APPENDIX

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CASE STUDIES

A.1 Trace Chemical Data for New England Biosolids

The U.S. EPA reviewed the potential risks posed by traces of chemicals (organic pollutants) found in sewage sludges and did not set regulatory standards for them, because one or more of the following applied to the trace chemicals identified in sewage sludges:

- "The pollutant has been banned for use…; has restricted use…; or is not manufactured for use in the United States.

- Based on the results of the National Sewage Sludge Survey (NSSS), the pollutant has a low percent detect in sewage sludge.
- Based on data from the NSSS, the limit for an organic pollutant in the Part 503 exposure assessment by use or disposal practice is not expected to be exceeded in sewage sludge that is used or disposed" (U.S. EPA Technical Support Document, Vol. 2, Appendix B).

U.S. EPA is currently developing numerical regulatory standards for dioxins and co-planar PCBs in land-applied biosolids because they are found in low levels in more than 5% of sewage sludges and they persist in the environment (they do not readily degrade in soils, as do many chemical compounds).

Because EPA does not require testing for trace chemicals, in New England, as elsewhere, there is less data on the levels of trace chemicals in biosolids than there is data for trace metals. However, several states (e.g. Maine and New Hampshire) require testing for trace chemicals, and several other large wastewater treatment facilities test for them routinely (e.g. Massachusetts Water Resources Authority).

In 1993, Morin and Switzenbaum of the Civil Engineering Department at the University of Massachusetts at Amherst reviewed the literature regarding levels of trace organic chemicals in sewage sludges around the U.S. They found "the concentrations of individual trace organics measured in the EPA [e.g. the 1988 National Sewage Sludge Survey] and other studies exhibit wide variability between sludges from different municipalities but are consistently very low."

Morin and Switzenbaum also completed testing for about 160 organic chemical compounds on several biosolids compost products from western Massachusetts. Testing included volatile organics, semi-volatile organics, and pesticides. Their report stated: "It is evident from the results that very few trace organic compounds were detected in either the parent sludge (raw compost) or finished compost samples." The only chemicals detected, and the levels found, are listed in Chart A-1.

In its 1998 publication "Target Organic Compounds in Maine Biosolids," the Maine Wastewater Control Association noted that "in the State of Maine, biosolids from larger public wastewater treatment facilities have been tested for organic priority pollutants for many years. The data generated has generally shown either very low levels of or no organic priority pollutants…. Over the course of four years of testing from thirteen treatment plants in Maine, only twelve organic priority pollutants were detected more than once" (Maine Wastewater Control Association, 1998).

Chart A-1: Only a few trace chemicals were detected, at low levels, out of about 160 tested for in several western Massachusetts biosolids composts.

(adapted from Morin & Switzenbaum Table 5-1)

Sample location and date	Compounds detected in finished compost	Concentration (mg/kg) dry wt.
1) Holyoke, 10/1/92	Dimethyl disulfide	0.05
2) Springfield, 10/1/92	Lindane	1.1
	Bis (2-ethylhexyl) phthalate	*51
	Benzoic acid	58
	Acetone	*2.8
	Methylethyl ketone (MEK)	2.6
	Dimethyl disulfide	1.8
3) Williamstown, 10/8/92	Bis (2-ethylhexyl) phthalate	*0.86
	4-Methylphenol	0.73
	Methylethyl ketone (MEK)	0.26
	Acetone	*1.5
	Toluene	0.015

(adapted from Morin & Switzenbaum Table 5-2)

Sample location and date	Raw/Final compost	Compounds detected in compost	Concentration (mg/kg) dry wt.
4) Holyoke 11/19/92	Raw	Bis (2-ethylhexyl) phthalate	11
		Acetone	82
		Methylethyl ketone (MEK)	79
		Toluene	0.34
		Total xylenes	0.15
		Dimethyl disulfide	0.64
	Final	Bis (2-ethylhexyl) phthalate	37
		Pyrene	3.2
5) Holyoke 1/7/93	Raw	Bis (2-ethylhexyl) phthalate	*18
		Acetone	73
		Methylethyl ketone (MEK)	220
		Chloroform	0.084
		Ethylbenzene	0.031
		Toluene	0.42
		Total xylenes	0.18
	Final	Bis (2-ethylhexyl) phthalate	*39
		Dimethyl disulfide	0.72
6) Holyoke 3/18/93	Raw	Bis (2-ethylhexyl) phthalate	51
	Final	Bis (2-ethylhexyl) phthalate	59
		Dimethyl disulfide	0.36
7) Holyoke 6/23/93	Raw	Bis (2-ethylhexyl) phthalate	36
		Acetone	19
		Methylethyl ketone (MEK)	15
	Final	Bis (2-ethylhexyl) phthalate	46

*-Also detected in laboratory blank at a similar level.

During the period 1995 - 1998, the state of New Hampshire collected data and tested Lowell, MA biosolids for over 100 priority pollutant chemicals. Lowell's biosolids, at the time, were treated to Class B standards (Lowell is now developing a Class A process). Fourteen separate testing events occurred, spread over the three year period. Only about 20 chemicals were detected, some of them only once. Chart A-2 includes those chemicals most often detected.

Chart A-2: Trace chemicals found most often in tests of 14 different Lowell, MA biosolids samples, 1995 - 1998 (from NH-DES, May 19, 1998 memo).

Chemical compound name (and how many times out of 14 it was detected)	**Range of levels detected (mg/kg)**
Acetone (7)	0.14 - 18.92
Bis (2-ethylhexyl) pthalate (14)	1.593 -62.37
2-Butanone (5)	0.06 - 8.62
Chloroform (5)	0.026 - 0.625
p-Isopropyltoluene (6)	0.046 - 0.816
4-Methylphenol (5)	0.878 - 47.52
Toluene (12)	0.052 - 4.25
Total Cresol (6)	8.1 - 50

Since 1999, New Hampshire regulations have required four separate tests for 168 trace chemicals in any biosolids that are to be recycled in the state. This testing requirement has created more data, which is summarized in Chart A-4 (from Carpenter, 2000).

Finally, to put trace levels of chemicals--some of which are naturally-occurring and some of which are common in the environment--in perspective, it is useful to compare them to levels found in other materials. Chart A-3 provides such a comparison for two chemicals that show up in biosolids occasionally: acetone and methly-ethyl ketone (MEK or 2-Butanone), two chemicals that were of public concern when found in groundwater in New Hampshire.

Chart A-3: Comparing the levels of two chemical contaminants in New England biosolids to natural levels in other materials (from Carpenter, 2000).

Material	**Acetone**	**Methyl Ethyl Ketone**
	Median values mg/kg (dry weight)	
Biosolids	1.5	0.60
Dairy Manure (1 sample)	0.65	0.68
Dried beans	0.88	0.15
Split peas	0.53	0.11

Chart A-4: Trace chemicals found in New Hampshire biosolids from NH-DES Sludge Quality Testing for 168 compounds (from Carpenter, 2000).

Compound	% detection	Average (mg/kg)	Median (mg/kg)	possible sources
bis(2-Ethylhexyl)phthalate	88%	28.6	20	plasticizer, plastic pipes
3/4-Methylphenol	65%	41.6	8	decomposition by-product
Toluene	61%	1.5	0.19	vehicle exhaust, gas stations
4-Chloroaniline	53%	5.1	3.2	Dyes, biosynthesis?
2-Butanone(MEK)	52%	3.2	0.60	decomposition by-product
Acetone	49%	9.7	1.50	decomposition by-product
1,2,4-Trimethylbenzene	40%	0.09	0.05	
p-isopropyltoluene	37%	0.24	0.05	
1,4-Dichlorobenzene	37%	0.23	0.05	disinfectant
Phenol	34%	7.5	4.5	decomposition by-product
Chloroform	23%	0.05	0.03	by-product of water chlorination
1,3,5-Trimethylbenzene	23%	0.08	0.03	
mp-Xylene	21%	0.05	0.03	Engine exhaust, forest fires

Dioxins--a group of organic chemicals that are potentially harmful in very small amounts--are detectable in biosolids. Dioxins and related compounds (e.g. co-planar PCBs) are of environmental concern because of their resistance to decay or biodegradation in the environment. Most dioxins found in biosolids are likely there because of the fact that the largest source of dioxins is from aerial deposition and runoff carries dioxin from the environment into wastewater treatment systems. Some may also enter wastewater from industrial and domestic sources. The greatest human exposure to dioxins is through meat and dairy consumption: dioxin accumulates in animal fats. The U. S. EPA is currently assessing the potential risks of dioxins in biosolids. A U.S. EPA regulatory limit for dioxins in land applied biosolids is due to be finalized in December, 2001. Maine and New Hampshire already have strict limits on dioxins in biosolids.

What is known about dioxins in New England biosolids is (see Chart A-5, below):

- from recent test data, New England biosolids have low to average levels of dioxins in comparison to U. S. averages, and

- average levels of dioxins in New England biosolids are similar to dioxin levels currently found in background soils and other materials (e.g. yard and leaf waste composts).

In summary, the data that exists regarding the levels and potential risks of trace chemicals in New England (and other) biosolids is similar to that found in other parts of the country and the data reviewed in the U.S. EPA risk assessment process. Although additional research regarding a few chemicals is recommended (e.g. see R.V. Anderson), current scientific knowledge indicates that biosolids use does not create any significant risk from the trace chemicals they may contain.

Chart A-5: Levels of dioxins found in New England biosolids (from Carpenter, 2000). The group of chemicals called "dioxins" actually includes several individual chemicals of similar nature that are commonly reported with one summary value--the "TEQ." As is typical for dioxin reporting, the measurements here are parts per trillion (ppt - 1 ppt = 1 second in 30,000 years).

	Sampling years	Number of samples	Mean ppt (dry weight) TEQ	Median ppt (dry weight) TEQ
Maine	1995-1997	31	6.3	5.4
New Hampshire	1999/2000	95	5.2	3.5
Vermont	1997	28	11.2	8.6
NSSS	1988	208	83[1]	37[1]

1 Data taken from Jones, K.C. and A.P. Stewart 1996. *Dioxins and furans in sewage sludges*. Non-detects were reported as 1/2 the detection limit when calculating TEQ values.

Source	Concentration (ppt TEQ dry weight)
U.S. soils average	8
rural average	4
urban average	19
Leaf and yard waste compost	5 - 91 (29 samples)
Cow manure compost	3.4 (4 samples)
Fish	0.59
Human body burden	28

A.2 Trace Metal Data Sources

Biosolids use and disposal figures were obtained from state regulatory staff David Wright (ME), Cathy Jamieson (VT), Larry Polese (MA), Alex Pinto (RI), and Robert Norwood (CT) and checked against other published numbers (e.g. *Biocycle* magazine).

Biosolids production facilities nationwide are required to submit the results of their trace metals testing to their individual state departments of environmental protection and the U.S. Environmental Protection Agency. For this report, NEBRA collected and reviewed metals testing data from these archives.