Organophosphorus Cumulative Risk Assessment – 2006 Update

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August 2006

Appendices have been separated from the original PDF into individual PDF documents for viewing on-line.

This PDF contains the C, D, E, and G appendices

C-1. The Sources of Residue Inputs for the Assessment of the Cumulative Dietary Exposure to Organophosphorus Pesticides on Foods

See file II_C1.xls

Foods in CSFII 1994-1998 are listed in descending order of per capita consumption by children

C-2. Summary of PDP Residue Analyses of Organophosphorus Pesticides on Foods (1994-2004)

See file II_C_2.xls

C-3. A summary of FDA Total Diet Study Analyses for Organophosphorus Pesticides in Meats (1991-2001)

Table II.C-3.1 A summary of FDA Total Diet Study Analyses for Organophosphorus Pesticides in Meats (1991-2001).

Food No	Sample Description	Year	Market Basket	Residue Found	Concentration (ppm)
017	ham, baked	1991	3	no residue found	0
017	ham, baked	1992	1	no residue found	0
017	ham, baked	1992	2	parathion	0.02
017	ham, baked	1992	2	phosalone	0.06
017	ham, baked	1993	1	no residue found	0
017	ham, baked	1993	2	no residue found	0
017	ham, baked	1993	3	no residue found	0
017	ham, baked	1994	1	no residue found	0
017	ham, baked	1994	2	no residue found	0
017	ham, baked	1994	3	parathion	0.02
017	ham, baked	1994	4	no residue found	0
017	ham, baked	1995	1	no residue found	0
017	ham, baked	1995	2	no residue found	0
017	ham, baked	1995	3	no residue found	0
017	ham, baked	1996	1	no residue found	0
017	ham, baked	1996	2	no residue found	0
017	ham, baked	1996	3	diazinon	0.01
017	ham, baked	1996	3	fenamiphos	0.03
017	ham, baked	1996	3	parathion	0.02
017	ham, baked	1996	4	no residue found	0
017	ham, baked	1997	1	no residue found	0
017	ham, baked	1997	2	no residue found	0
017	ham, baked	1997	3	no residue found	0

Food No	Sample Description	Year	Market Basket	Residue Found	Concentration (ppm)
017	ham, baked	1997	4	no residue found	0
017	ham, baked	1998	1	no residue found	0
017	ham, baked	1998	2	no residue found	0
017	ham, baked	1998	3	no residue found	0
017	ham, baked	1998	4	parathion	0.02
017	ham, baked	1998	4	profenofos	0.02
017	ham, baked	1998	4	terbufos	0.02
017	ham, baked	1999	1	no residue found	0
017	ham, baked	1999	2	no residue found	0
017	ham, baked	1999	3	no residue found	0
017	ham, baked	2000	1	no residue found	0
017	ham, baked	2000	2	no residue found	0
017	ham, baked	2000	3	no residue found	0
017	ham, baked	2000	4	no residue found	0
017	ham, baked	2001	1	no residue found	0
017	ham, baked	2001	2	no residue found	0
017	ham, baked	2001	3	demeton-S sulfone	0.1
017	ham, baked	2001	3	fenamiphos sulfoxide	0.04
017	ham, baked	2001	3	parathion	0.02
017	ham, baked	2001	4	no residue found	0
018	pork chop, pan-cooked	1991	3	no residue found	0
018	pork chop, pan-cooked	1992	1	no residue found	0
018	pork chop, pan-cooked	1992	2	no residue found	0
018	pork chop, pan-cooked	1993	1	no residue found	0
018	pork chop, pan-cooked	1993	2	no residue found	0
018	pork chop, pan-cooked	1993	3	parathion	0.02
018	pork chop, pan-cooked	1994	1	chlorpyrifos	0.002
018	pork chop, pan-cooked	1994	1	diazinon	0.0008
018	pork chop, pan-cooked	1994	1	parathion	0.02
018	pork chop, pan-cooked	1994	2	no residue found	0

Food No	Sample Description	Year	Market Basket	Residue Found	Concentration (ppm)
018	pork chop, pan-cooked	1994	3	no residue found	0
018	pork chop, pan-cooked	1994	4	no residue found	0
018	pork chop, pan-cooked	1995	1	no residue found	0
018	pork chop, pan-cooked	1995	2	no residue found	0
018	pork chop, pan-cooked	1995	3	no residue found	0
018	pork chop, pan-cooked	1996	1	no residue found	0
018	pork chop, pan-cooked	1996	2	diazinon	0.01
018	pork chop, pan-cooked	1996	2	parathion	0.02
018	pork chop, pan-cooked	1996	3	no residue found	0
018	pork chop, pan-cooked	1996	4	no residue found	0
018	pork chop, pan-cooked	1997	1	no residue found	0
018	pork chop, pan-cooked	1997	2	no residue found	0
018	pork chop, pan-cooked	1997	3	no residue found	0
018	pork chop, pan-cooked	1997	4	no residue found	0
018	pork chop, pan-cooked	1998	1	diazinon	0.01
018	pork chop, pan-cooked	1998	1	parathion	0.02
018	pork chop, pan-cooked	1998	1	trichlorfon	0.02
018	pork chop, pan-cooked	1998	2	no residue found	0
018	pork chop, pan-cooked	1998	3	no residue found	0
018	pork chop, pan-cooked	1998	4	no residue found	0
018	pork chop, pan-cooked	1999	1	no residue found	0
018	pork chop, pan-cooked	1999	2	no residue found	0
018	pork chop, pan-cooked	1999	3	no residue found	0
018	pork chop, pan-cooked	2000	1	no residue found	0
018	pork chop, pan-cooked	2000	2	azinphos-methyl oxygen analog	0.04
018	pork chop, pan-cooked	2000	2	diazinon	0.02
018	pork chop, pan-cooked	2000	2	fenthion oxygen analog sulfoxide	0.02
018	pork chop, pan-cooked	2000	2	naled	0.02
018	pork chop, pan-cooked	2000	2	parathion	0.02
018	pork chop, pan-cooked	2000	3	no residue found	0

Food No	Sample Description	Year	Market Basket	Residue Found	Concentration (ppm)
018	pork chop, pan-cooked	2000	4	no residue found	0
018	pork chop, pan-cooked	2001	1	no residue found	0
018	pork chop, pan-cooked	2001	2	no residue found	0
018	pork chop, pan-cooked	2001	3	no residue found	0
018	pork chop, pan-cooked	2001	4	chlorethoxyfos	0.02
018	pork chop, pan-cooked	2001	4	diazinon	0.02
018	pork chop, pan-cooked	2001	4	parathion	0.02
019	pork sausage, pan-cooked	1991	3	no residue found	0
019	pork sausage, pan-cooked	1992	1	no residue found	0
019	pork sausage, pan-cooked	1992	2	no residue found	0
019	pork sausage, pan-cooked	1993	1	no residue found	0
019	pork sausage, pan-cooked	1993	2	no residue found	0
019	pork sausage, pan-cooked	1993	3	no residue found	0
019	pork sausage, pan-cooked	1994	1	no residue found	0
019	pork sausage, pan-cooked	1994	2	no residue found	0
019	pork sausage, pan-cooked	1994	3	no residue found	0
019	pork sausage, pan-cooked	1994	4	no residue found	0
019	pork sausage, pan-cooked	1995	1	no residue found	0
019	pork sausage, pan-cooked	1995	2	no residue found	0
019	pork sausage, pan-cooked	1995	3	no residue found	0
019	pork sausage, pan-cooked	1996	1	no residue found	0
019	pork sausage, pan-cooked	1996	2	no residue found	0
019	pork sausage, pan-cooked	1996	3	no residue found	0
019	pork sausage, pan-cooked	1996	4	no residue found	0
019	pork sausage, pan-cooked	1997	1	no residue found	0
019	pork sausage, pan-cooked	1997	2	diazinon	0.01
019	pork sausage, pan-cooked	1997	2	ethion	0.002
019	pork sausage, pan-cooked	1997	2	methamidophos	0.02
019	pork sausage, pan-cooked	1997	2	parathion	0.02
019	pork sausage, pan-cooked	1997	3	ethion	0.003

Food No	Sample Description	Year	Market Basket	Residue Found	Concentration (ppm)
019	pork sausage, pan-cooked	1997	3	phosalone	0.003
019	pork sausage, pan-cooked	1997	4	no residue found	0
019	pork sausage, pan-cooked	1998	1	no residue found	0
019	pork sausage, pan-cooked	1998	2	ethion	0.002
019	pork sausage, pan-cooked	1998	3	acephate	0.02
019	pork sausage, pan-cooked	1998	3	diazinon	0.01
019	pork sausage, pan-cooked	1998	3	parathion	0.02
019	pork sausage, pan-cooked	1998	3	phosalone	0.04
019	pork sausage, pan-cooked	1998	4	no residue found	0
019	pork sausage, pan-cooked	1999	1	ethion	0.002
019	pork sausage, pan-cooked	1999	2	no residue found	0
019	pork sausage, pan-cooked	1999	3	no residue found	0
019	pork sausage, pan-cooked	2000	1	no residue found	0
019	pork sausage, pan-cooked	2000	2	ethion	0.003
019	pork sausage, pan-cooked	2000	3	no residue found	0
019	pork sausage, pan-cooked	2000	4	no residue found	0
019	pork sausage, pan-cooked	2001	1	no residue found	0
019	pork sausage, pan-cooked	2001	2	diazinon	0.04
019	pork sausage, pan-cooked	2001	2	fenthion oxygen analog	0.04
019	pork sausage, pan-cooked	2001	2	fenthion sulfone	0.08
019	pork sausage, pan-cooked	2001	2	parathion	0.04
019	pork sausage, pan-cooked	2001	3	no residue found	0
019	pork sausage, pan-cooked	2001	4	no residue found	0
020	pork bacon, pan-cooked	1991	3	no residue found	0
020	pork bacon, pan-cooked	1992	1	no residue found	0
020	pork bacon, pan-cooked	1992	2	no residue found	0
020	pork bacon, pan-cooked	1993	1	parathion	0.02
020	pork bacon, pan-cooked	1993	2	parathion	0.02
020	pork bacon, pan-cooked	1993	3	no residue found	0
020	pork bacon, pan-cooked	1994	1	no residue found	0

Food No	Sample Description	Year	Market Basket	Residue Found	Concentration (ppm)
020	pork bacon, pan-cooked	1994	2	no residue found	0
020	pork bacon, pan-cooked	1994	3	no residue found	0
020	pork bacon, pan-cooked	1994	4	no residue found	0
020	pork bacon, pan-cooked	1995	1	no residue found	0
020	pork bacon, pan-cooked	1995	2	no residue found	0
020	pork bacon, pan-cooked	1995	3	no residue found	0
020	pork bacon, pan-cooked	1996	1	no residue found	0
020	pork bacon, pan-cooked	1996	2	no residue found	0
020	pork bacon, pan-cooked	1996	3	no residue found	0
020	pork bacon, pan-cooked	1996	4	no residue found	0
020	pork bacon, pan-cooked	1997	1	azinphos-ethyl	0.2
020	pork bacon, pan-cooked	1997	1	diazinon	0.01
020	pork bacon, pan-cooked	1997	1	parathion	0.02
020	pork bacon, pan-cooked	1997	2	no residue found	0
020	pork bacon, pan-cooked	1997	3	no residue found	0
020	pork bacon, pan-cooked	1997	4	diazinon	0.01
020	pork bacon, pan-cooked	1997	4	parathion	0.02
020	pork bacon, pan-cooked	1997	4	trichlorfon	0.02
020	pork bacon, pan-cooked	1998	1	no residue found	0
020	pork bacon, pan-cooked	1998	2	no residue found	0
020	pork bacon, pan-cooked	1998	3	no residue found	0
020	pork bacon, pan-cooked	1998	4	no residue found	0
020	pork bacon, pan-cooked	1999	1	no residue found	0
020	pork bacon, pan-cooked	1999	2	no residue found	0
020	pork bacon, pan-cooked	1999	3	no residue found	0
020	pork bacon, pan-cooked	2000	1	no residue found	0
020	pork bacon, pan-cooked	2000	2	no residue found	0
020	pork bacon, pan-cooked	2000	3	no residue found	0
020	pork bacon, pan-cooked	2000	4	chlorpyrifos oxygen analog	0.2
020	pork bacon, pan-cooked	2000	4	dimethoate	0.04

Food No	Sample Description	Year	Market Basket	Residue Found	Concentration (ppm)
020	pork bacon, pan-cooked	2000	4	malathion oxygen analog	0.2
020	pork bacon, pan-cooked	2000	4	parathion	0.04
020	pork bacon, pan-cooked	2001	1	no residue found	0
020	pork bacon, pan-cooked	2001	2	no residue found	0
020	pork bacon, pan-cooked	2001	3	no residue found	0
020	pork bacon, pan-cooked	2001	4	no residue found	0
021	pork roast, baked	1991	3	no residue found	0
021	pork roast, baked	1992	1	no residue found	0
021	pork roast, baked	1992	2	no residue found	0
021	pork roast, baked	1993	1	no residue found	0
021	pork roast, baked	1993	2	no residue found	0
021	pork roast, baked	1993	3	no residue found	0
021	pork roast, baked	1994	1	no residue found	0
021	pork roast, baked	1994	2	no residue found	0
021	pork roast, baked	1994	3	no residue found	0
021	pork roast, baked	1994	4	no residue found	0
021	pork roast, baked	1995	1	ethion oxygen analog	0.02
021	pork roast, baked	1995	1	parathion	0.02
021	pork roast, baked	1995	2	no residue found	0
021	pork roast, baked	1995	3	no residue found	0
021	pork roast, baked	1996	1	no residue found	0
021	pork roast, baked	1996	2	no residue found	0
021	pork roast, baked	1996	3	no residue found	0
021	pork roast, baked	1996	4	azinphos-methyl	0.2
021	pork roast, baked	1996	4	diazinon	0.01
021	pork roast, baked	1996	4	parathion	0.02
021	pork roast, baked	1997	1	no residue found	0
021	pork roast, baked	1997	2	no residue found	0
021	pork roast, baked	1997	3	no residue found	0
021	pork roast, baked	1997	4	no residue found	0

Food No	Sample Description	Year	Market Basket	Residue Found	Concentration (ppm)
021	pork roast, baked	1998	1	no residue found	0
021	pork roast, baked	1998	2	no residue found	0
021	pork roast, baked	1998	3	diazinon	0.02
021	pork roast, baked	1998	3	omethoate	0.04
021	pork roast, baked	1998	3	parathion	0.02
021	pork roast, baked	1998	3	tribufos	0.02
021	pork roast, baked	1998	4	no residue found	0
021	pork roast, baked	1999	1	no residue found	0
021	pork roast, baked	1999	2	no residue found	0
021	pork roast, baked	1999	3	no residue found	0
021	pork roast, baked	2000	1	no residue found	0
021	pork roast, baked	2000	2	no residue found	0
021	pork roast, baked	2000	3	diazinon	0.02
021	pork roast, baked	2000	3	fenthion oxygen analog sulfoxide	0.1
021	pork roast, baked	2000	3	naled	0.1
021	pork roast, baked	2000	3	parathion	0.02
021	pork roast, baked	2000	4	no residue found	0
021	pork roast, baked	2001	1	no residue found	0
021	pork roast, baked	2001	2	diazinon	0.02
021	pork roast, baked	2001	2	fenthion oxygen analog	0.02
021	pork roast, baked	2001	2	fenthion sulfone	0.04
021	pork roast, baked	2001	2	parathion	0.02
021	pork roast, baked	2001	3	no residue found	0
021	pork roast, baked	2001	4	no residue found	0
022	lamb chop, pan-cooked	1991	3	no residue found	0
022	lamb chop, pan-cooked	1992	1	no residue found	0
022	lamb chop, pan-cooked	1992	2	no residue found	0
022	lamb chop, pan-cooked	1993	1	no residue found	0
022	lamb chop, pan-cooked	1993	2	no residue found	0
022	lamb chop, pan-cooked	1993	3	no residue found	0

Food No	Sample Description	Year	Market Basket	Residue Found	Concentration (ppm)
022	lamb chop, pan-cooked	1994	1	chlorpyrifos	0.006
022	lamb chop, pan-cooked	1994	1	diazinon	0.009
022	lamb chop, pan-cooked	1994	1	parathion	0.02
022	lamb chop, pan-cooked	1994	2	no residue found	0
022	lamb chop, pan-cooked	1994	3	diazinon	0.002
022	lamb chop, pan-cooked	1994	4	parathion	0.02
022	lamb chop, pan-cooked	1995	1	no residue found	0
022	lamb chop, pan-cooked	1995	2	no residue found	0
022	lamb chop, pan-cooked	1995	3	no residue found	0
022	lamb chop, pan-cooked	1996	1	no residue found	0
022	lamb chop, pan-cooked	1996	2	no residue found	0
022	lamb chop, pan-cooked	1996	3	no residue found	0
022	lamb chop, pan-cooked	1996	4	no residue found	0
022	lamb chop, pan-cooked	1997	1	no residue found	0
022	lamb chop, pan-cooked	1997	2	no residue found	0
022	lamb chop, pan-cooked	1997	3	diazinon	0.01
022	lamb chop, pan-cooked	1997	3	mevinphos, (e)-	0.01
022	lamb chop, pan-cooked	1997	3	parathion	0.02
022	lamb chop, pan-cooked	1997	4	no residue found	0
022	lamb chop, pan-cooked	1998	1	no residue found	0
022	lamb chop, pan-cooked	1998	2	no residue found	0
022	lamb chop, pan-cooked	1998	3	no residue found	0
022	lamb chop, pan-cooked	1998	4	no residue found	0
022	lamb chop, pan-cooked	1999	1	chlorpyrifos	0.0002
022	lamb chop, pan-cooked	1999	2	diazinon	0.02
022	lamb chop, pan-cooked	1999	2	disulfoton sulfone	0.02
022	lamb chop, pan-cooked	1999	2	ethoprop	0.02
022	lamb chop, pan-cooked	1999	2	parathion	0.02
022	lamb chop, pan-cooked	1999	3	cadusafos	0.02
022	lamb chop, pan-cooked	1999	3	diazinon	0.002

Food No	Sample Description	Year	Market Basket	Residue Found	Concentration (ppm)
022	lamb chop, pan-cooked	1999	3	diazinon	0.02
022	lamb chop, pan-cooked	1999	3	parathion	0.02
022	lamb chop, pan-cooked	2000	1	no residue found	0
022	lamb chop, pan-cooked	2000	2	no residue found	0
022	lamb chop, pan-cooked	2000	3	no residue found	0
022	lamb chop, pan-cooked	2000	4	no residue found	0
022	lamb chop, pan-cooked	2001	1	no residue found	0
022	lamb chop, pan-cooked	2001	2	no residue found	0
022	lamb chop, pan-cooked	2001	3	no residue found	0
022	lamb chop, pan-cooked	2001	4	no residue found	0
029	bologna, sliced	1991	3	no residue found	0
029	bologna, sliced	1992	1	no residue found	0
029	bologna, sliced	1992	2	no residue found	0
029	bologna, sliced	1993	1	no residue found	0
029	bologna, sliced	1993	2	no residue found	0
029	bologna, sliced	1993	3	no residue found	0
029	bologna, sliced	1994	1	no residue found	0
029	bologna, sliced	1994	2	no residue found	0
029	bologna, sliced	1994	3	no residue found	0
029	bologna, sliced	1994	4	no residue found	0
029	bologna, sliced	1995	1	no residue found	0
029	bologna, sliced	1995	2	no residue found	0
029	bologna, sliced	1995	3	no residue found	0
029	bologna, sliced	1996	1	no residue found	0
029	bologna, sliced	1996	2	no residue found	0
029	bologna, sliced	1996	3	diazinon	0.01
029	bologna, sliced	1996	3	fenamiphos	0.03
029	bologna, sliced	1996	3	parathion	0.02
029	bologna, sliced	1996	4	no residue found	0
029	bologna, sliced	1997	1	no residue found	0

Food No	Sample Description	Year	Market Basket	Residue Found	Concentration (ppm)
029	bologna, sliced	1997	2	no residue found	0
029	bologna, sliced	1997	3	no residue found	0
029	bologna, sliced	1997	4	no residue found	0
029	bologna, sliced	1998	1	diazinon	0.01
029	bologna, sliced	1998	1	DDVP	0.02
029	bologna, sliced	1998	1	parathion	0.02
029	bologna, sliced	1998	2	no residue found	0
029	bologna, sliced	1998	3	no residue found	0
029	bologna, sliced	1998	4	no residue found	0
029	bologna, sliced	1999	1	no residue found	0
029	bologna, sliced	1999	2	no residue found	0
029	bologna, sliced	1999	3	no residue found	0
029	bologna, sliced	2000	1	no residue found	0
029	bologna, sliced	2000	2	azinphos-methyl oxygen analog	0.08
029	bologna, sliced	2000	2	diazinon	0.04
029	bologna, sliced	2000	2	fenthion oxygen analog sulfoxide	0.04
029	bologna, sliced	2000	2	naled	0.04
029	bologna, sliced	2000	2	parathion	0.04
029	bologna, sliced	2000	3	no residue found	0
029	bologna, sliced	2000	4	no residue found	0
029	bologna, sliced	2001	1	no residue found	0
029	bologna, sliced	2001	2	no residue found	0
029	bologna, sliced	2001	3	no residue found	0
029	bologna, sliced	2001	4	no residue found	0
030	salami, sliced	1991	3	no residue found	0
030	salami, sliced	1992	1	no residue found	0
030	salami, sliced	1992	2	no residue found	0
030	salami, sliced	1993	1	no residue found	0
030	salami, sliced	1993	2	no residue found	0
030	salami, sliced	1993	3	no residue found	0

Food No	Sample Description	Year	Market Basket	Residue Found	Concentration (ppm)
030	salami, sliced	1994	1	no residue found	0
030	salami, sliced	1994	2	no residue found	0
030	salami, sliced	1994	3	no residue found	0
030	salami, sliced	1994	4	no residue found	0
030	salami, sliced	1995	1	no residue found	0
030	salami, sliced	1995	2	no residue found	0
030	salami, sliced	1995	3	no residue found	0
030	salami, sliced	1996	1	no residue found	0
030	salami, sliced	1996	2	diazinon	0.01
030	salami, sliced	1996	2	parathion	0.02
030	salami, sliced	1996	3	no residue found	0
030	salami, sliced	1996	4	no residue found	0
030	salami, sliced	1997	1	no residue found	0
030	salami, sliced	1997	2	diazinon	0.01
030	salami, sliced	1997	2	methamidophos	0.02
030	salami, sliced	1997	2	parathion	0.02
030	salami, sliced	1997	3	no residue found	0
030	salami, sliced	1997	4	no residue found	0
030	salami, sliced	1998	1	no residue found	0
030	salami, sliced	1998	2	no residue found	0
030	salami, sliced	1998	3	no residue found	0
030	salami, sliced	1998	4	no residue found	0
030	salami, sliced	1999	1	no residue found	0
030	salami, sliced	1999	2	no residue found	0
030	salami, sliced	1999	3	no residue found	0
030	salami, sliced	2000	1	no residue found	0
030	salami, sliced	2000	2	azinphos-methyl oxygen analog	0.04
030	salami, sliced	2000	2	diazinon	0.02
030	salami, sliced	2000	2	fenthion oxygen analog sulfoxide	0.02
030	salami, sliced	2000	2	naled	0.02

Food No	Sample Description	Year	Market Basket	Residue Found	Concentration (ppm)
030	salami, sliced	2000	2	parathion	0.02
030	salami, sliced	2000	3	no residue found	0
030	salami, sliced	2000	4	chlorpyrifos oxygen analog	0.1
030	salami, sliced	2000	4	dimethoate	0.02
030	salami, sliced	2000	4	malathion oxygen analog	0.1
030	salami, sliced	2000	4	parathion	0.02
030	salami, sliced	2001	1	no residue found	0
030	salami, sliced	2001	2	no residue found	0
030	salami, sliced	2001	3	no residue found	0
030	salami, sliced	2001	4	no residue found	0
238	veal cutlet, pan-cooked	1991	3	no residue found	0
238	veal cutlet, pan-cooked	1992	1	no residue found	0
238	veal cutlet, pan-cooked	1992	2	no residue found	0
238	veal cutlet, pan-cooked	1993	1	parathion	0.02
238	veal cutlet, pan-cooked	1993	2	no residue found	0
238	veal cutlet, pan-cooked	1993	3	parathion	0.02
238	veal cutlet, pan-cooked	1994	1	parathion	0.02
238	veal cutlet, pan-cooked	1994	2	no residue found	0
238	veal cutlet, pan-cooked	1994	3	malathion	0.001
238	veal cutlet, pan-cooked	1994	4	no residue found	0
238	veal cutlet, pan-cooked	1995	1	no residue found	0
238	veal cutlet, pan-cooked	1995	2	no residue found	0
238	veal cutlet, pan-cooked	1995	3	no residue found	0
238	veal cutlet, pan-cooked	1996	1	no residue found	0
238	veal cutlet, pan-cooked	1996	2	no residue found	0
238	veal cutlet, pan-cooked	1996	3	no residue found	0
238	veal cutlet, pan-cooked	1996	4	azinphos-methyl	0.2
238	veal cutlet, pan-cooked	1996	4	diazinon	0.01
238	veal cutlet, pan-cooked	1996	4	parathion	0.02
238	veal cutlet, pan-cooked	1997	1	no residue found	0

Food No	Sample Description	Year	Market Basket	Residue Found	Concentration (ppm)
238	veal cutlet, pan-cooked	1997	2	no residue found	0
238	veal cutlet, pan-cooked	1997	3	no residue found	0
238	veal cutlet, pan-cooked	1997	4	no residue found	0
238	veal cutlet, pan-cooked	1998	1	no residue found	0
238	veal cutlet, pan-cooked	1998	2	no residue found	0
238	veal cutlet, pan-cooked	1998	3	no residue found	0
238	veal cutlet, pan-cooked	1998	4	parathion	0.02
238	veal cutlet, pan-cooked	1998	4	profenofos	0.02
238	veal cutlet, pan-cooked	1998	4	terbufos	0.02
238	veal cutlet, pan-cooked	1999	1	no residue found	0
238	veal cutlet, pan-cooked	1999	2	no residue found	0
238	veal cutlet, pan-cooked	1999	3	no residue found	0
238	veal cutlet, pan-cooked	2000	1	no residue found	0
238	veal cutlet, pan-cooked	2000	2	no residue found	0
238	veal cutlet, pan-cooked	2000	3	no residue found	0
238	veal cutlet, pan-cooked	2000	4	no residue found	0
238	veal cutlet, pan-cooked	2001	1	no residue found	0
238	veal cutlet, pan-cooked	2001	2	no residue found	0
238	veal cutlet, pan-cooked	2001	3	demeton-S sulfone	0.1
238	veal cutlet, pan-cooked	2001	3	fenamiphos sulfoxide	0.04
238	veal cutlet, pan-cooked	2001	3	parathion	0.02
238	veal cutlet, pan-cooked	2001	4	no residue found	0
239	ham luncheon meat, sliced	1991	3	no residue found	0
239	ham luncheon meat, sliced	1992	1	no residue found	0
239	ham luncheon meat, sliced	1992	2	parathion	0.02
239	ham luncheon meat, sliced	1992	2	phosalone	0.06
239	ham luncheon meat, sliced	1993	1	no residue found	0
239	ham luncheon meat, sliced	1993	2	no residue found	0
239	ham luncheon meat, sliced	1993	3	no residue found	0
239	ham luncheon meat, sliced	1994	1	no residue found	0

Food No	Sample Description	Year	Market Basket	Residue Found	Concentration (ppm)
239	ham luncheon meat, sliced	1994	2	no residue found	0
239	ham luncheon meat, sliced	1994	3	parathion	0.02
239	ham luncheon meat, sliced	1994	4	no residue found	0
239	ham luncheon meat, sliced	1995	1	ethion oxygen analog	0.02
239	ham luncheon meat, sliced	1995	1	parathion	0.02
239	ham luncheon meat, sliced	1995	2	diazinon	0.01
239	ham luncheon meat, sliced	1995	2	parathion	0.02
239	ham luncheon meat, sliced	1995	3	no residue found	0
239	ham luncheon meat, sliced	1996	1	no residue found	0
239	ham luncheon meat, sliced	1996	2	no residue found	0
239	ham luncheon meat, sliced	1996	3	no residue found	0
239	ham luncheon meat, sliced	1996	4	no residue found	0
239	ham luncheon meat, sliced	1997	1	no residue found	0
239	ham luncheon meat, sliced	1997	2	no residue found	0
239	ham luncheon meat, sliced	1997	3	no residue found	0
239	ham luncheon meat, sliced	1997	4	no residue found	0
239	ham luncheon meat, sliced	1998	1	diazinon	0.01
239	ham luncheon meat, sliced	1998	1	DDVP	0.02
239	ham luncheon meat, sliced	1998	1	parathion	0.02
239	ham luncheon meat, sliced	1998	2	no residue found	0
239	ham luncheon meat, sliced	1998	3	no residue found	0
239	ham luncheon meat, sliced	1998	4	no residue found	0
239	ham luncheon meat, sliced	1999	1	no residue found	0
239	ham luncheon meat, sliced	1999	2	no residue found	0
239	ham luncheon meat, sliced	1999	3	no residue found	0
239	ham luncheon meat, sliced	2000	1	no residue found	0
239	ham luncheon meat, sliced	2000	2	no residue found	0
239	ham luncheon meat, sliced	2000	3	no residue found	0
239	ham luncheon meat, sliced	2000	4	no residue found	0
239	ham luncheon meat, sliced	2001	1	no residue found	0

Food No	Sample Description	Year	Market Basket	Residue Found	Concentration (ppm)
239	ham luncheon meat, sliced	2001	2	diazinon	0.02
239	ham luncheon meat, sliced	2001	2	fenthion oxygen analog	0.02
239	ham luncheon meat, sliced	2001	2	fenthion sulfone	0.04
239	ham luncheon meat, sliced	2001	2	parathion	0.02
239	ham luncheon meat, sliced	2001	3	no residue found	0
239	ham luncheon meat, sliced	2001	4	no residue found	0

C-4. Permissible Crop Translations for Pesticide Monitoring Data Table

Table II.C-4.1 Permissible Crop Translations for Pesticide Monitoring Data[24].

Commodity Analyzed	Commodity translated to...	Comments
Potato	Subgroup 1-C	
Carrot	Subgroup 1-A or 1-C	
Head Lettuce	Cabbage, Chinese cabbage napa (tight headed varieties), Brussels sprouts, radicchio	All have a head morphology best represented by lettuce. All are in Subgroup 5A except radicchio (4-A).
Broccoli	Cauliflower, Chinese broccoli, Chinese cabbage bok choy, Chinese mustard, kohlrabi	Broccoli better represents these heading, thickly stemmed and/or more branching cole crops than spinach does.
Spinach	Subgroup 4-A, Subgroup 5-B and Subgroup 4-B (except celery and fennel unless a strong case can be made)	Celery and fennel typically are excluded since residues may be higher in these crops due to the whorled, overlapping petioles which may retain spray residues.
Green Bean	Subgroups 6-A and 6-B	
Soybean	Subgroup 6-C	
Tomato or bell pepper	Group 8	All are fruiting vegetables.
Cucumber	Subgroup 9-B	All are cucurbit vegetables; residues in melon and pumpkin expected to be lower because of removal of rind.
Cantaloupe or Winter squash	Subgroup 9-A and pumpkin	
Orange	Group 10	Fruit will be peeled before analysis by PDP.
Apple or Pear	Group 11	All are pome fruits.
Peach	Group 12, except cherries (sweet and tart)	All are stone fruits.
Grape	Kiwifruit	Based on similar cultural practices.
Wheat	Group 15, except corn, rice, or wild rice	All are small grain crops or closely related thereto.
Milk	Meat	Metabolism study must indicate that residues in meat, fat, and meat-by-products will likely be equal to or lower than residues in milk. If dermal use is allowed on beef cattle, then it must be permitted and used on dairy cattle as well.

[24] Extracted from OPP/HED SOP 99.3

C-5. Processing Factors Used in Estimating Residues of OP Pesticides in Food Commodities

See file II_C_5.xls

C-6. Translation of Residue Source Data to CSFII Food Forms

See file II_C_6.xls

C-7. Summary of Residue Distribution Inputs to DEEM-FCID for Cumulative OP Exposure Assessment

See file II_C_7.xls

C-8. Analysis of Chemicals and Foods in the Upper Portion of OP Cumulative Exposure Distribution for Children 3-5 Years Old

See file II_C_8.xls

C-9. Co-Occurrence of Organophosphorus Pesticides on PDP Samples, 1994-2004

See file II.C_9.xls

D-1. Supplemental Distributions of Exposure Data Incorporated in the Residential Assessment

Study Summary

MRID 410547-05 (Exposures of Applicators to Propoxur during Residential Application of an Aerosol Spray Containing 1% Propoxur): Applicators in the study each applied one 16-ounce aerosol can in each of the 15 residences situated in Vero Beach, Florida. The entire contents were applied to each house. The volunteers sprayed to cracks, crevices along baseboards and other woodwork, under sinks and behind appliances. The majority of the exposure was to the hands, neck and head (~85%).

Unit Exposure Data

Table II.D-1.1 Dermal Unit Exposure Data (MRID 41054705) Used for Indoor Aerosol Applicator Scenarios)

Dermal Unit Exposure Values (mg/oz ai handled)
5.4
5.3
7
3.4
2.3
3
7.1
2.5
3.4
0.9
3.8
0.98
2.7
0.85
0.85

Table II.D-1.2 Inhalation Unit Exposure Data (MRID 41054705 Used for Indoor Aerosol Applicator Scenarios)

Inhalation Unit Exposure Values (mg/oz ai handled)
0.33
0.043
0.51
0.38
0.49
0.48
0.42
0.35
0.56
0.16
0.25
0.22
0.25
0.1
0.14

Statistical Analysis Details

Distributional parameters were estimated for the dermal unit exposure (Table II.D.1 1) and inhalation unit exposure (Table II.D.1 2) values for pressurized can sprayer applications of propoxur. Both unit exposure values are expressed in terms of milligrams per ounce of active ingredient applied. The dermal and inhalation unit exposure values were assumed to be lognormally distributed (i.e. fitted with a lognormal distribution). For these datasets, the shape (α) and scale (β) lognormal parameters were estimated by calculating the mean and standard deviation of the natural logarithms (base e) of the dermal and inhalation unit exposure values, respectively. Parametric estimates of the arithmetic mean (μ) and standard deviation (σ) of the lognormal distribution were then calculated based on the shape and scale parameter estimates. The formulae used to calculate the mean and standard deviation are given below

$$\mu = \exp(\alpha + \tfrac{1}{2}\beta^2)$$

$$\sigma = \mu\sqrt{\exp(\beta^2) - 1}$$

Shapiro-Wilk (S-W) normality test statistics were used to assess the lognormal assumption implicit in the parametric calculations of the mean and standard deviation. The means, standard deviations, and p-values of

the S-W statistics are provided in Table II.D.1 3. A small p-value indicates that logarithms of the dermal and inhalation unit exposure values are not normally distributed, or equivalently, that the dermal and inhalation unit exposure values are not lognormally distributed. For both the dermal and inhalation pressurized can datasets, the S-W p-values are greater than 0.05.

Table II.D-1.3 Lognormal Distributions of Dermal and Inhalation Unit Exposure Values Used for Indoor Aerosol Applicator Scenarios)

Application Method	Exposure Route	Deposition (mg/cm^2) and Air Concentration (mg/m^3) Distributions	Shapiro-Wilk p-value
Handheld Aerosol Spray Can	Dermal	LN(10.03, 12.84)	0.069
	Inhalation	LN(0.34, 0.27)	0.063
NOTES: LN(μ, σ) represents a lognormal distribution with mean=μ and standard deviation=σ.			

Additionally, probability plots were used to qualitatively assess the appropriateness of the lognormal assumptions. Generally a probability plot displays the actual values of a dataset (represented as points) and their expected values (represented as a line) for the specified distribution. The closer the actual values are to their expected values (i.e. the more the actual values approximate a straight line), the more likely the dataset is of the specified distribution. The probability plots for the dermal and inhalation unit exposure datasets are provided in Figures II.D.1 1 and 2. The probability plots indicate that both datasets are reasonably approximated by lognormal distributions.

Figure II.D-1.1 Dermal Unit Exposure Probability Plot

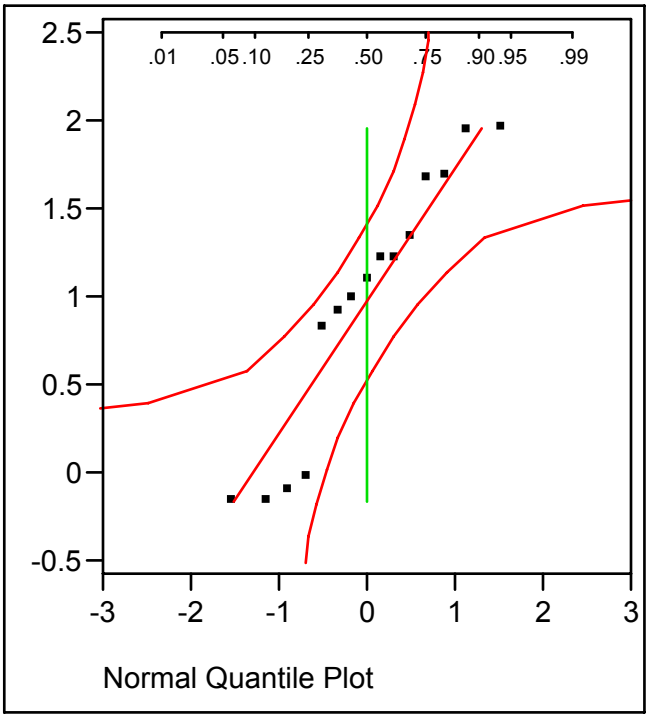
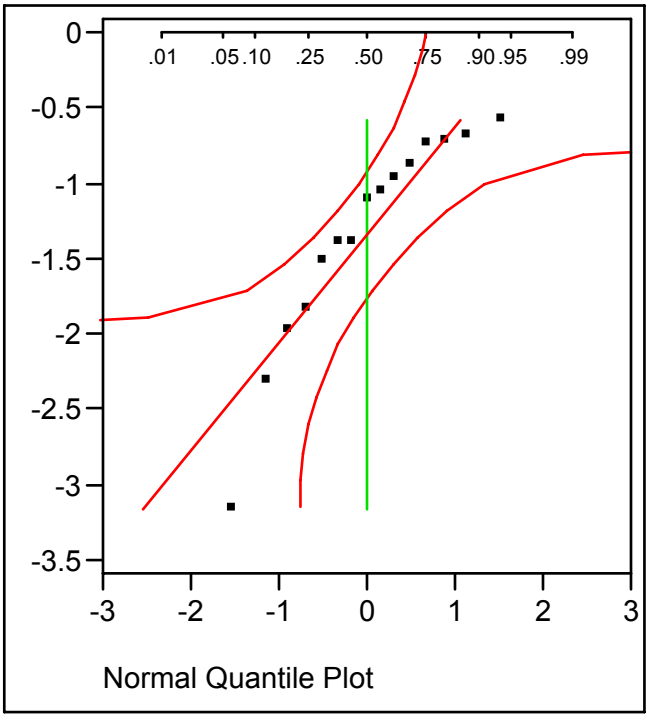


Figure II.D-1.2 Inhalation Unit Exposure Probability Plot



E-1. OP Cumulative Exposure in Drinking Water: The Effects of Water Chlorination on Organophosphate (OP) Pesticides (Phase I)

This report is an addendum to the 2002 OP CRA drinking water appendix II.E.4 – Effects of Drinking Water Treatment on Organophosphate Pesticides. Phase I of this study evaluated the potential of ten OP pesticides to form oxons as a result oxidation during drinking water treatment processes. Phase II of the study evaluated the potential of the sulfone and sulfoxide transformation products of disulfoton, phorate, and terbufos to form oxons.

The studies were conducted by the USEPA Office of Pesticide Program (OPP) Biological and Economic Analysis Division (BEAD) laboratories and have been reviewed by the USEPA Office of Research and Development (ORD). The results support the oxon characterization in the drinking water exposure assessment for the 2006 OP CRA.

1. Executive Summary – Phase I

Ten organophosphate (OP) pesticides [phorate, disulfoton, terbufos, methidathion, bensulide, chlorethoxyfos, phosmet, methyl parathion, phostebupirim, and temephos] were evaluated for their potential to undergo oxidation to their respective oxons in laboratory water simulating the chlorination process in drinking water facilities over a 72 hour exposure period. Samples were collected after 0, 1, 4, 24, and 72 hours of chlorination and analyzed by both gas chromatography-mass selective detection (GC-MSD) and liquid chromatography-tandem mass spectrometry (LC/MS/MS) to determine the presence of the pesticides and their oxons.

The results show that only two of the ten OP pesticides [methidathion and methyl parathion] are stable in buffered water (without chlorination) over the 72 hour exposure period. The eight remaining OP pesticides [phorate, disulfoton, terbufos, bensulide, chlorethyoxyfos, phostebupirim, phosmet, and temephos] were unstable and degraded in the buffered water over the 72 hour exposure period.

The results also show that in chlorinated water, three of the ten OP pesticides [phorate, disulfoton, and terbufos] did not undergo oxidation to their oxons under the experiment conditions. Phosmet oxon was initially formed; however, it degraded and was not detected after 24 hours. Five of the remaining six OP pesticides [methidathion, bensulide, chlorethyoxyfos, methyl parathion, and phostebupirim] formed stable oxons over the 72 exposure period. The oxon of the last remaining OP pesticide, temephos, is not commercially available and its presence could not be confirmed under

the experimental conditions. However, a full scan spectrum of the oxidation products from an exploratory LC/MS study revealed the presence of a compound with the same molecular ion profile as would be expected for the temephos oxon. Table II.E-1.1 summarizes the results of the experiment.

Table II.E-1.1 Results for parameters examined in study.

OP Pesticide	Stability in water over 72 hours (no chlorination)	Oxon formation after 1 hour (upon chlorination)	Oxon stability after 72 hours
Phorate	Poor	No	-
Disulfoton	Poor	No	-
Terbufos	Poor	No	-
Methidathion	Good	Yes	Good
Bensulide	Poor	Yes	Good
Chlorethoxyfos	Poor	Yes	Good
Methyl parathion	Good	Yes	Good
Phosmet	Poor	Yes	Poor
Phostebupirim	Poor	Yes	Good
Temephos	Poor	Possible (not confirmed)	n/a

In accordance with the Quality Assurance Project Plan (QAPP) for study, there were two elements necessary for the strict qualitative interpretation whether the ten OP pesticides underwent oxidative desulfonation during a 72 hour contact time in chlorinated laboratory water. This conclusion would be reached if the oxons are detected at any quantifiable level in either replication in the chlorinated laboratory water treatments at any sampling time and the OP pesticides are stable in non-chlorinated laboratory water. Only methidathion and methyl parathion met those criteria.

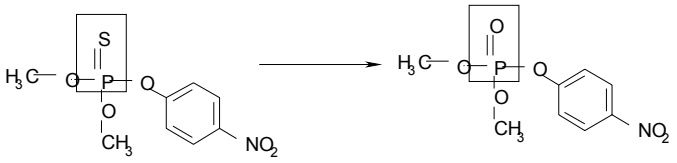
2. Introduction

The application of pesticides in arable lands has resulted in the contamination of natural waters such as surface water and groundwater. The initial contamination at the application sites has spread via surface runoff to nearby lakes, rivers, and streams and through subsurface transport to aquifers. The contaminated surface waters and ground waters are eventually used as source or raw waters in some community drinking water systems. After subjecting the raw water to different treatment processes in the water purification facilities, the concentrations of the pesticides may change or remain essentially the same in the treated or final drinking water. Studies conducted by scientists at EPA's ORD in Cincinnati (Miltner et al, 1989) indicate that conventional treatment (coagulation/clarification, filtration, softening, recarbonation, and chlorination) are generally not effective in removing certain pesticides from

raw water. However, other pesticides are unstable in the presence of chemical disinfectant such as chlorine.

Previous studies in Japan (Magara et al, 1994) and United States (Tierney et al, 2001; Duirk and Collette, 2006) indicate that certain organophosphate pesticides can be transformed to their oxons during chemical disinfection by chlorine compounds. This chemical transformation process is shown in Figure III.E-1.1.

Figure II.E-1.1 Oxidative Desulfonation Reaction of an Organophosphate Pesticide in Chlorinated Water.



This transformation is a concern because chlorination is the most commonly used disinfection technique in many US drinking water treatment plants and the product oxons are generally considered to be more toxic than the parent compounds.

The Food Quality Protection Act of 1996 (FQPA) requires that all chemical pesticide residues in or on food be examined for any possible adverse health effects through exposure. Drinking water is one of the pathways for dietary exposure. Three organophosphate pesticides (diazinon, chlorpyrifos, and malathion) have been examined and have been found to transform during chlorination into their associated oxons. However, a number of other organophosphate pesticides have little or no data on their potential for transformation during these conditions. Consequently, data and additional information are needed on the probable oxidation of these organophosphate pesticides and the relative stability of oxons in chlorinated water. The ten organophosphate pesticides and their degradation products considered in this study are listed in Table II.E-1. 2.

Table II.E-1.2 Selected Organophosphate Pesticides from the Cumulative OP Assessment without Water Treatment Data on Chlorination Effects on Oxon Formation

OP Parent	OP Degradation Products
Phorate	phorate oxon phorate sulfoxide phorate sulfone phorate sulfoxide oxon phorate sulfone oxon
Disulfoton	disulfoton oxon disulfoton sulfoxide disulfoton sulfone disulfoton sulfoxide oxon disulfoton sulfone oxon
Terbufos	terbufos oxon terbufos sulfoxide terbufos sulfone terbufos sulfoxide oxon terbufos sulfone oxon
Methidathion	methidathion oxon
Bensulide	bensulide oxon
Chlorethoxyfos	chlorethoxyfos oxon
Methyl parathion	methyl paraoxon
Phosmet	phosmet oxon
Phostebupirim	phostebupirim oxon
Temephos	Temephos oxon (not available)

The objective of this study was to provide a qualitative screening level assessment on the potential for oxon formation in chlorinated laboratory water and the stability of the selected organophosphate pesticides in both un-chlorinated and chlorinated water and the stability of their respective oxons in the chlorinated laboratory water. There are approximately twenty organophosphate pesticides considered in the cumulative OP risk assessment. The ten selected pesticides being tested in this study consisted of the pesticides, which are capable of forming oxons, have outdoor use patterns, and have no chlorination water treatment data available. These data will be used in the revised cumulative OP risk assessment to characterize the potential for human exposure to oxons in treated water.

3. Project Description

The project description is listed in the study protocol in Appendix 1 (Section 7). A brief summary description follows:

For each of the ten OP pesticides to be tested, the experimental design consisted of:

- One replicate OP control [test water + OP pesticide, without chlorine]
- One replicate chlorine control [test water + chlorine]
- Two replicates of treatment [OP pesticide + test water + chlorine]
- One buffered water sample spiked with the ten pesticides and nine oxons at a concentration of ½ of the spiking concentration (50 ppb) at each sampling time.

Chlorination experiments were conducted in Fisher Environmental Grade reagent water to eliminate chlorine demand considerations. Similar testing conditions using laboratory waters are recommended as screening level testing for CCL water treatment studies and pesticide treatment studies at ORD. The chlorine dose in the laboratory water was equivalent to the recommended maximum disinfectant residual (RMDL) of 4 mg/L free chlorine concentration ± 10%. The pH of the Fisher reagent water was adjusted to pH 8 to represent typical water treatment conditions. The experiment was conducted for 72 hours with sampling times immediately prior to chlorination (~2 minutes after pesticide dosing), 1 hour, 4 hours, 24 hours, and 72 hours post chlorination. The 24 and 72 hour sampling times were selected to represent the treatment system water residence and/or distribution transport times of approximately 24 hr or longer. The pesticide concentration in the experiment was 100 ppb or below the solubility limit of the pesticide whichever is lower. The experiments were conducted using a mixture of the OP pesticides delivered to the system with low co-solvent concentrations or in the absence of co-solvents. The chlorine demand from co-solvents and degradation processes was determined by measuring free chlorine at each sampling interval.

4. Method and Materials

Fisher Scientific Certified Environmental Grade water was used as the test water. Water quality parameters of the test water were:

Test	Value	Unit
Color	< 5	APHA
Residue after Evaporation	< 1	ppm
Fluorescence (as quinine)	< 100	ppt
Resistivity	> 18	MΩ
Total Organic Carbon	< 20	ppb

Water samples were labeled clearly, and included date, time, and name of the preparer(s). To preserve the integrity of the data, all samples were stored at ~ 4^{o}C until extraction to minimize the physicochemical changes in the samples. If sample extraction into a solvent was necessary, extracts were stored below 0^{o}C and also analyzed as soon as possible. All samples used and generated during the study were properly disposed of.

Quality assurance samples consisted of:
1) reagent water blank – analysis of reagent water (one time only);
2) method blank – analysis of buffered reagent water plus chlorine; (time 1 hr);
3) non-chlorinated degradation check – analysis of buffered reagent water plus OPs; (time 0, 1, 4, 24, and 72 hrs);
4) matrix water blank – analysis of buffered reagent water (time 0);
5) matrix water spike – analysis of buffered reagent water plus 50 ppb of the OP parent(s) plus 50 ppb oxon(s) (one spike per analytical sample set).

These measures were classified as critical measurements and were prepared and analyzed with each group of samples to monitor laboratory contamination and method performance. Addition of surrogate compounds to environmental samples was also recommended to measure the efficiency of the method. The surrogate compounds was not normally found in the environment and was selected such that the interference with elution of target analytes and the effect from sample matrix were minimal.

a. Analytical Procedures

The analytical procedures used were able to accurately identify and measure the presence of the target analytes in the samples. Identification and quantitation of residues were by gas

chromatography-mass selective detection (GC/MSD) and/or liquid chromatography/tandem mass spectrometry (LC/MS/MS) techniques.

A calibration curve was constructed with mixtures(s) of pure standards (target analytes) with the spiking level and method detection limit as the bounding concentrations. Complete initial calibration curves were prepared monthly, and the individual calibration standards verified each day of operation.

In some cases, the analytical procedures were not completely developed to allow for complete quantification of the parent OP and its degradation products. Nevertheless, the analytical method was capable of providing clear separation of known pesticide residues on chromatograms to allow for residue identification.

b. Test Protocol

These studies were conducted at the OPP/BEAD/ACB Fort Meade and OPP/BEAD/ECB Stennis Space Center laboratories. A complete description of testing protocol can be found in the Appendix 1 (Section 7).

The control treatments were used to assess whether the OP pesticide undergoes oxidation in non-chlorinated laboratory water and to assess whether OP pesticide or its degradation products were in the chlorinated water without pesticide dosing. Because the experimental design had minimal replication and the analytical methods were not fully vetted for all the OP pesticides and their oxon degradation products, there was **strict qualitative interpretation** (i.e. presence or absence of oxon) on whether OP pesticides underwent oxidative desulfonation during a 72 hour contact time in chlorinated laboratory water. This deduction was reached if oxons were detected at any quantifiable level in either replication in the chlorinated laboratory water treatments at any sampling time and the OP pesticide was stable in non-chlorinated laboratory water. Additionally, the detection of oxons in chlorinated water at the 24 hour or 72 hour sampling times will suggest the oxon was stable enough in chlorinated water to have the potential for dietary exposure through drinking water

The primary focuses of these studies were the OP parent pesticides and their associated oxons, degradation products. Later studies will address the measurements of the sulfone, sulfoxide, sulfone oxon, and sulfoxide oxon degradation products for selected OP pesticides. Method detection and reporting limits will be reported in revisions to this QAPP once the analytical methods have been assessed.

c. Assessment and Oversight

A QA/QC laboratory audit was performed at the conclusion of the water chlorination studies with OP pesticides and their oxon degradation products. Subsequently, QA/QC audits will be performed at the conclusion of the water chlorination studies with certain OP pesticides and their sulfone, sulfoxide, sulfone oxon, and sulfoxide oxon.

5. Results

a. The Formation of Oxons from Ten OP Pesticides in Water

Ten organophosphate (OP) pesticides [phorate, disulfoton, terbufos, methidathion, bensulide, chlorethoxyfos, phosmet, methyl parathion, phostebupirim, and temephos] were evaluated for their potential to undergo oxidation to their respective oxons in laboratory water simulating the chlorination process in drinking water facilities. In these studies, the OP pesticides were dissolved into pH 8.0 buffered water and then chlorinated with a sodium hypochlorite solution. Over a 72 hour exposure period, water samples were collected, extracted whenever applicable, and analyzed by both gas chromatography-mass selective detection (GC-MSD) and liquid chromatography-tandem mass spectrometry (LC/MS/MS) to determine the presence of the pesticides and their oxons. The results are presented in Appendix 2 (Section 8) for both the GS-MSD and LC/MS/MS studies.

The results of both studies (GC-MSD & LC/MS/MS) showed that three of the ten OP pesticides (phorate, disulfoton, and terbufos) did not undergo oxidation into their oxons under the experiment conditions. Phosmet oxon was initially formed; however, it degraded and was not detected after 24 hours. Five of the remaining six OP pesticides [methidathion, bensulide, chlorethyoxyfos, methyl parathion, and phosetebuprim] formed stable oxons over the 72 exposure period. The oxon of the last remaining OP pesticide, temephos, is not commercially available and its presence could not be confirmed under the experimental conditions. However, a full scan spectrum of the oxidation products in an exploratory LC/MS study revealed the presence of a compound with the same molecular ion profile as would be expected for the temephos oxon. This exploratory study was conducted at a concentration of 5 ppm of temephos in chlorinated laboratory water. The detected compound increased in concentration during a 24 hour exposure period, simultaneously, with the decrease of the parent OP temephos. The lack of an authentic standard of the temephos oxon limits the complete confirmation of this oxon.

The analytical methods of GC-MSD and LC/MS/MS were complimentary to each other in the detection of all 10 OP pesticide parents and their oxons. The current GC/MSD conditions were not suitable for the detection of bensulide, while the LC/MS/MS conditions were not suitable for the detection of methyl parathion and chlorethoxyfos. However, their oxons were detectable under both method conditions.

b. The Stability of Ten OP Pesticides in Water

Ten organophosphate (OP) pesticides [phorate, disulfoton, terbufos, methidathion, bensulide, chlorethyoxyfos, phosmet, methyl parathion, phosetebuprim, and temephos] were evaluated in buffered laboratory water to act as a control to the separate studies of the pesticides in the buffered water during the chlorination process. In these studies the OP pesticides were dissolved into a pH 8.0 buffered water. Over a 72 hour exposure period, water samples were collected, extracted, and analyzed by both gas chromatography-mass selective detection (GC-MSD) and liquid chromatography-tandem mass spectrometry (LC/MS/MS) to determine the presence of the pesticides and their oxons without chlorination. The results are presented in Appendix 2 (Section 8) for both the GS-MSD and LC/MS/MS studies.

The results demonstrated that two of the ten OP pesticides [methidathion and methyl parathion], are stable in the buffered water without chlorination over the 72 hour exposure period. The eight remaining OP pesticides [phorate, disulfoton, terbufos, bensulide, chlorethyoxyfos, phosetebuprim, phosmet, and temephos] were unstable and degraded in the buffered water over the 72 hour exposure period.

c. The Stability of Free Chlorine Concentrations in Water

The concentration of chlorine as free chlorine was evaluated in buffered laboratory water to act as a control to the separate studies of the pesticides in the buffered water during the chlorination process. In these studies chlorine as free chlorine was added to a pH 8.0 buffered water. Over a 72 hour exposure period, water samples were collected and analyzed to determine the stable concentration of this form of chlorine. In both studies the concentration of free chlorine remained stable within 10% of the initial concentration and neither the OP pesticides nor their oxons were detected at any time during the 72 hour exposure period.

d. The Stability of 10 OP Pesticides and Their Oxons as Laboratory Control Spike Samples

Ten organophosphate (OP) pesticides [phorate, disulfoton, terbufos, methidathion, bensulide, chlorethyoxyfos, phosmet, methyl parathion, phosetebuprim, and temephos] and their nine available oxons [temephos oxon is not available] were spiked into pH 8.0 buffered laboratory water to act as laboratory control spike samples. These samples were used to assess the detection of these compounds at the time of analysis. The water samples were collected, spiked, extracted whenever applicable, and analyzed by both gas chromatography-mass selective detection (GC-MSD) and liquid chromatography-tandem mass spectrometry (LC/MS/MS) to determine the concentration of the pesticides and their oxons. The results are presented in Appendix 2 (Section 8) for both the GS-MSD and LC/MS/MS studies.

The results demonstrated that these pesticides, with the exception of methyl parathion and methidathion, were unstable and degrade in the buffered water if they were allowed to remain for any prolonged period prior to extraction and/or analysis. In the LC/MS/MS studies the laboratory control spike samples remained in the buffered water until analyzed. That time period could be as much as 4 hours. This resulted in varying degrees of degradation of the pesticides. In the GC-MSD studies the laboratory control spike samples were extracted at different time periods. For the D = 0 sample period the water sample was extracted within 1 hour, D = 4 sample period within 24 hours, and D = 72 within 1 minute. The results demonstrated that the longer the time between collections and extraction the less stable were the pesticides in water.

On the other hand, all nine oxons were stable in the buffered water prior to analysis in both of the studies.

6. Summary

There were two elements necessary to the strict qualitative interpretation whether these ten OP pesticides underwent oxidative desulfonation during a 72 hour contact time in chlorinated laboratory water. This conclusion could be reached if:

1) The oxons are detected at any quantifiable level in either replication in the chlorinated laboratory water treatments at any sampling time
   - o There were six quantifiable oxons detected in the chlorinated laboratory water within the seventy two hour exposure period

[methidathion oxon, methyl paraoxon, phosmet oxon, bensulide oxon, phostebupirim oxon, and chlorethoxyfos oxon].
- o There was mass spectral evidence of the possible formation of a seventh oxon [temephos oxon]. However, there is, at present, no authentic temephos oxon standard to positively confirm this result.

and

2) The OP pesticides are stable in non-chlorinated laboratory water.
   - o There were only two OP pesticides that were stable in the unchlorinated laboratory water [methidathion and methyl parathion].

3) Additionally, the detection of oxons in chlorinated water at the 24 hour or 72 hour sampling times would suggest the oxon is stable enough in chlorinated water to have the potential for dietary exposure through drinking water.
   - o Both of these oxons [methidathion oxon and methyl paraoxon] were stable at both the 24 hour and 72 hour sampling times.

Only methidathion and methyl parathion meet the criteria as established in the QAPP to conclude that they underwent oxidative desulfonation.

7. References

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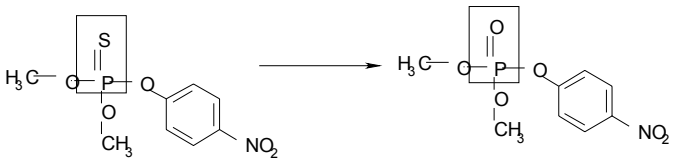
8. Appendix 1: Procedures for the Preliminary Laboratory Study on the Effects of Chlorinated Water on OP Pesticides

This appendix was prepared by the Water Treatment Effects Workgroup, Environmental Fate and Effects Division of the USEPA Office of Pesticide Programs on April 24, 2006.

a. Introduction

Previous studies in Japan (Magara et al, 1994) and United States (Tierney et al, 2001) indicate that certain organophosphate pesticides can be transformed during disinfection by chlorine compounds to oxons. This chemical transformation process is shown in Figure II.E-1.2.

Figure II.E-1.2 Oxidative Desulfonation Reaction of an Organophosphate Pesticide in Chlorinated Water.



This transformation is a concern because chlorination is widely used in many drinking water treatment plants and the product oxons are generally considered to be more toxic than the parent compounds. Consequently, data and additional information are needed on the probable oxidation of selected organophosphate pesticides and the relative stability of oxons in chlorinated water. The organophosphate pesticides and their degradation products considered in this testing protocol are listed in Table II.E-1.3.

Table II.E-1.1 Selected Organophosphate Pesticides from the Cumulative OP Assessment without Water Treatment Data on Chlorination Effects on Oxon Formation

OP Parent	OP Degradation Products
Phorate	phorate oxon phorate sulfoxide phorate sulfone phorate sulfoxide oxon phorate sulfone oxon
Disulfoton	disulfoton oxon disulfoton sulfoxide disulfoton sulfone disulfoton sulfoxide oxon disulfoton sulfone oxon
Terbufos	terbufos oxon terbufos sulfoxide terbufos sulfone terbufos sulfoxide oxon terbufos sulfone oxon
Methidathion	methidathion oxon
Bensulide	bensulide oxon
Chlorethoxyfos	chlorethoxyfos oxon
Methyl parathion	methyl paraoxon
Phosmet	phosmet oxon
Phostebupirim	phostebupirim oxon
Temephos	temephos oxon (not available)

Chlorination experiments will be conducted in Fisher certified environmental grade test water. Although the experiments will be conducted in environmental grade water, water pH (pH=8) will be altered to represent water treatment plant conditions. The chlorine dose in the laboratory water will be equivalent to the recommended maximum disinfectant residual (RMDL) of 4 mg/L free chlorine. Because the laboratory water will have extremely low chlorine demand, the free chlorine concentration and total chlorine concentration should be similar. The pH of the laboratory water will be adjusted to pH 8 to represent typical water treatment conditions. The experiment will be conducted for 72 hours with sampling times immediately prior to chlorination and 1 hour, 4 hours, 24 hours, and 72 hours post chlorination. The 24 and 72 hour sampling times were selected to represent the treatment system water residence and/or distribution transport times of approximately 24 hr or longer. The pesticide concentration in the experiment will be 100 ug/L or below the solubility limit of the pesticide whichever is lower. The experiments will be conducted using a mixture of the OP pesticides. The experiments will be conducted with low co-solvent concentrations or in the absence of co-solvents. The chlorine demand from co-solvents and

degradation processes will be determined by measuring free chlorine at each sampling interval.

The experimental plan will consist of a series of preliminary studies and final studies. These studies will be conducted by EPA personnel at the Biological and Economic Analysis Division Fort Meade Analytical Laboratory and Stennis Space Center Environmental Chemistry Laboratory. The chlorination study protocol and QAPP will be reviewed by Richard Miltner, P.E. from the ORD/NRMRL/Water Supply and Water Resources Division/ Treatment Technology Evaluation Branch.

Final chlorination studies for selected OP pesticides will be conducted once analytical methods are developed with reliable identification of the OP pesticide and their oxon degradation products in chlorinated test water. These studies will be conducted using a factorial experimental design [5 sampling times x 2 replicates pesticide(s), chlorination treatments x 1 pesticide(s), non-chlorinated water treatment (control) + 1 chlorinated water (control) + 1-3 buffered water spiked with a intermediate level of parent(s) and oxon(s)].

b. Objectives

The objective is to qualitatively determine oxon formation and stability in chlorinated, laboratory water for selected OP pesticides. These data will be used in the revised cumulative OP risk assessment to characterize the potential for human exposure to oxons in treated water.

c. Glassware, Pipets, and other containers

Glassware, pipettes, and other devices used in the study should be chlorine-demand free. Soak dark or amber incubation bottles in detergent (Fisher FL-70, 4%, Fair Lawn, NJ or comparable) overnight, rinse four times with hot tap water, and then two times with distilled and deionized water. Place in 10 - 20 mg/L chlorine solution for 24 hr. After rinsing four times with distilled and deionized water and one to two times with laboratory clean water, dry in 1400 C oven overnight. Clean pipettes may need to be stored in ~ 50 mg/L Cl2 solution and rinsed three times with dosing solution before use. Store in same chlorine solution after use.

d. Materials

The following solutions will be prepared for this study:

(1) pH 6.7 borate buffer: 1.0 M boric acid [ACS grade] and 0.11 M NaOH (ACS grade) prepared in boiled laboratory reagent water;

(2) pH 8 borate buffer: 1.0 M boric acid (ACS grade) and 0.26 M NaOH (ACS grade) prepared in boiled laboratory reagent water;
(3) Chlorine solution (1000 - 3000 mg/L Cl2): Dilute reagent-grade stock solution of sodium hypochlorite (5 - 13%) with laboratory reagent water. Check the exact concentration using Standard Methods (1998) or a commercial chlorine measurement kit that can detect down to 0.1 mg/L Cl2.
(4) pH 8 hypochlorite-buffer solution: Add about 4 - 5 volume of chlorine solution (~ pH 11) to one volume of pH 6.7 borate buffer. The resulting solution gives a pH 8. About a 20% decrease in chlorine strength is expected. About 2.5 mL of this combined dosing hypochlorite-buffer solution can be added to a 1-L test water (<0.5% water sample volume change)

e.Test Waters

Fisher Environmental Grade water will be used in the water chlorination studies. Laboratory reagent water will be used for cleaning and reagent preparation.

f. Chlorine Residuals Measurement

Free chlorine residuals will be measured using a Hach pocket colorimeter analysis system and Hach Methods 8021 for free chlorine in water. This DPD method is equivalent to USEPA Method 330.5 for wastewater. It can measure free chlorine at reasonable detection limits (at least 0.1 mg/L free chlorine).

g. Preliminary and Final Study

Preliminary studies with one replication will be conducted to provide sufficient experience in measuring analytes in chlorinated water as well as an exercise in sequencing/timing the laboratory operations for the chlorination experiments. Once the preliminary studies have been conducted, final water chlorination studies will be done using two replicates for the test water. Appropriate OP pesticide and chlorine residual controls will be prepared and monitored during the chlorination tests.

h. Chlorine Dosing Study

Before the chlorination experiments are started, the chlorine demand of the test waters has to be established to determine the dose of chlorine solution that provides the target 4.0 ± 0.4 mg/L free chlorine residual. Chlorine demand of the Fisher environmental grade water will be determined. Chlorine demand is operationally defined as chlorine dose

(applied free chlorine) - free remaining chlorine residual under a specified contact or incubation period, pH and temperature. For the preliminary study, only one replicate is desirable. The unchlorinated Fisher Environmental Grade water can be used for this purpose, but it must include appropriate concentrations of co-solvents that will be used to introduce OP pesticides into solution as well as similar reaction vessels used in the experiment.

(1) Add 2 ml pH 8 borate buffer to 1 L (or proportional volumes) of unchlorinated Fisher Environmental Grade water.
(2) Check the pH. If necessary, adjust to pH 8 with dilute H2SO4 or dilute NaOH.
(3) Fill each incubation bottle (300 - 500 ml) three quarters full with the unchlorinated Fisher Environmental Grade water. Two bottles will be needed. Addition of co-solvent, in the appropriate concentration as would be employed in (I) below, may be necessary to mimic co-solvent additions through pesticide dosing procedures. The doses should be set up in duplicate to determine if the initial dosing at 4 mg/L will result in a > 1 mg/L free chlorine residual after 24 hours in the Fisher Environmental Grade water containing the co-solvents. Initial dose of 4.0 mg/L free chlorine is appropriate.
(4) Add pH 8 hypochlorite-buffer solution through a pipette held just above water surface. Dose the appropriate volume of hydrochlorite-buffer solution to give the required dose in full bottles.
(5) Cap the bottle and invert twice.
(6) Fill to top of bottle with pH 8 borate buffered unchlorinated Fisher Environmental Grade water and cap head space-free.
(7) Invert 10 times
(8) Incubate for 24 hr in the dark at room temperature.
(9) After incubation, measure the free chlorine residual, pH, and temperature. (Note: Addition of hypochlorite-buffer solution should be sequenced and timed to provide allowance for measurement of free chlorine residual and pH for each test water)
(10) The initial chlorine dose that yields an initial free chlorine residual of 4.0 ± 0.4 mg/L Cl_2 and a > 1.0 ± 0.4 mg/L at 24 hours will be selected and used in the chlorination and product stability assessment discussed below.

i. Chlorination and Product (Oxon) Stability Experiments

The study will be conducted in 4L low density polyethylene reaction vessels that can be covered with black plastic to simulate dark condition. For this final study , the chlorination experiment at pH=8 should be done in duplicate, along with one replicate OP control [test water + OP pesticides, without chlorine] , one replicate chlorine control [test water + chlorine], and one buffered water control [test water for spiking with immediate

concentrations of OPs and oxons] indicated as A1, A2, B, C, and D solutions in Table II.E-4, respectively.

i. For Treatment A:

(1) Put 2L of unchlorinated Fisher Environmental Grade water and add 4 ml of pH 8 borate buffer in a dark, 4L polyethylene reaction vessel. This will require five 4L vessels.

(2) Measure pH and adjust, if necessary, to pH 8 with dilute H2SO4 or dilute NaOH.

(3) Dose with OP pesticide(s) to achieve a concentration of 100 µg/L or below the water solubility limit, whichever is lower.

(4) Collect the unchlorinated, pesticide spiked OP sample.

(5) Add pH 8 hypochlorite-buffer solution to give an initial free chlorine residual of 4.0 ± 0.4 mg/L Cl2 and a subsequent free chlorine residual of > 1.0 ± 0.4 mg/L at 24 hours. Dose the appropriate volume of hypochlorite-buffer solution to give the required dose in the 2L sample. The time of chlorination is T = 0.

(6) Prior to taking water samples, stir solution with the aid of magnetic stirring bar for two minutes.

(7) Take samples at the time intervals for analysis summarized in Table 2:

OP pesticide – 0 (prechlorination), 1 hr, 4 hr, 24 hr, 72 hr

Transformation products (oxon, sulfoxide, sulfone, sulfone oxon, sulfoxide oxon) – 0 (prechlorination), 1 hr, 4hr, 24 hr, 72 hr

(8) The samples are immediately withdrawn from the reaction vessel and then quenched stoichiometrically with sodium thiosulfate (with slight excess) based on the free chlorine residual [1.25 mg per 100 ml aliquot]. The samples should be stored in the dark at 0 - 4°C, if they cannot be analyzed right away.

(9) Separate samples will be taken to measure the free chlorine residual, pH, and temperature.

(10) Analyze the quenched samples for the parent compound, primary product (oxon) by appropriate analytical method (GC/MS or LC/MS/MS). Other transformation products will be identified, when possible, and described as tentatively identified compounds.

ii. For Treatment B:

(1) Put 2L of unchlorinated Fisher Environmental Grade water and add 4 ml of pH 8 borate buffer in a dark, 4L polyethylene reaction vessel.

(2) Measure pH and adjust, if necessary, to pH 8 with dilute H2SO4 or dilute NaOH.

Dose with OP pesticide(s) to achieve a concentration of 100 µg/L or below the water solubility limit, whichever is lower.

(3) At approximately the same time as the collection of the chlorinated samples in Treatment A, collect the unchlorinated, pesticide spiked OP samples at 0, 1, 4, 24 and 72 hours. The samples should be stored in the dark at 0 - 4°C, if they cannot be analyzed right away.

(4) Separate samples will be taken to measure the pH and temperature.

(5) Analyze the samples for the parent compound, primary product (oxon) by appropriate analytical method (GC/MS or LC/MS/MS). Other transformation products will be identified, when possible, and described as tentatively identified compounds.

iii. For Treatment C:

(1) Put 2L of unchlorinated Fisher Environmental Grade water and add 4 ml of pH 8 borate buffer in a dark, 5L polyethylene reaction vessel.

(2) Measure pH and adjust, if necessary, to pH 8 with dilute H2SO4 or dilute NaOH.

(3) Add pH 8 hypochlorite-buffer solution to give an initial free chlorine residual of 4.0 ± 0.4 mg/L Cl2 and a subsequent free chlorine residual of > 1.0 ± 0.4 mg/L at 24 hours. Dose the appropriate volume of hypochlorite-buffer solution to give the required dose in the 2L sample.

(4) Prior to taking water samples, stir solution with the aid of magnetic stirring bar for two minutes.

(5) Collect a sample after about 1 hour for OP pesticides and for oxons.

(6) The sample is withdrawn from the reaction vessel and then quenched with the selected reducing agent (with slight excess) based on the free chlorine residual [1.25 mg per 100 ml aliquot]. The aliquots should be stored in the dark at 0 - 4° C, if they cannot be analyzed right away.

(7) A separate sample will be taken to measure the free chlorine residual, pH, and temperature at 1 hour.

(8) Analyze the sample for the parent compound, primary product (oxon) by appropriate analytical method (GC/MS or LC/MS/MS). Other transformation products will be identified, when possible, and described as tentatively identified compounds.

iv. For Treatment D:

(1) Put 2L of unchlorinated Fisher Environmental Grade water and add 4 ml of pH 8 borate buffer in a dark, 5L polyethylene reaction vessel.

(2) Measure pH and adjust, if necessary, to pH 8 with dilute H2SO4 or dilute NaOH.

(3) Collect 100 ml samples of the unchlorinated, buffered water at each sampling interval of 0, 1, 4, 24, and 72 hours.

(4) These samples will be spiked with the OP pesticide(s) and oxon(s) at a spiking level of 50 ppb, as necessary.

(6) The samples will be stored for possible analysis with sample set batches. The samples should be stored in the dark at 0-4° C, if they cannot be analyzed right away.

(7) A separate sample is taken to measure the pH and temperature.

(8) Analyze the samples for the parent compound, primary product (oxon) by appropriate analytical method (GC/MS or LC/MS/MS). Other transformation products will be identified, when possible, and described as tentatively identified compounds.

Table II.E-1.2 Proposed Sampling and Analysis Regime

Treatment Condition (Treated Water Samples and Controls: OP pesticide)	Sampling Times				
	Pre-chlorination	Postchlorination			
A1 OP Cl_2 H_2O **A2** OP Cl_2 H_2O	0	1 hr	4 hrs	24 hrs	72 hrs
	OP	OP	OP	OP	OP
	Oxon[1]	Oxon	Oxon	Oxon	Oxon
		Cl	Cl	Cl	Cl
B OP H2O	OP	OP	OP	OP	OP
	Oxon	Oxon	Oxon	Oxon	Oxon
C Cl2 H2O		OP			
		Oxon			
		Cl			
D H_2O	Spiked OP	Spiked OP	Spiked OP	Spiked OP	Spiked OP
	Spiked Oxon	Spiked Oxon	Spiked Oxon	Spiked Oxon	Spiked Oxon

1- Sulfone, sulfoxide, sulfone oxon, and sulfoxide oxon will be analyzed if appropriate for the test pesticide. This assumes analytical methods and analytical standards are available for the various degradation products.

j. Data Reduction and Reporting

Report detections of parent OP and its degradation products. Calculate concentrations, when possible, of OP pesticides and their stability products. Report identities and structural formulas of transformation products.

k. Interpretation of Results

The interpretation of study results will be dependent on the detection of oxon degradation products in the chlorinated test water treatments. The control treatments will be used to assess whether the OP pesticide undergoes oxidation in non-chlorinated test water and to assess whether OP pesticide or its degradation products are in the chlorinated water without pesticide dosing. Because the experimental design has minimal replication and the analytical methods are not fully vetted for all the OP pesticides and their oxon degradation products, there will be strict qualitative interpretation on whether OP pesticides undergo oxidative desulfonation during a 72 hour contact time in chlorinated laboratory water.

This deduction will be reached if oxons are detected in either replication in the chlorinated laboratory water treatments at any sampling time and the OP pesticide is stable in non-chlorinated laboratory water. Additionally, the detection of oxons in chlorinated water at the 24 hour or 72 hour sampling times will suggest the oxon is stable enough in chlorinated water to have the potential for dietary exposure through drinking water.

l. References

Magara, Y. et al., 1994. Degradation of pesticides by chlorination during water purification. Water Sci. Technol. 30(7): 119-128.

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9. Appendix 2: Results of Analyses of OP Pesticides and Oxons in the Water Chlorination Studies

Table II.E-1.3 Results of the GC-MSD Analyses of OP Pesticides and Oxons in the Water Chlorination Studies - ECB

OP	Time, hrs	Parent OP				Oxon			
		A1	A2	B	D-spike[2]	A1	A2	B	D-spike[2]
Methidathion	0	106	64	107	51	ND	ND	ND	48
	1	ND	ND	110	NA	90	98	ND	NA
	4	ND	ND	109	47	81	97	ND	47
	24	ND	ND	103	NA	72	77	ND	NA
	72	ND	ND	101	59	66	67	ND	59
Methyl parathion	0	95	94	96	47	ND	ND	ND	48
	1	12	ND	89	NA	90	69	ND	NA
	4	ND	ND	98	46	72	85	ND	47
	24	ND	ND	83	NA	66	70	ND	NA
	72	ND	ND	88	53	68	66	ND	59
Phosmet	0	80	81	81	20	ND	ND	ND	20
	1	ND	ND	103	NA	57	69	ND	NA
	4	ND	ND	17	2	7	9	ND	2
	24	ND	ND	ND	NA	ND	ND	ND	NA
	72	ND	ND	ND	49	ND	ND	ND	43
Phorate	0	62	61	62	38	ND	ND	ND	38
	1	ND	ND	68	NA	ND	ND	ND	NA
	4	ND	ND	52	25	ND	ND	ND	32
	24	ND	ND	17	NA	ND	ND	ND	NA
	72	ND	ND	11	45	ND	ND	ND	45
Bensulide[1]	0	NA	NA	NA	NA	NA	NA	NA	NA
	1	NA	NA	NA	NA	NA	NA	NA	NA
	4	NA	NA	NA	NA	NA	NA	NA	NA
	24	NA	NA	NA	NA	NA	NA	NA	NA
	72	NA	NA	NA	NA	NA	NA	NA	NA
Chlorethoxy-fos	0	41	43	41	29	ND	ND	ND	39
	1	12	12	42	NA	26	30	ND	NA
	4	ND	ND	32	26	41	55	ND	38
	24	ND	ND	3	NA	26	30	ND	NA
	72	ND	ND	ND	51	23	23	ND	54
Disulfoton	0	64	64	64	36	ND	ND	ND	40
	1	ND	ND	68	NA	ND	ND	ND	NA
	4	ND	ND	56	34	ND	ND	ND	37
	24	ND	ND	24	NA	ND	ND	ND	NA
	72	ND	ND	16	45	ND	ND	ND	48
Terbufos	0	63	63	65	39	ND	ND	ND	38
	1	ND	ND	64	NA	ND	ND	ND	NA

OP	Time, hrs	Parent OP				Oxon			
		A1	A2	B	D-spike[2]	A1	A2	B	D-spike[2]
	4	ND	ND	46	34	ND	ND	ND	31
	24	ND	ND	9	NA	ND	ND	ND	NA
	72	ND	ND	ND	49	ND	ND	ND	46
Phostebupirim	0	79	79	78	41	ND	ND	ND	44
	1	2	2	71	NA	44	43	ND	NA
	4	ND	ND	65	42	42	50	ND	43
	24	ND	ND	30	NA	44	43	ND	NA
	72	ND	ND	14	51	47	50	ND	52
Temephos[3]	0	93	94	94	50	NA	NA	NA	NA
	1	ND	ND	121	NA	NA[3]	NA	NA	NA
	4	ND	ND	93	41	NA	NA	NA	NA
	24	ND	ND	43	NA	NA	NA	NA	NA
	72	ND	ND	11	50	NA	NA	NA	NA

[1] Bensulide is not suitable for the current GC-MSD conditions
[2] Only the D-Spike Samples at 0, 4, and 72 hours were analyzed.
[3] Temephos oxon standard is not available.

Table II.E-1.4 Results of the LC/MS/MS Analyses of OP Pesticides and Oxons in the Water Chlorination Studies - ACB

OP	Time, hrs	Parent OP				Oxon			
		A1	A2	B	D-spike[1]	A1	A2	B	D-spike[1]
Methidathion	0	67	64	72	39	ND	ND	ND	44
	1	ND	ND	73	44	80	81	ND	48
	4	ND	ND	73	45	87	81	ND	50
	24	ND	ND	74	47	80	76	ND	51
	72	ND	ND	77	NA	58	50	ND	NA
Methyl parathion[2]	0	NA	NA	NA	NA	ND	ND	ND	52
	1	NA	NA	NA	NA	58	46	ND	53
	4	NA	NA	NA	NA	79	72	ND	55
	24	NA	NA	NA	NA	81	72	ND	58
	72	NA	NA	NA	NA	78	75	ND	NA
Phosmet[3]	0	NA	NA	NA	NA	NA	NA	NA	NA
	1	NA	NA	NA	NA	NA	NA	NA	NA
	4	NA	NA	NA	NA	NA	NA	NA	NA
	24	NA	NA	NA	NA	NA	NA	NA	NA
	72	NA	NA	NA	NA	NA	NA	NA	NA
Phorate	0	22	23	26	18	ND	ND	ND	45
	1	ND	ND	24	19	ND	ND	ND	43
	4	ND	ND	20	18	ND	ND	ND	45
	24	ND	ND	11	22	ND	ND	ND	50
	72	ND	ND	8	NA	ND	ND	ND	NA

OP	Time, hrs	Parent OP				Oxon			
		A1	A2	B	D-spike[1]	A1	A2	B	D-spike[1]
Bensulide[1]	0	15	15	18	14	ND	ND	ND	43
	1	2	2	21	15	58	57	ND	44
	4	2	3	16	14	57	52	ND	46
	24	ND	ND	15	15	55	49	ND	48
	72	ND	ND	17	NA	60	56	ND	NA
Chlorethoxy-fos[2]	0	NA	NA	NA	NA	ND	ND	ND	40
	1	NA	NA	NA	NA	17	15	ND	38
	4	NA	NA	NA	NA	25	23	ND	38
	24	NA	NA	NA	NA	24	20	ND	40
	72	NA	NA	NA	NA	17	13	ND	NA
Disulfoton	0	ND	ND	ND	10	ND	ND	ND	49
	1	ND	ND	ND	9	ND	ND	ND	47
	4	ND	ND	ND	10	ND	ND	ND	50
	24	ND	ND	ND	11	ND	ND	ND	51
	72	ND	ND	ND	NA	ND	ND	ND	NA
Terbufos	0	11	11	13	11	ND	ND	ND	33
	1	ND	ND	12	11	ND	ND	ND	30
	4	ND	ND	8	11	ND	ND	ND	32
	24	ND	ND	3	12	ND	ND	ND	39
	72	ND	ND	6	NA	ND	ND	ND	NA
Phostebupirim	0	19	19	23	18	ND	ND	ND	48
	1	2	3	22	17	49	ND	ND	48
	4	1	1	14	18	55	51	ND	48
	24	ND	ND	8	18	59	54	ND	51
	72	ND	ND	10	NA	56	52	ND	NA
Temephos[4]	0	55	54	67	10	NA[4]	NA	NA	NA
	1	3	3	46	9	NA	NA	NA	NA
	4	3	3	49	9	NA	NA	NA	NA
	24	ND	ND	40	10	NA	NA	NA	NA
	72	ND	ND	NA	NA	NA	NA	NA	NA

[1] Sample D-spike 72 hr was not included
[2] Methyl parathion and chloroethoxyfos are not suitable for the current LC/MS conditions
[3] only traces remained after 24 hr.
[4] Temephos oxon standard is not available.

E-2. OP Cumulative Exposure in Drinking Water: The Effects of Water Chlorination on Three Specific Organophosphate (OP) Pesticides (Phase II)

This report is an addendum to the 2002 OP CRA drinking water appendix III.E.4 – Effects of Drinking Water Treatment on Organophosphate Pesticides. Phase I of this study evaluated the potential of ten OP pesticides to form oxons as a result oxidation during drinking water treatment processes. Phase II of the study evaluated the potential of the sulfone and sulfoxide transformation products of disulfoton, phorate, and terbufos to form oxons.

The studies were conducted by the USEPA Office of Pesticide Program (OPP) Biological and Economic Analysis Division (BEAD) laboratories and have been reviewed by the USEPA Office of Research and Development (ORD). The results support the oxon characterization in the drinking water exposure assessment for the 2006 OP CRA.

1. Executive Summary – Phase II

Three organophosphate (OP) pesticides [phorate, disulfoton, terbufos] were evaluated for their potential to undergo oxidation to their respective oxidative products [oxons, sulfoxides, sulfoxide oxons, sulfones, and sulfone oxons] in laboratory water simulating the chlorination process in drinking water facilities over a 72 hour exposure period. Samples were collected after 0, 0.25, 4, 24, and 72 hours of chlorination and analyzed by both gas chromatography-mass selective detection (GC-MSD) and liquid chromatography-tandem mass spectrometry (LC/MS/MS) to determine the presence of the pesticides and their oxidative products. The data obtained supplement previous data obtained on a more extensive group of organophosphate pesticides (Phase I).

The results of the Phase II Experiment confirm the results of the Phase I Experiment in that these three OP pesticides [phorate, disulfoton, terbufos] are unstable and degraded in unchlorinated buffered laboratory water over the 72 hour exposure period. In addition, as in the Phase I experiments, phorate, disulfoton, and terbufos did not undergo oxidation to their oxons upon chlorination under the experiment conditions.

However, in the current experiment, it was determined that two of the OP pesticides [phorate and disulfoton] underwent oxidation to other oxidation products [sulfone oxons]. The phorate sulfone oxon was detected at the 4 and 24 sampling times at trace concentrations (detection limit) and was not detected at the 72 hours. The disulfoton sulfone oxon was detected at the 0.25 hour sampling time in significant concentrations which increased at 4 hours, and then gradually decreased during the 72 hour exposure

period. This oxidative product was present at both the 24 and 72 hour sampling times.

In the first four hours of the experiment, significant amounts of the sulfoxide oxons of the three OP pesticides were detected; however, they were not stable for more than 4 hours, which suggests that the sulfoxide oxons are one of the intermediate oxidation products to the sulfone oxons.

Re-examination of the gas chromatographic/mass spectrometric chromatograms (GC-MSD) of the Phase I Experiment reveals the presence of these same oxidative products at approximately the same exposure periods and further confirms the findings of the Phase II Experiment.

Table II.E-2.1 Results for pesticides and oxidation products examined in study.

OP Pesticide	Parent OP			Sulfoxide Oxon		Sulfone Oxon	
	Stability in water over 72 hrs (no chlorin-ation)	Oxon formation after 1 hr (upon chlorin-ation)	Oxon stability after 72 hrs	Forma-tion after 1 hr	Stability after 72 hrs	Forma-tion after 1 hr	Stabili ty after 72 hrs
Phorate	Poor	None	-	Yes	No	Yes	No
Disulfoton	Poor	None	-	Yes	No	Yes	Yes
Terbufos	Poor	None	-	Yes	No	No	-

In accordance with the Quality Assurance Project Plan (QAPP) for this phase of the study, there were two elements necessary for the strict qualitative interpretation whether the three OP pesticides underwent oxidative desulfonation during a 72 hour contact time in chlorinated laboratory water. This conclusion would be reached if the oxidative products are detected at any quantifiable level in either replication in the chlorinated laboratory water treatments at any sampling time and the OP pesticides are stable in non-chlorinated laboratory water. Because none of the parent OPs were stable in non-chlorinated water, none of the three pesticides met those criteria.

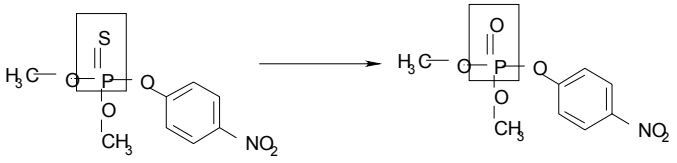
2. Introduction

The application of pesticides in arable lands has resulted in the contamination of natural waters such as surface water and groundwater. The initial contamination at the application sites has spread via surface runoff to nearby lakes, rivers, and streams and through subsurface transport to aquifers. The contaminated surface waters and ground waters are eventually used as source or raw waters in some community drinking water systems. After subjecting the raw water to different treatment processes in the water purification facilities, the concentrations of the

pesticides may change or remain essentially the same in the treated or final drinking water. Studies conducted by scientists at EPA's ORD in Cincinnati (Miltner et al, 1989) indicate that conventional treatment (coagulation/clarification, filtration, softening, recarbonation, and chlorination) are generally not effective in removing certain pesticides from raw water. However, other pesticides are unstable in the presence of chemical disinfectant such as chlorine.

Previous studies in Japan (Magara et al, 1994) and United States (Tierney et al, 2001; Duirk and Collette, 2006) indicate that certain organophosphate pesticides can be transformed to their oxons during chemical disinfection by chlorine compounds. This chemical transformation process is shown in Figure II.E.2 1.

Figure II.E-2.1 Oxidative Desulfonation Reaction of an Organophosphate Pesticide in Chlorinated Water.



This transformation is a concern because chlorination is the most commonly used disinfection technique in many US drinking water treatment plants and the product oxons are generally considered to be more toxic than the parent compounds.

The Food Quality Protection Act of 1996 (FQPA) requires that all chemical pesticide residues in or on food be examined for any possible adverse health effects through exposure. Drinking water is one of the pathways for dietary exposure. Five organophosphate pesticides (diazinon, chlorpyrifos, methidathion, methyl parathion, and malathion) have been examined and have been found to transform during chlorination into their associated oxons. Three specific organophosphate pesticides [phorate, disulfoton, and terbufos] have other known oxidative products [sulfoxides, sulfoxide oxons, sulfones, and sulfone oxons] for which there is little or no data on their potential for oxidative transformation during these conditions. Consequently, data and additional information are needed on the probable oxidation of these organophosphate pesticides and the relative stability of oxidative products in chlorinated water. The three organophosphate pesticides and their degradation products considered in this study are listed in Table II.E-2.2.

Table II.E-2.2 Selected Organophosphate Pesticides from the Cumulative OP Assessment without Water Treatment Data on Chlorination Effects on Oxon Formation

OP Parent	OP Degradation Products
Phorate	phorate oxon phorate sulfoxide phorate sulfone phorate sulfoxide oxon phorate sulfone oxon
Disulfoton	disulfoton oxon disulfoton sulfoxide disulfoton sulfone disulfoton sulfoxide oxon disulfoton sulfone oxon
Terbufos	terbufos oxon terbufos sulfoxide terbufos sulfone terbufos sulfoxide oxon terbufos sulfone oxon

The objective of this study is to provide a qualitative screening level assessment on the potential for oxidation product formations in chlorinated laboratory water and the stability of the selected organophosphate pesticides in both un-chlorinated and chlorinated water and the stability of their respective oxidation products in the chlorinated laboratory water. There were approximately twenty organophosphate pesticides considered in the cumulative OP risk assessment. The three selected pesticides being tested in this study consist of the pesticides, which are capable of forming multiple oxidation products, have outdoor use patterns, and have no chlorination water treatment data available. These data will be used in the revised cumulative OP risk assessment to characterize the potential for human exposure to oxons in treated water.

3. Project Description

The project description is listed in the study protocol in Appendix 1 (Section 7). A brief summary description follows:

For each of the ten OP pesticides to be tested, the experimental design consisted of:

- One replicate OP control [test water + OP pesticide, without chlorine]
- One replicate chlorine control [test water + chlorine]
- Two replicates of treatment [OP pesticide + test water + chlorine]
- One buffered water sample spiked with the ten pesticides and nine oxons at a concentration of ½ of the spiking concentration (50 ppb) at each sampling time.

Chlorination experiments will be conducted in Fisher Environmental Grade reagent water to eliminate chlorine demand considerations. Similar testing conditions using laboratory waters are recommended as screening level testing for CCL water treatment studies and pesticide treatment studies at ORD. The chlorine dose in the laboratory water will be equivalent to the recommended maximum disinfectant residual (RMDL) of 4 mg/L free chlorine concentration ± 10%. The pH of the Fisher reagent water will be adjusted to pH 8 to represent typical water treatment conditions. The experiment will be conducted for 72 hours with sampling times immediately prior to chlorination (~2 minutes before pesticide dosing), 0.25 hour, 4 hours, 24 hours, and 72 hours post chlorination. The 24 and 72 hour sampling times were selected to represent the treatment system water residence and/or distribution transport times of approximately 24 hr or longer. The pesticide concentration in the experiment will be 100 ppb or below the solubility limit of the pesticide whichever is lower. The experiments will be conducted using a mixture of the OP pesticides delivered to the system with low co-solvent concentrations or in the absence of co-solvents. The chlorine demand from co-solvents and degradation processes will be determined by measuring free chlorine at each sampling interval.

4. Method and Materials

Fisher Scientific Certified Environmental Grade water was used as the test water. Water quality parameters of the test water were:

Test	Value	Unit
Color	< 5	APHA
Residue after Evaporation	< 1	ppm
Fluorescence (as quinine)	< 100	ppt
Resistivity	> 18	MΩ
Total Organic Carbon	< 20	ppb

Water samples must be labeled clearly, and should include date, time, and name of the preparer(s). To preserve the integrity of the data, all samples must be stored at ~ 4^{o}C until extraction to minimize the physicochemical changes in the samples. If sample extraction into a solvent is necessary, extracts must be stored below 0^{o}C and also analyzed as soon as possible. All samples used and generated during the study should be properly disposed of.

Quality assurance samples shall consist of:
1) reagent water blank – analysis of reagent water (one time only);
2) method blank – analysis of buffered reagent water plus chlorine; [Carboy C, Table 1]; (time 0.25 hr);

3) non-chlorinated degradation check – analysis of buffered reagent water plus OPs [Carboy B, Table 2]; (time 0, 0.25, 4, 24, and 72 hrs);
4) matrix water blank – analysis of buffered reagent water (time 0);
5) matrix water spike – analysis of buffered reagent water plus 50 ppb of the OP parent(s) plus 50 ppb oxon(s) (one spike per analytical sample set).

These measures are classified as critical measurements and should be prepared and analyzed with each group of samples to monitor laboratory contamination and method performance. Addition of surrogate compounds to environmental samples is also recommended to measure the efficiency of the method. The surrogate compounds should not be normally found in the environment and should be selected such that the interference with elution of target analytes and the effect from sample matrix are minimal.

a. Analytical Procedures

The analytical procedures used should be able to accurately identify and measure the presence of the target analytes in the samples. Identification and quantitation of residues will be by gas chromatography-mass selective detection (GC/MSD) and/or liquid chromatography/tandem mass spectrometry (LC/MS/MS) techniques.

A calibration curve will be constructed with mixtures(s) of pure standards (target analytes) at concentrations that range from twice the spiking level to the method detection limit. Complete initial calibration curves shall be prepared monthly, and the individual calibration standards verified each day of operation.

In some cases, the analytical procedures may not be completely developed to allow for complete quantification of the parent OP and its degradation products. Nevertheless, the analytical method should be capable of providing clear separation of known pesticide residues on chromatograms to allow for residue identification.

b. Test Protocol

These studies will be conducted at the OPP/BEAD/ACB Fort Meade and OPP/BEAD/ECB Stennis Space Center laboratories. A complete description of testing protocol can be found in the Appendix 1 (Section 7). Final studies will not be conducted for compounds unless the analytical method has been shown to be capable of detecting of the parent compounds and their oxons in chlorinated water during the preliminary testing stage.

The control treatments will be used to assess whether the OP pesticide undergoes oxidation in non-chlorinated laboratory water and to assess whether OP pesticide or its oxidation products are in the chlorinated water without pesticide dosing. Because the experimental design has minimal replication and the analytical methods are not fully vetted for all the OP pesticides and their oxidation products, there will be strict qualitative interpretation (i.e. presence or absence of oxidation product) on whether OP pesticides [phorate, disulfoton, and terbufos] undergo oxidative desulfonation during a 72 hour contact time in chlorinated laboratory water. This deduction will be reached if their oxidation products [sulfoxides and sulfones and their associated sulfoxide and sulfone oxons] are detected at any quantifiable level in either replication in the chlorinated laboratory water treatments at any sampling time and the OP pesticide is stable in non-chlorinated laboratory water. Additionally, the detection of oxidation products in chlorinated water at the 24 hour or 72 hour sampling times will suggest the oxidation product is stable enough in chlorinated water to have the potential for dietary exposure through drinking water.

c. Assessment and Oversight

A QA/QC laboratory audit will be performed at the conclusion of the water chlorination studies with OP pesticides and their sulfone, sulfoxide, sulfone oxon, and sulfoxide oxon.

5. Results

a. The Formation of Oxidation Products from the Three OP Pesticides in Chlorinated Water

Three organophosphate (OP) pesticides [phorate, disulfoton, terbufos] were evaluated for their potential to undergo oxidation to their respective oxidation products in laboratory water simulating the chlorination process in drinking water facilities. In these studies, the OP pesticides were dissolved into pH 8.0 buffered water and then chlorinated with a sodium hypochlorite solution. Over a 72 hour exposure period, water samples were collected, processed, and analyzed by both gas chromatography-mass selective detection (GC-MSD) and liquid chromatography-tandem mass spectrometry (LC/MS/MS) to determine the presence of the pesticides and their oxons. The results are presented in Appendix 2 for both the GS-MSD and LC/MS/MS studies.

The results of both studies (GC-MSD & LC/MS/MS) showed that the three OP pesticides (phorate, disulfoton, and terbufos) did not undergo oxidation into their oxons under the experiment conditions.

Two of the twelve remaining oxidation products [phorate sulfone oxon and disulfoton sulfone oxon] formed stable compounds over the 24 exposure period, but only the disulfoton sulfone oxon was present at 72 hours. The phorate sulfone oxon was present at trace concentration at the minimum detection limit; the disulfoton sulfone oxon was present at higher concentrations. In the first four hours of the experiment, phorate sulfoxide oxon, disulfoton sulfoxide oxon, and terbufos sulfoxide oxon were detected; however, they were unstable and disulfoton sulfoxide oxon was not detected at the 4 hour exposure time and phorate sulfoxide oxon and terbufos sulfoxide oxon were not detected at the 24 hour exposure time.

A re-examination of the full scan of the gas chromatographic/mass spectrometric (GC-MSD) chromatograms from the Phase I Experiment confirmed these findings.

The analytical methods of GC-MSD and LC/MS/MS were complimentary in the detection of the three OP pesticide parents and the majority of their oxidation products. The current GC/MSD conditions were not suitable for the detection of phorate sulfoxide, phorate sulfoxide oxon, terbufos sulfoxide, and terbufos sulfoxide oxon; however, the LC/MS/MS conditions were suitable for all 18 compounds in the study.

b. The Stability of Three OP Pesticides in Unchlorinated Water

The three organophosphate (OP) pesticides [phorate, disulfoton, terbufos] were evaluated in buffered laboratory water to act as a control to the separate studies of the pesticides in the buffered water during the chlorination process. In these studies the OP pesticides were dissolved into a pH 8.0 buffered water. Over a 72 hour exposure period, water samples were collected, processed, and analyzed by both gas chromatography-mass selective detection (GC-MSD) and liquid chromatography-tandem mass spectrometry (LC/MS/MS) to determine the presence of the pesticides and their oxons without chlorination. The results are presented in Appendix 2 for both the GS-MSD and LC/MS/MS studies.

The results demonstrated and confirm that the three OP pesticides [phorate, disulfoton, and terbufos] are unstable and degrade in the buffered water without chlorination over the 72 hour exposure period. Trace concentrations of disulfoton sulfoxide were detected at the minimum detection limit.

A re-examination of the full scan of the gas chromatographic/mass spectrometric (GC-MSD) chromatograms from the Phase I Experiment confirmed these findings.

c. The Stability of Free Chlorine Concentrations in Water

The concentration of chlorine as free chlorine was evaluated in buffered laboratory water to act as a control to the separate studies of the pesticides in the buffered water during the chlorination process. In these studies chlorine as free chlorine was added to a pH 8.0 buffered water. Over a 72 hour exposure period, water samples were collected and analyzed to determine the stable concentration of this form of chlorine. In both studies the concentration of free chlorine remained stable within 25% of the initial concentration and neither the OP pesticides nor their oxidation products were detected at any time during the 72 hour exposure period.

d. The Stability of the Three OP Pesticides and Their Oxidation Products as Laboratory Control Spike Samples

Three organophosphate (OP) pesticides [phorate, disulfoton, terbufos] and their fifteen available oxidation products (Table 1) were spiked into pH 8.0 buffered laboratory water to act as laboratory control spike samples. These samples were used to assess the method performance of the course of the study. The water samples were collected, spiked, processed, and analyzed by both gas chromatography-mass selective detection (GC-MSD) and liquid chromatography-tandem mass spectrometry (LC/MS/MS) to determine the concentration of the pesticides and their oxidation products. The results are presented in Appendix 2 for both the GS-MSD and LC/MS/MS studies.

6. Summary

There were two elements necessary to the **strict qualitative interpretation** whether these three OP pesticides underwent oxidative desulfonation during a 72 hour contact time in chlorinated laboratory water. This conclusion could be reached if:

1) The oxidation products of the three OP pesticides are detected at any quantifiable level in either replication in the chlorinated laboratory water treatments at any sampling time.

- There were five quantifiable oxidation products detected in the chlorinated laboratory water during the seventy two hour exposure period [phorate sulfoxide oxon, phorate sulfone oxon, disulfoton

sulfoxide oxon, disulfoton sulfone oxon, and terbufos sulfoxide oxon].

and

2) The OP pesticides are stable in non-chlorinated laboratory water.
   - o All three OP pesticides were unstable and degraded in the unchlorinated laboratory water.

3) Additionally, there were detection of oxidation products in chlorinated water at the 24 hour or 72 hour sampling times would suggest the oxidation product is stable enough in chlorinated water to have the potential for dietary exposure through drinking water.
   - o One of the oxidation products [phorate sulfone oxon] was stable at trace levels at the 24 hour sampling time and one of the oxidation products [disulfoton sulfone oxon] was stable at both the 24 and 72 hour sampling times.

None of the three parent OP pesticides meet the criteria as established in the QAPP to conclude that they underwent oxidative desulfonation into their respective oxons. However, it should be noted that two of the parents [phorate and disulfoton] underwent oxidative desulfonation to phorate sulfone oxon and disulfoton sulfone oxon.

7. References

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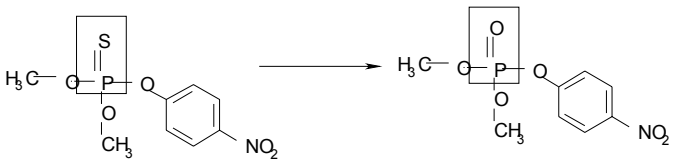
8. Appendix 1: Procedures for the Preliminary Laboratory Study on the Effects of Chlorinated Water on OP Pesticides, Phase II

This appendix was prepared by the Water Treatment Effects Workgroup, Environmental Fate and Effects Division of the USEPA Office of Pesticide Programs on June 8, 2006.

a. Introduction

Previous studies in Japan (Magara et al, 1994) and United States (Tierney et al, 2001) indicate that certain organophosphate pesticides can be transformed during disinfection by chlorine compounds to oxons. This chemical transformation process is shown in Figure II.E.2 2.

Figure II.E-2.2 Oxidative Desulfonation Reaction of an Organophosphate Pesticide in Chlorinated Water.



This transformation is a concern because chlorination is widely used in many drinking water treatment plants and the product oxons are generally considered to be more toxic than the parent compounds. Consequently, data and additional information are needed on the probable oxidation of selected organophosphate pesticides and the relative stability of oxons in chlorinated water. In the Laboratory Study on the Effects of Chlorinated Water on OP Pesticides, Phase I, ten organophosphate (OP) pesticides were examined and it was determined that five OP pesticides [methidathion, bensulide, chlorethyoxyfos, methyl parathion, and phostebupirim] formed stable oxons in chlorinated water. However, three of those pesticides [phorate, disulfoton, and terbufos] have additional oxidation products [sulfoxides, sulfoxide oxons, sulfones, and sulfone oxons] that can be formed. The organophosphate pesticides and their oxidation products considered in this testing protocol are listed in Table II.E.2 3.

Table II.E-2.3 Selected Organophosphate Pesticides from the Cumulative OP Assessment without Water Treatment Data on Chlorination Effects on Oxon Formation

OP Parent	OP Degradation Products
Phorate	phorate oxon phorate sulfoxide phorate sulfone phorate sulfoxide oxon phorate sulfone oxon
Disulfoton	disulfoton oxon disulfoton sulfoxide disulfoton sulfone disulfoton sulfoxide oxon disulfoton sulfone oxon
Terbufos	terbufos oxon terbufos sulfoxide terbufos sulfone terbufos sulfoxide oxon terbufos sulfone oxon

Chlorination experiments will be conducted in Fisher certified environmental grade test water. Although the experiments will be conducted in environmental grade water, water pH (pH=8) will be altered to represent water treatment plant conditions. The chlorine dose in the laboratory water will be equivalent to the recommended maximum disinfectant residual (RMDL) of 4 mg/L free chlorine. Because the laboratory water will have extremely low chlorine demand, the free chlorine concentration and total chlorine concentration should be similar. The pH of the laboratory water will be adjusted to pH 8 to represent typical water treatment conditions. The experiment will be conducted for 72 hours with sampling times immediately prior to chlorination and 0.25 hour, 4 hours, 24 hours, and 72 hours post chlorination. The 24 and 72 hour sampling times were selected to represent the treatment system water residence and/or distribution transport times of approximately 24 hr or longer. The pesticide concentration in the experiment will be 100 □g/L or below the solubility limit of the pesticide whichever is lower. The experiments will be conducted using a mixture of the OP pesticides. The experiments will be conducted with low co-solvent concentrations or in the absence of co-solvents. The chlorine demand from co-solvents and degradation processes will be determined by measuring free chlorine at each sampling interval.

The experimental plan will consist of a series of preliminary studies and final studies. These studies will be conducted by EPA personnel at the Biological and Economic Analysis Division Fort Meade Analytical Laboratory and Stennis Space Center Environmental

Chemistry Laboratory. The chlorination study protocol and QAPP will be reviewed by Richard Miltner, P.E. from the ORD/NRMRL/Water Supply and Water Resources Division/ Treatment Technology Evaluation Branch.

Final chlorination studies for selected OP pesticides will be conducted once analytical methods are developed with reliable identification of the OP pesticide and their oxon degradation products in chlorinated test water. These studies will be conducted using a factorial experimental design [5 sampling times x 2 replicates pesticide(s), chlorination treatments x 1 pesticide(s), non-chlorinated water treatment (control) + 1 chlorinated water (control) + 1-3 buffered water spiked with a intermediate level of parent(s) and oxon(s)].

b. Objectives

The objective is to qualitatively determine oxon formation and stability in chlorinated, laboratory water for selected OP pesticides. These data will be used in the revised cumulative OP risk assessment to characterize the potential for human exposure to oxons in treated water.

c. Glassware, Pipets, and other containers

Glassware, pipettes, and other devices used in the study should be chlorine-demand free. Soak dark or amber incubation bottles in detergent (Fisher FL-70, 4%, Fair Lawn, NJ or comparable) overnight, rinse four times with hot tap water, and then two times with distilled and deionized water. Place in 10 - 20 mg/L chlorine solution for 24 hr. After rinsing four times with distilled and deionized water and one to two times with laboratory clean water, dry in 1400 C oven overnight. Clean pipettes may need to be stored in ~ 50 mg/L Cl2 solution and rinsed three times with dosing solution before use. Store in same chlorine solution after use.

d. Materials

The following solutions will be prepared for this study:

(5) pH 6.7 borate buffer: 1.0 M boric acid [ACS grade] and 0.11 M NaOH (ACS grade) prepared in boiled laboratory reagent water;
(6) pH 8 borate buffer: 1.0 M boric acid (ACS grade) and 0.26 M NaOH (ACS grade) prepared in boiled laboratory reagent water;
(7) Chlorine solution (1000 - 3000 mg/L Cl2): Dilute reagent-grade stock solution of sodium hypochlorite (5 - 13%) with laboratory reagent water. Check the exact concentration using Standard Methods (1998)

or a commercial chlorine measurement kit that can detect down to 0.1 mg/L Cl2.

(8) pH 8 hypochlorite-buffer solution: Add about 4 - 5 volume of chlorine solution (~ pH 11) to one volume of pH 6.7 borate buffer. The resulting solution gives a pH 8. About a 20% decrease in chlorine strength is expected. About 2.5 mL of this combined dosing hypochlorite-buffer solution can be added to a 1-L test water (<0.5% water sample volume change)

e. Test Waters

Fisher Environmental Grade water will be used in the water chlorination studies. Laboratory reagent water will be used for cleaning and reagent preparation.

f. Chlorine Residuals Measurement

Free chlorine residuals will be measured using a Hach pocket colorimeter analysis system and Hach Methods 8021 for free chlorine in water. This DPD method is equivalent to USEPA Method 330.5 for wastewater. It can measure free chlorine at reasonable detection limits (at least 0.1 mg/L free chlorine).

g. Preliminary and Final Study

Preliminary studies with one replication will be conducted to provide sufficient experience in measuring analytes in chlorinated water as well as an exercise in sequencing/timing the laboratory operations for the chlorination experiments. Once the preliminary studies have been conducted, final water chlorination studies will be done using two replicates for the test water. Appropriate OP pesticide and chlorine residual controls will be prepared and monitored during the chlorination tests.

h. Chlorine Dosing Study

Before the chlorination experiments are started, the chlorine demand of the test waters has to be established to determine the dose of chlorine solution that provides the target 4.0 ± 0.4 mg/L free chlorine residual. Chlorine demand of the Fisher environmental grade water will be determined. Chlorine demand is operationally defined as chlorine dose (applied free chlorine) - free remaining chlorine residual under a specified contact or incubation period, pH and temperature. For the preliminary study, only one replicate is desirable. The unchlorinated Fisher Environmental Grade water can be used for this purpose, but it must include appropriate concentrations of co-solvents

that will be used to introduce OP pesticides into solution as well as similar reaction vessels used in the experiment.

1. Add 2 ml pH 8 borate buffer to 1 L (or proportional volumes) of unchlorinated Fisher Environmental Grade water.
2. Check the pH. If necessary, adjust to pH 8 with dilute H_2SO_4 or dilute NaOH.
3. Fill each incubation bottle (300 - 500 ml) three quarters full with the unchlorinated Fisher Environmental Grade water. Two bottles will be needed. Addition of co-solvent, in the appropriate concentration as would be employed in (I) below, may be necessary to mimic co-solvent additions through pesticide dosing procedures. The doses should be set up in duplicate to determine if the initial dosing at 4 mg/L will result in a > 1 mg/L free chlorine residual after 24 hours in the Fisher Environmental Grade water containing the co-solvents. Initial dose of 4.0 mg/L free chlorine is appropriate.
4. Add pH 8 hypochlorite-buffer solution through a pipette held just above water surface. Dose the appropriate volume of hydrochlorite-buffer solution to give the required dose in full bottles.
5. Cap the bottle and invert twice.
6. Fill to top of bottle with pH 8 borate buffered unchlorinated Fisher Environmental Grade water and cap head space-free.
7. Invert 10 times
8. Incubate for 24 hr in the dark at room temperature.
9. After incubation, measure the free chlorine residual, pH, and temperature. (Note: Addition of hypochlorite-buffer solution should be sequenced and timed to provide allowance for measurement of free chlorine residual and pH for each test water)
10. The initial chlorine dose that yields an initial free chlorine residual of 4.0 ± 0.4 mg/L Cl_2 and a > 1.0 ± 0.4 mg/L at 24 hours will be selected and used in the chlorination and product stability assessment discussed below.

i. Chlorination and Product (Oxon) Stability Experiments

The study will be conducted in 4L low density polyethylene reaction vessels that can be covered with black plastic to simulate dark condition. For this final study , the chlorination experiment at pH=8 should be done in duplicate, along with one replicate OP control [test water + OP pesticides, without chlorine] , one replicate chlorine control [test water + chlorine], and one buffered water control [test water for spiking with

immediate concentrations of OPs and oxons] indicated as A1, A2, B, C, and D solutions in Table II.E-4, respectively.

i. For Treatment A:

(1) Put 2L of unchlorinated Fisher Environmental Grade water and add 4 ml of pH 8 borate buffer in a dark, 4L polyethylene reaction vessel. This will require five 4L vessels.

(2) Measure pH and adjust, if necessary, to pH 8 with dilute H2SO4 or dilute NaOH.

(3) Dose with OP pesticide(s) to achieve a concentration of 100 µg/L or below the water solubility limit, whichever is lower.

(4) Collect the unchlorinated, pesticide spiked OP sample.

(5) Add pH 8 hypochlorite-buffer solution to give an initial free chlorine residual of 4.0 ± 0.4 mg/L Cl2 and a subsequent free chlorine residual of > 1.0 ± 0.4 mg/L at 24 hours. Dose the appropriate volume of hypochlorite-buffer solution to give the required dose in the 2L sample. The time of chlorination is T = 0.

(6) Prior to taking water samples, stir solution with the aid of magnetic stirring bar for two minutes.

(7) Take samples at the time intervals for analysis summarized in Table 2:

OP pesticide – 0 (prechlorination), 1 hr, 4 hr, 24 hr, 72 hr
Transformation products (oxon, sulfoxide, sulfone, sulfone oxon, sulfoxide oxon) – 0 (prechlorination), 1 hr, 4hr, 24 hr, 72 hr

(8) The samples are immediately withdrawn from the reaction vessel and then quenched stoichiometrically with sodium thiosulfate (with slight excess) based on the free chlorine residual [1.25 mg per 100 ml aliquot]. The samples should be stored in the dark at 0 - 4°C, if they cannot be analyzed right away.

(9) Separate samples will be taken to measure the free chlorine residual, pH, and temperature.

(10) Analyze the quenched samples for the parent compound, primary product (oxon) by appropriate analytical method (GC/MS or LC/MS/MS). Other transformation products will be identified, when possible, and described as tentatively identified compounds.

ii. For Treatment B:

(1) Put 2L of unchlorinated Fisher Environmental Grade water and add 4 ml of pH 8 borate buffer in a dark, 4L polyethylene reaction vessel.

(2) Measure pH and adjust, if necessary, to pH 8 with dilute H2SO4 or dilute NaOH.

Dose with OP pesticide(s) to achieve a concentration of 100 µg/L or below the water solubility limit, whichever is lower.

(3) At approximately the same time as the collection of the chlorinated samples in Treatment A, collect the unchlorinated, pesticide spiked OP samples at 0, 1, 4, 24 and 72 hours. The samples should be stored in the dark at 0 - 4°C, if they cannot be analyzed right away.

(4) Separate samples will be taken to measure the pH and temperature.

(5) Analyze the samples for the parent compound, primary product (oxon) by appropriate analytical method (GC/MS or LC/MS/MS). Other transformation products will be identified, when possible, and described as tentatively identified compounds.

iii. For Treatment C:

(1) Put 2L of unchlorinated Fisher Environmental Grade water and add 4 ml of pH 8 borate buffer in a dark, 5L polyethylene reaction vessel.

(2) Measure pH and adjust, if necessary, to pH 8 with dilute H_2SO_4 or dilute NaOH.

(3) Add pH 8 hypochlorite-buffer solution to give an initial free chlorine residual of 4.0 ± 0.4 mg/L Cl_2 and a subsequent free chlorine residual of > 1.0 ± 0.4 mg/L at 24 hours. Dose the appropriate volume of hypochlorite-buffer solution to give the required dose in the 2L sample.

(4) Prior to taking water samples, stir solution with the aid of magnetic stirring bar for two minutes.

(5) Collect a sample after about 1 hour for OP pesticides and for oxons.

(6) The sample is withdrawn from the reaction vessel and then quenched with the selected reducing agent (with slight excess) based on the free chlorine residual [1.25 mg per 100 ml aliquot]. The aliquots should be stored in the dark at 0 - 4° C, if they cannot be analyzed right away.

(7) A separate sample will be taken to measure the free chlorine residual, pH, and temperature at 1 hour.

(8) Analyze the sample for the parent compound, primary product (oxon) by appropriate analytical method (GC/MS or LC/MS/MS). Other transformation products will be identified, when possible, and described as tentatively identified compounds.

iv. For Treatment D:

(1) Put 2L of unchlorinated Fisher Environmental Grade water and add 4 ml of pH 8 borate buffer in a dark, 5L polyethylene reaction vessel.

(2) Measure pH and adjust, if necessary, to pH 8 with dilute H2SO4 or dilute NaOH.

(3) Collect 100 ml samples of the unchlorinated, buffered water at each sampling interval of 0, 1, 4, 24, and 72 hours.

(4) These samples will be spiked with the OP pesticide(s) and oxon(s) at a spiking level of 50 ppb, as necessary.

(6) The samples will be stored for possible analysis with sample set batches. The samples should be stored in the dark at 0-4° C, if they cannot be analyzed right away.

(7) A separate sample is taken to measure the pH and temperature.

(8) Analyze the samples for the parent compound, primary product (oxon) by appropriate analytical method (GC/MS or LC/MS/MS). Other transformation products will be identified, when possible, and described as tentatively identified compounds.

Table II.E-2.4 Proposed Sampling and Analysis Regime

Treatment Condition (Treated Water Samples and Controls: OP pesticide)	Sampling Times				
	Pre-chlorination	Postchlorination			
A1 OP Cl_2 H_2O **A2** OP Cl_2 H_2O	0	1 hr	4 hrs	24 hrs	72 hrs
	OP	OP	OP	OP	OP
	Oxon[1]	Oxon	Oxon	Oxon	Oxon
		Cl	Cl	Cl	Cl
B OP H2O	OP	OP	OP	OP	OP
	Oxon	Oxon	Oxon	Oxon	Oxon
C Cl2 H2O		OP			
		Oxon			
		Cl			
D H_2O	Spiked OP	Spiked OP	Spiked OP	Spiked OP	Spiked OP
	Spiked Oxon	Spiked Oxon	Spiked Oxon	Spiked Oxon	Spiked Oxon

1- Sulfone, sulfoxide, sulfone oxon, and sulfoxide oxon will be analyzed if appropriate for the test pesticide. This assumes analytical methods and analytical standards are available for the various degradation products.

j. Data Reduction and Reporting

Report detections of parent OP and its degradation products. Calculate concentrations, when possible, of OP pesticides and their stability products. Report identities and structural formulas of transformation products.

k. Interpretation of Results

The interpretation of study results will be dependent on the detection of oxidation products in the chlorinated test water treatments. The control treatments will be used to assess whether the OP pesticide undergoes oxidation in non-chlorinated laboratory water and to assess whether OP pesticide or its oxidation products are in the chlorinated water without pesticide dosing. Because the experimental design has minimal replication and the analytical methods are not fully vetted for all the OP pesticides and their oxidation products, there will be **strict qualitative interpretation** (i.e. presence or absence of oxidation products) on whether OP pesticides [phorate, disulfoton, and terbufos] undergo oxidative desulfonation during a 72 hour contact time in chlorinated laboratory water. This deduction will be reached if their oxidation products [sulfoxides and sulfones and their associated sulfoxide and sulfone oxons] are detected at any quantifiable level in either replication in the chlorinated laboratory water treatments at any sampling time and the OP pesticide is stable in non-chlorinated laboratory water. Additionally, the detection of oxidation products in chlorinated water at the 24 hour or 72 hour sampling times will suggest the oxidation product is stable enough in chlorinated water to have the potential for dietary exposure through drinking water

l. References

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USEPA, Laboratory Study on the Effects of Chlorinated Water on OP Pesticides, Final Report, OPP/EFED/WTEWG, May 15, 2006.

9. Appendix 2: Results for the Laboratory Study on the Effects of Chlorinated Water on OP Pesticides, Phase II

Table II.E-2.5 Results of the LC/MS/MS Analyses of the OP Pesticides Terbufos, Phorate and Disulfoton and Degradation in Chlorinated and Unchlorinated Water

Sample	Sample Time	parent	oxon	Sulfox-ide	sulfone	oxon sulfox-ide	oxon sulfone
MDL		5	5	10	25	4	4
Terbufos							
A1	0	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
	15 min	N.D.	N.D.	N.D.	N.D.	35	N.D.
	4 h	N.D.	N.D.	N.D.	N.D.	4	N.D.
	24 h	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
	72 h	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
A2	0	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
	15 min	N.D.	N.D.	N.D.	N.D.	31	N.D.
	4 h	N.D.	N.D.	N.D.	N.D.	5	N.D.
	24 h	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
	72 h	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
B	0	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
	15 min	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
	4 h	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
	24 h	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
	72 h	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
C		N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
D	0	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	15 min	N.D.	41	37	42	52	55
	4 h	N.D.	34	32	41	49	54
	24 h	N.D.	34	33	47	50	48
	72 h	N.D.	38	34	39	51	53
Phorate							
A1	0	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
	15 min	N.D.	N.D.	N.D.	N.D.	73	N.D.
	4 h	N.D.	N.D.	N.D.	N.D.	35	5
	24 h	N.D.	N.D.	N.D.	N.D.	N.D.	8
	72 h	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
A2	0	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
	15 min	N.D.	N.D.	N.D.	N.D.	82	N.D.
	4 h	N.D.	N.D.	N.D.	N.D.	47	4
	24 h	N.D.	N.D.	N.D.	N.D.	N.D.	6
	72 h	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
B	0	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
	15 min	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
	4 h	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

Sample	Sample Time	parent	oxon	Sulfox-ide	sulfone	oxon sulfox-ide	oxon sulfone
MDL		5	5	10	25	4	4
	24 h	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
	72 h	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
C		N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
D	0	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	15 min	N.D.	45	69	33	49	50
	4 h	N.D.	41	56	35	44	42
	24 h	N.D.	42	56	37	49	45
	72 h	N.D.	47	83	39	53	47
Disulfoton							
A1	0	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
	15 min	N.D.	N.D.	N.D.	N.D.	54	21
	4 h	N.D.	N.D.	N.D.	N.D.	N.D.	54
	24 h	N.D.	N.D.	N.D.	N.D.	N.D.	47
	72 h	N.D.	N.D.	N.D.	N.D.	N.D.	26
A2	0	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
	15 min	N.D.	N.D.	N.D.	N.D.	51	24
	4 h	N.D.	N.D.	N.D.	N.D.	N.D.	54
	24 h	N.D.	N.D.	N.D.	N.D.	N.D.	41
	72 h	N.D.	N.D.	N.D.	N.D.	N.D.	23
B	0	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
	15 min	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
	4 h	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
	24 h	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
	72 h	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
C		N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
D	0	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	15 min	N.D.	42	40	42	51	65
	4 h	N.D.	40	45	41	54	54
	24 h	N.D.	40	37	39	49	50
	72 h	N.D.	38	40	40	53	55

Table II.E-2.6 Results of the ECB GC-MSD Analyses of the OP Pesticides Terbufos, Phorate and Disulfoton and Degradation in Chlorinated and Unchlorinated Water

Sample	Sample Time	parent	oxon	Sulfox-ide	sulfone	oxon sulfox-ide	oxon sulfone
Terbufos							
MDL		**1**	**3**		**1**		**1**
A1	**0**	51	N.D.		N.D.		N.D.
	15 min	N.D.	N.D.		N.D.		N.D.
	4 h	N.D.	N.D.		N.D.		N.D.
	24 h	N.D.	N.D.		N.D.		N.D.
	72 h	N.D.	N.D.		N.D.		N.D.
A2	**0**	59	N.D.		N.D.		N.D.
	15 min	N.D.	N.D.		N.D.		N.D.
	4 h	N.D.	N.D.		N.D.		N.D.
	24 h	N.D.	N.D.		N.D.		N.D.
	72 h	N.D.	N.D.		N.D.		N.D.
B	**0**	N.A.	N.A.		N.A.		N.A.
	15 min	73	N.D.		N.D.		N.D.
	4 h	23	N.D.		N.D.		N.D.
	24 h	7	N.D.		N.D.		N.D.
	72 h	2	N.D.		N.D.		N.D.
C		N.D.	N.D.		N.D.		N.D.
D	**0**	N.A.	N.A.		N.A.		N.A.
	15 min	N.A.	N.A.		N.A.		N.A.
	4 h	29	36		47		52
	24 h	44	52		56		59
	72 h	33	35		48		42
Phorate							
MDL		**1**	**3**		**1**		**2**
A1	**0**	56	N.D.		N.D.		N.D.
	15 min	N.D.	N.D.		N.D.		N.D.
	4 h	N.D.	N.D.		N.D.		4
	24 h	N.D.	N.D.		N.D.		2
	72 h	N.D.	N.D.		N.D.		N.D.
A2	**0**	63	N.D.		N.D.		N.D.
	15 min	N.D.	N.D.		N.D.		N.D.
	4 h	N.D.	N.D.		N.D.		4
	24 h	N.D.	N.D.		N.D.		2
	72 h	N.D.	N.D.		N.D.		N.D.
B	**0**	N.A.	N.A.		N.A.		N.A.
	15 min	78	N.D.		N.D.		N.D.
	4 h	29	N.D.		N.D.		N.D.
	24 h	14	N.D.		N.D.		N.D.
	72 h	8	N.D.		N.D.		N.D.
C		N.D.	N.D.		N.D.		N.D.

Sample	Sample Time	parent	oxon	Sulfox-ide	sulfone	oxon sulfox-ide	oxon sulfone
D	0	N.A.	N.A.		N.A.		N.A.
	15 min	N.A.	N.A.		N.A.		N.A.
	4 h	27	31		47		46
	24 h	43	48		57		50
	72 h	35	32		49		42
Disulfoton							
MDL		1	1	1	3	3	3
A1	0	58	N.D.	3	N.D.	5	N.D.
	15 min	N.D.	N.D.	N.D.	N.D.	N.D.	36
	4 h	N.D.	N.D.	N.D.	N.D.	N.D.	38
	24 h	N.D.	N.D.	N.D.	N.D.	N.D.	22
	72 h	N.D.	N.D.	N.D.	N.D.	N.D.	14
A2	0	66	N.D.	4	N.D.	3	N.D.
	15 min	N.D.	N.D.	N.D.	N.D.	15	36
	4 h	N.D.	N.D.	N.D.	N.D.	N.D.	29
	24 h	N.D.	N.D.	N.D.	N.D.	N.D.	20
	72 h	N.D.	N.D.	N.D.	N.D.	N.D.	17
B	0	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	15 min	77	N.D.	3	N.D.	4	N.D.
	4 h	33	N.D.	3	N.D.	N.D.	N.D.
	24 h	2	N.D.	2	N.D.	N.D.	N.D.
	72 h	3	N.D.	3	N.D.	N.D.	N.D.
C		N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
D	0	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	15 min	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	4 h	31	31	43	47	28	58
	24 h	44	44	46	52	25	60
	72 h	36	35	46	35	23	49

E-3. Water Outputs – Region A

See file Water Outputs – Region A.xls

E-4. Water Outputs – Region B

See file Water Outputs – Region B.xls

E-5. Water Outputs – Region C

See file Water Outputs – Region C.xls

E-6. Water Outputs – Region D

See file Water Outputs – Region D.xls

E-7. Water Outputs – Region E

See file Water Outputs – Region E.xls

E-8. Water Outputs – Region F

See file Water Outputs – Region F.xls

E-9. Water Outputs – Region G

See file Water Outputs – Region G.xls

G-1. Sensitivity Analysis: Cancellation of Azinphos-Methyl Group 3 Uses

A. Background

The food component of the Organophosphorus Cumulative Risk Assessment (OP CRA) is to a large extent based on pesticide residue information collected by USDA's Pesticide Data Program (PDP) from 1994 to 2004. The PDP sampling design and procedures provide OPP with a nationally representative sample of selected food commodities available to the US population in grocery stores.

Inherent in the use of such monitoring data that has been collected over an extended length of time is the concern that any changes in pesticide use patterns will not be reflected in the data. The OPs in particular have undergone sizable changes in use patterns as a result of the individual chemical decisions. In cases for which legal agreements have been signed or voluntary cancellations implemented, the uses have been removed from the assessment.

The OP CRA Update 2006 has incorporated the phase-out of domestic uses that was recently proposed by the Agency concerning the remaining (Group 3) uses of azinphos-methyl (AZM). Specifically, all domestic uses for AZM on almonds, Brussels sprouts, pistachios, walnuts, apples, blueberries, cherries, parsley, and pears are to be phased out effective in 2007 or 2010. This information was incorporated into this Update by removing from the food assessment all AZM residues on these crops which are domestically-grown[25]; residues on imported crops were not changed. All other uses of this pesticide have already been voluntarily cancelled by the manufacturer.

These mitigation actions for AZM were proposed due primarily to issues associated with worker exposure, and not dietary exposure. Thus, dietary risk and exposure estimates presented in OP CRA Update 2006 are not expected to differ significantly from those that do not incorporate these 2007 and 2010 AZM proposed use cancellations.

The purpose of this sensitivity analysis is to determine the extent to which the inclusion of domestic AZM residues on Group 3 crops affect the exposure and risk estimates presented in Chapter I.C.

[25]As part of its standard sampling procedure, USDA PDP collects detailed information for each of the hundreds of samples collected each year. An essential component of this detailed sampling information is the origin of sample. Specifically whether the food commodity was grown domestically or imported.

B. Approach

In the food component of the OP CRA Update 2006, PDP analytical samples of AZM residues identified as domestic in origin were completely removed from the assessment. As a sensitivity analysis and to ensure that risks prior to any use cancellations are not above the Agency's level of concern, OPP has performed a parallel exposure analysis in which AZM Group 3 domestic uses are retained.

PDP samples of domestic origin that were analyzed for residues of AZM (or its metabolite) were included in this sensitivity analyses for any commodities that are used by OPP to represent pesticide residues in almonds, Brussels sprouts, pistachios, walnuts, apples, blueberries, cherries, parsley, and pears[26]. All other residue and consumption information from the food component of the OP CRA Updated 2006 remained unchanged for this sensitivity analysis (see Chapter I.C for details). Resulting exposure and risk estimates under this scenario would be expected to be more typical of the near term (e.g., through 2007 and 2010) before the AZM Group 3 cancellation becomes effective.

C. Results

In Chapter I.C, the margins of exposure (MOEs) at 95th, 99th, and 99.9th percentiles of exposure are reported for the 21-day exposure period for various age groups, the mostly highly exposed of which were children 1-2 and 3-5 years old. Briefly, the MOEs for the 21-day assessment are above or very close to the target of 100 at the 99.9th percentile of exposure for all age groups; the MOEs for the 95th and 99th percentiles of exposure are well above 100.

Table II.G-4.1 provides a comparison of MOEs at 99.9th percentiles of exposure from the 21-day food assessment presented in Chapter I.C and the 21-day food assessment described in this Appendix. Tables II.G-4.2 and II.G-4.3 provide similar comparisons of the MOEs at the 99th and 95th percentiles of exposure. Although only two most highly exposed age groups are presented in these Tables, the MOEs for the all other age groups exceed the target MOE of 100 at the percentiles presented.

[26] For detailed information regarding crops and foods to which PDP commodities are translated see Appendices II.C.4 and II.C.6.

Table II.G-1.1 Cumulative Food Assessment MOEs at the 99.9th Percentile Exposure.

	Single Day MOE without AZM Group 3 Uses	Single Day MOE with AZM Group 3 Uses
Children 1-2 yrs	110	110
Children 3-5 yrs	99	98

Table II.G-1.2 Cumulative Food Assessment MOEs at the 99th Percentile.

	Single Day MOE without AZM Group 3 Uses	Single Day MOE with AZM Group 3 Uses
Children 1-2 yrs	250	240
Children 3-5 yrs	300	290

Table II.G-1.3 Cumulative Food Assessment MOEs at the 95th Percentile of Exposure.

	Single Day MOE without AZM Group 3 Uses	Single Day MOE with AZM Group 3 Uses
Children 1-2 yrs	550	520
Children 3-5 yrs	670	620

D. Conclusions

When these Group 3 AZM uses are included in this alternative assessment (i.e, incorporated back into the exposure and risk calculations), MOEs at the 99.9th percentile of exposure remain virtually unchanged for children 1-2 and change from 99 to 98 for children 3-5. Thus, the AZM use cancellations that have been proposed to take effect in 2007 to 2010 do not significantly impact the dietary exposure and risk estimates presented in the OP CRA Update 2006.

G- 2. Characterization of Potential Oxon Formation and Exposure in Drinking Water

A number of OP pesticides have the potential to convert to more toxic oxon transformation products as a result of chlorination/oxidation during standard drinking water treatment. Additional studies conducted since 2002 confirm the potential for OP pesticides to form stable oxon transformation products as a result of chlorination. Less data are available characterizing the potency of most oxons For those oxons with insufficient toxicity information, EPA used high end adjustment factors of 10X and 100X to account for the potential increased potency of the oxon relative to the parent. With protective assumptions (100% conversion from the parent to the oxon, instantaneous transformation to oxon with no degradation), EPA estimated that the oxons would not appreciably change the cumulative OP distributions with a 10X or, in most scenarios, with the 100X oxon adjustment factor. As described in detail below, the exception is for Region C (Southwest / Central Valley, CA, exposure scenario) where the 100X oxon adjustment factor increased estimated peak cumulative concentrations by as much as 35-50X, largely due to methidathion. Overall, EPA's continues to conclude that risk from drinking water exposure to OPs is below the level of concern for the cumulative risk assessment. As described below, the increase in peak cumulative concentrations for methidathion are believed to result from compounding high end assumptions on the potency and the exposure to the oxon. This compounding decreases the confidence surrounding the risk estimates.

This appendix characterizes the degree of confidence and uncertainty in regarding oxon formation and decline and oxon toxicity and identifies additional information needed to quantify the potential impacts of oxon formation on the OP cumulative exposure in drinking water.

1. Screening Level Approach: Potential for Oxon Formation as a Result of Drinking Water Treatment

For the OP pesticides, information on the potential to form oxons as a result of chlorination and on differential toxicities between parent and oxon are not sufficient to make quantitative adjustments to the cumulative exposure estimates. The Agency has used a screening level approach to evaluate the potential contribution of potential oxon exposure in drinking water to the cumulative risk of the OPs. The purpose of this analysis was

1) to consider the degree to which exposure to the oxons from drinking water may qualitatively change the Agency's conclusion that the risk from drinking water

exposure to OPs is below the level of concern and

2) to determine whether additional information may be needed concerning oxon toxicity, extent and rate of oxon formation as a result of standard drinking water treatment, and/or the rate of breakdown of the oxons after formation in order to better refine and quantify risk to the oxons.

Based on published literature, registrant-submitted studies, US EPA laboratory studies (summarized in Appendices II.E.1 and II.E.2), and monitoring data (most notably a 1999-2000 USGS reservoir monitoring study; see Bloomquist et al, 2001), EPA has identified ten OP pesticides with the potential to form stable oxons as a result of chlorination: azinphos methyl, bensulide, chlorethoxyphos, chlorpyrifos, diazinon, dimethoate, disulfoton sulfone, malathion, methidathion, methyl parathion, and phostebuipirim. The supporting evidence is summarized in Table I.E-2 of the drinking water exposure section (I.E) and in Appendices II.E-1 and II.E.2. The studies summarized in Table I.E-2 are only designed to determine whether oxons form as a result of chlorination and whether they are stable for at least 72 hours after formation. More extensive studies would be required to determine the rates of formation and decline of oxons in treated water.

2. Estimating the Impacts of Potential Oxon Formation on OP Cumulative Distributions in Drinking Water

In estimating potential oxon impacts, the Agency assumed that any transformation as a result of chlorination results in complete conversion to the oxon and that the resulting oxon would be stable for at least 72 hours, sufficient time to move through the distribution system. The resulting estimates of oxon residues in drinking water represent an upper bound of the potential oxon levels that may actually occur in drinking water. As mentioned earlier, the studies referenced in Table I.E-2 were not designed to determine definitively what percentage of the parent OP might convert to the oxon. While this percentage is likely to vary depending on treatment conditions, anything less than 100% conversion will result in lower oxon levels than estimated. Similarly, the Agency's assumption that the oxons remain stable after they are formed is an upper bound estimate of the extent that the oxons degrade at any appreciable rate between the time they are formed to when they are distributed at the tap.

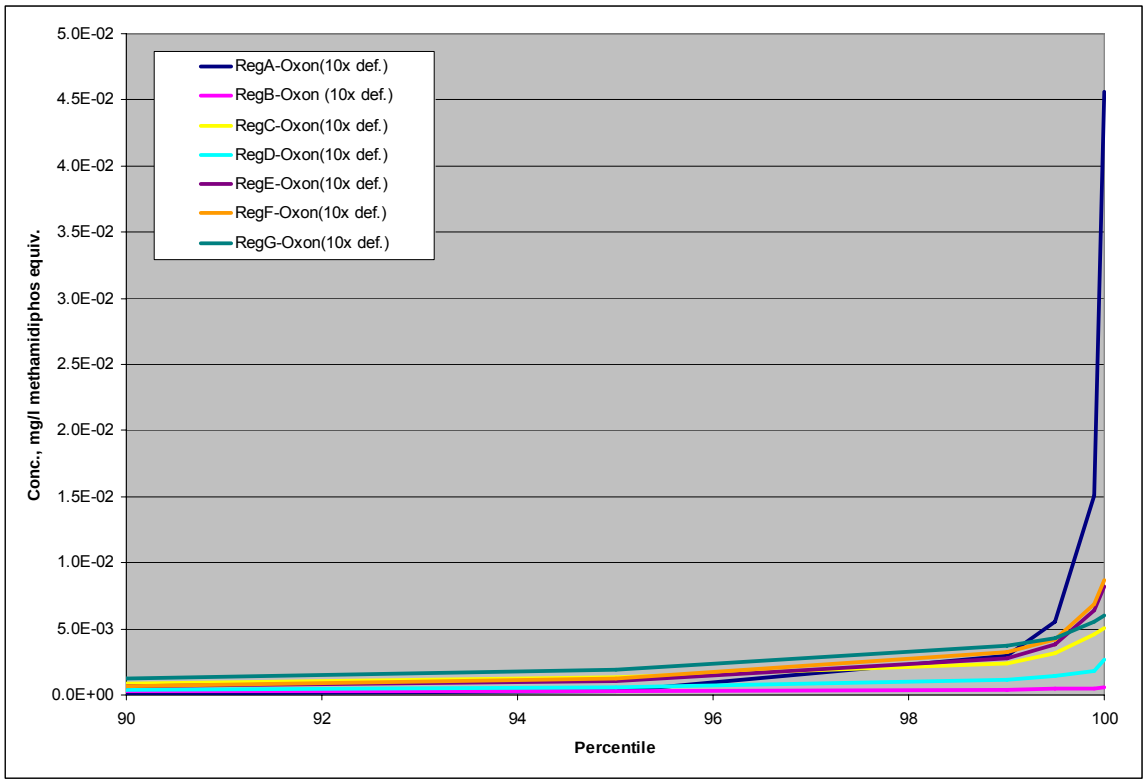
EPA had sufficient data to estimate oxon adjustment factors that reflect the greater toxicity of the oxon for three OP pesticides - dimethoate (3X), chlorpyrifos (10X) and methyl parathion (10X). For the remaining OP pesticides which form oxons, insufficient data exists to determine a potential oxon adjustment factor. For these pesticides, the Agency used

oxon adjustment factors of 10X and 100X to consider upper bound estimates of potential oxon potentcy. These adjustment factors were applied to the pesticide concentrations in water.

As noted in the drinking water exposure section (I.E), the exposure scenario for Region A (Florida) had the highest estimated peak concentrations of any of the regional scenarios. Because none of the OP residues driving exposure in this region formed oxons, this regional distribution served as a reference point to compare the impact of oxon formation on drinking water exposures in other regions.

While the 10X oxon adjustment factor resulted in increases in estimated peak concentrations ranging from less than 25% to 3-5X (Region C), **all** of the regional distributions remained well below that of Region A (Figure II.G.2 1) and thus below the level of concern for the cumulative risk assessment. Peak concentrations from the Region A scenario (dark blue line in the figure) is at least 6X to more than an order of magnitude greater than those from any other region.

Figure II.G-2.1 Frequency distribution of each of the regional OP cumulative drinking water exposures, including oxon adjustment factors (10X).



When the 100X oxon adjustment factor is applied, peak concentrations in Regions B, C, E, F, and G shifted upwards in relation to that of Region A but remained below the below the level of concern for the

cumulative risk assessment. The noted exception is for the cumulative distribution for Region C which increased by 30 to 50X, surpassing the distribution of Region A (Figure II.G.2 2), primarily due to the oxon of methidathion. This resulted in estimated MOEs for drinking water exposure ranging from 16 to 99 for the first third of the year for children 1 to 2 years of age at the 99.9th percentile (21-day rolling average) (Figure II.G.2 3).

Figure II.G-2.2 Frequency distribution of each of the regional OP cumulative drinking water exposures, including oxon adjustment factors (100X).

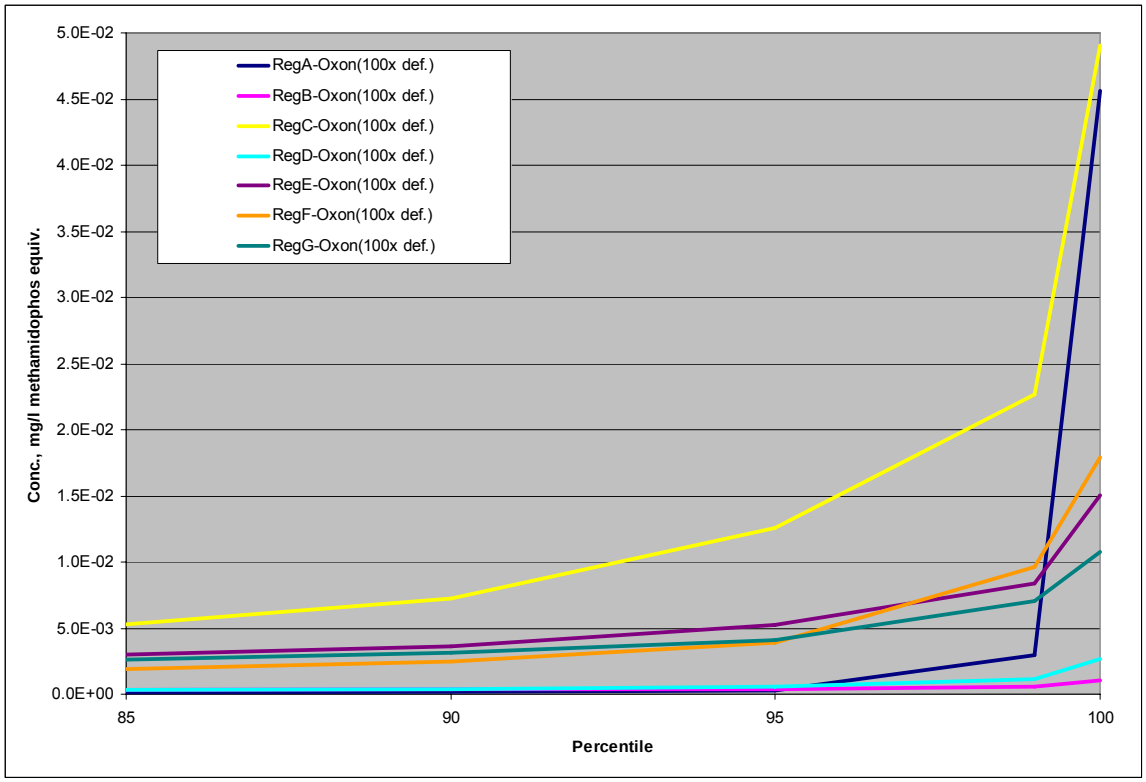
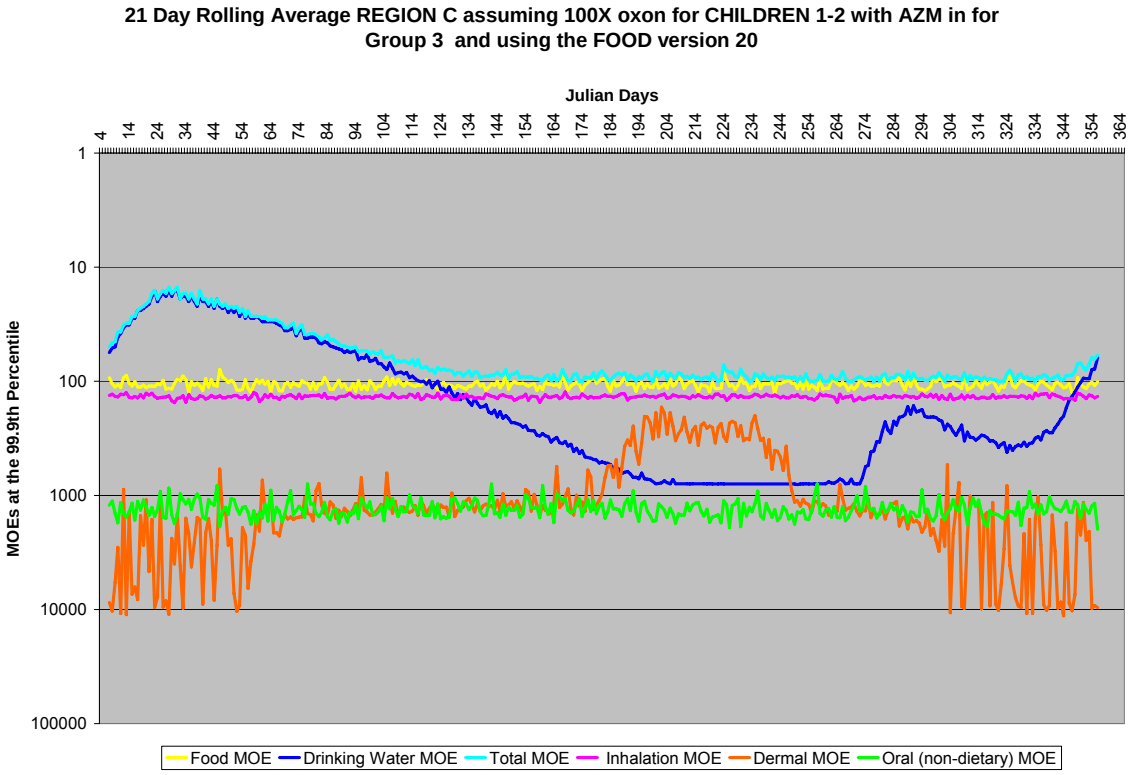


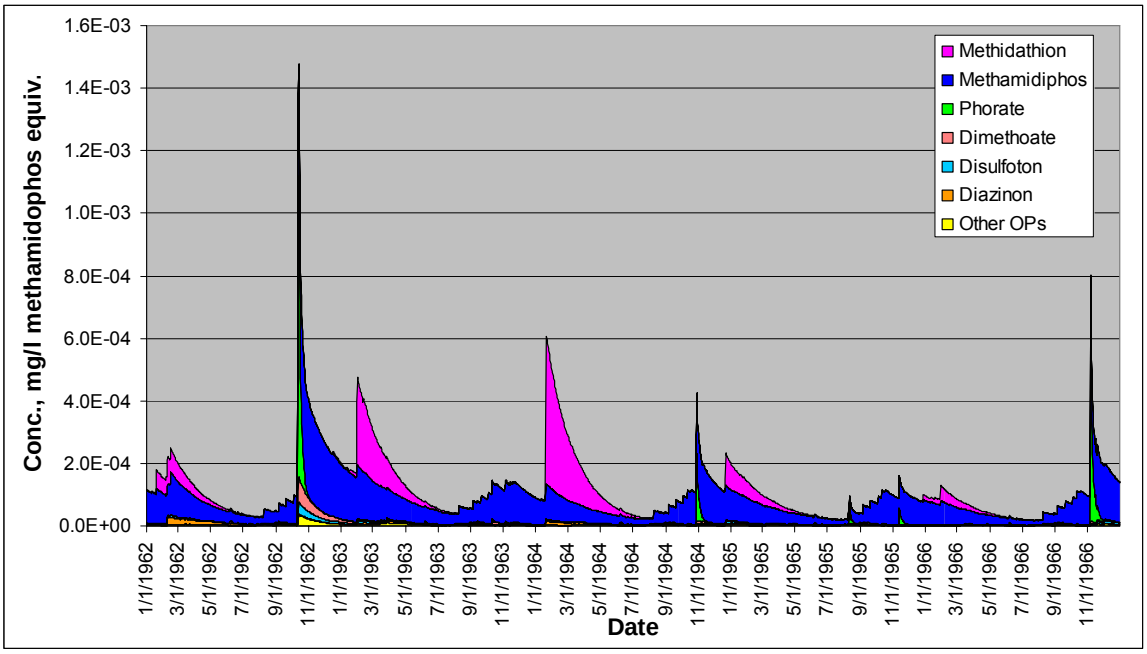
Figure II.G-2.3 Margins of Exposure (MOE) for Cumulative OP Residues from Multiple Routes of Exposure in Region C for Children 1-2 Years Old at the 99.9th Percentile of Exposure.



3. Characterizing Oxon Exposure in Region C

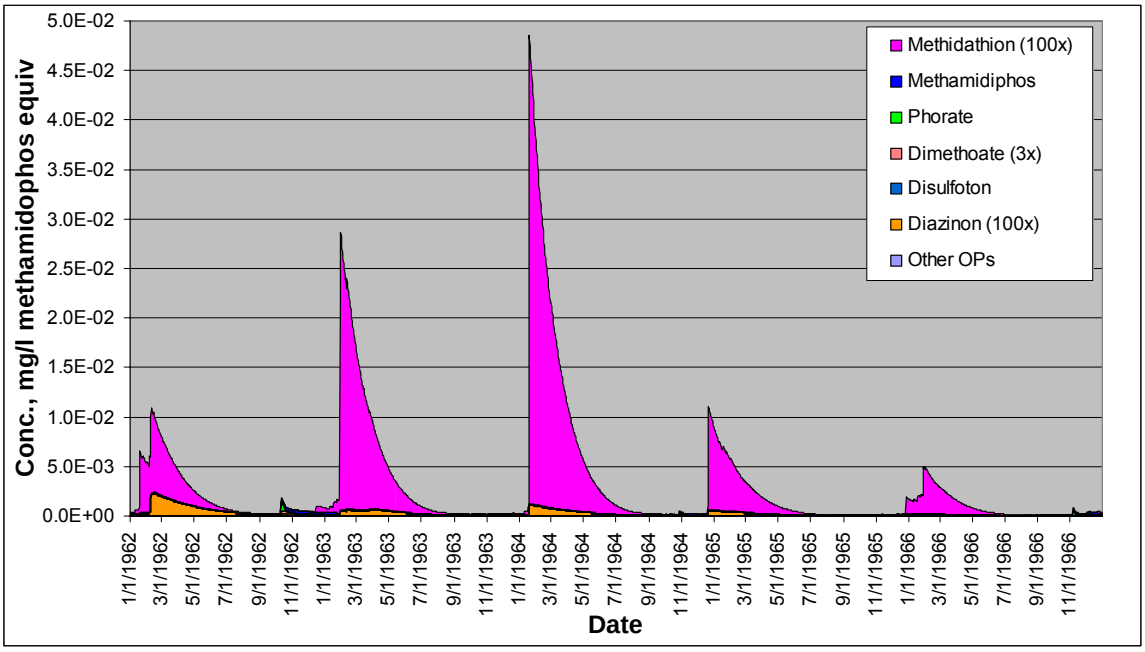
The exposure scenario for Region C includes a number of oxon formers with peak concentrations within two orders of magnitude of the cumulative peaks (chlorpyrifos, diazinon, dimethoate, methidathion, methyl parathion). With no oxon adjustments taken into account, the major OP pesticides contributing to the cumulative OP residues are methamidiphos, methidathion, and phorate (including the sulfone and sulfoxide residues). Figure II.G.2 4 provides a representative illustration of the relative contributions of OP residues to the cumulative exposure across 4 years (of a 35-year simulation). Of the major contributors, only methidathion has the potential to form an oxon as a result of chlorination.

Figure II.G-2.4 Contributions of individual OP pesticides to the RPF-adjusted cumulative load for Region C (CA Central Valley) with no oxon adjustment factor.



When the100X oxon adjustment factor is used, methidathion becomes the dominant contributor to the OP cumulative exposure (Figure II.G.2 5). Note that the scale of the graph increases by 30X between the two figures. The phorate peak shown in 1962 (Figure II.G.2 4), which remains unchanged because no oxons are formed, is dwarfed in Figure II.G.2 5 while the methidathion peaks increase with the oxon adjustment factor.

Figure II.G-2.5 Contributions of individual OP pesticides to the RPF-adjusted cumulative load for Region C (CA Central Valley) with a default 100X oxon adjustment factor.



4. Characterizing the Risk to Methidathion Oxon

The Agency has taken a screening approach to evaluating the impact of direct exposure to oxons derived from drinking water processing chlorination. This approach included high end assumptions for conversion from the parent to the oxon, stability of the oxon, and the toxicity of oxon degradate. These assumptions used in combination result in exaggerated risk to the oxon. Even with these high end assumptions, the risk from the oxons are below the level for the majority of scenarios, including all scenarios which used the 10X toxicity adjustment factor. The noted exception was for methidathion oxon in Region C when using the 100X toxicity adjustment factor.

Methidathion was included in the 2006 USEPA BEAD study (Appendix II.E.1). Although the studies were not designed to make quantitative estimates of oxon formation and decline, it does provide an indication of the relative degree of oxon formation and stability. Methidathion was stable in buffered, nonchlorinated water. In other word, there is potential for it to persist in the water as it goes through the treatment plant. Methidathion converted fairly rapidly under chlorination - 90-98% conversion to the oxon within 1 hr. These data suggest that the assumption that 100% of the parent compound converts to the oxon is not unreasonable. After 72 hr, two-thirds of the oxon was still detected,

suggesting that methidation-oxon is fairly stable within the perspective of a DW treatment distribution system.

Monitoring data on methidathion is scarce, particularly in methidathion use areas. While methidathian was not included in the USGS NAWQA study, a study conducted by California DPR and USGS found methidathion detections from dormant spray to orchards in 18% of water samples monitored (see Water Appendix III.E 2 from the 2002 OP CRA). The modeled exposure for methidation has a maximum of 0.15 ppb and a 99th percentile concentration of 0.06 ppb. These concentrations are comparable to maximum reported detections from available monitoring studies. Information from the USEPA BEAD study combined with the monitoring studies suggests that actual estimates of DW exposure for methidathion and its oxon are reasonable approximations of the potential concentrations in Region C where methidathion is used on orchard crops.

The relative potency of methidathion oxon compared to the parent compound for brain ChE inhibition s unknown but is expected to be lower than the 100X toxicity adjustment factor. For dimethoate, methyl parathion, and chlorpyrifos where there is sufficient information to evaluate relative potency for brain ChE inhibition, the oxon is less than 10X more potent compared to the parent for brain ChE inhibition. Theorectically, if the oxon were up to 100X more potent than the parent, then the oxon would be almost 20X more potent than dicrotophos which is the most potent OP pesticide and which does not require activation to the oxon but instead is active as the parent compound. Although not impossible, it is unlikely that methidathion oxon is actually 100X more potent that the parent. Moreover, there are no available data comparing the relative sensitivity of juvenile and adult animals (ie, a comparative ChE study) for methidathion. As such, the full 10X FQPA factor has been retained for methidathion. Overall, the Agency believes that the uncertainties associated with the toxicity of the oxon are key in the characterization of the risk to methidathion oxon in drinking water. The Agency also believes that risks reported here are exaggerated and the actual risk is significantly lower. To confim this, the Agency will be issuing a data call-in notice for a 28-day repeated-dose toxicity study with methidathion oxon.

G-3. Characterization of OP Cumulative Residues in Drinking Water: Region A

EPA estimated distributions of individual and cumulative OP pesticide residues in drinking water in high potential exposure areas across different regions of the country. In the south Florida scenario, which represents the few surface water sources of drinking water in Region A, estimated concentrations of total phorate residues (parent plus sulfoxide and sulfone transformation products) reached as high as 1 to 11 ug/l (ppb) for periods of short duration (days). The transformation products form in the environment and, based on available literature, are expected to be equal in toxicity to phorate. These phorate peaks drove the OP cumulative exposure estimates for drinking water in this region, resulting in MOEs ranging from 79 to 94 for Children 1-2 year old at the 99.9th percentile of exposure on days 229 to 244.

The drinking water exposure estimated for this region is likely an overestimate because laboratory studies indicate that phorate and its sulfoxide and sulfone transformation products are likely to break down rapidly (on the order of minutes to hours) during the chlorination process of drinking water treatment (see Appendices II.E.1 and II.E.2) In addition, the estimated concentrations of total phorate residues are likely to be overestimates for the following reasons:

- Peak concentrations assume that phorate applications on sugarcane occur on the same day. Because of the estimated acreage being treated, phorate applications are likely to be spread out over time. Thus, the peak concentrations are likely to be lower than estimated.

- The estimated phorate concentrations better reflect concentrations in drainage canals and water retention structures. Reductions in concentrations are likely to occur with holding time (phorate residues degrade with half-lives on the order of days in aquatic environments) and with dilution as the drainage waters flow into larger water bodies used for drinking water supplies.

While these factors cannot be quantified, qualitatively they indicate that concentrations of total phorate residues in drinking water will be substantially lower than estimated for this region. This appendix characterizes the estimated total phorate concentrations for those high-exposure drinking water sources in south Florida and documents the lines of evidence indicating that actual OP levels in drinking water will be lower than estimated.

1. Estimated Exposures for Drinking Water in Region A

Of the OP pesticides used in the south Florida region, phorate had the highest estimated concentrations (Table II.G.3 2). The phorate residues in Table II.G.3 1 reflect a combination of the parent phorate and the sulfoxide and sulfone transformation products.

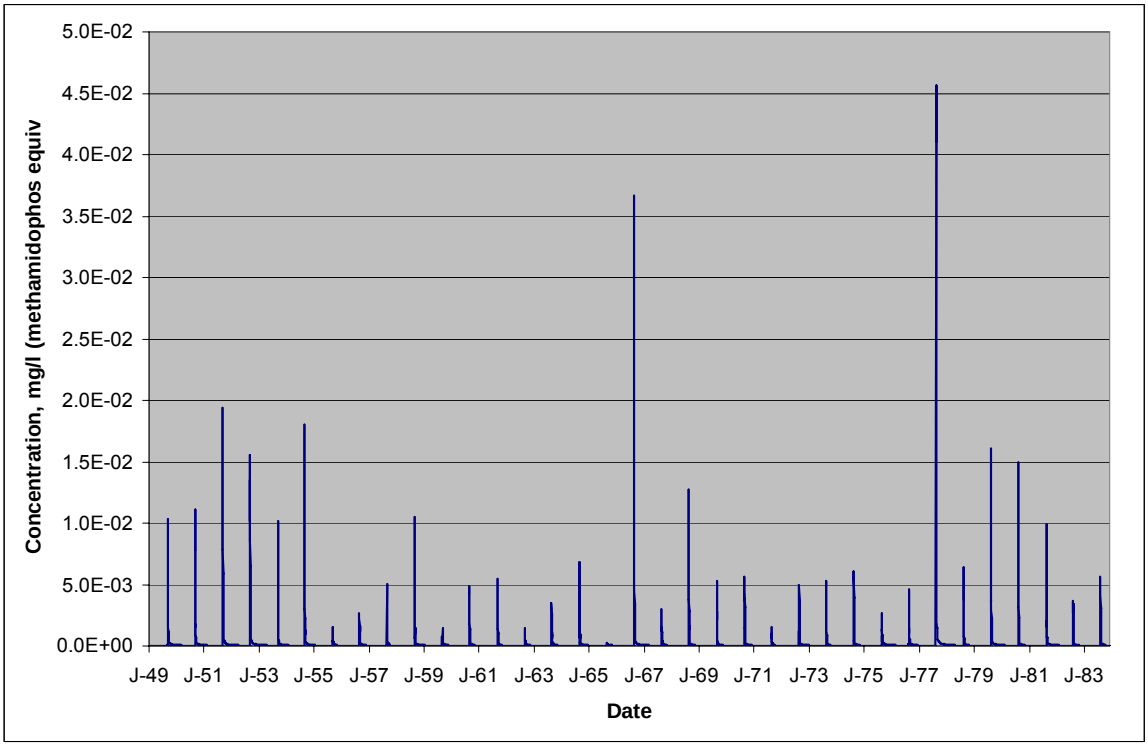
Table II.G-3.1 Estimated percentile concentrations of individual OP pesticides in the south Florida surface water exposure scenarios (not adjusted for relative potency).

Chemical	Crop/Use	Percentile concentration in ug/l (ppb)				
		Max	99th	95th	90th	80th
Region A (Florida): South FL						
Acephate	Peppers	7.6E-02	6.8E-03	8.5E-04	2.8E-04	8.7E-05
Chlorpyrifos	Corn, citrus	2.0E-01	9.6E-02	4.9E-02	3.3E-02	2.1E-02
Diazinon	Lettuce, tomato	2.9E-02	1.5E-02	8.8E-03	6.1E-03	3.9E-03
Ethoprop	Sugarcane	1.5E+00	5.1E-01	2.5E-01	1.7E-01	9.8E-02
Methamid-ophos	Acephate degradate, tomato	9.3E-03	1.7E-03	2.6E-04	8.4E-05	1.6E-05
Phorate (1)	Corn, sugarcane	1.1E+01	7.2E-01	1.8E-02	1.1E-04	5.4E-09

(1) Estimated concentrations for phorate reflect combined residues of the parent and its sulfoxide and sulfone transformation products.

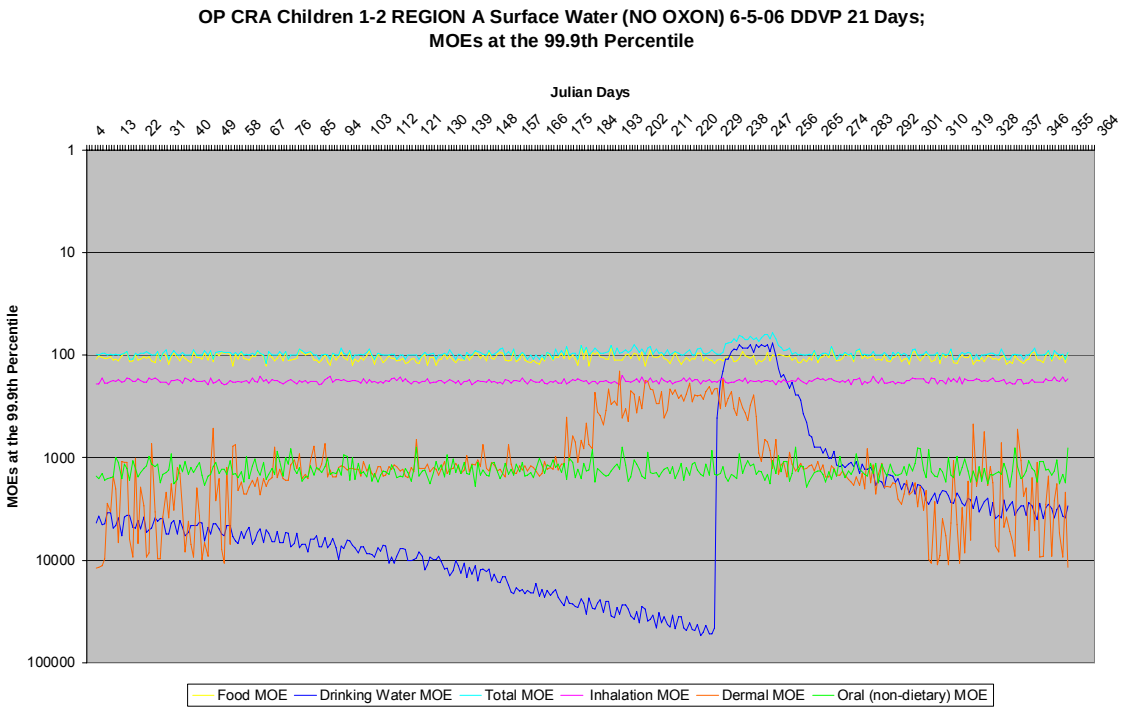
The temporal and spatial extent of potential high OP exposure is limited to a relatively short duration in the fall, associated with phorate and ethoprop applications to sugarcane. Figure II.G.3 1 shows the distribution of combined OP concentrations (in methamidophos equivalents) over 35 years of simulated weather patterns. Generally one to two brief peaks (few days in duration) occur within a short time span every year. The magnitude of the peaks varies, depending on the timing of the runoff events after application and on the magnitude of runoff. The estimated peaks assume that the applications occur on the same day every year. Year-to-year peaks are likely to vary in timing because the actual dates of application may vary within an optimal window of application from year to year. Thus, the spread in yearly peaks may be broader than shown in the figure.

Figure II.G-3.1 Estimated OP Cumulative Concentrations (in Methamidophos Equivalents) Reflecting 35 Years of Weather Data.



When the drinking water exposure estimates are folded into the cumulative exposure assessment, the estimated peak concentrations for drinking water result in MOEs ranging from 79 to 94 for children from 1-2 years in age at the 99.9th percentile (Figure II.G-3.2). The brief period of high exposure (days 229 through 244) coincide with the expected period of peak exposure based on an early September application of phorate on sugarcane and sweet corn and of ethoprop on sugarcane.

Figure II.G-3.2 Margins of Exposure (MOE) for Cumulative OP Residues Region A (Florida) for Children 1-2 Years Old at the 99.9th Percentile of Exposure.



2. Principal Contributors to the OP Cumulative Drinking Water Exposure in Region A

A CEC analysis of the 99.8th to 100th percentile of exposure to children (age 1-2 years) shows that the contributing drinking water exposures at this high end of exposure predominantly come from two drinking water years – 1977 (50% of exposures) and 1966 (20% of exposures) (Table II.G-3.2). This coincides with the two highest peak concentrations estimated for the region (Figure II.G.3 1). The estimated exposures do not represent historic exposure levels, but only the probability of exposure based on variability in weather patterns. However, the analysis indicates that the highest drinking water exposures are not driven solely by the highest water concentrations in those exposure years (Table II.G-3.2).

Table II.G-3.2 Exposure analysis for Children 1-2 Years Old For Region A (1).

Demographics						Exposure (mg/ kg-Body Wt /da)			Water	
PID-HH#	Indiv	Itera-tion	Sex	Age	Body wt (kg)	Total	Dietary	Water	Conc. (mg/l)	Year
10154 49603	2	7	F	1Y	10.5	0.0011957	0.0000062	0.0011894	0.0125	1977
20523 52340	2	6	F	2Y	13.2	0.0023352	0.0000447	0.0022905	0.0302	1977
9745 42121	3	8	M	2Y	15.9	0.0013612	0.0012711	0.0000900	0.00143	1979
20068 47302	1	8	F	1Y	10.0	0.0014643	0.0000159	0.0014484	0.0145	1966
8842 28601	1	5	F	1Y	9.5	0.0010625	0.0001106	0.0009519	0.00904	1966
19253 34813	1	1	M	2Y	11.8	0.0010390	0.0006013	0.0004376	0.00516	1979
8162 25601	3	1	F	1Y	12.3	0.0017498	0.0017483	0.0000015	1.84E-05	1965
18787 28857	1	4	F	2Y	12.3	0.0010176	0.0000572	0.0009603	0.0118	1977
6334 16123	1	3	M	1Y	10.9	0.0010806	0.0001243	0.0009563	0.0104	1977
18015 24339	1	2	M	1Y	13.6	0.0012331	0.0010390	0.0001940	0.00264	1952
6212 15150	1	4	F	1Y	15.0	0.0013518	0.0001001	0.0012517	0.0188	1977
16390 16808	1	6	M	1Y	11.4	0.0017784	0.0000445	0.0017339	0.0198	1977
5230 52024	1	3	F	2Y	13.6	0.0014841	0.0000356	0.0014485	0.0197	1977
14272 35208	1	6	M	2Y	9.5	0.0017544	0.0002197	0.0015347	0.0146	1977
5209 52015	2	8	F	1Y	9.5	0.0011210	0.0001125	0.0010085	0.00958	1977
13763 28721	2	9	M	2Y	10.0	0.0009571	0.0001491	0.0008079	0.00808	1977
4933 48010	2	6	F	1Y	11.4	0.0016704	0.0000564	0.0016140	0.0184	1966
12492 21720	1	10	M	1Y	12.3	0.0009911	0.0001691	0.0008221	0.0101	1966
4878 46511	1	2	F	2Y	13.2	0.0011330	0.0001690	0.0009640	0.0127	1977
11652 17244	1	8	F	1Y	14.5	0.0016687	0.0014836	0.0001851	0.00268	1951
4619 42505	3	3	M	2Y	12.7	0.0013135	0.0012202	0.0000933	0.00118	1952
10231 51115	8	6	F	2Y	13.6	0.0013701	0.0000125	0.0013576	0.0185	1977
3607 28010	3	1	M	1Y	10.0	0.0010041	0.0000574	0.0009468	0.00947	1966

Demographics						Exposure (mg/ kg-Body Wt /da)			Water	
PID-HH#	Indiv	Itera-tion	Sex	Age	Body wt (kg)	Total	Dietary	Water	Conc. (mg/l)	Year
19271 35305	1	6	F	1Y	9.5	0.0016609	0.0000355	0.0016254	0.0154	1977
3401 27034	3	5	M	2Y	10.9	0.0012668	0.0010322	0.0002346	0.00256	1952
18015 24339	1	4	M	1Y	13.6	0.0011644	0.0011456	0.0000187	0.000254	1959
2280 21515	1	8	F	1Y	9.5	0.0009687	0.0001143	0.0008545	0.00812	1977
14272 35208	1	7	M	2Y	9.5	0.0012525	0.0010988	0.0001537	0.00146	1969
1361 17013	5	4	M	2Y	20.5	0.0010669	0.0000757	0.0009911	0.0203	1977
12629 22731	1	5	M	1Y	11.4	0.0010534	0.0003172	0.0007362	0.00839	1966
1215 16502	1	3	F	1Y	11.4	0.0010485	0.0000754	0.0009732	0.0111	1966
11552 16751	3	6	M	2Y	15.9	0.0016186	0.0000886	0.0015300	0.0243	1977
1148 16008	1	4	M	2Y	12.3	0.0009942	0.0009483	0.0000460	0.000566	1955
19098 31824	2	3	F	1Y	10.9	0.0011833	0.0000285	0.0011548	0.0126	1977
1148 16008	1	1	M	2Y	12.3	0.0016165	0.0004836	0.0011328	0.0139	1966
14131 32216	2	5	F	2Y	12.7	0.0009783	0.0003152	0.0006631	0.00842	1977
1110 15546	3	9	F	1Y	10.5	0.0010144	0.0000318	0.0009826	0.0103	1977
20108 47804	1	10	F	1Y	15.9	0.0011481	0.0011221	0.0000260	0.000413	1953
753 14009	2	6	F	2Y	11.4	0.0013223	0.0001919	0.0011304	0.0129	1966
12467 21706	1	8	M	2Y	16.8	0.0009591	0.0000395	0.0009196	0.0154	1977
16398 16813	2	2	F	1Y	10.9	0.0013047	0.0012731	0.0000316	0.000344	1983
101 10512	1	3	F	1Y	10.0	0.0014294	0.0000200	0.0014093	0.0141	1977

(1) CALENDEX-FCID CEC Records File for CHILDREN 1-2 WATER CONSUMPTION35
CSFII 1994-98

Analysis Date 07-24-2006/16:05:12/8

Exposure analysis for 3 combined weeks: starting week 35 (of 52)

Exposure amounts adjusted for body weight

Dietary Residue file: C:\Calendexfiles\work\OPCRA\final\23July\water_OPCRA20.R98 Last saved: 7/23/2006 9:40:05 AM

Dietary Adjustment factor #2 used.

Dietary Matching File not used.

No non-dietary (residential) analysis

PRZM-EXAMS file: C:\Calendexfiles\work\OPCRA\final\water\OPCRA_RegA_NoOxon 6-5-06.PE1 Last saved:

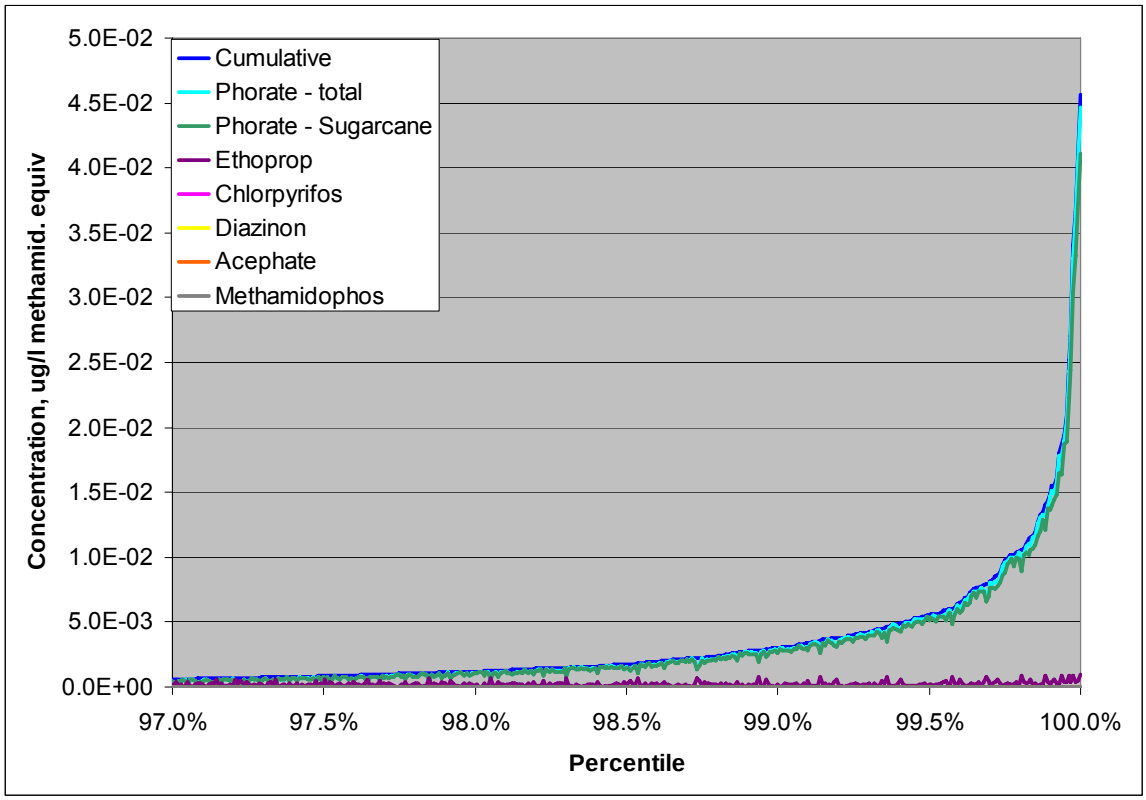
Demographics						Exposure (mg/ kg-Body Wt /da)			Water	
PID-HH#	Indiv	Itera-tion	Sex	Age	Body wt (kg)	Total	Dietary	Water	Conc. (mg/l)	Year

6/14/2006 2:21:06 PM
PE Analysis applied to Direct Water
PE Analysis applied to Indirect Water
NOEL Oral = 0.08 mg/kg-BodyWt/day

Lower and upper boundary percentiles entered as 99.800 100.000
Lower and upper exposure boundaries computed as: 0.000955 0.002335
Number of records in this file = 42

The cumulative peak for drinking water is driven largely by phorate and its sulfoxide and sulfone residues, which form in the environment. Figure II.G-3.3 shows the tail of the estimated OP cumulative distribution in drinking water sources, along with the component OP residues contributing to the cumulative exposure (all concentrations are in methamidophos equivalents). While both phorate and ethoprop are applied to sugarcane at the same time and can occur together in water, the cumulative OP concentrations (shown as a dark blue line in Figure II.G-3.3) are driven largely by phorate residues (shown as a light blue line). This reflects differences in the amounts of pesticide applied, fate and transport properties, as well as relative potency differences, between phorate residues and ethoprop. Further, the analysis indicates that the estimated cumulative OP residues in the upper tail of the distribution are driven largely by phorate use on sugarcane (shown as the green line in Figure II.G-3.3).

Figure II.G-3.3 Upper Percentiles of Frequency Distribution of Cumulative OP Concentrations (in Methamidophos Equivalents) With Component OP Residues.



3. Characterization of Phorate Concentrations in Drinking Water

a. Fate and Transport Modeling of Total Phorate Residues

Because evidence from literature studies indicate that the sulfoxide and sulfone transformation products of phorate are expected to be similar in toxicity to the parent compound, EPA simulated the fate and transport of the combined toxic residues. Degradation (hydrolysis, aerobic soil and aquatic metabolism) were calculated based on total (phorate + sulfoxide + sulfone) residues. In the field, the individual components will degrade at different rates. Phorate breaks down relatively quickly in water (aerobic aquatic metabolism half-life of <2 days). The sulfoxide has a half-life of 9 days and the sulfone 21 days. The half-life for the combined residues was ~50 days. This combined half-life appears to be skewed by the tail of the degradation profile, which is not well represented by a first-order degradation model. Thus, the phorate residues are likely to decline more rapidly than estimated by the half-life rate used in the exposure assessment.

EPA used the sorption coefficient of the most mobile of the three chemicals (K_{oc} of 91 for phorate sulfoxide). While this provides a protective exposure estimate, it will also lead to overestimates to the extent that the other components are less mobile.

b. Total Phorate Load in Water

The majority of OP and phorate use in the south Florida exposure scenario is on sugarcane. While only a relatively small fraction of the sugarcane acreage was treated with OP pesticides (10% of acres treated with phorate; 6% with ethoprop), this still accounts for a relatively large acreage compared to other uses in the area. The estimated 43,000 acres of sugarcane treated with phorate is still greater than the total combined acreage of the other OP use crops. The drinking water exposure assessment assumes that the entire crop area is treated at the same time. While this assumption is not unreasonable for smaller watersheds supplying small community water systems, it is less probable that all 43,000 acres of sugarcane will be treated at the same time.

As applications are spread out over time, the total phorate load carried to water as a result of any single runoff event will be less than estimated assuming the entire application occurs in the same day. Since the phorate residues are not expected to be persistent in water, degradation between runoff events not only spreads out the estimated peak concentrations, but should reduce the total load moving through the drinking water system at any time.

The Agency does not have any information that would allow it to quantifiably adjust the distribution and timing of application of phorate across the extent of treated sugarcane acreage in Florida. Thus, while we can qualitatively characterize the impact of spreading out the application, we cannot quantify it at this time.

c. Nature of Drinking Water Supply

Only a small number of surface water sources of drinking water occur in south Florida. Sugarcane is grown south of Lake Okeechobee in the Everglades Agricultural Area (EAA), and to the east into Palm Beach County. Three community water systems (CWS) draw from the southern end of Lake Okeechobee, and the city of West Palm Beach draws water from Clear Lake, which is fed in part by drainage water from the EAA. The agricultural areas in south Florida include extensive drainage canals and water retention structures. Thus, the drinking water exposure scenario for Region A better represents water being held in canals or retention bodies than in reservoirs that directly supply

the community water systems. Drainage canals from sugarcane fields are not used directly for drinking water, but water from drainage canals eventually feed water bodies used in southern Florida for drinking water supply.

Because the phorate residues degrade in water, any increase in holding time in retention structures or travel time in canals will result in some degradation and a lowering of residues in water. Additional dilution will occur where the drainage water flows into larger water bodies used for water supply. While the potential dilution effect is accounted for to a large extent by the percent crop area adjustment applied for this region, the decline in residues with travel time has not been taken into account.

d. Drinking Water Treatment Effects

Although the drinking water treatment studies documented in Appendices II.E.1 and II.E.2 (EPA, 2006a and 2006b) were designed only to determine the potential for oxon formation as a result of chlorination, they also indicate that the phorate residues (parent plus transformation products) are not likely to be stable as a result of chlorination. Phorate concentrations dropped to non-detectable levels within 1 hour of chlorination in benchtop jar tests (Appendices II.E.1 and II.E.2). Similarly, concentrations of phorate sulfoxide and sulfone also dropped to non-detectable levels shortly after chlorination. While phorate sulfoxide oxon was briefly detected in the lab studies, the oxon was not stable.

Thus, the overall phorate levels in drinking water in south Florida are likely to be much lower than estimated here.

G-4. Sensitivity Analysis: Acute Hazard Endpoints Compared to Single Day Food Estimates.

1. Background

The food component of the Organophosphorus Cumulative Risk Assessment (OP CRA) Update 2006 presented both single-day and 21-day exposure estimates for various age groups based on toxicity values derived from 21-day and longer (steady state) animal toxicity studies. As explained more fully in Chapter I.G, the Agency believes that the 21-day rolling average analysis better represents the cumulative risk to the OPs. The Agency further believes that the single day values compared with relative potency factors (RPFs) and points of departure (PoDs) derived from animal data representing steady state brain cholinesterase inhibition provide high end estimates using compounding conservative assumptions.

Although the Agency's OP CRA uses steady state brain cholinesterase data to extrapolate risk from 21-day rolling average exposure profiles, the Agency is concerned with the potential for peak exposures to OPs. Single chemical aggregate risk assessments include thorough analysis of acute exposure to individual OPs. The CRA is designed to evaluate the combined risk to many OPs. The Agency has conducted a sensitivity analysis where cumulative risks from single day food exposures were calculated using RPFs and PoD derived from acute toxicity studies in rat. The purpose of this analysis was:

1) to better understand the relationship between the results reported for the single-day and 21-day rolling average analyses compared with the steady state hazard data and;

2) to ensure that the CRA was protective of potential peak exposures to multiple OPs in food.

2. Approach

The following analysis is meant only as a sensitivity analysis and is not intended to replace the results presented in I.C and I.G for the 21-day rolling average analysis. The Agency only collected acute toxicity information for those OPs that most significantly contribute to food exposure for children 1-2 and 3-5 years old. Data from comparative cholinesterase studies where juvenile (post-natal day 11) or adult rats were exposed to an oral single dose were preferred when available.

Similar to that described in I.B for data from repeated dosing comparative cholinesterase studies, the OPCum Risk program was used to derive the estimates provided in II.G-4.1. In cases where the adult and pup data were adequately modeled with OPCum Risk, the adult BMD was used to derive the acute RPF with pup data used to derive the FQPA safety factor for acute dosing. This approach is similar to that used for the steady state, repeated dosing studies in I.B.

For four OPs, the pup data were adequately modeled with the OPCumRisk but the adult data were not. For these four, the pup data were used directly to estimate the acute RPF. It is preferred to derive RPFs from a uniform sex and life stage but for purposes of this sensitivity analysis, this is a reasonable approach.

BMD modeling was not attempted for some OPs, instead the acute value was estimated from either a NOAEL or LOAEL or an extrapolation between the NOAEL and LOAEL. For all other OPs not identified as contributors to the cumulative food exposure assessment, the toxicity information used in this acute analysis was the same as that reported for the steady state, repeated exposures. As such, the current analysis provides an upper bound on potential acute cumulative risks to the OPs.

Acute RPFs were calculated using methamidophos as the index chemical. RPFs were estimated based on the ratios of BMD_{10} or other endpoint as appropriate. The acute PoD was based on the methamidophos $BMDL_{10}$ of 0.22 mg/kg from acute brain cholinesterase inhibition in adult female rat.

These acute endpoints were incorporated into a single-day food assessment. The same sources of consumption information and residue data that were used in the single-day and 21-day food assessments discussed in Section I.C were included in this sensitivity analysis. Specifically dietary consumption information from USDA's Continuing Survey of Food Intake by Individuals (1994-1996/1998) and data on OP residues found in food from USDA's Pesticide Data Program (1994-2004) were used to assess the single-day food exposure.

Table II.G-4.1 Summary Table of Acute Endpoints from Adult or Juvenile Rats from Single Dosing Studies for Some OPs.

OP	Acute endpoint (mg/kg)	Source	FQPA SF	Acute RPF (methamidophos equivalents)
Azinphos methyl	0.44	BMD_{10} for female pups (see below)	1	0.59
Chlorpyrifos	1.1	Estimated from Zheng et al (2000) in neonates	1	0.24
Malathion	52.5	BMD_{10} for female pups from Reiss (2006)	1	0.0050
Methyl parathion	0.15	BMD_{10} for female pups (see below)	1	1.73
Acephate	0.29	BMD_{10} for female adult rats (see below)	1	0.90
Diazinon	0.63	BMD_{10} for female adult rats (see below)	2	0.41
Dimethoate	2.19	BMD_{10} for female adult rats (see below). Other BMD estimates from same study can be found in USEPA, 2004.	1	0.12
Disulfoton	0.138	BMD_{10} for female adult rats (see below)	1	1.88
Methamidophos	0.26	BMD_{10} for female adult rats (see below)	2	1.00
Omethoate	0.18	BMD_{10} for female adult rats from TXR No. 0052940, April 11, 2005	1	1.44
ODM	0.5	estimated from MRID 43929901	10	0.52
Phosmet	9	estimated from MRID 44673301	10	0.029
Phorate	0.75	estimated from MRID 44719901	10	0.35
Methidathion	1	LOAEL from MRID 43145901, 43145902	10	0.26
Chlorpyrifos methyl	16.2	steady state BMD_{10}	10	0.016

3. Results

In Chapter I.C, the margins of exposure (MOEs) at 95th, 99th, and 99.9th percentiles of exposure are reported for the 21-day and single-day food assessments based on steady state endpoints. These MOEs were reported for various age groups, the mostly highly exposed of which were children 1-2 and 3-5 years old. Briefly, the MOEs for the 21-day assessment are above or very close to the target of 100 at the 99.9th percentile of exposure for all age groups; the MOEs for the 95th and 99th percentiles of exposure are well above 100.

In the single day analyses (using steady state RPFs and PoDs), at the 95th and 99th percentiles of exposure the MOEs for all age groups are above 100. However for the single-day analyses (using steady state RPFs and PoDs), the MOEs at the 99.9th percentile of exposure do not reach the target value of 100 for any of the age groups. More specifically, the MOEs at the 99.9th percentile of exposure for children 1-2 and children 3-5 years old are 31 and 35, respectively. MOEs of 100 were reached at approximately the 99.3rd and 99.5th percentile of exposure for children 1-2 and 3-5 years old, respectively (see Chapter I.C for detailed reporting of the MOEs).

When the RPFs based on single-day acute endpoints are incorporated into the single-day exposure food assessment, the MOEs at the 99.9th percentile exceeded the target of 100 for all age groups except children 1-2 and 3-5 years old. The MOEs for these two most highly exposed age groups reached the target of 100 at approximately the 99.7th and 99.8th percentiles of exposure, respectively. It is important to note that for most OPs, the steady state RPFs are included in this sensitivity analysis. In the event that acute toxicity information were used for more OPs in this analysis, the MOEs would increase as would the percentile at which the MOEs reach 100.

Table II.G.4 2-4 provides a comparison of MOEs at 99.9th percentiles of exposure from the 21-day and single-day food assessments presented in Chapter I.C and the single-day food assessment described in this Appendix. Tables II.G.4 3 and II.G.4 4 provide similar comparisons of the MOEs at the 99th and 95th percentiles of exposure. Although three age groups are presented in these Tables, the MOEs for the all other age groups exceed the target MOE of 100 at the percentiles presented.

Table II.G-4.2 Cumulative Food Assessment MOEs at the 99.9th Percentile Exposure.

	21-Day Analysis Based on Steady State Endpoints	Single-Day Analysis Based on Steady State Endpoints	Single-Day Analysis Based on Single-Day Endpoints
Children 1-2 yrs	110	30	52
Children 3-5 yrs	99	34	63
Adults 20-49 yrs	280	75	130

Table II.G-4.3 Cumulative Food Assessment MOEs at the 99th Percentile Exposure.

	21-Day Analysis Based on Steady State Endpoints	Single-Day Analysis Based on Steady State Endpoints	Single-Day Analysis Based on Single-Day Endpoints
Children 1-2 yrs	250	130	200
Children 3-5 yrs	300	160	250
Adults 20-49 yrs	610	290	480

Table II.G-4.4 Cumulative Food Assessment MOEs at the 95th Percentile Exposure.

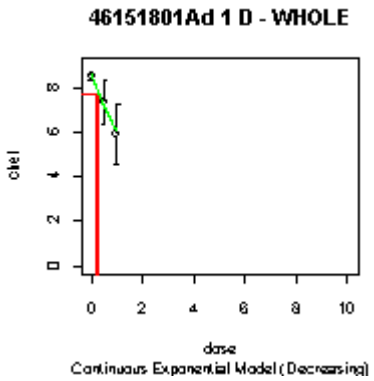
	21-Day Analysis Based on Steady State Endpoints	Single-Day Analysis Based on Steady-State Endpoints	Single-Day Analysis Based on Single-Day Endpoints
Children 1-2 yrs	550	440	610
Children 3-5 yrs	670	510	690
Adults 20-49 yrs	820	990	1400

4. Conclusion

In order to better characterize the single-day food exposure estimates, the Agency performed a sensitivity analysis that paired single day-exposure duration with single-day acute endpoints based on brain cholinesterase data. By incorporating endpoints from toxicity studies with exposure durations comparable to those being assessed in the food exposure, the Agency has a better understanding of the extent to which the use of steady state endpoints in the single-day food assessment overstates the risks of exposure to OPs. Based on this sensitivity analysis, the Agency concludes that 1) use of steady state endpoints in the single-day food assessment overestimates risk by almost 2-fold at the upper percentiles of exposure and 2) OP CRA was protective of potential peak exposures to multiple OPs in food.

5. BMD analysis for: Acephate

```
                    Acephate:1-D:BRAIN:F:WHOLE
                      Sun Feb 17 20:03:32 2002
               MRID: 46151801Ad   Guideline: NONGUIDELINE
               Continuous Exponential Model (Decreasing)
               Formula: chei = B + (A-B)*exp(-(m*dose)^g)

Variance Function: power

Highest 2 doses dropped from data set.


   The BMD corresponds to a dose that results in a 10% reduction in the
                    response relative to the control
    ------------------------------------------------------------------
                    Summary of Model Fitting Results

      AIC       BIC    logLik
114.57073 118.77432 -54.28537

Coefficients:
      Value Std.Error
A 8.6366705 0.5264088
m 0.3582992 0.0947503

Correlation:
          A         m
A 1.0000000 0.7728167
m 0.7728167 1.0000000

Approximate 95% confidence intervals

 Coefficients:
      lower      est.    upper
A 7.6229684 8.6366705 9.785175
m 0.2084456 0.3582992 0.615884

 Residual standard error:
   lower     est.    upper
1.433447 1.806305 2.442940

Degrees of freedom: 30 total; 28 residual
    ------------------------------------------------------------------
                            Goodness of Fit
 The chi-squared goodness-of-fit values should be taken as general
indications of fit only.  P-values are likely to be inaccurate to some
degree

Pearson Chi-Square Statistic: 0.2075 with 1 degrees of freedom.  P =
0.649

  dose  n chei Expected   sd   Exp.SD  X2 Resid.
1  0.0 10 8.53 8.636671 0.21 1.821972 -0.1851411
```



```
2  0.5 10 7.40 7.220091 1.44 1.529698  0.3719182
3  1.0 10 5.96 6.035858 1.90 1.284309 -0.1867796

    ------------------------------------------------------------------
                            BMD Computation

                     BMD = 0.2941:  BMDL = 0.2049

    ------------------------------------------------------------------
                            Potency Measures

A unit dose (1 mg/kg) would result in 100*exp(-Potency)% of background
activity

Potency: 0.3583
se: 0.09475
var=se^2: 0.008978
Per cent. of background at unit dose: 70
Per cent. of background at the highest dose: 70
ED50 (95% CI): 1.935 ( 1.152 , 3.248 )

ln(Potency) -1.026
se[log(Potency)]: 0.2644
se[log(Potency)]^2: 0.06993
```

Acephate:1-D:BRAIN:M:WHOLE
Sun Feb 17 20:05:00 2002
MRID: 46151801Ad Guideline: NONGUIDELINE
Continuous Exponential Model (Decreasing)
Formula: chei = B + (A-B)*exp(-(m*dose)^g)

Variance Function: power

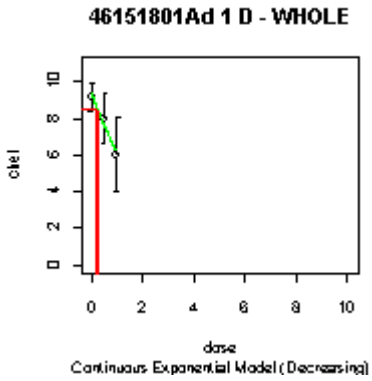
Highest 2 doses dropped from data set.

The BMD corresponds to a dose that results in a 10% reduction in the response relative to the control

---

Summary of Model Fitting Results

```
      AIC       BIC    logLik
139.48858 143.69217 -66.74429

Coefficients:
      Value Std.Error
A 9.4233756 0.8201802
m 0.4236354 0.1359193

Correlation:
          A         m
A 1.0000000 0.7704751
m 0.7704751 1.0000000

Approximate 95% confidence intervals

 Coefficients:
      lower      est.     upper
A 7.8845617 9.4233756 11.262517
m 0.2195680 0.4236354  0.817364

 Residual standard error:
   lower     est.    upper
2.213380 2.789110 3.772136

Degrees of freedom: 30 total; 28 residual
```



Goodness of Fit

The chi-squared goodness-of-fit values should be taken as general indications of fit only. P-values are likely to be inaccurate to some degree

Pearson Chi-Square Statistic: 0.415 with 1 degrees of freedom. P = 0.519

	dose	n	chei	Expected	sd	Exp.SD	X2 Resid.
1	0.0	10	9.19	9.423376	1.04	2.835597	-0.2602621
2	0.5	10	8.01	7.624568	1.89	2.317218	0.5259940
3	1.0	10	6.01	6.169131	2.85	1.893605	-0.2657450

BMD Computation

BMD = 0.2487: BMDL = 0.1628

Potency Measures

A unit dose (1 mg/kg) would result in 100*exp(-Potency)% of background activity

Potency: 0.4236
se: 0.1359
var=se^2: 0.01847
Per cent. of background at unit dose: 65
Per cent. of background at the highest dose: 65
ED50 (95% CI): 1.636 (0.8724 , 3.069)

ln(Potency) -0.8589
se[log(Potency)]: 0.3208
se[log(Potency)

Acephate:1-D:BRAIN:F:WHOLE
Sun Feb 17 20:06:14 2002
MRID: 46151801Pup Guideline: NONGUIDELINE
Continuous Exponential Model (Decreasing)
Formula: chei = B + (A-B)*exp(-(m*dose)^g)

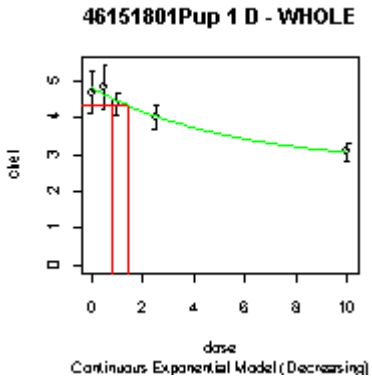
Variance Function: power

The BMD corresponds to a dose that results in a 10% reduction in the response relative to the control

---

Summary of Model Fitting Results

```
      AIC       BIC    logLik
 91.79047  99.43856 -41.89524

Coefficients:
      Value Std.Error
A 4.8229620 0.1653141
B 2.7338332 0.5168364
m 0.1831715 0.1177195

Correlation:
          A         B         m
A 1.0000000 0.5470928 0.6625012
B 0.5470928 1.0000000 0.9503303
m 0.6625012 0.9503303 1.0000000
```




```
Approximate 95% confidence intervals

 Coefficients:
       lower      est.     upper
A 4.50160020 4.8229620 5.1672654
B 1.86895853 2.7338332 3.9989351
m 0.05027613 0.1831715 0.6673504

 Residual standard error:
    lower      est.     upper
0.5610703 0.6739836 0.8442186

Degrees of freedom: 50 total; 47 residual
```

Goodness of Fit

```
 The chi-squared goodness-of-fit values should be taken as general
indications of fit only.  P-values are likely to be inaccurate to some
degree

Pearson Chi-Square Statistic: 1.695 with 2 degrees of freedom.  P =
0.429

  dose  n chei Expected   sd    Exp.SD   X2 Resid.
1  0.0 10 4.70 4.822962 0.80 0.6680708 -0.58203428
2  0.5 10 4.86 4.640128 0.86 0.6432862  1.08085114
3  1.0 10 4.39 4.473295 0.42 0.6205997 -0.42443042
4  2.5 10 4.04 4.055401 0.45 0.5634268 -0.08643678
5 10.0 10 3.07 3.068384 0.36 0.4252122  0.01202137
```

```
-------------------------------------------------------------------
                          BMD Computation

                  BMD = 1.433:  BMDL = 0.846

-------------------------------------------------------------------
                          Potency Measures

A unit dose (1 mg/kg) would result in 100*exp(-Potency)% of background
activity

Potency: 0.1832
se: 0.1177
var=se^2: 0.01386
Per cent. of background at unit dose: 83
Per cent. of background at the highest dose: 16
ED50 (95% CI): 3.784 ( 1.074 , 13.34 )

ln(Potency) -1.697
se[log(Potency)]: 0.6427
se[log(Potency)]^2: 0.413
```

Acephate:1-D:BRAIN:M:WHOLE
Sun Feb 17 20:06:48 2002
MRID: 46151801Pup Guideline: NONGUIDELINE
Continuous Exponential Model (Decreasing)
Formula: chei = B + (A-B)*exp(-(m*dose)^g)

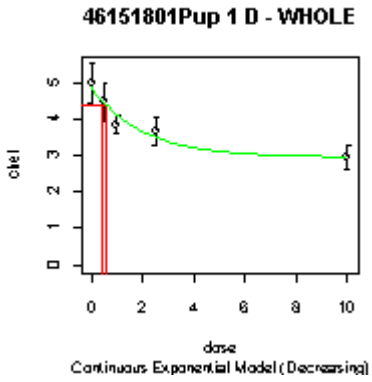
Variance Function: power

The BMD corresponds to a dose that results in a 10% reduction in the response relative to the control

---

Summary of Model Fitting Results

```
      AIC       BIC    logLik
 91.73380  99.38189 -41.86690

Coefficients:
      Value Std.Error
A 4.8538392 0.1916032
B 2.9464190 0.1488105
m 0.5017972 0.1441051

Correlation:
          A         B         m
A 1.0000000 0.1359877 0.5910295
B 0.1359877 1.0000000 0.5823909
m 0.5910295 0.5823909 1.0000000

Approximate 95% confidence intervals

 Coefficients:
      lower      est.     upper
A 4.4832911 4.8538392 5.2550135
B 2.6617570 2.9464190 3.2615241
m 0.2815946 0.5017972 0.8941948

 Residual standard error:
    lower      est.     upper
0.6092851 0.7319014 0.9167653

Degrees of freedom: 50 total; 47 residual
```



Goodness of Fit

The chi-squared goodness-of-fit values should be taken as general indications of fit only. P-values are likely to be inaccurate to some degree

Pearson Chi-Square Statistic: 3.052 with 2 degrees of freedom. P = 0.217

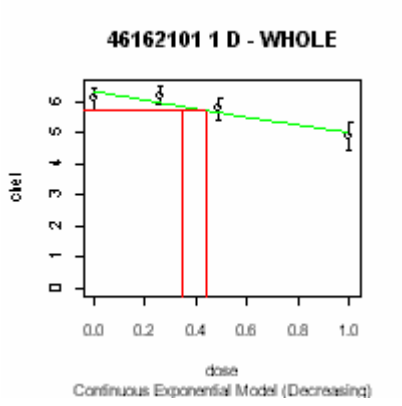
	dose	n	chei	Expected	sd	Exp.SD	X2 Resid.
1	0.0	10	4.96	4.853839	0.75	0.7240145	0.4636783
2	0.5	10	4.47	4.430585	0.73	0.6536323	0.1906897
3	1.0	10	3.84	4.101250	0.35	0.6006885	-1.3753328
4	2.5	10	3.64	3.490454	0.53	0.5083676	0.9302434
5	10.0	10	2.93	2.959042	0.47	0.4409028	-0.2082983

```
-------------------------------------------------------------------
                          BMD Computation

                  BMD = 0.5852:  BMDL = 0.3935

-------------------------------------------------------------------
                          Potency Measures

A unit dose (1 mg/kg) would result in 100*exp(-Potency)% of background
activity

Potency: 0.5018
se: 0.1441
var=se^2: 0.02077
Per cent. of background at unit dose: 61
Per cent. of background at the highest dose: 0.66
ED50 (95% CI): 1.381 ( 0.7868 , 2.425 )

ln(Potency) -0.6896
se[log(Potency)]: 0.2872
```

se[log(Potency)]^2: 0.08247

6. BMD analysis for: Azinphos methyl

```
                        Azinphos-methyl:1-D:BRAIN:F:WHOLE
                       Tue Jan 25 22:32:28 2005
                 MRID: 46162101   Guideline: NONGUIDELINE
               Continuous Exponential Model (Decreasing)
               Formula: chei = B + (A-B)*exp(-(m*dose)^g)

Variance Function: power


   The BMD corresponds to a dose that results in a 10% reduction in the
                    response relative to the control
    ------------------------------------------------------------------
                    Summary of Model Fitting Results

      AIC       BIC    logLik
 67.98541  73.05205 -30.99270

Coefficients:
      Value  Std.Error
A 6.3561429 0.14634233
m 0.2375225 0.04047062

Correlation:
          A         m
A 1.0000000 0.7634762
m 0.7634762 1.0000000

Approximate 95% confidence intervals

 Coefficients:
      lower      est.     upper
A 6.0666864 6.3561429 6.6594101
m 0.1682302 0.2375225 0.3353557

 Residual standard error:
    lower      est.     upper
0.4763423 0.5828629 0.7511810

Degrees of freedom: 40 total; 38 residual
    ------------------------------------------------------------------
                              Goodness of Fit
 The chi-squared goodness-of-fit values should be taken as general
indications of fit only.  P-values are likely to be inaccurate to some
degree

Pearson Chi-Square Statistic: 4.731 with 2 degrees of freedom.  P =
0.0939

  dose  n chei Expected  sd    Exp.SD  X2 Resid.
1 0.00 10  6.1 6.356143 0.5 0.5947195 -1.3619781
2 0.26 10  6.2 5.975489 0.4 0.5608027  1.2659842
3 0.49 10  5.8 5.657803 0.5 0.5324153  0.8445772
```



```
4 1.00 10  4.9 5.012322 0.6 0.4744902 -0.7485759

    ------------------------------------------------------------------
                              BMD Computation

                      BMD = 0.4436:  BMDL = 0.3465

    ------------------------------------------------------------------
                              Potency Measures

A unit dose (1 mg/kg) would result in 100*exp(-Potency)% of background
activity

Potency: 0.2375
se: 0.04047
var=se^2: 0.001638
Per cent. of background at unit dose: 79
Per cent. of background at the highest dose: 79
ED50 (95% CI): 2.918 ( 2.09 , 4.075 )

ln(Potency) -1.437
se[log(Potency)]: 0.1704
se[log(Potency)]^2: 0.02903
```

Azinphos-methyl:1-D:BRAIN:M:WHOLE
Tue Jan 25 22:32:43 2005
MRID: 46162101 Guideline: NONGUIDELINE
Continuous Exponential Model (Decreasing)
Formula: chei = B + (A-B)*exp(-(m*dose)^g)

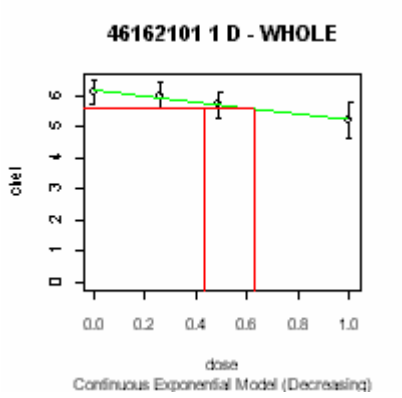
Variance Function: power

The BMD corresponds to a dose that results in a 10% reduction in the response relative to the control

---

Summary of Model Fitting Results

```
      AIC       BIC    logLik
 81.23741  86.30405 -37.61871

Coefficients:
      Value  Std.Error
A 6.1740066 0.16787774
m 0.1668837 0.04759997

Correlation:
          A         m
A 1.0000000 0.7648504
m 0.7648504 1.0000000

Approximate 95% confidence intervals

 Coefficients:
       lower      est.     upper
A 5.84334017 6.1740066 6.5233849
m 0.09367979 0.1668837 0.2972911

 Residual standard error:
    lower      est.     upper
0.5522574 0.6757542 0.8708973

Degrees of freedom: 40 total; 38 residual
```



Goodness of Fit

The chi-squared goodness-of-fit values should be taken as general indications of fit only. P-values are likely to be inaccurate to some degree

Pearson Chi-Square Statistic: 0.3202 with 2 degrees of freedom. P = 0.852

	dose	n	chei	Expected	sd	Exp.SD	X2 Resid.
1	0.00	10	6.1	6.174007	0.5	0.6833425	-0.34247732
2	0.26	10	6.0	5.911847	0.6	0.6546946	0.42579500
3	0.49	10	5.7	5.689230	0.6	0.6303551	0.05402769
4	1.00	10	5.2	5.225050	0.8	0.5795639	-0.13667817

BMD Computation

BMD = 0.6313: BMDL = 0.4297

Potency Measures

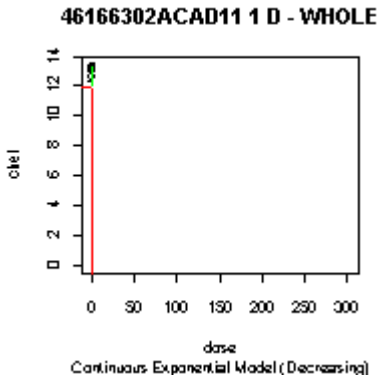
A unit dose (1 mg/kg) would result in 100*exp(-Potency)% of background activity

Potency: 0.1669
se: 0.0476
var=se^2: 0.002266
Per cent. of background at unit dose: 85
Per cent. of background at the highest dose: 85
ED50 (95% CI): 4.153 (2.375 , 7.264)

ln(Potency) -1.79
se[log(Potency)]: 0.2852
se[log(Potency)]^2: 0.08136

7. BMD analysis for: Diazinon

```
                        DIAZINON:1-D:BRAIN:F:WHOLE
                        Fri Jan 04 17:10:29 1980
              MRID: 46166302ACAD11   Guideline: NONGUIDELINE
                Continuous Exponential Model (Decreasing)
                Formula: chei = B + (A-B)*exp(-(m*dose)^g)

Variance Function: power

Highest 2 doses dropped from data set.


   The BMD corresponds to a dose that results in a 10% reduction in the
                    response relative to the control
    ------------------------------------------------------------------
                    Summary of Model Fitting Results

      AIC       BIC    logLik
12.023744 15.557906 -3.011872

Coefficients:
       Value  Std.Error
A 13.2366258 0.07685665
m  0.1662615 0.03335668

Correlation:
          A         m
A 1.0000000 0.6319335
m 0.6319335 1.0000000

Approximate 95% confidence intervals

 Coefficients:
       lower       est.      upper
A 13.0781907 13.2366258 13.3969802
m  0.1096711  0.1662615  0.2520528

 Residual standard error:
    lower      est.     upper
0.2267656 0.2932080 0.4149923

Degrees of freedom: 24 total; 22 residual
    ------------------------------------------------------------------
                              Goodness of Fit
 The chi-squared goodness-of-fit values should be taken as general
indications of fit only.  P-values are likely to be inaccurate to some
degree

Pearson Chi-Square Statistic: 0.8582 with 1 degrees of freedom.  P =
0.354

  dose n chei Expected  sd    Exp.SD   X2 Resid.
1 0.00 8 13.3 13.23663 0.2 0.2918109  0.61426556
2 0.03 8 13.1 13.17077 0.2 0.2903590 -0.68935997
```



```
3 0.30 8 12.6 12.59260 0.4 0.2776128  0.07541153

    ------------------------------------------------------------------
                              BMD Computation

                      BMD = 0.6337:  BMDL = 0.4765

    ------------------------------------------------------------------
                              Potency Measures

A unit dose (1 mg/kg) would result in 100*exp(-Potency)% of background
activity

Potency: 0.1663
se: 0.03336
var=se^2: 0.001113
Per cent. of background at unit dose: 85
Per cent. of background at the highest dose: 95
ED50 (95% CI): 4.169 ( 2.814 , 6.177 )

ln(Potency) -1.794
se[log(Potency)]: 0.2006
se[log(Potency)]^2: 0.04025
```

DIAZINON:1-D:BRAIN:M:WHOLE
Fri Jan 04 17:10:41 1980
MRID: 46166302ACAD11 Guideline: NONGUIDELINE
Continuous Exponential Model (Decreasing)
Formula: chei = B + (A-B)*exp(-(m*dose)^g)

Variance Function: power

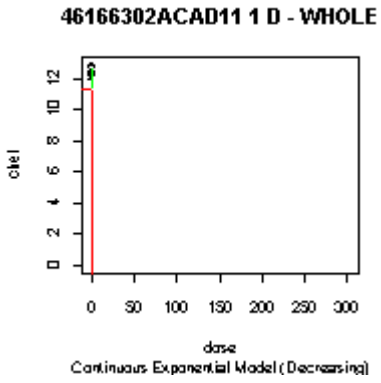
Highest 2 doses dropped from data set.

The BMD corresponds to a dose that results in a 10% reduction in the response relative to the control

---

Summary of Model Fitting Results

```
     AIC      BIC   logLik
3.077858 6.612020 1.461071

Coefficients:
       Value  Std.Error
A 12.5768854 0.06336178
m  0.1052754 0.02894230

Correlation:
          A         m
A 1.0000000 0.6319335
m 0.6319335 1.0000000

Approximate 95% confidence intervals

 Coefficients:
        lower       est.      upper
A 12.44616514 12.5768854 12.7089785
m  0.05952703  0.1052754  0.1861827

 Residual standard error:
    lower      est.     upper
0.1878795 0.2429283 0.3438288

Degrees of freedom: 24 total; 22 residual
```



Goodness of Fit

The chi-squared goodness-of-fit values should be taken as general indications of fit only. P-values are likely to be inaccurate to some degree

Pearson Chi-Square Statistic: 4.744 with 1 degrees of freedom. P = 0.0294

	dose	n	chei	Expected	sd	Exp.SD	X2 Resid.
1	0.00	8	12.7	12.57689	0.3	0.2405733	1.4474623
2	0.03	8	12.4	12.53723	0.1	0.2398147	-1.6184846
3	0.30	8	12.2	12.18588	0.2	0.2330941	0.1713184

BMD Computation

BMD = 1.001: BMDL = 0.6892

Potency Measures

A unit dose (1 mg/kg) would result in 100*exp(-Potency)% of background activity

Potency: 0.1053
se: 0.02894
var=se^2: 0.0008377
Per cent. of background at unit dose: 90
Per cent. of background at the highest dose: 97
ED50 (95% CI): 6.584 (3.841 , 11.29)

ln(Potency) -2.251
se[log(Potency)]: 0.2749
se[log(Potency)]^2: 0.07558

DIAZINON:1-D:BRAIN:F:WHOLE
Fri Jan 04 17:10:54 1980
MRID: 46166302ACPU11 Guideline: NONGUIDELINE
Continuous Exponential Model (Decreasing)
Formula: chei = B + (A-B)*exp(-(m*dose)^g)

Variance Function: power

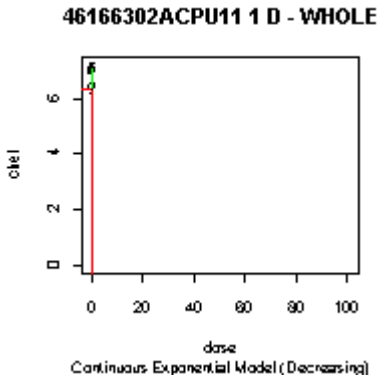
Highest 2 doses dropped from data set.

The BMD corresponds to a dose that results in a 10% reduction in the response relative to the control

---

Summary of Model Fitting Results

```
       AIC        BIC     logLik
-12.586972  -9.052810   9.293486

Coefficients:
      Value  Std.Error
A 7.0868338 0.04691799
m 0.3406463 0.03803346

Correlation:
          A         m
A 1.0000000 0.6319335
m 0.6319335 1.0000000

Approximate 95% confidence intervals

 Coefficients:
      lower      est.     upper
A 6.9901967 7.0868338 7.1848067
m 0.2702358 0.3406463 0.4294024

 Residual standard error:
    lower      est.     upper
0.1380279 0.1784701 0.2525979

Degrees of freedom: 24 total; 22 residual
```



Goodness of Fit

The chi-squared goodness-of-fit values should be taken as general indications of fit only. P-values are likely to be inaccurate to some degree

```
Pearson Chi-Square Statistic: 0.1007 with 1 degrees of freedom.  P =
0.751

  dose n chei Expected  sd    Exp.SD   X2 Resid.
1 0.00 8  7.1 7.086834 0.2 0.1781391  0.20904876
2 0.03 8  7.0 7.014779 0.1 0.1763279 -0.23707302
3 0.30 8  6.4 6.398380 0.2 0.1608337  0.02849558
```

BMD Computation

BMD = 0.3093: BMDL = 0.2613

Potency Measures

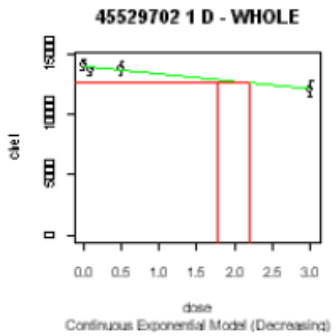
A unit dose (1 mg/kg) would result in 100*exp(-Potency)% of background activity

Potency: 0.3406
se: 0.03803
var=se^2: 0.001447
Per cent. of background at unit dose: 71
Per cent. of background at the highest dose: 90
ED50 (95% CI): 2.035 (1.635 , 2.533)

ln(Potency) -1.077
se[log(Potency)]: 0.1117
se[log(Potency)]^2: 0.01247

8. BMD analysis for: Dimethoate

```
                    DIMETHOATE:1-D:BRAIN:F:WHOLE
                      Wed Aug 18 20:21:06 2004
                MRID: 45529702   Guideline: NONGUIDELINE
               Continuous Exponential Model (Decreasing)
               Formula: chei = B + (A-B)*exp(-(m*dose)^g)

Variance Function: power


   The BMD corresponds to a dose that results in a 10% reduction in the
                        response relative to the control
    ------------------------------------------------------------------
                        Summary of Model Fitting Results

      AIC       BIC    logLik
 511.0838  515.4810 -252.5419

Coefficients:
         Value     Std.Error
A 1.400226e+04 1.530550e+02
m 4.801487e-02 7.186638e-03

Correlation:
          A         m
A 1.0000000 0.5913828
m 0.5913828 1.0000000

Approximate 95% confidence intervals

 Coefficients:
         lower          est.         upper
A 1.369314e+04 1.400226e+04 1.431835e+04
m 3.536891e-02 4.801487e-02 6.518233e-02

 Residual standard error:
   lower     est.    upper
563.8050 705.5395 943.0758

Degrees of freedom: 32 total; 30 residual
    ------------------------------------------------------------------
                              Goodness of Fit
 The chi-squared goodness-of-fit values should be taken as general
indications of fit only.  P-values are likely to be inaccurate to some
degree

Pearson Chi-Square Statistic: 2.517 with 2 degrees of freedom.  P =
0.284

  dose n      chei Expected       sd   Exp.SD   X2 Resid.
1  0.0 8 14150.00 14002.26 554.8488 698.0731  0.59861865
2  0.1 8 13625.00 13935.19 444.8114 694.7413 -1.26283056
3  0.5 8 13850.00 13670.10 687.1265 681.5724  0.74655058
4  3.0 8 12106.25 12123.84 826.5408 604.7383 -0.08228062
```



BMD Computation

BMD = 2.194: BMDL = 1.761

Potency Measures

A unit dose (1 mg/kg) would result in 100*exp(-Potency)% of background activity

Potency: 0.04801
se: 0.007187
var=se^2: 5.165e-05
Per cent. of background at unit dose: 95
Per cent. of background at the highest dose: 87
ED50 (95% CI): 14.44 (10.77 , 19.36)

ln(Potency) -3.036
se[log(Potency)]: 0.1497
se[log(Potency)]^2: 0.0224

DIMETHOATE:1-D:BRAIN:M:WHOLE
Wed Aug 18 20:21:12 2004
MRID: 45529702 Guideline: NONGUIDELINE
Continuous Exponential Model (Decreasing)
Formula: chei = B + (A-B)*exp(-(m*dose)^g)

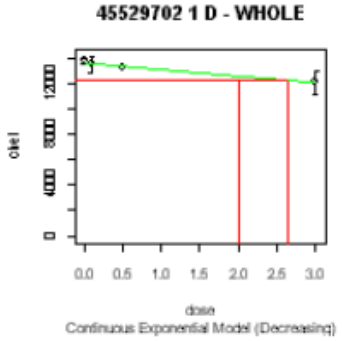
Variance Function: power

The BMD corresponds to a dose that results in a 10% reduction in the response relative to the control

---

Summary of Model Fitting Results

```
      AIC       BIC    logLik
 515.1097  519.5069 -254.5549
```



Coefficients:

```
         Value     Std.Error
A 1.365711e+04 161.84622769
m 3.992759e-02   0.00778649
```

Correlation:

```
          A         m
A 1.0000000 0.5916283
m 0.5916283 1.0000000
```

Approximate 95% confidence intervals

Coefficients:

```
         lower          est.         upper
A 1.333055e+04 1.365711e+04 1.399168e+04
m 2.681049e-02 3.992759e-02 5.946226e-02
```

Residual standard error:

```
   lower     est.    upper
595.7456 745.5096 996.5029
```

Degrees of freedom: 32 total; 30 residual

Goodness of Fit

The chi-squared goodness-of-fit values should be taken as general indications of fit only. P-values are likely to be inaccurate to some degree

Pearson Chi-Square Statistic: 0.4635 with 2 degrees of freedom. P = 0.793

```
  dose n      chei Expected        sd   Exp.SD   X2 Resid.
1  0.0 8 13793.75 13657.11  247.0360 738.2140  0.52351076
2  0.1 8 13543.75 13602.69  802.4238 735.2619 -0.22674697
3  0.5 8 13293.75 13387.17  241.1838 723.5707 -0.36517900
4  3.0 8 12131.25 12115.41 1096.4024 654.5977  0.06846042
```

BMD Computation

BMD = 2.639: BMDL = 1.998

Potency Measures

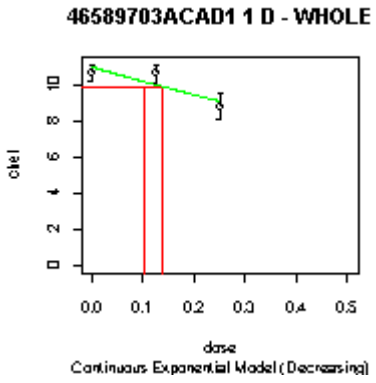
A unit dose (1 mg/kg) would result in 100*exp(-Potency)% of background activity

Potency: 0.03993
se: 0.007786
var=se^2: 6.063e-05
Per cent. of background at unit dose: 96
Per cent. of background at the highest dose: 89
ED50 (95% CI): 17.36 (11.85 , 25.44)

ln(Potency) -3.221
se[log(Potency)]: 0.195
se[log(Potency)]^2: 0.03803

9. BMD analysis for: Disulfoton

```
                    DISULFOTON:1-D:BRAIN:F:WHOLE
                       Fri Jan 04 18:43:46 1980
              MRID: 46589703ACAD1   Guideline: NONGUIDELINE
                Continuous Exponential Model (Decreasing)
                Formula: chei = B + (A-B)*exp(-(m*dose)^g)

Variance Function: power

Highest 1 doses dropped from data set.


   The BMD corresponds to a dose that results in a 10% reduction in the
                       response relative to the control
    ------------------------------------------------------------------
                       Summary of Model Fitting Results

      AIC       BIC    logLik
 43.86740  46.53852 -18.93370

Coefficients:
      Value Std.Error
A 11.084294 0.2999007
m  0.762279 0.1683987

Correlation:
          A         m
A 1.0000000 0.7723353
m 0.7723353 1.0000000

Approximate 95% confidence intervals

 Coefficients:
       lower      est.     upper
A 10.4664220 11.084294 11.738641
m  0.4772279  0.762279  1.217593

 Residual standard error:
    lower      est.     upper
0.5830565 0.7828680 1.1914695

Degrees of freedom: 18 total; 16 residual
    ------------------------------------------------------------------
                              Goodness of Fit
 The chi-squared goodness-of-fit values should be taken as general
indications of fit only.  P-values are likely to be inaccurate to some
degree

Pearson Chi-Square Statistic: 6.682 with 1 degrees of freedom.  P =
0.00974

   dose n  chei  Expected    sd    Exp.SD X2 Resid.
1 0.000 6 10.74 11.084294 0.423 0.8038437 -1.049140
2 0.125 6 10.71 10.076886 0.500 0.7347869  2.110553
```



```
3 0.250 6  8.87  9.161037 0.712 0.6716626 -1.061385

    ---------------------------------------------------------------
                            BMD Computation

                    BMD = 0.1382:  BMDL = 0.1014

    ---------------------------------------------------------------
                            Potency Measures

A unit dose (1 mg/kg) would result in 100*exp(-Potency)% of background
activity

Potency: 0.7623
se: 0.1684
var=se^2: 0.02836
Per cent. of background at unit dose: 47
Per cent. of background at the highest dose: 83
ED50 (95% CI): 0.9093 ( 0.5897 , 1.402 )

ln(Potency) -0.2714
se[log(Potency)]: 0.2209
se[log(Potency)]^2: 0.0488
```

DISULFOTON:1-D:BRAIN:M:WHOLE
Fri Jan 04 18:43:53 1980
MRID: 46589703ACAD1 Guideline: NONGUIDELINE
Continuous Exponential Model (Decreasing)
Formula: chei = B + (A-B)*exp(-(m*dose)^g)

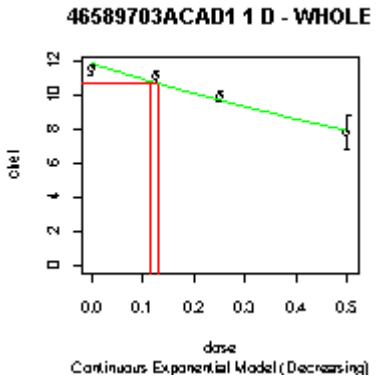
Variance Function: power

The BMD corresponds to a dose that results in a 10% reduction in the response relative to the control

---

Summary of Model Fitting Results

```
      AIC       BIC    logLik
 51.32418  54.85835 -22.66209

Coefficients:
       Value  Std.Error
A 11.9124247 0.24419930
m  0.8093126 0.07207062

Correlation:
          A         m
A 1.0000000 0.7614023
m 0.7614023 1.0000000

Approximate 95% confidence intervals

 Coefficients:
       lower       est.    upper
A 11.4166006 11.9124247 12.42978
m  0.6728372  0.8093126  0.97347

 Residual standard error:
    lower      est.     upper
0.5805750 0.7506838 1.0624814

Degrees of freedom: 24 total; 22 residual
```



Goodness of Fit

The chi-squared goodness-of-fit values should be taken as general indications of fit only. P-values are likely to be inaccurate to some degree

Pearson Chi-Square Statistic: 3.568 with 2 degrees of freedom. P = 0.168

	dose	n	chei	Expected	sd	Exp.SD	X2 Resid.
1	0.000	6	11.54	11.912425	0.300	0.7701785	-1.1844664
2	0.125	6	11.08	10.766268	0.323	0.6988619	1.0996225
3	0.250	6	9.92	9.730388	0.266	0.6341490	0.7324017
4	0.500	6	7.81	7.948042	0.926	0.5221452	-0.6475853

BMD Computation

BMD = 0.1302: BMDL = 0.1136

Potency Measures

A unit dose (1 mg/kg) would result in 100*exp(-Potency)% of background activity

Potency: 0.8093
se: 0.07207
var=se^2: 0.005194
Per cent. of background at unit dose: 45
Per cent. of background at the highest dose: 67
ED50 (95% CI): 0.8565 (0.7193 , 1.02)

ln(Potency) -0.2116
se[log(Potency)]: 0.08905
se[log(Potency)]^2: 0.00793

DISULFOTON:1-D:BRAIN:F:WHOLE
Fri Jan 04 18:44:04 1980
MRID: 46589704ACPU1 Guideline: NONGUIDELINE
Continuous Exponential Model (Decreasing)
Formula: chei = B + (A-B)*exp(-(m*dose)^g)

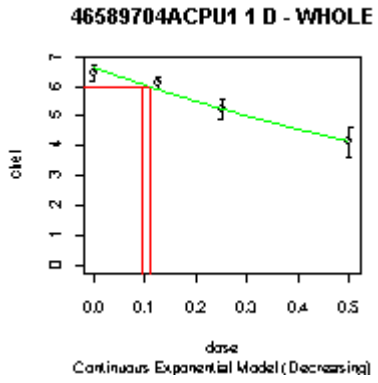
Variance Function: power

The BMD corresponds to a dose that results in a 10% reduction in the response relative to the control

---

Summary of Model Fitting Results

```
      AIC       BIC    logLik
 73.55314  78.61978 -33.77657

Coefficients:
      Value  Std.Error
A 6.6436319 0.17322549
m 0.9404764 0.09151811

Correlation:
          A         m
A 1.0000000 0.7619614
m 0.7619614 1.0000000

Approximate 95% confidence intervals

 Coefficients:
      lower      est.    upper
A 6.3020495 6.6436319 7.003729
m 0.7723146 0.9404764 1.145253

 Residual standard error:
    lower      est.     upper
0.5642684 0.6904511 0.8898384

Degrees of freedom: 40 total; 38 residual
```



Goodness of Fit

The chi-squared goodness-of-fit values should be taken as general indications of fit only. P-values are likely to be inaccurate to some degree

Pearson Chi-Square Statistic: 1.927 with 2 degrees of freedom. P = 0.382

	dose	n	chei	Expected	sd	Exp.SD	X2 Resid.
1	0.000	10	6.47	6.643632	0.388	0.7057578	-0.7779896
2	0.125	10	6.13	5.906771	0.280	0.6293962	1.1215727
3	0.250	10	5.23	5.251636	0.508	0.5612968	-0.1218960
4	0.500	10	4.12	4.151296	0.732	0.4464055	-0.2216976

BMD Computation

BMD = 0.112: BMDL = 0.09657

Potency Measures

A unit dose (1 mg/kg) would result in 100*exp(-Potency)% of background activity

Potency: 0.9405
se: 0.09152
var=se^2: 0.008376
Per cent. of background at unit dose: 39
Per cent. of background at the highest dose: 62
ED50 (95% CI): 0.737 (0.609 , 0.8919)

ln(Potency) -0.06137
se[log(Potency)]: 0.09731
se[log(Potency)]^2: 0.009469

DISULFOTON:1-D:BRAIN:M:WHOLE
Fri Jan 04 18:44:12 1980
MRID: 46589704ACPU1 Guideline: NONGUIDELINE
Continuous Exponential Model (Decreasing)
Formula: chei = B + (A-B)*exp(-(m*dose)^g)

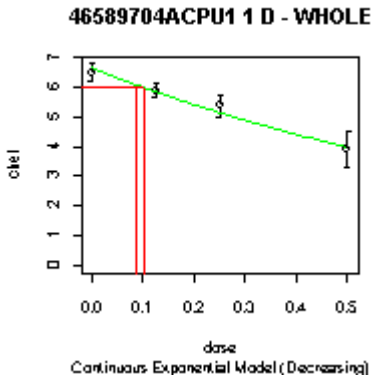
Variance Function: power

The BMD corresponds to a dose that results in a 10% reduction in the response relative to the control

---

Summary of Model Fitting Results

```
      AIC       BIC    logLik
 86.02089  91.08752 -40.01044

Coefficients:
     Value Std.Error
A 6.668492 0.2059587
m 1.033329 0.1089400

Correlation:
         A        m
A 1.000000 0.760291
m 0.760291 1.000000

Approximate 95% confidence intervals

 Coefficients:
      lower     est.    upper
A 6.2643172 6.668492 7.098744
m 0.8347373 1.033329 1.279168

 Residual standard error:
    lower      est.     upper
0.6719825 0.8222525 1.0597012

Degrees of freedom: 40 total; 38 residual
```



Goodness of Fit

The chi-squared goodness-of-fit values should be taken as general indications of fit only. P-values are likely to be inaccurate to some degree

Pearson Chi-Square Statistic: 2.08 with 2 degrees of freedom. P = 0.354

	dose	n	chei	Expected	sd	Exp.SD	X2 Resid.
1	0.000	10	6.49	6.668492	0.416	0.8375500	-0.6739183
2	0.125	10	5.90	5.860457	0.369	0.7404007	0.1688910
3	0.250	10	5.38	5.150333	0.538	0.6545200	1.1096240
4	0.500	10	3.88	3.977800	0.859	0.5114876	-0.6046525

BMD Computation

BMD = 0.102: BMDL = 0.08689

Potency Measures

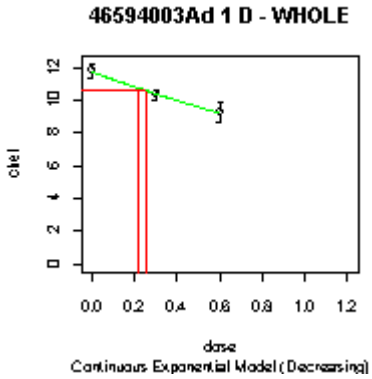
A unit dose (1 mg/kg) would result in 100*exp(-Potency)% of background activity

Potency: 1.033
se: 0.1089
var=se^2: 0.01187
Per cent. of background at unit dose: 36
Per cent. of background at the highest dose: 60
ED50 (95% CI): 0.6708 (0.5456 , 0.8248)

ln(Potency) 0.03279
se[log(Potency)]: 0.1054
se[log(Potency)]^2: 0.01111

10. BMD analysis for: Methamidophos

```
                    Methamidophos:1-D:BRAIN:F:WHOLE
                        Sun Feb 17 20:34:28 2002
                  MRID: 46594003Ad   Guideline: NONGUIDELINE
                  Continuous Exponential Model (Decreasing)
                  Formula: chei = B + (A-B)*exp(-(m*dose)^g)

Variance Function: power

Highest 1 doses dropped from data set.


   The BMD corresponds to a dose that results in a 10% reduction in the
                       response relative to the control
    ------------------------------------------------------------------
                       Summary of Model Fitting Results

      AIC       BIC    logLik
 27.83708  30.50820 -10.91854

Coefficients:
       Value  Std.Error
A 11.7415463 0.19811091
m  0.4025792 0.04353016

Correlation:
          A         m
A 1.0000000 0.7750096
m 0.7750096 1.0000000

Approximate 95% confidence intervals

 Coefficients:
       lower       est.      upper
A 11.3289921 11.7415463 12.1691240
m  0.3201118  0.4025792  0.5062919

 Residual standard error:
    lower      est.     upper
0.3972568 0.5333953 0.8117898

Degrees of freedom: 18 total; 16 residual
    ------------------------------------------------------------------
                              Goodness of Fit
 The chi-squared goodness-of-fit values should be taken as general
indications of fit only.  P-values are likely to be inaccurate to some
degree

Pearson Chi-Square Statistic: 0.299 with 1 degrees of freedom.  P =
0.585

  dose n  chei  Expected    sd    Exp.SD  X2 Resid.
1  0.0 6 11.79 11.741546 0.462 0.5316938  0.2232240
```



```
2  0.3 6 10.32 10.405763 0.245 0.4707343 -0.4462707
3  0.6 6  9.26  9.221945 0.606 0.4167640  0.2236627

    ------------------------------------------------------------------
                            BMD Computation

                     BMD = 0.2617:  BMDL = 0.2222

    ------------------------------------------------------------------
                            Potency Measures

A unit dose (1 mg/kg) would result in 100*exp(-Potency)% of background
activity

Potency: 0.4026
se: 0.04353
var=se^2: 0.001895
Per cent. of background at unit dose: 67
Per cent. of background at the highest dose: 79
ED50 (95% CI): 1.722 ( 1.393 , 2.128 )

ln(Potency) -0.9099
se[log(Potency)]: 0.1081
se[log(Potency)]^2: 0.01169
```

Methamidophos:1-D:BRAIN:M:WHOLE
Sun Feb 17 20:35:03 2002
MRID: 46594003Ad Guideline: NONGUIDELINE
Continuous Exponential Model (Decreasing)
Formula: chei = B + (A-B)*exp(-(m*dose)^g)

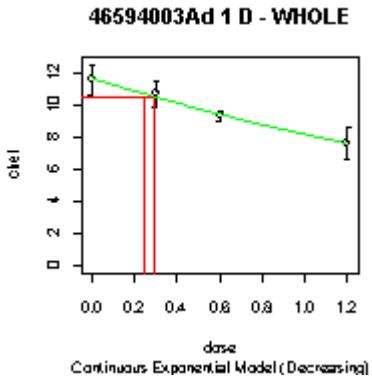
Variance Function: power

The BMD corresponds to a dose that results in a 10% reduction in the response relative to the control

---

Summary of Model Fitting Results

```
      AIC       BIC    logLik
 60.62975  64.16391 -27.31488

Coefficients:
       Value  Std.Error
A 11.6774231 0.30115998
m  0.3599319 0.03754709

Correlation:
         A        m
A 1.000000 0.763505
m 0.763505 1.000000

Approximate 95% confidence intervals

 Coefficients:
       lower       est.      upper
A 11.0692642 11.6774231 12.3189950
m  0.2899110  0.3599319  0.4468645

 Residual standard error:
    lower      est.     upper
0.7306618 0.9447461 1.3371477

Degrees of freedom: 24 total; 22 residual
```



Goodness of Fit

The chi-squared goodness-of-fit values should be taken as general indications of fit only. P-values are likely to be inaccurate to some degree

Pearson Chi-Square Statistic: 0.5066 with 2 degrees of freedom. P = 0.776

	dose	n	chei	Expected	sd	Exp.SD	X2 Resid.
1	0.0	6	11.58	11.677423	0.92	0.9520748	-0.25064938
2	0.3	6	10.68	10.482192	0.81	0.8549987	0.56670237
3	0.6	6	9.30	9.409297	0.31	0.7678208	-0.34867669
4	1.2	6	7.59	7.581712	0.94	0.6192252	0.03278316

BMD Computation

BMD = 0.2927: BMDL = 0.2499

Potency Measures

A unit dose (1 mg/kg) would result in 100*exp(-Potency)% of background activity

Potency: 0.3599
se: 0.03755
var=se^2: 0.00141
Per cent. of background at unit dose: 70
Per cent. of background at the highest dose: 65
ED50 (95% CI): 1.926 (1.57 , 2.363)

ln(Potency) -1.022
se[log(Potency)]: 0.1043
se[log(Potency)]^2: 0.01088

Methamidophos:1-D:BRAIN:F:WHOLE
Sun Feb 17 20:35:35 2002
MRID: 46594004Pup Guideline: NONGUIDELINE
Continuous Exponential Model (Decreasing)
Formula: chei = B + (A-B)*exp(-(m*dose)^g)

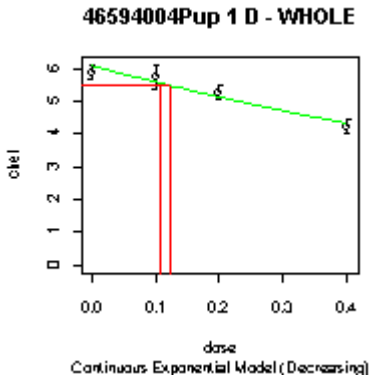
Variance Function: power

The BMD corresponds to a dose that results in a 10% reduction in the response relative to the control

---

Summary of Model Fitting Results

```
      AIC       BIC    logLik
 41.32496  46.31564 -17.66248

Coefficients:
      Value  Std.Error
A 6.0844265 0.11060609
m 0.8573064 0.08206989

Correlation:
          A         m
A 1.0000000 0.7565147
m 0.7565147 1.0000000

Approximate 95% confidence intervals

 Coefficients:
      lower      est.    upper
A 5.8643944 6.0844265 6.312714
m 0.7061503 0.8573064 1.040818

 Residual standard error:
    lower      est.     upper
0.3556643 0.4362566 0.5644058

Degrees of freedom: 39 total; 37 residual
```



Goodness of Fit

The chi-squared goodness-of-fit values should be taken as general indications of fit only. P-values are likely to be inaccurate to some degree

Pearson Chi-Square Statistic: 5.558 with 2 degrees of freedom. P = 0.0621

	dose	n	chei	Expected	sd	Exp.SD	X2 Resid.
1	0.0	10	5.88	6.084427	0.299	0.4487305	-1.4406276
2	0.1	10	5.74	5.584539	0.543	0.4134931	1.1889237
3	0.2	10	5.26	5.125721	0.299	0.3810228	1.1144414
4	0.4	9	4.22	4.318076	0.289	0.3235313	-0.9094258

BMD Computation

BMD = 0.1229: BMDL = 0.1062

Potency Measures

A unit dose (1 mg/kg) would result in 100*exp(-Potency)% of background activity

Potency: 0.8573
se: 0.08207
var=se^2: 0.006735
Per cent. of background at unit dose: 42
Per cent. of background at the highest dose: 71
ED50 (95% CI): 0.8085 (0.6702 , 0.9754)

ln(Potency) -0.154
se[log(Potency)]: 0.09573
se[log(Potency)]^2: 0.009164

Methamidophos:1-D:BRAIN:M:WHOLE
Sun Feb 17 20:36:06 2002
MRID: 46594004Pup Guideline: NONGUIDELINE
Continuous Exponential Model (Decreasing)
Formula: chei = B + (A-B)*exp(-(m*dose)^g)

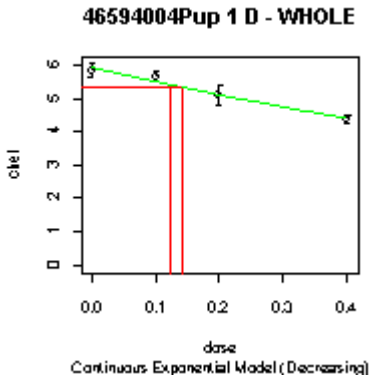
Variance Function: power

The BMD corresponds to a dose that results in a 10% reduction in the response relative to the control

---

Summary of Model Fitting Results

```
      AIC       BIC    logLik
15.656566 20.723205 -4.828283

Coefficients:
      Value  Std.Error
A 5.9354948 0.07809821
m 0.7491898 0.05757268

Correlation:
          A         m
A 1.0000000 0.7628871
m 0.7628871 1.0000000

Approximate 95% confidence intervals

 Coefficients:
      lower      est.     upper
A 5.7794803 5.9354948 6.0957208
m 0.6412533 0.7491898 0.8752943

 Residual standard error:
    lower      est.     upper
0.2558400 0.3130514 0.4034538

Degrees of freedom: 40 total; 38 residual
```



Goodness of Fit

The chi-squared goodness-of-fit values should be taken as general indications of fit only. P-values are likely to be inaccurate to some degree

Pearson Chi-Square Statistic: 3.792 with 2 degrees of freedom. P = 0.150

	dose	n	chei	Expected	sd	Exp.SD	X2 Resid.
1	0.0	10	5.82	5.935495	0.293	0.3185202	-1.146635272
2	0.1	10	5.65	5.507063	0.196	0.2959672	1.527220781
3	0.2	10	5.11	5.109556	0.409	0.2750110	0.005110363
4	0.4	10	4.37	4.398548	0.131	0.2374451	-0.380199278

BMD Computation

BMD = 0.1406: BMDL = 0.1249

Potency Measures

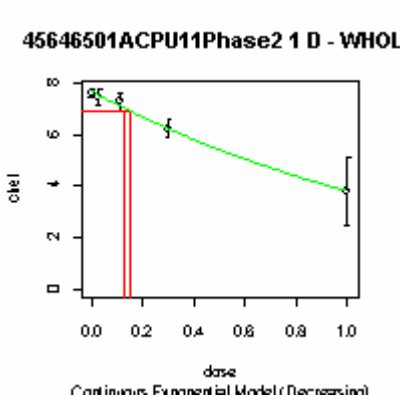
A unit dose (1 mg/kg) would result in 100*exp(-Potency)% of background activity

Potency: 0.7492
se: 0.05757
var=se^2: 0.003315
Per cent. of background at unit dose: 47
Per cent. of background at the highest dose: 74
ED50 (95% CI): 0.9252 (0.7958 , 1.076)

ln(Potency) -0.2888
se[log(Potency)]: 0.07685
se[log(Potency)]^2: 0.005905

11. BMD analysis for: Methyl parathion

```
                METHYL PARATHION:1-D:BRAIN:F:WHOLE
                      Fri Jan 04 14:23:23 1980
          MRID: 45646501ACPU11Phase2   Guideline: NONGUIDELINE
               Continuous Exponential Model (Decreasing)
               Formula: chei = B + (A-B)*exp(-(m*dose)^g)

Variance Function: power


   The BMD corresponds to a dose that results in a 10% reduction in the
                        response relative to the control
    ------------------------------------------------------------------
                        Summary of Model Fitting Results

      AIC       BIC    logLik
128.17946 133.24610 -61.08973

Coefficients:
      Value  Std.Error
A 7.7267980 0.28009260
m 0.7052234 0.07745722

Correlation:
          A         m
A 1.0000000 0.6121186
m 0.6121186 1.0000000

Approximate 95% confidence intervals

 Coefficients:
      lower      est.    upper
A 7.1800853 7.7267980 8.315139
m 0.5646286 0.7052234 0.880827

 Residual standard error:
   lower     est.    upper
1.134360 1.388028 1.788860

Degrees of freedom: 40 total; 38 residual
    ------------------------------------------------------------------
                              Goodness of Fit
 The chi-squared goodness-of-fit values should be taken as general
indications of fit only.  P-values are likely to be inaccurate to some
degree

Pearson Chi-Square Statistic: 0.1504 with 3 degrees of freedom.  P =
0.985

  dose n chei Expected    sd    Exp.SD    X2 Resid.
1 0.00 8 7.66 7.726798 0.199 1.3985679 -0.135090484
2 0.03 8 7.49 7.565042 0.360 1.3695188 -0.154981141
3 0.11 8 7.30 7.150054 0.426 1.2949706  0.327505621
4 0.30 8 6.25 6.253414 0.427 1.1337783 -0.008516336
```



```
5 1.00 8 3.81 3.817024 1.564 0.6947557 -0.028596565

    ----------------------------------------------------------------
                            BMD Computation

                    BMD = 0.1494:  BMDL = 0.1265

    ----------------------------------------------------------------
                            Potency Measures

A unit dose (1 mg/kg) would result in 100*exp(-Potency)% of background
activity

Potency: 0.7052
se: 0.07746
var=se^2: 0.006
Per cent. of background at unit dose: 49
Per cent. of background at the highest dose: 49
ED50 (95% CI): 0.9829 ( 0.7925 , 1.219 )

ln(Potency) -0.3492
se[log(Potency)]: 0.1098
se[log(Potency)]^2: 0.01206
```

METHYL PARATHION:1-D:BRAIN:M:WHOLE
Fri Jan 04 14:23:32 1980
MRID: 45646501ACPU11Phase2 Guideline: NONGUIDELINE
Continuous Exponential Model (Decreasing)
Formula: chei = B + (A-B)*exp(-(m*dose)^g)

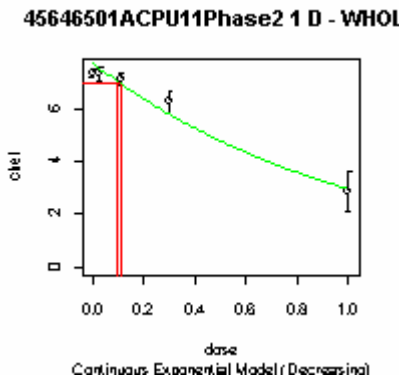
Variance Function: power

The BMD corresponds to a dose that results in a 10% reduction in the response relative to the control

---

Summary of Model Fitting Results

```
      AIC       BIC    logLik
102.81324 107.87987 -48.40662

Coefficients:
     Value  Std.Error
A 7.808377 0.21686653
m 0.963874 0.06213863

Correlation:
          A         m
A 1.0000000 0.5990743
m 0.5990743 1.0000000

Approximate 95% confidence intervals

 Coefficients:
      lower     est.    upper
A 7.3814671 7.808377 8.259976
m 0.8459437 0.963874 1.098245

 Residual standard error:
    lower      est.     upper
0.8454012 1.0344514 1.3331785

Degrees of freedom: 40 total; 38 residual
```



Goodness of Fit

The chi-squared goodness-of-fit values should be taken as general indications of fit only. P-values are likely to be inaccurate to some degree

Pearson Chi-Square Statistic: 4.648 with 3 degrees of freedom. P = 0.199

	dose	n	chei	Expected	sd	Exp.SD	X2 Resid.
1	0.00	8	7.40	7.808377	0.189	1.0752320	-1.0742457
2	0.03	8	7.41	7.585821	0.325	1.0469749	-0.4749847
3	0.11	8	7.18	7.022863	0.284	0.9752001	0.4557539
4	0.30	8	6.33	5.847621	0.514	0.8238399	1.6561161
5	1.00	8	2.89	2.978212	0.903	0.4425588	-0.5637685

BMD Computation

BMD = 0.1093: BMDL = 0.09883

Potency Measures

A unit dose (1 mg/kg) would result in 100*exp(-Potency)% of background activity

Potency: 0.9639
se: 0.06214
var=se^2: 0.003861
Per cent. of background at unit dose: 38
Per cent. of background at the highest dose: 38
ED50 (95% CI): 0.7191 (0.6338 , 0.816)

ln(Potency) -0.03679
se[log(Potency)]: 0.06447
se[log(Potency)]^2: 0.004156