APPENDIX B-
ECOLOGICAL BENCHMARKS

SURFACE WATER ECOLOGICAL BENCHMARKS

Canadian WQG

The National Guidelines and Standards Office of the Environmental Quality Branch of Environment Canada provides nationally approved, science-based guidelines for water quality. The Canadian Water Quality Guidelines (CWQG) are developed to provide basic scientific information about water quality parameters and ecologically relevant toxicological threshold values for Canadian species to protect specific water uses. In deriving Canadian water quality guidelines for aquatic life, all components of the aquatic ecosystem (e.g., algae, macrophytes, invertebrates, fish) are considered if the data are available. The goal is to protect all life stages during an indefinite exposure to water. The guidelines provide a numeric value or narrative statement outlining the recommended guideline for over 100 substances, which, if exceeded, may impair the health of Canadian ecosystems and their beneficial uses. In 1999, the Canadian Council of Ministers of the Environment released Canadian Environmental Quality Guidelines (CCME 1999) which included all media (i.e., water, soil air, sediment, and tissue).

The CWQGs are derived from the available literature on the effects of the substance or physical property (e.g., temperature) on various species for the protection of the appropriate use (e.g., aquatic life). Guidelines should not be regarded as a blanket value for national water quality; guidelines may need to be modified on a site-specific basis to account for local conditions. For most water quality variables, a single maximum value, which is not to be exceeded, is recommended as a Canadian water quality guideline. This maximum value is based on a long_term no_effect concentration. Unless otherwise specified, a guideline value refers to the total concentration in an unfiltered sample. When available, the lowest_observable_effects level (LOEL) from a chronic exposure study on the most sensitive native Canadian species is multiplied by a safety factor of 0.1 to arrive at the final guideline concentration. Alternatively, the lowest LC50 or EC50 from an acute exposure study is multiplied by an acute/chronic ratio or the appropriate application factor (i.e., 0.05 for nonpersistent variables; 0.01 for persistent variables) to determine the final guideline concentration.

Aluminum is dependent on pH, Ca2+, and DOC:

0.005 mg/L if pH < 6.5, Ca < 4 mg/L, DOC < 2 mg/L, or

0.1 mg/L if pH >=6.5, Ca >=4 mg/L, DOC >=2 mg/L

I did not enter a value for aluminum

Ammonia is pH dependent:

1.37 mg/L at pH 8.0 and temp 10 C, or

2.2 mg/L at pH 6.5 and temp 10 C

I did not enter a value for ammonia

Cadmium is hardness dependent:

Cd value = 0.001 * [10 ^{0.86 log(hardness)-3.2}]

Formula was for ug/L, so I multiplied by 0.001 to get it to mg/L.

Copper is hardness dependent:

0.002 mg/L at hardness 0-120 mg/L CaCO3

0.003 mg/L at hardness 120-180 mg/L

0.004 mg/L at hardness >180

entered 0.002 as default

Lead is hardness dependent:

0.001 mg/L at hardness from 0-60 mg/L CaCO3

0.002 from 60-120

0.004 from 120-180

0.007 at hardness >180

entered 0.002 as default

Nickel is hardness dependent:

0.025 mg/L at hardness from 0-60 mg/L CaCO3

0.065 from 60-120

0.11 from 120-180

0.15 at hardness >180

entered 0.065 as default

Obtained from Environment Canada's Canadian Environmental Quality Guidelines web page at http://www2.ec.gc.ca/ceqg_rcqe/water.htm.

EC20 Daphnids

This benchmark is the lowest test EC20 (20% effects concentration) values for daphnids. It represents the highest tested concentration not causing a reduction of as much as 20% in the reproductive output of female test organisms.

Suter, G.W. II. 1996. Toxicological benchmarks for screening contaminants of potential concern for effects on freshwater biota. Environ. Toxic. Chem. 15:1232-1241.

EC20 Fish

This benchmark is the lowest test EC20 (20% effects concentration) values for fish. It represents the highest tested concentration not causing a reduction of as much as 20% in the reproductive output of female test organisms.

Suter, G.W. II. 1996. Toxicological benchmarks for screening contaminants of potential concern for effects on freshwater biota. Environ. Toxic. Chem. 15:1232-1241.

EC25 Bass Population

This benchmark consists of estimates of the concentration causing a 25% reduction in the recruit abundance of a population of largemouth bass.

Suter, G.W. II. 1996. Toxicological benchmarks for screening contaminants of potential concern for effects on freshwater biota. Environ. Toxic. Chem. 15:1232-1241.

EC20 Sensitive Species

These benchmarks were derived similar to chronic criteria, except that the lowest EC20 for the chemical was used in place of the lowest chronic value.

Suter, G.W. II. 1996. Toxicological benchmarks for screening contaminants of potential concern for effects on freshwater biota. Environ. Toxic. Chem. 15:1232-1241.

EPA Region 4- Acute

These benchmarks, derived by the EPA's Southeastern region, are criteria or test endpoints divided by a factor of 10. The Region IV surface water screening values were obtained from Water Quality Criteria documents and represent the chronic ambient water quality criteria values for the protection of aquatic life. They are intended to protect 95% of the species, 95% of the time. If there was insufficient information available to derive a criterion, the lowest reported effect level was used with the application of a safety factor of ten to protect for a more sensitive species. A safety factor of ten was also used to derive a chronic value if only acute information was available. Since these numbers are based on conservative endpoints and sensitive ecological effects data, they represent a preliminary screening of site contaminant levels to determine if there is a need to conduct further investigations at the site. Note that equations for hardness dependent metals do not match those in EPA (1999); the hardness equations should be the same and likely will be updated in the near future.

EPA Region 4- Chronic

These benchmarks, derived by the EPA's Southeastern region, are criteria or test endpoints divided by a factor of 10. The Region IV surface water screening values were obtained from Water Quality Criteria documents and represent the chronic ambient water

quality criteria values for the protection of aquatic life. They are intended to protect 95% of the species, 95% of the time. If there was insufficient information available to derive a criterion, the lowest reported effect level was used with the application of a safety factor of ten to protect for a more sensitive species. A safety factor of ten was also used to derive a chronic value if only acute information was available. Since these numbers are based on conservative endpoints and sensitive ecological effects data, they represent a preliminary screening of site contaminant levels to determine if there is a need to conduct further investigations at the site. Note that equations for hardness dependent metals do not match those in EPA (1999); the hardness equations should be the same and likely will be updated in the near future.

EPA Region 5 EDQLs

The EDQL reference database consists of Region 5 media-specific (soil, water, sediment, and air) EDQLs for RCRA Appendix IX hazardous constituents. The EDQLs are initial screening levels with which the site contaminant concentrations can be compared. The EDQLs help to focus the investigation on those areas and chemicals that are most likely to pose an unacceptable risk to the environment. EDQLs also impact the data requirements for the planning and implementation of field investigations. The ecological risk assessment will be further refined based on the initial screening. EDQLs alone are not intended to serve as cleanup levels. http://www.epa.gov/Region5/rcraca/edql.htm

LCV Aquatic Plants

The lowest acceptable chronic value for aquatic plants is based on the geometric mean of the Lowest Observed Effect Concentration and the No Observed Effect Concentration. Chronic values are used to calculate the chronic NAWQC, but the lowest chronic value may be lower than the chronic NAWQC. Because of the short generation time of algae and the relative lack of standard chronic tests for aquatic plants, EPA guidelines are followed in using any algal test of at least 96-hour duration and any biologically meaningful response for the plant values.

Suter, G.W. II and C.L. Tsao 1996. Toxicological benchmarks for screening potential contaminants of concern for effects on aquatic biota: 1996 revision. ES/ER/TM-96/R2. Oak Ridge National Laboratory, Oak Ridge, TN. (http://www.hsrd.ornl.gov/ecorisk/tm96r2.pdf)

LCV Daphnids

The lowest acceptable chronic value for daphnids is based on either the geometric mean of the Lowest Observed Effect Concentration and the No Observed Effect Concentration or an extrapolation from 48-hour LC50s using equations from Suter et al (1987) and Suter (1993).

The equations for a daphnid CV for a metallic contaminant is:

$$\text{Log CV} = 0.96 \log \text{LC50} - 1.08 \quad (\text{PI} = 1.56)$$

For a non-metallic contaminant:

$$\text{Log CV} = 1.11 \log \text{LC50} - 1.30 \quad (\text{PI} = 1.35)$$

The LC50 is the lowest species mean 48-hour EC50 for Daphnids. The 95% prediction interval is log CV +- the PI value (95% prediction intervals contain 95% of observations).

Suter, G.W. II and C.L. Tsao 1996. Toxicological benchmarks for screening potential contaminants of concern for effects on aquatic biota: 1996 revision. ES/ER/TM-96/R2. Oak Ridge National Laboratory, Oak Ridge, TN. (http://www.hsrd.ornl.gov/ecorisk/tm96r2.pdf)

Suter, G.W. II, A.E. Rosen, E. Linder, and D.F. Parkhurst 1987. End points for responses of fish to chronic toxic exposures. Environmental Toxicology and Chemistry 6:793-809.

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

LCV Fish

The lowest acceptable chronic value for fish is based on either the geometric mean of the Lowest Observed Effect Concentration and the No Observed Effect Concentration or an extrapolation from 96-hour LC50s using equations from Suter et al (1987) and Suter (1993).

The equations for a fish CV for a metallic contaminant is:

$$\text{Log CV} = 0.73 \log \text{LC50} - 0.70 \quad (\text{PI} = 1.2)$$

For a non-metallic contaminant:

$$\text{Log CV} = 1.07 \log \text{LC50} - 1.51 \quad (\text{PI} = 1.5)$$

The LC50 is the lowest species mean 96-hour EC50 for fish. The 95% prediction interval is log CV +- the PI value (95% prediction intervals contain 95% of observations).

Suter, G.W. II and C.L. Tsao 1996. Toxicological benchmarks for screening potential contaminants of concern for effects on aquatic biota: 1996 revision. ES/ER/TM-96/R2. Oak Ridge National Laboratory, Oak Ridge, TN. (http://www.hsrd.ornl.gov/ecorisk/tm96r2.pdf)

Suter, G.W. II, A.E. Rosen, E. Linder, and D.F. Parkhurst 1987. End points for responses of fish to chronic toxic exposures. Environmental Toxicology and Chemistry 6:793-809.

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

LCV Non-Daphnid Inverts

The lowest acceptable chronic value for aquatic plants is based on the geometric mean of the Lowest Observed Effect Concentration and the No Observed Effect Concentration. Chronic values are used to calculate the chronic NAWQC, but the lowest chronic value may be lower than the chronic NAWQC. Because of the short generation time of algae and the relative lack of standard chronic tests for aquatic plants, EPA guidelines are followed in using any algal test of at least 96-hour duration and any biologically meaningful response for the plant values.

Suter, G.W. II and C.L. Tsao 1996. Toxicological benchmarks for screening potential contaminants of concern for effects on aquatic biota: 1996 revision. ES/ER/TM-96/R2. Oak Ridge National Laboratory, Oak Ridge, TN. (http://www.hsrd.ornl.gov/ecorisk/tm96r2.pdf)

NAWQC- Acute

Acute National Ambient Water Quality Criteria. These criteria are applicable regulatory standards. The National Ambient Water Quality Criteria (NAWQC) are calculated by the EPA as half the Final Acute Value (FAV), which is the fifth percentile of the distribution of 48- to 96-hour LC50 values or equivalent median effective concentration (EC50) values for each criterion chemical (Stephan et al. 1985). The acute NAWQC are intended to correspond to concentrations that would cause less than 50% mortality in 5% of exposed populations in a brief exposure. They may be used as a reasonable upper screening benchmark because waste site assessments are concerned with sublethal effects and largely with continuous exposures, rather than the lethal effects and episodic exposures to which the acute NAWQC are applied. The chronic NAWQC are the FAVs divided by the Final Acute-Chronic Ratio (FACR), which is the geometric mean of quotients of at least three LC50/CV ratios from tests of different families of aquatic organisms (Stephan et al. 1985). It is intended to prevent significant toxic effects in chronic exposures and is used as a lower screening benchmark. NAWQC for several metals are functions of water hardness. Values for hardness-dependent metals default to 100 mg $CaCO_3$/L, but equations are provided to obtain values based on site-specific hardness values. Recommended values for metals are expressed in terms of dissolved metal in the water column.

United States Environmental Protection Agency. 1999. National Recommended Water Quality Criteria – Correction. Office of Water, U.S. Environmental Protection Agency, Washington, D.C. April. EPA 822-Z-99-001. (Available at http://www.epa.gov/ost/pc/revcom.pdf)

NAWQC- Chronic

Chronic National Ambient Water Quality Criteria. These criteria are applicable regulatory standards. The National Ambient Water Quality Criteria (NAWQC) are calculated by the EPA as half the Final Acute Value (FAV), which is the fifth percentile of the distribution of 48_ to 96-hour LC50 values or equivalent median effective concentration (EC50) values for each criterion chemical (Stephan et al. 1985). The acute NAWQC are intended to correspond to concentrations that would cause less than 50% mortality in 5% of exposed populations in a brief exposure. They may be used as a reasonable upper screening benchmark because waste site assessments are concerned with sublethal effects and largely with continuous exposures, rather than the lethal effects and episodic exposures to which the acute NAWQC are applied. The chronic NAWQC are the FAVs divided by the Final Acute-Chronic Ratio (FAC), which is the geometric mean of quotients of at least three LC50/CV ratios from tests of different families of aquatic organisms (Stephan et al. 1985). It is intended to prevent significant toxic effects in chronic exposures and is used as a lower screening benchmark. NAWQC for several metals are functions of water hardness. Values for hardness-dependent metals default to 100 mg $CaCO_3$/L, but equations are provided to obtain values based on site-specific hardness values. Recommended values for metals are expressed in terms of dissolved metal in the water column.

United States Environmental Protection Agency. 1999. National Recommended Water Quality Criteria – Correction. Office of Water, U.S. Environmental Protection Agency, Washington, D.C. April. EPA 822-Z-99-001. (Available at http://www.epa.gov/ost/pc/revcom.pdf)

Tier II SAV

These are secondary acute values that are conservative estimates of water quality criteria for those chemicals for which available data are insufficient to derive criteria. EPA developed Final Water Quality Guidance for the Great Lakes System. The final Guidance contains numeric acute and chronic criteria to protect aquatic life for 15 pollutants, and a two_tiered methodology to derive criteria (Tier I) or values (Tier II) for additional pollutants. Tier I aquatic life criteria for each chemical are based on laboratory toxicity data for a variety of aquatic species (e.g., fish and invertebrates) representative of species in freshwater. The Guidance also includes a Tier II methodology to be used in the absence of the full set of data needed to meet Tier I data requirements. The Tier I aquatic life methodology includes data requirements similar to current guidelines for developing national water quality criteria. For example, both require acceptable toxicity data for aquatic species in at least eight different families representing differing habitats and taxonomic groups. The Tier II aquatic life methodology is used to derive Tier II values, which can be calculated with fewer

toxicity data than Tier I. Tier II values can be based on toxicity data from a single taxonomic family, provided the data are acceptable. The Tier II methodology generally produces more stringent values than the Tier I methodology, reflecting greater uncertainty in the absence of additional toxicity data. The final Guidance expresses the criteria for metals in dissolved form because the dissolved metal more closely approximates the bioavailable fraction of metal in the water column than does the total recoverable metal. The dissolved criteria are obtained by multiplying the chronic and/or acute criterion by appropriate conversion factors.

The final Guidance also contains numeric criteria to protect wildlife for four pollutants and a methodology to derive Tier I criteria for additional persistent bioaccumulative pollutants. Wildlife criteria are derived to establish ambient concentrations of chemicals which, if not exceeded, will protect mammals and birds from adverse impacts from that chemical due to consumption of food and/or water from the Great Lakes System. The methodology focuses on endpoints related to reproduction and population survival rather than the survival of individual members of a species. The methodology incorporates pollutant_specific effect data for a variety of mammals and birds and species_specific exposure parameters for two mammals and three birds representative of mammals and birds in the Great Lakes basin that are likely to experience significant exposure to bioaccumulative contaminants through the aquatic food web.

EPA. 40 CFR Parts 9, 122, 123, 131, and 132. (http://www.mvaconsulting.com/glwqi.html#intro)

Tier II SCV

These are secondary chronic values that are conservative estimates of water quality criteria for those chemicals for which available data are insufficient to derive criteria. EPA developed Final Water Quality Guidance for the Great Lakes System. The final Guidance contains numeric acute and chronic criteria to protect aquatic life for 15 pollutants, and a two_tiered methodology to derive criteria (Tier I) or values (Tier II) for additional pollutants. Tier I aquatic life criteria for each chemical are based on laboratory toxicity data for a variety of aquatic species (e.g., fish and invertebrates) representative of species in freshwater. The Guidance also includes a Tier II methodology to be used in the absence of the full set of data needed to meet Tier I data requirements. The Tier I aquatic life methodology includes data requirements similar to current guidelines for developing national water quality criteria. For example, both require acceptable toxicity data for aquatic species in at least eight different families representing differing habitats and taxonomic groups. The Tier II aquatic life methodology is used to derive Tier II values, which can be calculated with fewer toxicity data than Tier I. Tier II values can be based on toxicity data from a single taxonomic family, provided the data are acceptable. The Tier II methodology generally produces more stringent values than the Tier I methodology, reflecting greater uncertainty in the absence of additional toxicity data. The final Guidance expresses the criteria for metals in dissolved form because the dissolved metal more closely approximates the bioavailable fraction of metal in the water column than does the total recoverable metal. The dissolved criteria are obtained by multiplying the chronic and/or acute criterion by appropriate conversion factors.

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EPA. 40 CFR Parts 9, 122, 123, 131, and 132. (http://www.mvaconsulting.com/glwqi.html#intro)

SEDIMENT ECOLOGICAL BENCHMARKS

ARCS NEC

U.S. EPA Assessment and Remediation of Contaminated Sediments Program. The representative effect concentration selected from among the high no-effect-concentrations for Hyalella azteca and Chironomus riparius are presented in EPA (1996) based on the ranking method presented in Jones et al. (1997). It is a concentration above which adverse effects to these organisms may occur. The majority of the data are for freshwater sediments. These are no effects benchmarks.

EPA (U.S. Environmental Protection Agency) 1996. Calculation and evaluation of sediment effect concentrations for the amphipod Hyalella azteca and the midge Chironomus riparius. EPA 905/R96/008. Great Lakes National Program Office, Chicago, IL. (http://www.cerc.usgs.gov/clearinghouse/data/brdcerc0004.html)

Jones, D.S. , G.W. Suter II, and R.N. Hull 1997. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Sediment-Associated Biota: 1997 Revision. ES/ER/TM-95/R3. Oak Ridge National Laboratory, Oak Ridge, Tennessee. (http://www.hsrd.ornl.gov/ecorisk/tm95r4.pdf)

ARCS TEC

U.S. EPA Assessment and Remediation of Contaminated Sediments Program. The representative effect concentration selected from among the ER-Ls and TELs for Hyalella azteca and Chironomus riparius are presented in EPA (1996) based on the ranking method presented in Jones et al. (1997). It is a concentration above which adverse effects to these organisms are not expected. The majority of the data are for freshwater sediments. These are possible-effects benchmarks.

EPA (U.S. Environmental Protection Agency) 1996. Calculation and evaluation of sediment effect concentrations for the amphipod Hyalella azteca and the midge Chironomus riparius. EPA 905/R96/008. Great Lakes National Program Office, Chicago, IL. (http://www.cerc.usgs.gov/clearinghouse/data/brdcerc0004.html)

Jones, D.S. , G.W. Suter II, and R.N. Hull 1997. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Sediment-Associated Biota: 1997 Revision. ES/ER/TM-95/R3. Oak Ridge National Laboratory, Oak Ridge, Tennessee. (http://www.hsrd.ornl.gov/ecorisk/tm95r4.pdf)

ARCS PEC

U.S. EPA Assessment and Remediation of Contaminated Sediments Program. The representative effect concentration selected from among the ER-MS and PELs for Hyalella azteca and Chironomus riparius are presented in EPA (1996) based on the ranking method presented in Jones et al. (1997). It is a concentration below which adverse effects to these organisms likely to occur. The majority of the data are for freshwater sediments. These are probable-effects benchmarks.

EPA (U.S. Environmental Protection Agency) 1996. Calculation and evaluation of sediment effect concentrations for the amphipod Hyalella azteca and the midge Chironomus riparius. EPA 905/R96/008. Great Lakes National Program Office, Chicago, IL. (http://www.cerc.usgs.gov/clearinghouse/data/brdcerc0004.html)

Jones, D.S. , G.W. Suter II, and R.N. Hull 1997. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Sediment-Associated Biota: 1997 Revision. ES/ER/TM-95/R3. Oak Ridge National Laboratory, Oak Ridge, Tennessee. (http://www.hsrd.ornl.gov/ecorisk/tm95r4.pdf)

Canadian ISQG

The Water Quality Guidelines Task Group of the Canadian Council of Ministers of the Environment (CCME) developed chemical concentrations recommended to support and maintain aquatic life associated with bed sediments. These values are derived from available scientific information on biological effects of sediment-associated chemicals and are intended to support the functioning of healthy ecosystems. The Sediment quality guidelines protocol relies on the National Status and Trends Program approach and the Spiked-Sediment Toxicity Test approach. The Interim Sediment Quality Guidelines (ISQG) correspond to threshold level effects below which adverse biological effects are not expected.

Obtained from Environment Canada's Canadian Environmental Quality Guidelines web page at http://www2.ec.gc.ca/ceqg_rcqe/sediment.htm.

Canadian PEL

The Water Quality Guidelines Task Group of the Canadian Council of Ministers of the Environment (CCME) developed chemical concentrations recommended to support and maintain aquatic life associated with bed sediments. These values are derived from available scientific information on biological effects of sediment-associated chemicals and are intended to support the functioning of healthy ecosystems. The Sediment quality guidelines protocol relies on the National Status and Trends Program approach and the Spiked-Sediment Toxicity Test approach. The Probable Effects Levels (PEL) correspond to concentrations above which adverse biological effects are frequently found.

Obtained from Environment Canada's Canadian Environmental Quality Guidelines web page at http://www2.ec.gc.ca/ceqg_rcqe/sediment.htm.

EPA Region 4

The higher of two values, the EPA Contract Laboratory Program Practical Quantitation Limit and the Effects Value, which is the lower of the ER-L and the TEL. These are possible effects benchmarks.

EPA Region IV (U.S. Environmental Protection Agency Region IV) 1995. Ecological screening values, Ecological Risk Assessment Bulletin No. 2, Waste Management Division. Atlanta, Georgia. (superceded by http://www.epa.gov/region4/wastepgs/oftecser/ecolbul.htm#tbl3)

EPA Region 5 EDQLs

The EDQL reference database consists of Region 5 media-specific (soil, water, sediment, and air) EDQLs for RCRA Appendix IX hazardous constituents. The EDQLs are initial screening levels with which the site contaminant concentrations can be compared. The EDQLs help to focus the investigation on those areas and chemicals that are most likely to pose an unacceptable risk to the environment. EDQLs also impact the data requirements for the planning and implementation of field investigations. The ecological risk assessment will be further refined based on the initial screening. EDQLs alone are not intended to serve as cleanup levels. http://www.epa.gov/Region5/rcraca/edql.htm

FDEP TEL

Sediment quality assessment guidelines developed for the State of Florida for 34 priority substances based on the approach recommended by Long and Morgan (1990). They are intended to assist sediment quality assessment applications, such as

identifying priority areas for non-point source management actions, designing wetland restoration projects, and monitoring trends in environmental contamination. They are not intended to be used as sediment quality criteria.

Long, E.R. and L.G. Morgan 1990. The potential for biological effects of sediment-sorbed contaminants tested in the National Status and Trends Program. NOAA Technical Memorandum NOS OMA 52. National Oceanic and Atmospheric Administration. Seattle, WA.

MacDonald, D.D. 1994. Approach to the Assessment of Sediment Quality in Florida Coastal Waters. Office of Water Policy, Florida Department of Environmental Protection, Tallahassee, Florida. (http://www.dep.state.fl.us/dwm/documents/sediment/volume1.pdf)

FDEP PEL

Sediment quality assessment guidelines developed for the State of Florida for 34 priority substances based on the approach recommended by Long and Morgan (1990). They are intended to assist sediment quality assessment applications, such as identifying priority areas for non-point source management actions, designing wetland restoration projects, and monitoring trends in environmental contamination. They are not intended to be used as sediment quality criteria.

Long, E.R. and L.G. Morgan 1990. The potential for biological effects of sediment-sorbed contaminants tested in the National Status and Trends Program. NOAA Technical Memorandum NOS OMA 52. National Oceanic and Atmospheric Administration. Seattle, WA.

MacDonald, D.D. 1994. Approach to the Assessment of Sediment Quality in Florida Coastal Waters. Office of Water Policy, Florida Department of Environmental Protection, Tallahassee, Florida. (http://www.dep.state.fl.us/dwm/documents/sediment/volume1.pdf)

NOAA ERL

1. NOAA's National Status and Trends Program. Sediment Quality Guidelines. As presented on NOAA web page at http://www_orca.nos.noaa.gov/projects/nsandt/sedimentquality.html, 4/26/2000. (Values for As, Cd, Cr, Cu, Pb, Hg, Ni, Ag, total DDT, total PCBs, and total PAH were obtained from this source.) http://response.restoration.noaa.gov/cpr/sediment/SPQ.pdf

2. Long, E. R., D. D. MacDonald, S. L. Smith, and F. D. Calder. 1995. "Incidence of Adverse Biological Effects within Ranges of Chemical Concentrations in Marine and Estuarine Sediments," *Environ. Manage*.19: 81-97. (Values for metals and organics not listed in 1 or 3 were obtained from this source.)

3. Long, E. R. and L. G. Morgan. 1991. *The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program*, National Oceanographic and Atmospheric Administration, Tech. Memorandum NOS OMA 52, August 1991. Seattle, Washington. (Values for DDD, DDT, Antimony, Chlordane, Dieldrin, and Endrin were obtained from this source.)

NOAA ERM

1. NOAA's National Status and Trends Program. Sediment Quality Guidelines. As presented on NOAA web page at http://www_orca.nos.noaa.gov/projects/nsandt/sedimentquality.html, 4/26/2000. (Values for As, Cd, Cr, Cu, Pb, Hg, Ni, Ag, total DDT, total PCBs, and total PAH were obtained from this source.) http://response.restoration.noaa.gov/cpr/sediment/SPQ.pdf

2. Long, E. R., D. D. MacDonald, S. L. Smith, and F. D. Calder. 1995. "Incidence of Adverse Biological Effects within Ranges of Chemical Concentrations in Marine and Estuarine Sediments," *Environ. Manage*.19: 81-97. (Values for metals and organics not listed in 1 or 3 were obtained from this source.)

Long, E. R. and L. G. Morgan. 1991. *The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program*, National Oceanographic and Atmospheric Administration, Tech. Memorandum NOS OMA 52, August 1991. Seattle, Washington. (Values for DDD, DDT, Antimony, Chlordane, Dieldrin, and Endrin were obtained from this source.)

NOAA SQUIRT (http://response.restoration.noaa.gov/cpr/sediment/squirt/squirt.html)

Ontario Low

Persaud, D., R. Jaagumagi, and A. Hayton. 1993. Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. Ontario Ministry of the Environment and Energy. August. ISBN 0-7729-9248-7. (Available at http://www.ene.gov.on.ca/envision/gp/B1_3.pdf)

Ontario Severe

Persaud, D., R. Jaagumagi, and A. Hayton. 1993. Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. Ontario Ministry of the Environment and Energy. August. ISBN 0-7729-9248-7. (Available at http://www.ene.gov.on.ca/envision/gp/B1_3.pdf)

OSWER

OSWER (Office of Solid Waste and Emergency Response). 1996. Ecotox thresholds. U.S. Environmental Protection Agency. ECO Update 3 (2):1–12. (http://www.epa.gov/superfund/resources/ecotox/eco_updt.pdf)

Washington AET

A concentration above which toxic effects occurred at all sites in Puget Sound. These are probable effects benchmarks.

SOIL ECOLOGICAL BENCHMARKS

Dutch Intervention

Target Values for soil are related to negligible risk for ecosystems. This is assumed to be 1% of the Maximal Permissible Risk (MPR) level for ecosystems, where MPR is the concentration expected to be hazardous for 5% of the species in the ecosystem, or the 95% protection level. For metals, background concentrations are taken into account in arriving at a value. The relationship between soil concentration and irreparable damage to terrestrial species composition and the relationship between soil concentration and adverse effects on microbial and enzymatic processes were derived to quantify the ecotoxicological effects on ecosystems. The ecological Intervention Value is the concentration expected to be hazardous to 50% of the species in the ecosystem. It cannot be assumed that sensitive species will be protected at the Intervention levels. Site concentrations less than Target Values indicate no restrictions necessary; concentrations between Target Values and Intervention Values suggests further investigation or restrictions may be warranted. Site concentrations exceeding the Intervention Value indicate remediation is necessary. Site-specific values based on percent clay and organic matter for metals and percent organic matter for organic compounds may be derived.

Swartjes, F.A. 1999. Risk-based Assessment of Soil and Groundwater Quality in the Netherlands: Standards and Remediation Urgency. Risk Analysis 19(6): 1235-1249

The Netherlands Ministry of Housing, Spatial Planning and Environment's Circular on target values and intervention values for soil remediation http://www.minvrom.nl/minvrom/docs/bodem/S&I2000.PDF and Annex A: Target Values, Soil Remediation Intervention Values and Indicative Levels for Serious Contamination http://www.minvrom.nl/minvrom/docs/bodem/annexS&I2000.PDF were also consulted, but they combine the ecological and human health values.

Dutch Target

Target Values for soil are related to negligible risk for ecosystems. This is assumed to be 1% of the Maximal Permissible Risk (MPR) level for ecosystems, where MPR is the concentration expected to be hazardous for 5% of the species in the ecosystem, or the 95% protection level. For metals, background concentrations are taken into account in arriving at a value. The relationship between soil concentration and irreparable damage to terrestrial species composition and the relationship between soil concentration and adverse effects on microbial and enzymatic processes were derived to quantify the ecotoxicological effects on ecosystems. The ecological Intervention Value is the concentration expected to be hazardous to 50% of the species in the ecosystem. It cannot be assumed that sensitive species will be protected at the Intervention levels. Site concentrations less than Target Values indicate no restrictions necessary; concentrations between Target Values and Intervention Values suggests further investigation or restrictions may be warranted. Site concentrations exceeding the Intervention Value indicate remediation is necessary. Site-specific values based on percent clay and organic matter for metals and percent organic matter for organic compounds may be derived.

Swartjes, F.A. 1999. Risk-based Assessment of Soil and Groundwater Quality in the Netherlands: Standards and Remediation Urgency. Risk Analysis 19(6): 1235-1249

The Netherlands Ministry of Housing, Spatial Planning and Environment's Circular on target values and intervention values for soil remediation http://www.minvrom.nl/minvrom/docs/bodem/S&I2000.PDF and Annex A: Target Values, Soil Remediation Intervention Values and Indicative Levels for Serious Contamination http://www.minvrom.nl/minvrom/docs/bodem/annexS&I2000.PDF were also consulted, but they combine the ecological and human health values.]

Eco-SSL Avian

Ecological soil screening levels. Still in draft form so not included in this SADA version.

Eco-SSL Inverts

Ecological soil screening levels. Still in draft form so not included in this SADA version.

Eco-SSL Mammalian

Ecological soil screening levels. Still in draft form so not included in this SADA version.

Eco-SSL Plants

Draft Ecological Soil Screening Level (Eco-SSL) Guidance. The Eco-SSL guidance provides a set of risk-based soil screening levels (Eco-SSLs) for many of the soil contaminants that are frequently of ecological concern for terrestrial plants and animals at hazardous waste sites. It also describes the process used to derive these levels and provides guidance for their use. Still in draft form so not included in this SADA version.

EPA 2000. Ecological Soil Screening Level Guidance DRAFT. Office of Emergency and Remedial Response. (http://www.epa.gov/superfund/programs/risk/ecorisk/ecossl.htm)

EPA Region IV

EPA 1995. Supplemental Guidance to RAGS: Region 4 Bulletins No. 2. Ecological Risk Assessment. Region IV, Waste Management Division. Office of Health Assessment. Values presented are as updated Aug. 1999. (http://www.epa.gov/region4/wastepgs/oftecser/epatab4.pdf)

EPA Region 5 EDQLs

The EDQL reference database consists of Region 5 media-specific (soil, water, sediment, and air) EDQLs for RCRA Appendix IX hazardous constituents. The EDQLs are initial screening levels with which the site contaminant concentrations can be compared. The EDQLs help to focus the investigation on those areas and chemicals that are most likely to pose an unacceptable risk to the environment. EDQLs also impact the data requirements for the planning and implementation of field investigations. The ecological risk assessment will be further refined based on the initial screening. EDQLs alone are not intended to serve as cleanup levels. http://www.epa.gov/Region5/rcraca/edql.htm

ORNL Invertebrates

Efroymson, R.A., M.E. Will, and G.W. Suter II. 1997b. Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-126/R2. (Available at http://www.hsrd.ornl.gov/ecorisk/tm126r21.pdf)

ORNL Microbes

Efroymson, R.A., M.E. Will, and G.W. Suter II. 1997b. Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-126/R2. (Available at http://www.hsrd.ornl.gov/ecorisk/tm126r21.pdf)

ORNL Plants

Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten. 1997a. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-85/R3. (Available at http://www.hsrd.ornl.gov/ecorisk/tm85r3.pdf)