)	2	5	0/500/1000/2000/4000	mg/kg diet	NR	na	ADL	U	FD	84	d	NR	NR	JV	M	C	Lab	2	BEH	FDB	FCNS	WO	2000	4000	Y	38.4	Y	1.14	59.4	119	10	10	5	10	7	4	10	10	10	4	80
35	14461	Cunningham et al, 1966	Manganese sulfate	100	Cattle (*Bos taurus*)	2	4	0/1000/2000/3000	mg/kg diet	NR	na	CON	U	FD	100	d	10	w	JV	M	C	Lab	2	BEH	FDB	FCNS	WO	3000		Y	219	Y	5.39	73.8		10	10	5	10	7	4	4	10	10	4	74
36	35824	Black et al, 1985	Manganese carbonate	100	Sheep (*Ovis aries*)	2	4	0/2000/4000/8000	mg/kg diet	NR	na	ADL	U	FD	84	d	NR	NR	JV	M	C	Lab	2	BEH	FDB	FCNS	WO	4000	8000	Y	39.8	Y	1.11	112	223	10	10	5	10	7	4	10	10	10	4	80
37	35826	Black et al, 1985	Manganese oxide	100	Sheep (*Ovis aries*)	2	4	0/3000/6000/9000	mg/kg diet	NR	na	ADL	U	FD	21	d	NR	NR	JV	M	C	Lab	1	BEH	FDB	FCNS	WO	6000	9000	Y	47	Y	1.18	151	226	10	10	5	10	7	4	10	10	10	4	80
38	34752	Kontur and Fechter, 1985	Manganese (II) chloride	43.66	Rat (*Rattus norvegicus*)	1	4	0/0.18/0.30/0.45	g/d	NR	na	ADL	U	DR	21	d	NR	NR	GE	F	C	Lab	2	BEH	FDB	WCON	WO	0.18	0.3	Y	0.48418	Y	0.0358	162	271	10	5	5	10	7	4	10	10	10	4	75
39	33786	Komura and Sakamoto, 1991	Manganese carbonate	100	Mouse (*Mus musculus*)	4	2	0/2	g/kg diet	NR	na	ADL	U	FD	100	d	6	w	JV	M	C	Lab	2	BEH	FDB	FCNS	WO	2		Y	0.0282	Y	0.0037	262		10	10	5	10	7	4	4	3	10	4	67
40	33786	Komura and Sakamoto, 1991	Manganese dioxide	100	Mouse (*Mus musculus*)	4	2	0/2	g/kg diet	NR	na	ADL	U	FD	100	d	6	w	JV	M	C	Lab	2	BEH	FDB	FCNS	WO	2		Y	0.0282	Y	0.0038	270		10	10	5	10	7	4	4	6	10	4	70
41	33786	Komura and Sakamoto, 1991	Manganese chloride tetrahydrate	100	Mouse (*Mus musculus*)	4	2	0/2	g/kg diet	NR	na	ADL	U	FD	100	d	6	w	JV	M	C	Lab	2	BEH	FDB	FCNS	WO	2		Y	0.0282	Y	0.004	284		10	10	5	10	7	4	4	6	10	4	70
42	33511	Gaillard et al, 1996	Manganese chloride tetrahydrate	100	Rat (*Rattus norvegicus*)	1	2	0/554	mg/kg bw/d	NR	na	ADL	U	DR	11	w	3	w	JV	M	C	Lab	2	BEH	FDB	FCNS	WO	554		Y	0.445	Y	0.027	554		10	5	5	10	7	4	4	10	10	4	69
43	1282	Derevenco et al, 1988	Manganese chloride	43	Rat (*Rattus norvegicus*)	1	3	0/20/300	mg/kg bw/d	N	na	NR	U	FD	13	w	NR	NR	NR	B	C	Lab	1	BEH	BEH	GBHV	WO		20	N	0.5	N	0.038861		8.60	10	10	5	10	10	4	4	10	10	4	77
44	34806	Bonilla, 1984	Manganese chloride	100	Rat (*Rattus norvegicus*)	1	3	0/0.1/5.0	mg/ml	NR	na	NR	U	DR	1	mo	NR	NR	JV	M	C	Lab	1	BEH	BEH	ACTV	WO		0.1	Y	0.25	N	0.02843		11.4	10	5	5	10	6	4	4	10	10	4	68
45	34892	Ali et al., 1981	Manganese tetrahydrate	21.5	Rat (*Rattus norvegicus*)	1	2	0/1	mg/ml	NR	na	ADL	U	DR	90	d	40	d	JV	M	C	Lab	2	BEH	BEH	RSPT	WO		1	N	0.267	N	0.030164		24.3	10	5	5	10	5	4	4	10	10	4	67
46	35826	Black et al, 1985	Manganese oxide	100	Sheep (*Ovis aries*)	2	4	0/3000/6000/9000	ppm in mg/kg	NR	na	DLY	U	OR	7	d	NR	NR	JV	M	C	Lab	1	BEH	FDB	FCNS	WO		3000	Y	47	Y	1.19		76.0	10	8	10	10	7	4	4	10	10	4	77
47	34669	Nachtman et al, 1986	Manganese chloride tetrahydrate	100	Rat (*Rattus norvegicus*)	1	2	0/1	mg/ml	NR	na	ADL	U	DR	5	w	6	w	JV	M	C	Lab	2	BEH	BEH	ACTV	WO		1	Y	0.389	N	0.042324		109	10	5	5	10	6	4	4	10	10	4	68
48	34850	Chandra, 1983	Manganese	100	Rat (*Rattus norvegicus*)	1	2	0/1	mg/ml	NR	na	ADL	U	DR	30	d	NR	NR	JV	M	C	Lab	1	BEH	BEH	AGGT	WO		1	Y	0.25	N	0.02843		114	10	5	5	4	6	4	4	10	10	10	68
49	34677	Bonilla, 1978	Manganese (II) chloride	43.66	Rat (*Rattus norvegicus*)	1	2	0/10	mg/ml	NR	na	ADL	U	DR	2	mo	NR	NR	JV	M	C	Lab	1	BEH	FDB	FCNS	WO		10	Y	0.3	Y	0.0338		492	10	5	5	10	7	4	4	10	10	4	69

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		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
Physiology																																														
50	35824	Black et al, 1985	Manganese oxide	100	Sheep (*Ovis aries*)	2	5	0/500/1000/2000/4000	mg/kg diet	NR	na	ADL	U	FD	84	d	NR	NR	JV	M	C	Lab	4	PHY	PHY	FDCV	WO	1000	2000	Y	46.2	Y	1.46	31.6	63.2	10	10	5	10	7	4	10	10	10	4	80
51	14461	Cunningham et al, 1966	Manganese sulfate	100	Cattle (*Bos taurus*)	2	4	0/1000/2000/3000	mg/kg diet	NR	na	CON	U	FD	100	d	10	w	JV	M	C	Lab	4	PHY	PHY	FDCV	WO	3000		Y	219	Y	5.39	73.8		10	10	5	10	7	4	4	10	10	4	74
52	35824	Black et al, 1985	Manganese carbonate	100	Sheep (*Ovis aries*)	2	4	0/2000/4000/8000	mg/kg diet	NR	na	ADL	U	FD	84	d	NR	NR	JV	M	C	Lab	3	PHY	PHY	FDCV	WO	4000	8000	Y	39.8	Y	1.11	112	223	10	10	5	10	7	4	10	10	10	4	80
Pathology																																														
53	34702	Kayongo-Male et al, 1977	Manganese carbonate	100	Pig (*Sus scrofa*)	1	2	0/56	mg/kg diet	NR	na	ADL	M	FD	10	w	NR	NR	JV	B	C	Lab	1	PTH	HIS	GHIS	BO	56		N	61	N	2.016034	1.85		10	10	10	10	5	4	4	1	10	4	68
54	34921	Deskin, et al, 1981	Manganese chloride tetrahydrate	100	Rat (*Rattus norvegicus*)	1	4	0/1/10/20	mg/kg bw/d	NR	na	DLY	U	GV	24	d	1	d	JV	M	C	Lab	3	PTH	ORW	SMIX	BR	20		Y	0.07	N	0.00772	20.0		10	8	10	10	10	4	4	8	10	4	78
55	57	Rehnberg et al, 1980	Manganese Oxide	100	Rat (*Rattus norvegicus*)	1	4	0/21/71/214	mg/kg bw/d	NR	na	DLY	U	GV	11	d	1	d	JV	B	C	Lab	3	PTH	ORW	ORWT	BR	21	71	Y	0.0295	N	0.003794	21.0	71.0	10	8	10	10	10	4	8	10	10	4	84
56	34740	Svensson et al, 1985	Manganese chloride	100	Rat (*Rattus norvegicus*)	1	2	0/128.6	mg/kg bw/d	NR	na	6 per w	U	GV	20	d	2	d	JV	M	C	Lab	2	PTH	ORW	ORWT	TB	128.6		N	0.267	N	0.023203	129		10	8	10	10	10	4	4	1	10	4	71
57	1282	Derevenco et al, 1988	Manganese chloride	43	Rat (*Rattus norvegicus*)	1	3	0/20/300	mg/kg bw/d	N	na	NR	U	FD	13	w	NR	NR	NR	M	C	Lab	3	PTH	HIS	GHIS	BR		20	N	0.5	N	0.038861		8.60	10	10	5	10	10	4	4	10	10	4	77
58	14460	Chandra and Imam, 1973	Manganese chloride	100	Guinea pig (*Caviidae cavia*)	1	2	0/10	mg/kg bw/d	NR	na	DLY	U	GV	30	d	NR	NR	JV	M	C	Lab	1	PTH	HIS	NCRO	IN		10	Y	0.35	N	0.028985		10.0	10	8	10	10	10	4	4	10	10	4	80
59	35046	Wassermann and Wassermann, 197	Manganese chloride	100	Rat (*Rattus norvegicus*)	1	2	0/200	mg/L	NR	na	ADL	U	DR	10	d	2	mo	JV	M	C	Lab	1	PTH	HIS	GHIS	LI		200	N	0.235	N	0.02689		22.9	10	5	5	10	5	4	4	10	10	4	67
60	13236	Rana et al, 1985	Manganous chloride	100	Rat (*Rattus norvegicus*)	1	2	0/0.25	g/kg bw/d	NR	na	DLY	U	GV	30	d	90	d	JV	M	C	Lab	1	PTH	ORW	SMIX	LI		0.25	Y	0.1	N	0.01035		250	10	8	10	10	10	4	4	10	10	4	80
Reproduction																																														
61	14464	Grummer et al, 1950	Manganese sulfate monohydrate	100	Pig (*Sus scrofa*)	1	2	0/120	mg/kg diet	NR	na	ADL	U	FD	124	d	9	w	GE	F	C	FieldA	3	REP	REP	PROG	WO	120		Y	99.92641	Y	2.36	2.83		10	10	5	10	7	10	4	1	10	4	71
62	57	Rehnberg et al, 1980	Manganese Oxide	100	Rat (*Rattus norvegicus*)	1	4	0/21/71/214	mg/kg bw/d	NR	na	DLY	U	GV	20	d	1	d	JV	B	C	Lab	4	REP	REP	RHIS	TE	21	71	Y	0.0566	N	0.006483	21.0	71.0	10	8	10	10	10	10	8	10	10	4	90
63	35143	USDA, 1973	Manganese sulfate monohydrate	100	Rat (*Rattus norvegicus*)	4	5	0/0.763/3.63/16.9/78.3	mg/kg bw/d	NR	na	DLY	U	GV	9	d	NR	NR	GE	F	C	Lab	2	REP	REP	PROG	WO	78.3		Y	0.281	N	0.024199	78.3		10	8	10	10	10	10	4	1	10	4	77
64	35143	USDA, 1973	Manganese sulfate monohydrate	100	Rabbit (*Oryctolagus cuniculus*)	4	5	0/1.12/5.20/24.2/112.0	mg/kg bw/d	NR	na	DLY	U	GV	12	d	NR	NR	GE	F	C	Lab	2	REP	REP	PROG	WO	112		Y	2.31	N	0.136724	112		10	8	10	10	10	10	4	1	10	4	77
65	35143	USDA, 1973	Manganese sulfate monohydrate	100	Mouse (*Mus musculus*)	4	5	0/1.25/5.81/27.0/125.0	mg/kg bw/d	NR	na	DLY	U	GV	9	d	NR	NR	GE	F	C	Lab	2	REP	REP	PROG	WO	125		Y	0.0407	N	0.004944	125		10	8	10	10	10	10	4	1	10	4	77
66	35143	USDA, 1973	Manganese sulfate monohydrate	100	Hamster (*Mesocricetus auratus*)	4	5	0/1.36/6.32/29.3/136.0	mg/kg bw/d	NR	na	DLY	U	GV	4	d	NR	NR	GE	F	C	Lab	2	REP	REP	PROG	WO	136		Y	0.1265	N	0.012557	136		10	8	10	10	10	10	4	1	10	4	77
67	33496	Pappas et al, 1997	Manganese (II) chloride	43.66	Rat (*Rattus norvegicus*)	1	3	0/0.35/1.42	mg/g bw/d	NR	na	NR	U	DR	30	d	NR	NR	GE	F	C	Lab	1	REP	REP	PRWT	WO	0.35	1.42	N	0.338	N	0.003729	153	620	10	5	5	10	10	10	8	10	10	4	82
68	34752	Kontur and Fechter, 1985	Manganese (II) chloride	43.66	Rat (*Rattus norvegicus*)	1	4	0/0.18/0.30/0.45	g/d	NR	na	ADL	U	DR	21	d	NR	NR	GE	F	C	Lab	3	REP	REP	PRWT	WO	0.3	0.45	Y	0.4738	Y	0.0296	276	415	10	5	5	10	7	10	10	10	10	4	81
69	56	Laskey et al, 1982	Manganese oxide	100	Rat (*Rattus norvegicus*)	1	4	0/350/1050/3500	mg/kg diet	NR	na	ADL	U	FD	43	d	NR	NR	GE	F	C	Lab	1	REP	REP	PRWT	WO	3500		N	0.344	N	0.028576	291		10	10	5	10	5	10	4	10	10	4	78
70	34895	Leung et al, 1982	Manganese chloride tetrachloride	100	Rat (*Rattus norvegicus*)	1	3	0/10/20	mg/ml	NR	na	ADL	U	DR	26	d	NR	NR	GE	F	C	Lab	1	REP	REP	PRWT	WO	10	20	N	0.462	N	0.04941	1069	2139	10	5	5	10	5	10	10	10	10	4	79
71	14459	Becker and McCollum, 1938	Manganese chloride tetrahydrate	100	Rat (*Rattus norvegicus*)	1	5	0/0.00998/0.02495/0.0499/0.099	g/org/d	NR	na	ADL	U	FD	730	d	NR	NR	JV	M	C	Lab	1	REP	REP	TEDG	TE	0.0998		Y	0.05	Y	0.01	1996		10	10	5	10	7	10	4	1	10	10	77
72	1717	Bataineh et al., 1998	Manganese sulfate dihydrate	24.07	Rat (*Rattus norvegicus*)	1	2	0/1000	mg/L	NR	na	ADL	U	DR	12	w	NR	NR	AD	M	V	Lab	2	REP	REP	TEWT	TE		1000	Y	0.36266	N	0.039736		26.4	10	5	5	10	6	10	4	10	3	4	67
73	34755	Laskey et al, 1985	Manganese oxide (Mn3O4)	100	Rat (*Rattus norvegicus*)	1	2	0/71	mg/kg bw/d	NR	na	DLY	U	GV	21	d	0	d	JV	M	C	Lab	2	REP	REP	TEWT	TE		71	Y	0.0529	N	0.006132		71.0	10	8	10	10	10	10	4	10	10	4	86
Growth																																														
74	34990	Ivan and Grieve, 1975	Manganese sulfate monohydrate	100	Cattle (*Bos taurus*)	1	2	0/50	mg/kg diet	NR	na	ADL	U	FD	10	w	22-28	w	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	50		Y	229.8	N	5.997724	1.30		10	10	5	10	6	8	4	1	10	4	68
75	36002	Mohamed et al, 1986	Manganese sulfate	100	Water buffalo (*Bubalus carabanensis*)	1	3	0/574.68/697.68	mg/org/d	NR	na	ADL	M	FD	90	d	13-19	mo	JV	M	C	NR	1	GRO	GRO	BDWT	WO	697.68		Y	375.33	N	8.97686	1.86		10	10	10	10	6	8	4	1	10	4	73
76	34656	Svajgr et al., 1969	Manganese oxide	100	Pig (*Sus scrofa*)	1	2	0/100	mg/kg	NR	na	ADL	U	FD	84	d	NR	NR	JV	B	C	FieldA	1	GRO	GRO	BDWT	WO	50		Y	87.86	Y	2.41	2.74		10	10	5	10	7	8	4	1	10	4	69
77	14464	Grummer et al, 1950	Manganese sulfate monohydrate	100	Pig (*Sus scrofa*)	1	2	0/120	mg/kg diet	NR	na	ADL	U	FD	124	d	9	w	JV	B	C	FieldA	1	GRO	GRO	BDWT	WO	120		Y	99.92641	Y	2.36	2.83		10	10	5	10	7	8	4	1	10	4	69
78	136	Gershbein et al 1983	Manganese (II) chloride	100	Rat (*Rattus norvegicus*)	1	2	0/75	mg/kg diet	N	na	ADL	U	FD	80	d	44	d	JV	M	C	Lab	2	GRO	GRO	BDWT	WO	75		Y	0.47	N	0.036934	5.89		10	10	5	10	6	8	4	1	10	4	68
79	35470	Bhoot et al, 1981	Manganese chloride	100	Cattle (*Bos taurus*)	1	3	0/100/250	mg/kg diet	NR	na	ADL	U	FD	66	d	1	yr	JV	F	C	Lab	1	GRO	GRO	BDWT	WO	250		Y	146.5	Y	4.13	7.05		10	10	5	10	7	8	4	3	10	4	71
80	34504	Lee and Johnson, 1988	Manganese chloride	100	Rat (*Rattus norvegicus*)	1	3	0/43.8/82.4	mg/kg diet	NR	na	ADL	U	FD	2	w	NR	NR	JV	B	C	Lab	1	GRO	GRO	BDWT	WO	82.4		Y	0.227	N	0.020305	7.37		10	10	5	10	6	8	4	1	10	4	68
81	36045	Kontur and Fechter, 1985	Manganese chloride tetrahydrate	100	Rat (*Rattus norvegicus*)	1	3	0/6.9/13.8	mg/kg bw/d	NR	na	DLY	U	GV	21	d	1	d	JV	B	C	Lab	1	GRO	GRO	BDWT	WO	13.8		Y	0.035	N	0.004367	13.8		10	8	10	10	10	8	4	1	10	4	75
82	14468	Leibholz et al, 1962	Manganese sulfate	100	Pig (*Sus scrofa*)	2	4	0/40/400/4000	mg/kg diet	NR	na	ADL	U	FD	10	w	2	w	JV	B	C	Lab	1	GRO	GRO	BDWT	WO	400	4000	Y	37.3	N	1.345555	14.4	144	10	10	5	10	6	8	8	10	10	4	81
83	33403	Lipe et al, 1999	Manganese chloride	100	Rat (*Rattus norvegicus*)	2	3	0/10/20	mg/kg bw/d	NR	na	DLY	U	GV	30	d	30	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	20		Y	0.2752	N	0.023787	20.0		10	8	10	10	10	8	4	1	10	4	75
84	34921	Deskin, et al, 1981	Manganese chloride tetrahydrate	100	Rat (*Rattus norvegicus*)	1	4	0/1/10/20	mg/kg bw/d	NR	na	DLY	U	GV	24	d	1	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	20		Y	0.07	N	0.00772	20.0		10	8	10	10	10	8	4	1	10	4	75
85	57	Rehnberg et al, 1980	Manganese Oxide	100	Rat (*Rattus norvegicus*)	1	4	0/21/71/214	mg/kg bw/d	NR	na	DLY	U	GV	5	d	1	d	JV	B	C	Lab	2	GRO	GRO	BDWT	WO	21	71	Y	0.0144	N	0.002104	21.0	71.0	10	8	10	10	10	8	8	10	10	4	88
86	14461	Cunningham et al, 1966	Manganese sulfate	100	Cattle (*Bos taurus*)	2	4	0/820/2460/4920	mg/kg diet	NR	na	ADL	U	FD	84	d	10	w	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	820	2460	Y	229	Y	6.05	21.7	65.0	10	10	5	10	7	8	10	10	10	4	84
87	35824	Black et al, 1985	Manganese oxide	100	Sheep (*Ovis aries*)	2	5	0/500/1000/2000/4000	mg/kg diet	NR	na	ADL	U	FD	84	d	NR	NR	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	2000	4000	Y	38.4	Y	1.14	59.4	119	10	10	5	10	7	8	10	10	10	4	84
88	34755	Laskey et al, 1985	Manganese oxide (Mn3O4)	100	Rat (*Rattus norvegicus*)	1	2	0/71	mg/kg bw/d	NR	na	DLY	U	GV	21	d	0	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	71		Y	0.0529	N	0.006132	71.0		10	8	10	10	10	8	4	10	10	4	84
89	14461	Cunningham et al, 1966	Manganese sulfate	100	Cattle (*Bos taurus*)	2	4	0/1000/2000/3000	mg/kg diet	NR	na	CON	U	FD	100	d	10	w	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	3000		Y	219	Y	5.39	73.8		10	10	5	10	7	8	4	1	10	4	69
90	35143	USDA, 1973	Manganese sulfate monohydrate	100	Rat (*Rattus norvegicus*)	4	5	0/0.763/3.63/16.9/78.3	mg/kg bw/d	NR	na	DLY	U	GV	9	d	NR	mo	GE	F	C	Lab	3	GRO	GRO	BDWT	WO	78.3		Y	0.281	N	0.024199	78.3		10	8	10	10	10	8	4	1	10	4	75
91	14468	Leibholz et al, 1962	Manganese sulfate	100	Pig (*Sus scrofa*)	2	6	0/25/75/225/675/2025	mg/kg diet	NR	na	ADL	U	FD	6	w	2	w	JV	B	C	Lab	1	GRO	GRO	BDWT	WO	2025		Y	14.6	N	0.622379	86.3		10	10	5	10	6	8	4	1	10	4	68
92	34669	Nachtman et al, 1986	Manganese chloride tetrahydrate	100	Rat (*Rattus norvegicus*)	1	2	0/1	mg/ml	NR	na	ADL	U	DR	65	w	6	w	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	1		Y	0.739	N	0.075408	102		10	5	5	10	6	8	4	10	10	4	72
93	35824	Black et al, 1985	Manganese carbonate	100	Sheep (*Ovis aries*)	2	4	0/2000/4000/8000	mg/kg diet	NR	na	ADL	U	FD	84	d	NR	NR	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	4000	8000	Y	39.8	Y	1.11	112	223	10	10	5	10	7	8	10	10	10	4	84
94	35143	USDA, 1973	Manganese sulfate monohydrate	100	Rabbit (*Oryctolagus cuniculus*)	4	5	0/1.12/5.20/24.2/112.0	mg/kg bw/d	NR	na	DLY	U	GV	12	d	NR	NR	GE	F	C	Lab	3	GRO	GRO	BDWT	WO	112		Y	2.31	N	0.136724	112		10	8	10	10	10	8	4	1	10	4	75
95	35143	USDA, 1973	Manganese sulfate monohydrate	100	Mouse (*Mus musculus*)	4	5	0/1.25/5.81/27.0/125.0	mg/kg bw/d	NR	na	DLY	U	GV	9	d	NR	NR	GE	F	C	Lab	3	GRO	GRO	BDWT	WO	125		Y	0.0407	N	0.004944	125		10	8	10	10	10	8	4	1	10	4	75
96	35143	USDA, 1973	Manganese sulfate monohydrate	100	Hamster (*Mesocricetus auratus*)	4	5	0/1.36/6.32/29.3/136.0	mg/kg bw/d	NR	na	DLY	U	GV	4	d	NR	NR	GE	F	C	Lab	3	GRO	GRO	BDWT	WO	136		Y	0.1265	N	0.012557	136		10	8	10	10	10	8	4	1	10	4	75
97	34752	Kontur and Fechter, 1985	Manganese (II) chloride	43.66	Rat (*Rattus norvegicus*)	1	4	0/0.18/0.30/0.45	g/d	NR	na	ADL	U	DR	21	d	NR	NR	GE	F	C	Lab	1	GRO	GRO	BDWT	WO	0.18	0.3	Y	0.48418	Y	0.0358	162	271	10	5	5	10	7	8	10	10	10	4	79
98	33786	Komura and Sakamoto, 1991	Manganese carbonate	100	Mouse (*Mus musculus*)	4	2	0/2	g/kg diet	NR	na	ADL	U	FD	100	d	6	w	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	2		Y	0.0282	Y	0.0037	262		10	10	5	10	7	8	4	1	10	4	69
99	33786	Komura and Sakamoto, 1991	Manganese dioxide	100	Mouse (*Mus musculus*)	4	2	0/2	g/kg diet	NR	na	ADL	U	FD	100	d	6	w	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	2		Y	0.0282	Y	0.0038	270		10	10	5	10	7	8	4	1	10	4	69
100	34574	Johnson and Kies, 1987	Manganese carbonate	100	Rat (*Rattus norvegicus*)	1	3	0/450/4550	mg/kg diet	NR	na	ADL	U	FD	56	d	NR	NR	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	4550		Y	0.272	N	0.02356	394		10	10	5	10	6	8	4	1	10	4	68
101	33511	Gaillard et al, 1996	Manganese chloride tetrahydrate	100	Rat (*Rattus norvegicus*)	1	2	0/554	mg/kg bw/d	NR	na	ADL	U	DR	11	w	3	w	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	554		Y	0.445	Y	0.027	554		10	5	5	10	7	8	4	10	10	4	73
102	33403	Lipe et al, 1999	Manganese chloride	100	Rat (*Rattus norvegicus*)	2	3	0/10/20	mg/kg bw/d	NR	na	DLY	U	GV	24	d	90	d	AD	M	C	Lab	1	GRO	GRO	BDWT	WO		10	Y	0.43	N	0.03433		10.0	10	8	10	10	10	8	4	10	6	4	80
103	33786	Komura and Sakamoto, 1991	Manganese acetate	100	Mouse (*Mus musculus*)	4	2	0/2	g/kg diet	NR	na	ADL	U	FD	30	d	6	w	JV	M	C	Lab	1	GRO	GRO	BDWT	WO		2	Y	0.0282	Y	0.004		284	10	10	5	5	7	8	4	10	10	4	73
104	33786	Komura and Sakamoto, 1991	Manganese chloride tetrahydrate	100	Mouse (*Mus musculus*)	4	2	0/2	g/kg diet	NR	na	ADL	U	FD	30	d	6	w	JV	M	C	Lab	1	GRO	GRO	BDWT	WO		2	Y	0.0282	Y	0.004		284	10	10	5	10	7	8	4	10	10	4	78
Survival																																														
105	57	Rehnberg et al, 1980	Manganese Oxide	100	Rat (*Rattus norvegicus*)	1	4	0/21/71/214	mg/kg bw/d	NR	na	DLY	U	GV	17	d	1	d	JV	B	C	Lab	1	MOR	MOR	SURV	WO	21	71	Y	0.0483	N	0.005691	21.0	71.0	10	8	10	10	10	9	8	10	10	4	89

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		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
106	35143	USDA, 1973	Manganese sulfate monohydrate	100	Rat (*Rattus norvegicus*)	4	5	0/0.763/3.63/16.9/78.3	mg/kg bw/d	NR	na	DLY	U	GV	9	d	NR	NR	GE	F	C	Lab	1	MOR	MOR	SURV	WO	78.3		Y	0.281	N	0.024199	78.3		10	8	10	10	10	9	4	1	10	4	76
107	35143	USDA, 1973	Manganese sulfate monohydrate	100	Rabbit (*Oryctolagus cuniculus*)	4	5	0/1.12/5.20/24.2/112.0	mg/kg bw/d	NR	na	DLY	U	GV	12	d	NR	NR	GE	F	C	Lab	1	MOR	MOR	SURV	WO	112		N	2.3	N	0.136238	112		10	8	10	10	10	9	4	10	10	4	85
108	35143	USDA, 1973	Manganese sulfate monohydrate	100	Mouse (*Mus musculus*)	4	5	0/1.25/5.81/27.0/125.0	mg/kg bw/d	NR	na	DLY	U	GV	9	d	NR	NR	GE	F	C	Lab	1	MOR	MOR	SURV	WO	125		Y	0.0407	N	0.004944	125		10	8	10	10	10	9	4	10	10	4	85
109	35143	USDA, 1973	Manganese sulfate monohydrate	100	Hamster (*Mesocricetus auratus*)	4	5	0/1.36/6.32/29.3/136.0	mg/kg bw/d	NR	na	DLY	U	GV	4	d	NR	NR	GE	F	C	Lab	1	MOR	MOR	SURV	WO	136		Y	0.1265	N	0.012557	136		10	8	5	10	10	9	4	10	10	4	80
Data Not Used to Derive TRV																																														
110	34990	Ivan and Grieve, 1975	Manganese sulfate monohydrate	100	Cattle (*Bos taurus*)	1	2	0/50	mg/kg diet	NR	na	ADL	U	FD	10	w	22-28	w	JV	M	C	Lab	2	PHY	PHY	FDCV	WO	50		Y	229.8	N	6.00	1.30		10	10	5	10	6	4	4	1	10	4	64
111	34702	Kayongo-Male et al, 1977	Manganese carbonate	100	Pig (*Sus scrofa*)	1	2	0/56	mg/kg diet	NR	na	ADL	M	FD	10	w	NR	NR	JV	B	C	Lab	2	BIO	CHM	PCON	SR	56		N	61	N	2.016034	1.85		10	10	10	10	5	1	4	1	10	4	65
112	34656	Svajgr et al., 1969	Manganese oxide	100	Pig (*Sus scrofa*)	1	2	0/100	mg/kg	NR	na	ADL	U	FD	84	d	NR	NR	JV	B	C	FieldA	2	BEH	FDB	FCNS	WO	50		Y	87.86	Y	2.41	2.74		10	10	5	10	7	4	4	1	10	4	65
113	34656	Svajgr et al., 1969	Manganese oxide	100	Pig (*Sus scrofa*)	1	2	0/100	mg/kg	NR	na	ADL	U	FD	84	d	NR	NR	JV	B	C	FieldA	3	PHY	PHY	FDCV	WO	50		Y	87.86	Y	2.41	2.74		10	10	5	10	7	4	4	1	10	4	65
114	757	Mercado and Bibby 1973	Manganese chloride tetrahydrate	100	Rat (*Rattus norvegicus*)	1	2	0/50	mg/L	N	na	ADL	U	DR	50	d	23	d	JV	M	C	Lab	2	PHY	PHY	GPHY	XX	50		N	0.267	N	0.030164	5.65		10	5	5	10	5	4	4	1	10	4	58
115	757	Mercado and Bibby 1973	Manganese chloride tetrahydrate	100	Rat (*Rattus norvegicus*)	1	2	0/50	mg/L	N	na	ADL	U	DR	50	d	23	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	50		N	0.267	N	0.030164	5.65		10	5	5	10	5	8	4	1	10	4	62
116	136	Gershbein et al 1983	Manganese (II) chloride	100	Rat (*Rattus norvegicus*)	1	2	0/75	mg/kg diet	N	na	ADL	U	FD	80	d	44	d	JV	M	C	Lab	3	PTH	HIS	GHIS	MT	75		Y	0.47	N	0.036934	5.89		10	10	5	10	6	4	4	1	10	4	64
117	2640	Freundt and Ibrahim, 1990	Manganese chloride	100	Rat (*Rattus norvegicus*)	1	2	0/100	mg/L	NR	na	ADL	U	DR	91	d	NR	NR	AD	F	C	Lab	1	BEH	FDB	WCON	NR	100		Y	0.33	N	0.0365	11.1		10	5	5	10	6	4	4	1	10	4	59
118	2640	Freundt and Ibrahim, 1990	Manganese chloride	100	Rat (*Rattus norvegicus*)	1	2	0/100	mg/L	N	na	ADL	U	DR	91	d	NR	NR	AD	F	C	Lab	2	GRO	GRO	BDWT	WO	100		Y	0.33	N	0.0365	11.1		10	5	5	10	6	8	4	1	10	4	63
119	34892	Ali et al., 1981	Manganese tetrahydrate	21.5	Rat (*Rattus norvegicus*)	1	2	0/1	mg/ml	NR	na	ADL	U	DR	180	d	40	d	JV	M	C	Lab	1	GRO	GRO	BDWT	WO	1		N	0.267	N	0.030164	24.3		10	5	5	10	5	8	4	1	10	4	62
120	35742	Ho et al, 1984	Manganese carbonate	100	Cattle (*Bos taurus*)	1	2	0/1000	mg/kg diet	NR	na	ADL	U	FD	3	w	130	d	JV	M	C	Lab	1	BIO	CHM	HMGL	BL	1000		Y	89	N	2.750143	30.9		10	10	5	10	6	1	4	1	10	4	61
121	14468	Leibholz et al, 1962	Manganese sulfate	100	Pig (*Sus scrofa*)	2	6	0/25/75/225/675/2025	mg/kg diet	NR	na	ADL	U	FD	6	w	2	w	JV	B	C	Lab	3	BIO	CHM	HMGL	BL	2025		Y	14.6	N	0.622379	86.3		10	10	5	10	6	1	4	1	10	4	61
122	14468	Leibholz et al, 1962	Manganese sulfate	100	Pig (*Sus scrofa*)	2	6	0/25/75/225/675/2025	mg/kg diet	NR	na	ADL	U	FD	6	w	2	w	JV	B	C	Lab	2	PHY	PHY	FDCV	WO	2025		Y	14.6	N	0.622379	86.3		10	10	5	10	6	4	4	1	10	4	64
123	14461	Cunningham et al, 1966	Manganese sulfate	100	Cattle (*Bos taurus*)	2	4	0/820/2460/4920	mg/kg diet	NR	na	ADL	U	FD	84	d	10	w	JV	M	C	Lab	3	BIO	CHM	HMGL	BL	4920		Y	196	Y	4.45	112		10	10	5	10	7	1	4	1	10	4	62
124	14461	Cunningham et al, 1966	Manganese sulfate	100	Cattle (*Bos taurus*)	2	4	0/820/2460/4920	mg/kg diet	NR	na	ADL	U	FD	84	d	10	w	JV	M	C	Lab	3	BIO	CHM	HMGL	BL	4920		Y	196	Y	4.45	112		10	10	5	10	7	1	4	1	10	4	62
125	14461	Cunningham et al, 1966	Manganese sulfate	100	Cattle (*Bos taurus*)	2	4	0/820/2460/4920	mg/kg diet	NR	na	ADL	U	FD	84	d	10	w	JV	M	C	Lab	4	PHY	PHY	FDCV	WO	4920		Y	196	Y	4.45	112		10	10	5	10	7	4	4	1	10	4	65
126	35501	Ivan and Hidiroglou, 1980	Manganese sulfate hydrate	100	Sheep (*Ovis aries*)	1	3	0/300/3000	mg/kg diet	NR	na	ADL	U	FD	56	d	NR	NR	NR	M	C	Lab	2	BEH	FDB	FCNS	WO	3000		Y	34	Y	1.268	112		10	10	5	10	7	4	4	1	6	4	61
127	35501	Ivan and Hidiroglou, 1980	Manganese sulfate hydrate	100	Sheep (*Ovis aries*)	1	3	0/300/3000	mg/kg diet	NR	na	ADL	U	FD	56	d	NR	NR	NR	M	C	Lab	3	PHY	PHY	FDCV	WO	3000		Y	34	Y	1.268	112		10	10	5	10	7	4	4	1	6	4	61
128	35501	Ivan and Hidiroglou, 1980	Manganese sulfate hydrate	100	Sheep (*Ovis aries*)	1	3	0/300/3000	mg/kg diet	NR	na	ADL	U	FD	56	d	NR	NR	NR	M	C	Lab	1	GRO	GRO	BDWT	WO	3000		Y	34	Y	1.268	112		10	10	5	10	7	8	4	1	6	4	65
129	35707	Bonilla and Prasad, 1984	Manganese Chloride	100	Rat (*Rattus norvegicus*)	1	3	0/0.1/1.0	mg/ml	NR	na	ADL	U	DR	8	mo	NR	NR	JV	M	C	Lab	1	PTH	ORW	ORWT	BR	1		Y	0.25	N	0.02843	114		10	5	5	10	6	4	4	3	10	4	61
130	35824	Black et al, 1985	Manganese oxide	100	Sheep (*Ovis aries*)	2	5	0/500/1000/2000/4000	mg/kg diet	NR	na	ADL	U	FD	84	d	NR	NR	JV	M	C	Lab	3	BIO	CHM	HMGL	BL	4000		Y	38.4	Y	1.14	119		10	10	5	10	7	1	4	1	10	4	62
131	34586	Hastings and Llewellyn, 1987	Manganese sulfate	100	Hamster (*Mesocricetus auratus*)	1	2	0/1149	mg/kg diet	NR	na	ADL	U	FD	10	w	NR	NR	JV	M	C	Lab	1	PTH	HIS	GHIS	LI	1149		N	0.097	N	0.010094	120		10	10	5	10	5	4	4	1	10	4	63
132	14468	Leibholz et al, 1962	Manganese sulfate	100	Pig (*Sus scrofa*)	2	4	0/40/400/4000	mg/kg diet	NR	na	ADL	U	FD	10	w	2	w	JV	B	C	Lab	3	BIO	CHM	HMGL	BL	4000		Y	34.1	N	1.249916	147		10	10	5	10	6	1	4	1	10	4	61
133	14468	Leibholz et al, 1962	Manganese sulfate	100	Pig (*Sus scrofa*)	2	4	0/40/400/4000	mg/kg diet	NR	na	ADL	U	FD	10	w	2	w	JV	B	C	Lab	2	PHY	PHY	FDCV	WO	4000		Y	34.1	N	1.249916	146.6		10	10	5	10	6	4	4	1	10	4	64
134	35824	Black et al, 1985	Manganese carbonate	100	Sheep (*Ovis aries*)	2	4	0/2000/4000/8000	mg/kg diet	NR	na	ADL	U	FD	84	d	NR	NR	JV	M	C	Lab	4	BIO	CHM	HMGL	BL	8000		Y	36.8	Y	0.99	215		10	10	5	10	7	1	4	1	10	4	62
135	35826	Black et al, 1985	Manganese oxide	100	Sheep (*Ovis aries*)	2	4	0/3000/6000/9000	mg/kg diet	NR	na	ADL	U	FD	21	d	NR	NR	JV	M	C	Lab	2	BIO	CHM	HMCT	BL	9000		Y	47	Y	1.178	226		10	10	5	10	7	1	4	1	10	4	62
136	35826	Black et al, 1985	Manganese oxide	100	Sheep (*Ovis aries*)	2	4	0/3000/6000/9000	ppm in mg/kg	NR	na	DLY	U	OR	21	d	NR	NR	JV	M	C	Lab	2	BIO	CHM	HMCT	BL	9000		Y	47	Y	1.22	234		10	8	10	10	7	1	4	1	10	4	65
137	33786	Komura and Sakamoto, 1991	Manganese acetate	100	Mouse (*Mus musculus*)	4	2	0/2	g/kg diet	NR	na	ADL	U	FD	100	d	6	w	JV	M	C	Lab	2	BEH	FDB	FCNS	WO	2		Y	0.0282	Y	0.004	284		10	10	5	5	7	4	4	6	10	4	65
138	55	Carter et al, 1980	Manganese oxide	100	Rat (*Rattus norvegicus*)	1	4	0/400/1100/3550	mg/kg diet	NR	na	ADL	U	FD	43	d	NR	NR	GE	F	C	Lab	1	REP	REP	OTHR	PY	3550		N	0.344	N	0.028576	295		10	10	5	10	5	10	4	10	10	4	78
139	34574	Johnson and Kies, 1987	Manganese carbonate	100	Rat (*Rattus norvegicus*)	1	3	0/450/4550	mg/kg diet	NR	na	ADL	U	FD	56	d	NR	NR	JV	M	C	Lab	2	BIO	CHM	CHOL	SR	4550		Y	0.272	N	0.02356	394		10	10	5	10	6	1	4	1	10	4	61
140	33511	Gaillard et al, 1996	Manganese chloride tetrahydrate	100	Rat (*Rattus norvegicus*)	1	2	0/554	mg/kg bw/d	NR	na	ADL	U	DR	11	w	3	w	JV	M	C	Lab	3	PHY	PHY	EXCR	UB	554		Y	0.445	Y	0.027	554		10	5	5	10	7	4	4	6	10	4	65
141	34791	Seth et al, 1977	Manganese chloride tetrahydrate	27.8	Rat (*Rattus norvegicus*)	1	2	0/15	mg/kg bw/d	NR	na	DLY	U	GV	15	d	NR	NR	LC	F	C	Lab	1	REP	REP	OTHR	PY		15	Y	0.22	N	0.019789		4.17	10	8	10	10	10	10	4	10	10	4	86
142	34892	Ali et al., 1981	Manganese tetrahydrate	21.5	Rat (*Rattus norvegicus*)	1	2	0/1	mg/ml	NR	na	ADL	U	DR	30	d	40	d	JV	M	C	Lab	3	BIO	HRM	DOPA	BR		1	N	0.267	N	0.030164		24.3	10	5	5	10	5	1	4	10	10	4	64
143	1717	Bataineh et al., 1998	Manganese sulfate dihydrate	24.07	Rat (*Rattus norvegicus*)	1	2	0/1000	mg/L	N	na	ADL	U	DR	12	w	NR	NR	AD	M	V	Lab	3	BEH	BEH	AGGT	WO		1000	Y	0.36266	N	0.039736		26.4	10	5	5	10	6	4	4	10	3	4	61
144	1717	Bataineh et al., 1998	Manganese sulfate dihydrate	24.07	Rat (*Rattus norvegicus*)	1	2	0/1000	mg/L	NR	na	ADL	U	DR	12	w	NR	NR	AD	M	V	Lab	1	PTH	GRS	BDWT	WO		1000	Y	0.36266	N	0.039736		26.4	10	5	5	10	6	4	4	10	3	4	61
145	34850	Chandra, 1983	Manganese	100	Rat (*Rattus norvegicus*)	1	2	0/1	mg/ml	NR	na	ADL	U	DR	30	d	NR	NR	JV	M	C	Lab	2	BIO	HRM	DOPA	MU		1	Y	0.25	N	0.02843		114	10	5	5	4	6	1	4	10	10	10	65
146	33705	Chan et al, 1992	Manganese chloride tetrahydrate	14.53	Rat (*Rattus norvegicus*)	1	2	0/10	mg/ml	NR	na	NR	U	DR	26	d	NR	NR	LC	F	C	Lab	1	REP	REP	OTHR	PY		10	N	0.297	N	0.033198		162	10	5	5	10	5	10	4	10	10	4	73
147	35726	Ali et al, 1983	Manganese	100	Rat (*Rattus norvegicus*)	1	2	0/3	mg/ml	NR	na	ADL	U	DR	90	d	NR	NR	AD	M	C	Lab	1	BIO	ENZ	GENZ	BR		3	N	0.4702	N	0.050198		320	10	5	5	4	5	1	4	10	10	4	58
148	35726	Ali et al, 1983	Manganese	100	Rat (*Rattus norvegicus*)	1	2	0/3	mg/ml	NR	na	ADL	U	DR	90	d	NR	NR	AD	M	C	Lab	2	PTH	ITX	CONV	WO		3	N	0.4702	N	0.050198		320	10	5	5	4	5	4	4	10	10	4	61
149	34916	Hietanen et al, 1981	Manganese chloride	100	Rat (*Rattus norvegicus*)	1	2	0/0.5	% in diet	NR	na	ADL	U	DR	1	w	2.5-3.5	mo	AD	M	C	Lab	2	BIO	ENZ	AHHD	LI		0.5	N	0.462	N	0.04941		535	10	5	5	10	5	1	4	10	3	4	57
150	34621	Eriksson et al, 1987	Manganese chloride tetrahydrate	100	Rat (*Rattus norvegicus*)	1	2	0/10	g/L	NR	na	ADL	U	DR	60	d	20	d	JV	M	C	Lab	1	BIO	HRM	DOPA	BR		10	N	0.267	N	0.030164		1130	10	5	5	10	5	1	4	10	10	4	64

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

*NOAEL and LOAEL values that are equal and from the same reference represent different experimental designs. These are designated with different Phase numbers.