Exhibit 22

 Exhibit 22

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
WATER POLLUTION CONTROL PERMIT

LOG NUMBERS: 2015-60414 **PERMIT NO.:** 2015-SC-60414

FINAL PLANS, SPECIFICATIONS, APPLICATION AND SUPPORTING DOCUMENTS
PREPARED BY: Archer Daniels Midland Company

DATE ISSUED: December 29, 2015

SUBJECT: ARCHER DANIELS MIDLAND COMPANY-Land Application of Industrial Biosolids

PERMITTEE TO OPERATE

Archer Daniels Midland Company
4666 Faries Parkway
Decatur, Illinois 62526

Permit is hereby granted to the above designated permittee(s) to operate water pollution control facilities described as follows:

Application of approximately 6000 dry tons per year of anaerobically digested industrial biosolids to agricultural lands at rates not to exceed the agronomic nitrogen demand of the crop grown.

This operating permit expires on November 30, 2020.

This Permit is issued subject to the following Special Condition(s). If such Special Condition(s) require(s) additional or revised facilities, satisfactory engineering plan documents must be submitted to this Agency for review and approval for issuance of a Supplemental Permit.

SPECIAL CONDITION 1: Sludge applied to land under this permit shall be incorporated within 24 hours or one working day, whichever is least. Off-site interim storage of sludge is prohibited under this permit.

SPECIAL CONDITION 2: For the duration of this permit, the permittee shall determine the quantity of sludge produced by the treatment facility in dry tons or gallons with a percent total solids analysis. The permittee shall maintain adequate records of the quantities of sludge produced and have said records available for Agency inspection. The permittee shall submit to the Agency a semi-annual summary report of the quantities of sludge generated and disposed (in units of dry tons) by different disposal methods including but not limited to application on farmland, application on reclamation land, landfilling, public distribution, dedicated land disposal, sod farms, storage lagoons or any other specified disposal method. Said reports shall be submitted to the Agency by January 31 and July 31 of each year reporting the preceding July through December and January through June sludge disposal operations respectively. The permittee shall submit the semi-annual sludge management report to the following address:

THE STANDARD CONDITIONS OF ISSUANCE INDICATED ON THE REVERSE SIDE MUST BE COMPLIED WITH IN FULL. READ ALL CONDITIONS CAREFULLY.

SAK:JCH:\\illinois.gov\epa\spiusers1\jeff.hutton\2015-60414.docx

DIVISION OF WATER POLLUTION CONTROL

Alan Keller by ALO

cc: EPA-Champaign FOS
Records - Municipal

Alan Keller, P.E.
Manager, Permit Section

LOG NUMBERS: 2015-60414 **PERMIT NO.:** 2015-SC-60414

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SUBJECT: ARCHER DANIELS MIDLAND COMPANY-Land Application of Industrial Biosolids

Illinois Environmental Protection Agency
Bureau of Water
Compliance Assurance Section
Mail Code #19
1021 North Grand Avenue East
Post Office Box 19276
Springfield, Illinois 62794-9276

SPECIAL CONDITION 3: For the duration of this permit, the permittee shall sample all different sludges being applied to land or publicly distributed on a quarterly basis and chemically analyze said samples in accordance with the recommended procedures contained in the latest edition of Standard Methods for the Examination of Water and Wastewater for the following parameters:

Nutrients	Metals	Other
Total Kjeldahl Nitrogen	Cadmium	pH
Ammonia Nitrogen	Copper	% TS
Phosphorus	Lead	% VS
Potassium	Manganese	
	Nickel	
	Zinc	

In addition to the above parameters, anaerobically digested sludge shall also be tested for volatile acids. The results of these analyses shall be submitted to this Agency on a quarterly basis. The permittee shall update the sludge application rate utilizing all sludge analyses obtained after the previous sludge application period.

SPECIAL CONDITION 4:

A. Sludge shall be applied to sites within the following guidelines:

1. Sludge shall not be applied to sites during precipitation.
2. Sludge shall not be applied to sites which are saturated or with ponded water.
3. Sludge shall not be applied to ice or snow covered sites.
4. Frozen land, which is not ice or snow covered and has a slope of 5% or less, may be used for land application of sludge provided a 200 foot grassy area exists between the sludge applied land and any surface water or potable water supply well.

B. It is not recommended that sludge be applied to sites:

1. When precipitation is imminent,
2. Which have received greater than 1/4 inch rainfall within the 24-hour period preceding the intended sludge application time.

C. Sludge shall not be applied to land which lies within 200 feet from a community water supply well, potable water supply well, surface waters or intermittent streams or within one-fourth of a mile of any potable water supply wells located in consolidated bedrock such as limestone or sinkhole areas unless a 50 foot depth of non-sandy or non-gravelly unconsolidated material exists. In no case shall sludge be applied within 400 feet of a community water supply well deriving water from an unconfined shallow fractured or highly permeable bedrock formation or from an unconsolidated and unconfined sand and gravel formation.

D. Sludge shall not be applied within 100 feet of an occupied residence.

E. Sludge shall not be applied to sites during the periods in which the seasonal high water table rises within 3 feet of the surface at the site.

F. Sludge shall only be applied to land with a background soil pH of 6.5 or greater unless lime or other suitable materials are applied to the site prior to sludge application to raise the soil pH to a minimum of 6.5.

G. Sludge amended land shall have a crop grown and harvested pursuant to normal agricultural practices.

H. The delivery and application of sludge, and the choice of an application site, shall be made so as to minimize the emission of odors to nearby residents taking into account the direction of wind, humidity and day of the week.

I. Sludge application shall not exceed the following maximum metal loading rates over the lifetime of a site (pounds per acre).

1. Soils with 5-15 meq/100 grams Cation Exchange Capacity (CEC):

Metal	Total Loading	Annual Loading
Cadmium	10	2
Nickel	100	--
Copper	250	--
Zinc	500	--
Manganese	900	--
Lead	1000	--

2. Soils with 0-5 meq/100 grams CEC shall apply only half the metal loading rates set forth in item I(1) above.

3. Soils with 15 or greater meq/100 grams CEC may apply double the total metal loading rates set forth in item I(1) above, however a supplemental permit shall be required for that specific site.

J. Users applying sludge to sites greater than 300 acres under common ownership or control or users of more than 1500 dry tons per year shall obtain a sludge user permit from this Agency unless the site is specifically identified in the permittee's application.

K. User information sheets, in conformance with the Design Criteria for Sludge Application on Land (Title 35, Subtitle C, Chapter II, Part 391), shall be provided by the permittee to all sludge users and shall be signed by sludge users requesting more than 25 cubic yards. Records regarding sludge users shall be retained by the permittee for the duration of this permit and 2 years after the expiration date of this permit.

L. No sooner than 90 days and no later than 7 days prior to the application of sludge to land written notice shall be provided to the owner(s) of the land receiving the sludge, the owners of land adjacent to the land receiving the sludge and the Township and County officials whose jurisdiction encompasses the sludge application site.

M. The permittee shall retain agronomic calculations and supporting sludge analyses for a period of not less than 5 years. Said sludge analysis shall be in compliance with 40 CFR 503.8 and 35 Ill. Adm. Code 391.501. Such records shall be available to any person or party upon request

READ ALL CONDITIONS CAREFULLY:
STANDARD CONDITIONS

The Illinois Environmental Protection Act (Illinois Revised Statutes Chapter 111-12. Section 1039) grants the Environmental Protection Agency authority to impose conditions on permits which it issues.

1. Unless the construction for which this permit is issued has been completed, this permit will expire (1) two years after the date of issuance for permits to construct sewers or wastewater sources or (2) three years after the date of issuance for permits to construct treatment works or pretreatment works.

2. The construction or development of facilities covered by this permit shall be done in compliance with applicable provisions of Federal laws and regulations, the Illinois Environmental Protection Act, and Rules and Regulations adopted by the Illinois Pollution Control Board.

3. There shall be no deviations from the approved plans and specifications unless a written request for modification of the project, along with plans and specifications as required, shall have been submitted to the Agency and a supplemental written permit issued.

4. The permittee shall allow any agent duly authorized by the Agency upon the presentations of credentials:

   a. to enter at reasonable times, the permittee's premises where actual or potential effluent, emission or noise sources are located or where any activity is to be conducted pursuant to this permit;

   b. to have access to and copy at reasonable times any records required to be kept under the terms and conditions of this permit;

   c. to inspect at reasonable times, including during any hours of operation of equipment constructed or operated under this permit, such equipment or monitoring methodology or equipment required to be kept, used, operated, calibrated and maintained under this permit;

   d. to obtain and remove at reasonable times samples of any discharge or emission of pollutants;

   e. to enter at reasonable times and utilize any photographic, recording, testing, monitoring or other equipment for the purpose of preserving, testing, monitoring, or recording any activity, discharge, or emission authorized by this permit.

5. The issuance of this permit:

   a. shall not be considered as in any manner affecting the title of the premises upon which the permitted facilities are to be located;

   b. does not release the permittee from any liability for damage to person or property caused by or resulting from the construction, maintenance, or operation of the proposed facilities;

   c. does not release the permittee from compliance with other applicable statutes and regulations of the United States, of the State of Illinois, or with applicable local laws, ordinances and regulations;

   d. does not take into consideration or attest to the structural stability of any units or parts of the project;

   e. in no manner implies or suggests that the Agency (or its officers, agents or employees) assumes any liability, directly or indirectly, for any loss due to damage, installation, maintenance, or operation of the proposed equipment or facility.

6. Unless a joint construction/operation permit has been issued, a permit for operating shall be obtained from the agency before the facility or equipment covered by this permit is placed into operation.

7. These standard conditions shall prevail unless modified by special conditions.

8. The Agency may file a complaint with the Board for suspension or revocation of a permit:

   a. upon discovery that the permit application contained misrepresentations, misinformation or false statement or that all relevant facts were not disclosed; or

   b. upon finding that any standard or special conditions have been violated; or

   c. upon any violation of the Environmental Protection Act or any Rules or Regulation effective thereunder as a result of the construction or development authorized by this permit.

Exhibit 23

Sanitary District of Decatur
501 DIPPER LANE • DECATUR, ILLINOIS 62522 • 217/422-6931 • FAX: 217/423-8171

Exhibit 23

February 1, 2016

Luther Pohlmann
Vice President Corn Processing
Archer Daniels Midland Company
4666 Faries Parkway
Decatur, IL 62526

Re: Executive Order 16-002

Dear Mr. Pohlmann:

Enclosed you will find Executive Order 16-002 as prescribed by Sanitary District of Decatur (SDD) Ordinance 94-01 section 500.105 and issued by the SDD. This notice is issued to ADM for violations of its wastewater discharge permit #200 as issued in accordance with SDD Ordinance 94-01 as amended. Should you have any questions regarding this matter you may call me at 422-6931, extension 213.

Sincerely,

Kent D Newton

Kent Newton
Acting Executive Director

PC: Dean Frommelt
Mark Atkinson
Brad Crookshank
Stephen F. Nightingale, P.E.
Keith Richard
Charles S. Jarvis
Ed Flynn

SANITARY DISTRICT OF DECATUR, ILLINOIS
Industrial Waste Division

IN THE MATTER OF:	*	
Archer Daniels Midland Company	*	**EXECUTIVE ORDER** 16-002

LEGAL AUTHORITY

The following findings are made and this order issued pursuant to the authority vested in the Executive Director under section 500.105 of the District's Pretreatment Ordinance. This Order is based on findings of violations of wastewater discharge permit 200 and the SDD Pretreatment Ordinance as amended.

FINDINGS

1. Archer Daniels Midland Company (hereafter, "ADM") discharges non-domestic wastewater containing pollutants into the combined sewer system of the Sanitary District of Decatur (hereafter, "SDD").

2. SDD issued the latest version of wastewater discharge permit 200 to ADM on April 29, 2015 The permit contains restrictions and other limitations on the quality and/or quantity of the wastewater ADM discharges into the sewer system.

3. The discharge permit issued to ADM includes a daily maximum total nickel limit of 22.226 pounds per day (ppd) and a monthly average total nickel limit of 7.231 ppd.

4. Pursuant to the above referenced permit, data is routinely collected or submitted on the compliance status of ADM.

5. This data shows that ADM violated its wastewater discharge permit in the following manner:

   a. On October 16, and October 28 through November 1, 2015, ADM exceeded their daily maximum nickel limit with nickel loadings of 23.178 pounds, 29.578 pounds, 79.642 pounds, 62.087 pounds, 40.346 pounds, and 28.756 pounds of total nickel, respectively.

   b. During the months of October and November 2015, ADM exceeded their monthly average total nickel limit with average nickel loadings of 12.702 and 11.130 pounds of nickel per day respectively.

ORDER

THEREFORE, BASED ON THE ABOVE FINDINGS, ADM IS HEREBY ORDERED TO:

1. Within three months from the date of this order, present to the SDD for approval a sludge management plan and a schedule identifying how ADM will reduce the excess solids in the anaerobic digester system within one year from the date of this order. It is estimated this will be about seven million pounds. The plan shall also include what procedures will be put in place to maintain the reduced sludge volume once the target reduction has been achieved. Upon

approval of the plan and schedule ADM shall provide the SDD pretreatment coordinator with written progress reports on a quarterly basis followed by a final report upon completion of the excess sludge removal. Quarterly reports shall be submitted within four, seven, and ten months of the date of approval of the plan by SDD. A final report shall be submitted within 60 days of the date that is one year after the approval date of the plan and shall provide justification for ceasing excess sludge removal if the total amount removed is less than the estimated seven million pounds. Upon completion of the excess sludge reduction initiative ADM shall begin or continue the procedures outlined in the approved sludge management plan which are designed to maintain the reduced sludge volumes used in the operation of the digester system.

All reports shall be submitted to the following address:

Sanitary District of Decatur
Attn: Charles S. Jarvis
Pretreatment Coordinator
501 S. Dipper Lane
Decatur, Illinois 62522

2. This order does not constitute a waiver of industrial discharge permit, #200, which remains in full force and effect. The District reserves the right to seek all remedies available to it in the Pretreatment Ordinance for any violation cited by this order, and to revoke ADM's discharge permit at any time.

3. Failure to comply with the requirements of this order shall constitute a further violation of the Pretreatment Ordinance and may subject ADM to such other enforcement responses as may be appropriate.

4. This order entered this 1st day of February 2016, shall be effective upon receipt by ADM.

Signed: ______________________

Kent Newton
Acting Executive Director
Sanitary District of Decatur
501 Dipper Lane
Decatur, IL 62522

Exhibit 24

Response to U.S. EPA Toxicity Testing Comments
Sanitary District of Decatur, Illinois

Comment 1. On p. 1 of "Water Effect Ratio Testing to Support a Site-Specific Water Quality Standard Request for the Sanitary District of Decatur, Illinois," the Sanitary District of Decatur (SDD) states:

> During the summer of 2013, Region 5 requested additional information demonstrating that the BLM is consistent with certain aspects of nickel aquatic toxicity studies reported in the scientific literature. These discussions also led to a recommendation from IEPA and Region 5 that the District perform aquatic toxicity testing on its effluent discharge using the water effect ratio ("WER") procedure. The District is therefore proposing to perform WER testing to serve as additional confirmation for the predicted BLM-based WER and for the proposed site-specific water quality standard.

EPA would like to clarify that the Agency raised the *option* of pursuing a WER-based site-specific nickel criterion as an alternative to a BLM-based approach. EPA has not endorsed one method over another, but has raised concerns about the degree to which the current iteration of the nickel BLM accounts for toxicological data reported in the scientific literature. EPA raised the option of conducting a WER study to derive a site-specific nickel criterion in the context of uncertainty around the technical defensibility of the nickel BLM.

With respect to the proposed toxicity testing work, per discussions with SDD, the permittee has elected to pursue a site-specific nickel criterion using a BLM-based approach. SDD has also chosen to pursue toxicity testing on *Ceriodaphhnia dubia* and *Pimephales promelas* (though not "WER tests," per EPA's current WER guidance documents). SDD expressed that these tests are intended to determine the degree to which the nickel BLM accurately predicts toxic responses in *C. dubia* and *P. promelas* when exposed to nickel in site water. EPA will not be able to approve a site-specific criterion for nickel unless one of the following occurs:

> 1) SDD:
> a. addresses, in a satisfactory manner, EPA's comments on the nickel BLM, generally, and EPA's comments on SDD's application of the nickel BLM to the SDD and the Sangamon River, specifically, as discussed on the December 5, 2013 conference call between EPA, IEPA, and SDD, and;
>
> b. the application of a satisfactory nickel BLM indicates that Illinois's statewide nickel criterion can be raised to reflect site-specific water quality conditions at the SDD.
>
> 2) SDD conducts a full WER study, as described in EPA guidance and provided to SDD on November 4, 2013, and this study indicates that Illinois's statewide nickel criterion can be raised to reflect site-specific conditions at the SDD.

Response: The wording of the document has been revised to incorporate U.S. EPA's clarifications. SDD recognizes the information needs for U.S. EPA to consider approval of a site-specific water quality standard. SDD is seeking acceptance of the testing procedure for the limited purpose noted in previous discussions and in U.S. EPA's comment.

Comment 2. On p. 2 of "Water Effect Ratio Testing to Support a Site-Specific Water Quality Standard Request for the Sanitary District of Decatur, Illinois," SDD states:

> A report prepared by Robert Santore of HDR l HydroQual describes the application of the nickel BLM to the Sangamon River downstream of the District's discharge. This report, "Estimate of the BLM Adjustment to the Nickel Criterion for the Sanitary District of Decatur, Illinois," dated April 16, 2013 is included as Attachment A. The report provides an overview of the BLM and summarizes site sampling data, and proposes a WER of 2.62. The report also includes a recommended site specific water quality standard of 38.2 ug/L, based on the IEPA-assigned critical hardness value of 359 mg/L.
>
> As noted above, one round of WER testing is planned to serve as additional confirmation for the predicted BLM-based WER. This testing is proposed to be consistent with U.S. EPA guidance and will include chemical analysis of all BLM parameters for additional confirmation of the model prediction.

EPA notes that the April 16, 2013 report and the WER value proposed therein have not been revised since EPA's August 27, 2013 comments on both the nickel BLM used to conduct the modeling and the model's application to SDD. As noted in Comment 1, EPA will not be able to approve a site-specific nickel criterion for SDD until SDD successfully addresses EPA's comments on the nickel BLM and its application to SDD, or SDD conducts a full WER test, as outlined in EPA guidance documents.

Response: The April 16, 2013 report has been updated to incorporate corrected calcium and magnesium values in Table 3. SDD recognizes that additional information will need to be provided to address U.S. EPA's comments regarding the BLM.

Comment 3. The selection of organisms for toxicity testing may impact the magnitude of the resulting WER.

According to EPA's Water Quality Standards Handbook Appendix L, the primary toxicity test used to determine the WER should have an endpoint in lab dilution water that is close to, but not lower than, the CMC to which the WER is applied (http://water.epa.gov/scitech/swguidance/standards/upload/2002_06_11_standards_handbook_handbookappxL.pdf, p.45; see also Appendix D, p. 122 at the same link). If the LC50 for *C. dubia* in laboratory water is below the CMC, then the resulting WER value may be inflated. Given the apparent sensitivity of *C. dubia* to nickel (and conflicting information on exactly how sensitive *C. dubia* are), using this organism as a test species may produce a WER that overestimates the degree to which the site-specific criterion can be raised without impacting the level of protection provided by the chronic aquatic life water quality criterion.

If the proposed toxicity testing is primarily aimed at confirming the WER that is derived from the BLM, then it is important to ensure that organisms used in toxicity testing do not compromise the resulting WER due to elevated sensitivity to nickel. Choosing a test species that has been shown to be less sensitive to nickel than *C. dubia* would be one way of ensuring that the resulting WER is not skewed by test organism sensitivity.

Response: The WER would be adjusting the Illinois standard, not the national ambient water quality criteria. The Illinois CMC at a hardness of 50 mg/L is 45.9 µg/L. The toxicity of nickel to *C. dubia* at this hardness is 81 µg/L (Keithly et al., 2004). Based on the WER guidance, therefore, *C. dubia* appears to be an appropriate organism choice for the WER test.

The only other acute options would be *D. magna*, *D. pulex*.

Comment 4. Section 3.2 of the *C. dubia* study plan (p. 87 of the pdf shared by SDD) stipulates that testing be done in "very hard reconstituted laboratory water to achieve a nominal hardness, alkalinity, and pH of approximately 315 mg/L as CaCO3, 225 mg/L as CaCO3, and 8.0, respectively." Section 3.2 of the *P. promelas* study plan (p. 94 of the pdf shared by SDD) outlines testing to take place in "hard reconstituted laboratory water to achieve a nominal hardness, alkalinity, and pH of approximately 180 mg/L as CaCO3, 120 mg/L as CaCO3, and 8.0, respectively." In section IV. b. of "Water Effect Ratio Testing to Support a Site-Specific Water Quality Standard Request for the Sanitary District of Decatur, Illinois" (p. 3 of the pdf shared by SDD), it appears that the intent is to use very hard reconstituted water in all toxicity testing. Is there an error in the *P. promleas* study plan, or has a change been made to the plans as outlined by SDD?

Response: The reference to hard reconstituted water in the *P. promelas* protocol is an error. The protocol has been revised to state that testing with *P. promelas* will occur in very hard reconstituted water.

Comment 5. Given that the criterion to which a site-specific adjustment is proposed is a chronic criterion, would it make sense to conduct toxicity testing to calculate a cccWER? Given that the BLM-based WER will be derived using a model that is based solely upon acute toxicological data, would chronic toxicity testing provide a check to ensure that any chronic effects not captured in acute data sets used to develop the BLM are captured and considered?

Response: The chronic criterion for nickel is based on an acute species sensitivity distribution and an acute to chronic ratio. Deriving a site-specific chronic standard from an acute WER therefore would be no less defensible than the existing standard.

Comment 6. The Oregon State University study plans do not specify whether total or dissolved WERs will be calculated. Because calculation of both WERs is recommended in EPA's WER guidance, measurement of both total and dissolved metal at the beginning and end of tests (as well as prior to renewal, in the *P. promelas* test) is also recommended (Water Quality Standards Handbook Appendix L, p. 9). How do the methods proposed for use in calculating total and dissolved nickel compare to the methods used to derive nickel concentration in the toxicity database upon which the criterion was derived?

Response: The protocols have been revised to sample both total and dissolved nickel as recommended. Both a total and dissolved WER can be calculated based upon the analytical measurements throughout the tests.

Comment 7. How exactly is the WER to be calculated? (See Water Quality Standards Handbook Appendix L and EPA's 1997 guidance document entitled "Use of the WER Procedure with Hardness Equations" (http://water.epa.gov/scitech/swguidance/standards/handbook/upload/2003_08_06_standards_modif-intwer. pdf) for acceptable methodologies.) How are differences in site water and laboratory water composition (*i.e.* differences in physiochemical variables like hardness and ion levels) going to be accounted for in the calculation of the WER? Will the toxicity values obtained in laboratory water be adjusted to the same hardness and/or other water composition factors seen in the site water prior to determination of the WER, per EPA's guidance document entitled "Use of the WER Procedure with Hardness Equations" or Water Quality Standards Handbook Appendix L, pp. 39-43?

Response: From pg. 40 of the EPA WER guidance document: the experimentally determined WER will usually be a ratio of endpoints determined at two different hardnesses and will thus include contributions from a variety of differences between the two waters, including hardness.

The WER will be calculated as discussed in the guidance document. The use of the US EPA very hard water as a reference water is already a reasonably close match to the site hardness. The reference water LC50 could be further adjusted to match the site water hardness using the hardness slope for the Ni standard, but we anticipate that any such adjustment would be small, given the already close match in hardness anticipated in the reference and site water samples.

Comment 8. In sections 4.1 of both the *C. dubia* and *P. promelas* study plans, a dilution scheme of 0.5 is proposed. Could you please explain why the dilution factor of 0.5 was proposed (EPA recommends between 0.65 and 0.99 (Water Quality Standards Handbook Appendix L, p. 53))?

Response: The dilution scheme has been changed to the recommended factor of 0.7 in both study plans.

Comment 9. Will water be prepared and aged as recommended by EPA guidance (Water Quality Standards Handbook Appendix L, p. 54)?

Response: The test protocols have been revised to state that: The site effluent will be spiked with Ni and serial dilution will take place. The waters will then be allowed to equilibrate for 2-4 hours.

The test protocols will be revised to state that the laboratory dilution water will be prepared by serial dilution and allowed to equilibrate for 1-3 hours.

Comment 10. On p. 3 of "Water Effect Ratio Testing to Support a Site-Specific Water Quality Standard Request for the Sanitary District of Decatur, Illinois," SDD states that "[i]n addition to monitoring chemical parameters relevant to the toxicity testing, chemical analysis of BLM input parameters will be conducted on both the effluent sample and laboratory reconstituted water." To the extent that the level of any physiochemical variable relevant to the operation of the BLM is expected to change throughout the toxicity testing procedures, measurement at the beginning and end of test periods will help to ascertain the degree to which levels of these variables change and should be conducted.

Response: The only water quality parameter that is likely to change during the test is pH. We will monitor pH (and hardness) at the beginning and end of the test but we propose to measure all other parameters once at test initiation (except as noted above regarding total and dissolved nickel).

Comment 11. Section 5.0 of each of the Oregon State University study plans states "[s]tatistical analysis (hypothesis testing) of the test data will be conducted using a computer program. A statistical test (as determined by the USEPA Decision Tree [USEPA, 2002]) will be used to test for significant differences in the survival among test treatments and controls." To clarify, will the statistical methods used be consistent with EPA guidance (Water Quality Standards Handbook Appendix L, pp. 58-59 recommends probit or regression analysis)?

Response: The statistical methods used will be consistent with the most current EPA methods for determination of acute effects. The EPA Water Quality Standards Handbook Appendix L, pp. 58-59 references the older EPA acute testing version (1993). The newest EPA acute version (2002) dictates the flowchart for determination of the LC50 for multi-effluent concentration acute toxicity tests and this flowchart coincides with the statistical methodology described in the WER guidance (1994).

Comment 12. Are Oregon State University researchers confident that the acclimation procedures described in section 2 of the study plan for *P. promelas* will facilitate a successful test (*e.g.*, acceptable control mortality, etc.)? If so, please provide a brief explanation. Is the acclimation for *P. promelas* and age of organisms to be tested consistent with EPA methods (Water Quality Standards Handbook Appendix L , p. 47) and/or the toxicity data to which the new data will be compared (data used to develop BLM, data used to derive Illinois's criterion)?

Response: The Water Quality Standards Handbook Appendix L, p. 47 references EPA (1993 a, b, c) and/or by ASTM (1993 a, b, c, d, e). The most recent version of EPA guidance (2002) states that the age of organisms should be 1-14 days; less than or equal to 24-h range in age (required). A random selection of organisms (which have been acclimated to hard/very hard water) will be acclimated to the site water for as long as possible prior to the test without compromising the time constraints of first use of the site water.

To allow acclimation to the very hard water conditions, the protocol has been amended to use fish approximately 7-14 days old.

Toxicity Testing to Support
a Site-Specific Water Quality Standard Request
for the Sanitary District of Decatur, Illinois

I. INTRODUCTION

For approximately five years, the Sanitary District of Decatur ("District") has been developing information to pursue a site-specific water quality standard for nickel. The nickel standard is proposed to be applied to the portion of the Sangamon River influenced by the discharge from the District's main treatment plant in Macon County, Illinois. The District has anticipated that the technical basis for the proposed standard will be provided by the Biotic Ligand Model ("BLM") for nickel that has been developed by HDR I HydroQual.

During the time period that the District has been developing information, regular communications have occurred between the District, the Illinois Environmental Protection Agency ("IEPA"), and the Region 5 office of the U.S. Environmental Protection Agency ("Region 5"). During the summer of 2013, Region 5 requested additional information demonstrating that the BLM is consistent with certain aspects of nickel aquatic toxicity studies reported in the scientific literature. As part of these discussions, Region 5 raised the option of pursuing a Water Effect Ratio (WER)-based site-specific nickel criterion as an alternative to a BLM-based approach. The District is therefore proposing to perform toxicity testing following applicable portions of the federal WER guidance to serve as additional confirmation for the predicted BLM-based WER and for the proposed site-specific water quality standard.

II. STUDY PURPOSE AND APPROACH

The District's effluent discharge contains higher concentrations of nickel than typical domestic wastewater treatment plant discharges. These concentrations are also higher than the District's NPDES permit limit, which is based on the generally-applicable Illinois water quality standard. The permit limit is not currently in effect because of a variance granted to the District by the Illinois Pollution Control Board.

The flow in the Sangamon River is highly variable but because the District's discharge is located approximately three miles downstream of the dam impounding Lake Decatur, the river flow is near zero when no water is being released from the dam. The District's NPDES permit limits are therefore based on a critical 7Q10 low flow of zero.

The nickel in the District's effluent originates primarily in the pretreated discharge from one large industrial user. This industrial user has implemented both source reduction practices and wastewater treatment technology to decrease the amount of nickel discharged from its facility into the District's collection system.

Annual water quality studies have been conducted for more than a decade by personnel from the Biology Department of Eastern Illinois University, under contract to the District. These studies do not identify any negative impact on water quality in the Sangamon River due to nickel concentrations in the District's discharge. In light of the lack of any identified adverse impact from nickel in its discharge, the District is proposing a site-specific water quality standard based on the BLM.

A report prepared by Robert Santore of HDR I HydroQual describes the application of the nickel BLM to the Sangamon River downstream of the District's discharge. This report, "Estimate of the BLM Adjustment to the Nickel Criterion for the Sanitary District of Decatur, Illinois," dated April 16, 2013 is included as Attachment A. The report provides an overview of the BLM and summarizes site sampling data, and proposes a WER of 2.62. The report also includes a recommended site-specific water quality standard of 38.2 ug/L, based on the IEPA-assigned critical hardness value of 359 mg/L.

As noted above, one round of WER testing is planned to serve as additional confirmation for the predicted BLM-based WER. This testing is proposed to be consistent with U.S. EPA guidance and will include chemical analysis of all BLM parameters for additional confirmation of the model prediction.

III. BACKGROUND SITE INFORMATION

Information describing the District's wastewater treatment facility and the Sangamon River in the vicinity of the facility discharge is contained in the District's variance petition submitted to the Illinois Pollution Control Board on June 15, 2009. The petition is included as Attachment B. The petition also contains information on the nickel limit in the District's NPDES permit and nickel concentrations in the plant discharge.

Because the Sangamon River 7Q10 low flow at the discharge location is zero, the toxicity testing will be conducted using a sample of the District's effluent discharge that is undiluted by upstream flow. This condition is represented by very dry weather conditions during the late fall and winter months of 2013-2014, and river flow measured during this time at the USGS gauging station upstream of the discharge point has been 2 cfs or less except for brief periods. During these low flow conditions, the District's discharge flow is usually in the range of 19-24 mgd. To the extent reasonably possible, sample collection for the toxicity testing will be scheduled on a day that the effluent flow is within this range.

IV. SAMPLING AND TOXICITY TESTING PROCEDURE

It is the intent of the sampling and testing procedure to be consistent with U.S. EPA guidance contained in "Interim Guidance on Determination and Use of Water-Effect Ratios for Metals" (EPA 823-B-94-001). Many of the considerations in the guidance for steps that should be undertaken prior to beginning a WER study have already been done in other contexts. Information from the single toxicity testing round is not intended to be utilized as the sole basis for a WER, so the portions of the guidance dealing with scheduling of multiple sampling events, options for determining a WER, conditions for determining and using a WER, and implementing the results of a WER are inapplicable or will be addressed outside of the toxicity testing process.

The Oregon State University Aquatic Toxicology Laboratory ("OSU") has been engaged to perform the toxicity testing. OSU has provided two procedures documents for the toxicity testing, data analysis, and reporting entitled *"Water-Effect Ratio (WER) Testing of Acute Nickel Toxicity in Site Effluent Water and Laboratory Water to the Cladoceran, Ceriodaphnia dubia, under Static Test Conditions"* and *"Water-Effect Ratio (WER) Testing of Acute Nickel Toxicity in Site Effluent Water and Laboratory Water to the Fathead minnow, Pimephales promelas, under Static-Renewal Test Conditions"*; these documents are included as Attachment C.

a. Sampling Procedures

Sampling will be planned when the discharge flow is reflective of dry weather conditions, as noted above, and will be conducted when the plant operation is stable with respect to flow and pollutant loading. Flow will be measured by the District's in-place flow monitoring equipment. Sampling will consist of 24-hour time-based composite samples of the effluent collected at the plant discharge point, described in the District's NPDES permit as Outfall 001. An automatic composite sampler will be utilized, with the temperature maintained at 4 degrees C. All sample tubing will be replaced with new tubing prior to initiation of the toxicity test sampling in accordance with "clean" sampling techniques. Additional composite samplers are available if needed to collect the sample volume required by the laboratory. Sample aliquots for analyses requiring chemical preservation will be obtained from the composite sample container at the end of the compositing period.

The 24-hour sampling period will be established to end at around 6 a.m. The sample volume will correspond to that required by OSU. Samples will be placed into properly cleaned and prepared sample containers provided by OSU and shipped via priority overnight package delivery to arrive at the laboratory in time to begin testing within 36 hours of the end of the composite sampling period.

b. Toxicity Testing

The toxicity testing organisms will be *Ceriodaphnia dubia* and *Pimephales promelas*, cultured as described in Section 4.2 of the OSU procedure. The testing will utilize reconstituted "very hard" water prepared according to U.S. EPA guidance, to correspond to the high hardness usually present in the District's effluent. Sections 3 and 4 of the OSU procedure describe the toxicity testing protocol.

c. Chemical Analysis

In addition to monitoring chemical parameters relevant to the toxicity testing, chemical analysis of BLM input parameters will be conducted on both the effluent sample and laboratory reconstituted water. The chemical monitoring is also described in Section 4.5 of the OSU procedure.

V. REPORTING AND DATA ANALYSIS

The OSU laboratory will prepare a toxicity testing report as described in Section 6 of the procedure document. As noted in the procedure, the report will include all relevant information regarding the testing procedure and results.

Following review of the test results, a determination of the WER based on the toxicity testing will be made by HDR I HydroQual. As previously discussed with Region 5 and IEPA, this WER determination will serve as additional information for the overall determination of a BLM-predicted WER applicable to the District's discharge to the Sangamon River. All laboratory reports will be provided to IEPA and to Region 5 for their review.

Attachments

Attachment A – HDR I HydroQual report prepared by Robert Santore, "Estimate of the BLM Adjustment to the Nickel Criterion for the Sanitary District of Decatur, Illinois" (January 16, 2014)

Attachment B – Petition for Variance, filed by the Sanitary District of Decatur with the Illinois Pollution Control Board June 15, 2009

Attachment C – Oregon State University testing procedures, "Water-Effect Ratio (WER) Testing of Acute Nickel Toxicity in Site Effluent Water and Laboratory Water to the Cladoceran, *Ceriodaphnia dubia*, under Static Test Conditions" and "Water-Effect Ratio (WER) Testing of Acute Nickel Toxicity in Site Effluent Water and Laboratory Water to the Fathead Minnow, *Pimephales promelas*, under Static-Renewal Test Conditions" (April 2014)

Attachment A

Prepared for Proposed Site Specific Rule for Sanitary District of Decatur
From 35 Ill. Adm. Code Section 302.208(e)

ESTIMATE OF THE BLM ADJUSTMENT TO THE NICKEL CRITERION FOR THE SANITARY DISTRICT OF DECATUR, ILLINOIS

Prepared by
Robert Santore

April 16, 2013

HDR | HydroQual

I. INTRODUCTION

This report was prepared in support of the Sanitary District of Decatur's ("District") Petition to the Illinois Pollution Control Board ("Board") seeking a Site Specific Rule to establish an alternative water quality standard ("WQS") for Nickel from the point of its discharge into the Sangamon River from its Main Sewage Treatment Plant ("Main Plant") to the point of the confluence of the Sangamon River with the South Fork of the Sangamon River near Riverton, Illinois. The purpose of this report is to present the calculations, comparisons, and findings acquired from using the federally approved Biotic Ligand Model ("BLM") to adjust the Nickel WQS such that it considers local conditions found in that segment of the Sangamon River.

Adjustment of the WQS for metals in consideration of the local chemical conditions has frequently been shown to be appropriate at sites across the United States, since WQSs are based on water quality criteria ("WQC") that are defined using a traditional methodology that does not consider many of the factors that are known to affect metal toxicity to aquatic organisms. For example, the WQC for several metals (including Silver ("Ag"), Cadmium ("Cd"), Chromium (III) ("Cr(III)"), Lead ("Pb"), Nickel ("Ni"), and Zinc ("Zn"), as well as Copper ("Cu") prior to development of the BLM) are dependent on the hardness of the local water. The term "hardness" refers to the mineral content of the water and is primarily associated with the combined concentration of Calcium ("Ca") and Magnesium ("Mg"). Hardness is one of several key water quality constituents that have been shown to affect metal bioavailability and toxicity. The United States Environmental Protection Agency's ("US EPA") approach for deriving metals WQC as hardness-dependent relationships has considered how variation in toxic response may differ in areas that naturally have either very hard or very soft water.

However, factors other than hardness have been shown to affect metal bioavailability, and in particular variation in pH, alkalinity, and the presence of natural organic matter ("NOM") have all been shown to be as important, or even more important, than hardness in determining metal toxicity (Erickson, et al., 1996). These factors may increase or decrease the toxicity of metals. The dependence of metal toxicity on local chemical factors is referred to as the "bioavailability" of the metal to aquatic organisms. Since these bioavailability factors are not considered by WQC approaches that only consider hardness, the WQC may be more or less protective than needed for a specific receiving water. This issue has long been recognized by USEPA and, in response, US EPA has developed procedures for derivation of site specific adjustments to WQC (Carlson, et al. 1984; US EPA, 1992, 1994a). In particular, the Water Effect Ratio ("WER") approach is intended to account for local bioavailability factors that can affect metal toxicity (US EPA, 1994b). The site specific adjustment to a WQC provided by a WER is intended to correct for deficiencies in the WQC derivation process and to reduce the degree to which a WQC is over-protective or under-protective for a given location.

II. BACKGROUND ON NICKEL BLM

Although the WER has been in use for decades, it requires toxicity testing with multiple aquatic organisms in multiple samples. Costs and time required to accommodate WER testing can be significant. As an alternative, the BLM is a computational approach that can simulate the effects of water chemistry on metal toxicity, and on the physiological response of aquatic organisms to metals (Di Toro, et al, 2001; Santore, et al, 2001). The BLM provides information that is similar to the WER, but does so with much less cost and time required. The BLM is a mechanistic approach, not an empirical approach like the hardness equation, and it considers effects from numerous chemical factors such as pH, the presence of NOM, alkalinity, and major ions (including cations that contribute to hardness). The BLM considers how these factors affect either metal chemistry or organism physiology to determine metal bioavailability (Figure 1).

The BLM has been adopted by US EPA as a replacement for the hardness equation in the most recently updated metals criteria (US EPA, 2007). The use of the BLM provides similar benefits as the WER, and for criteria based on the BLM, the use of the WER is no longer required. For metals (such as Nickel) where US EPA has not adopted a BLM-based procedure for replacement of the hardness equation, the BLM can be used in a manner similar to the WER to modify the hardness equation based WQC. Use of the BLM to derive a site specific WQC provides the same level of protection as intended by US EPA guidelines (Stephan, et al, 1985). To the extent that a BLM derived site specific WQC is different from the national ambient WQC, those differences reflect how local factors which are not considered by the hardness-equation may change metal bioavailability and toxicity.

The BLM can be used to determine modifications to chemistry of receiving water using a procedure that is analogous to the WER. The WER compares the toxicity of Nickel or other toxicant in receiving water to that in reference water. The reference water is intended to represent the conditions comparable to those used to develop the toxicity database in which the acute and chronic WQC were developed. The WER is then simply the ratio of the measured toxic endpoint in the receiving water to that in the reference water. If multiple receiving water and reference water samples are used to generate the WER, the WER is determined for each pair of samples, and then an overall WER is usually determined as the geometric mean. The reference water chemistry must meet WER guidelines (US EPA, 1994b), and US EPA has provided synthetic recipes suitable for generating reference water samples with various hardness concentrations. These recipes can be incorporated into the BLM application to predict toxicity endpoints for suitable reference water that can be used in a WER-type analysis.

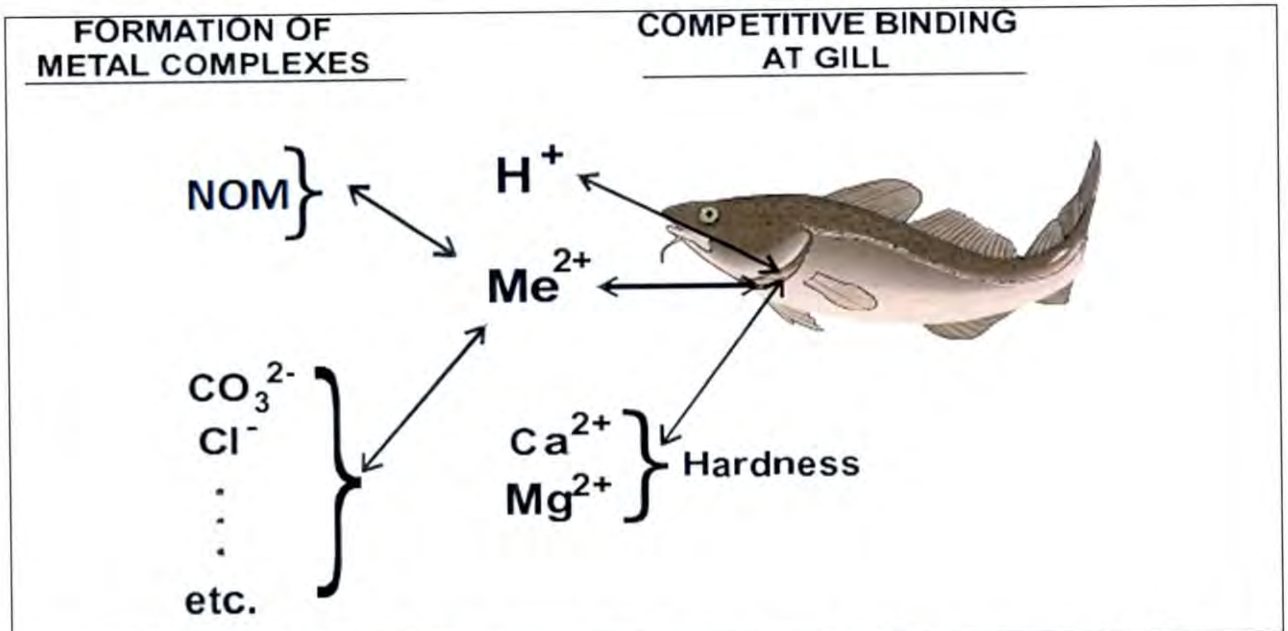

Figure 1. Conceptual model of the chemical and physiological processes represented in the BLM. Water chemistry, including inorganic complexes and binding by NOM, can affect the chemical speciation and reactivity of a metal (i.e., Me^{2+}). The accumulation of metal on biological surfaces, such as gill membranes, is related to the chemical reactivity of the metal as well as other factors such as pH and competitive binding of cations. The BLM is a general framework that has been applied to acute and chronic responses of numerous metals including Aluminum ("Al"), Ag, Cd, Cobalt ("Co"), Cu, Ni, Pb, and Zn.

III. BLM RESULTS WITH MEASURED WATER QUALITY

A. Overall Calibration Results to Fish and Invertebrates

The BLM is a generalized mechanistic approach that has been applied to a number of different metals including Nickel. Development efforts for Nickel focused on explaining available toxicity data for sensitive aquatic invertebrates and fish in a project sponsored by the Water Environment Research Foundation ("WERF") (WERF, 2003). The project for WERF included a detailed review of the chemical speciation of Nickel in freshwaters, analysis of Nickel accumulation in aquatic organisms, and a summary of important bioavailability factors, including pH, alkalinity, hardness, and the presence of NOM. The performance of the Nickel BLM was quite good, with excellent agreement between predicted and measured toxicity over a range of several orders of magnitude (Figure 2). Nearly all of the predicted toxicity values are within a factor of two of measured values.

Agreement with a factor of two of a given measured toxicity value has been shown to be about the degree to which replicate measurements agree with a mean value. Replicate toxicity tests used to determine replicate LC50 values for the same organism in the same water frequently does not produce exactly the same result. For example, replicate copper toxicity measurements, expressed as the median lethal concentration to 50% of the population (LC50), made to the same species of fish in water samples from Lake Superior tend to fall in ±2x envelope around a central mean (Figure 3; data are from Erickson et al., 1996). If replicate measurements agree with a central mean value no better than ±2x, then comparison of predicted toxicity values with measured values with a factor of ±2x would be the best that could be expected. Hence, predicted values such as those shown in Figure 2 are often shown within a ±2x envelope around the line of perfect agreement, and predicted values that fall within this envelope show excellent agreement with measured values.

The strength of the predictive ability of the BLM lies in the mechanistic and generalized nature of the model. Although the model simulates a complex set of chemical reactions and biological accumulation processes, these processes are characterized as generalized reactions based on thermodynamics. The model can therefore predict accumulation in aquatic organisms without recalibration of any of the model parameters that describe chemical speciation, or organism accumulation. Application of the same model and same model parameters are used to predict effects to diverse aquatic organisms including fish and invertebrates. The consistency of this approach is evidence of the mechanistic and generally applicable nature of this analysis. The only parameter that varies from one organism to another is the concentration of accumulated metal associated with toxicity (Santore, et al, 2001). The resulting model is capable of simulating Nickel toxicity to a range of organisms in a wide range of chemical conditions (Figure 2).

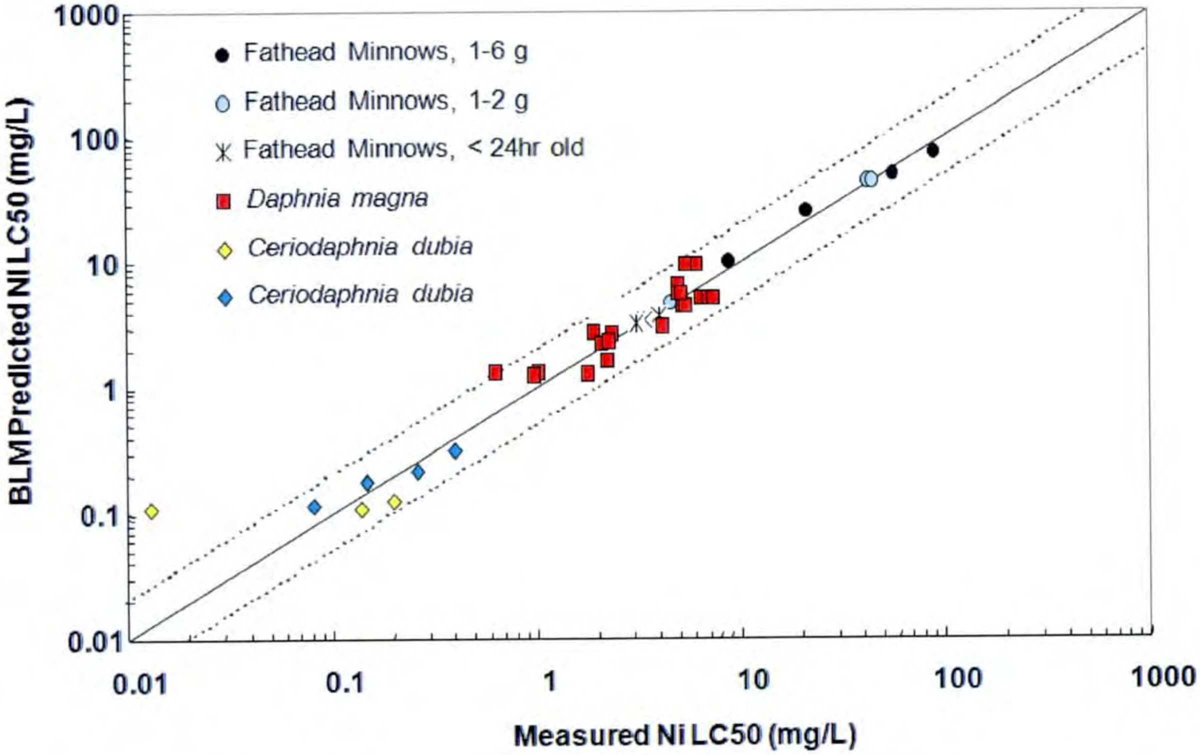

Figure 2. Comparison of the calibrated Nickel BLM to sensitive freshwater aquatic invertebrates and fish. Measured toxicity, as the lethal concentration to 50% of the test organisms, is shown on the horizontal axis. Predicted toxicity is shown on the vertical axis. The diagonal solid black line shows perfect agreement between measured and predicted values, and the dashed black lines show a region of ± factor of 2x from perfect agreement. The ± factor of 2x is intended to show agreement between measured and predicted values that comparable to the expected agreement between replicate measurements.

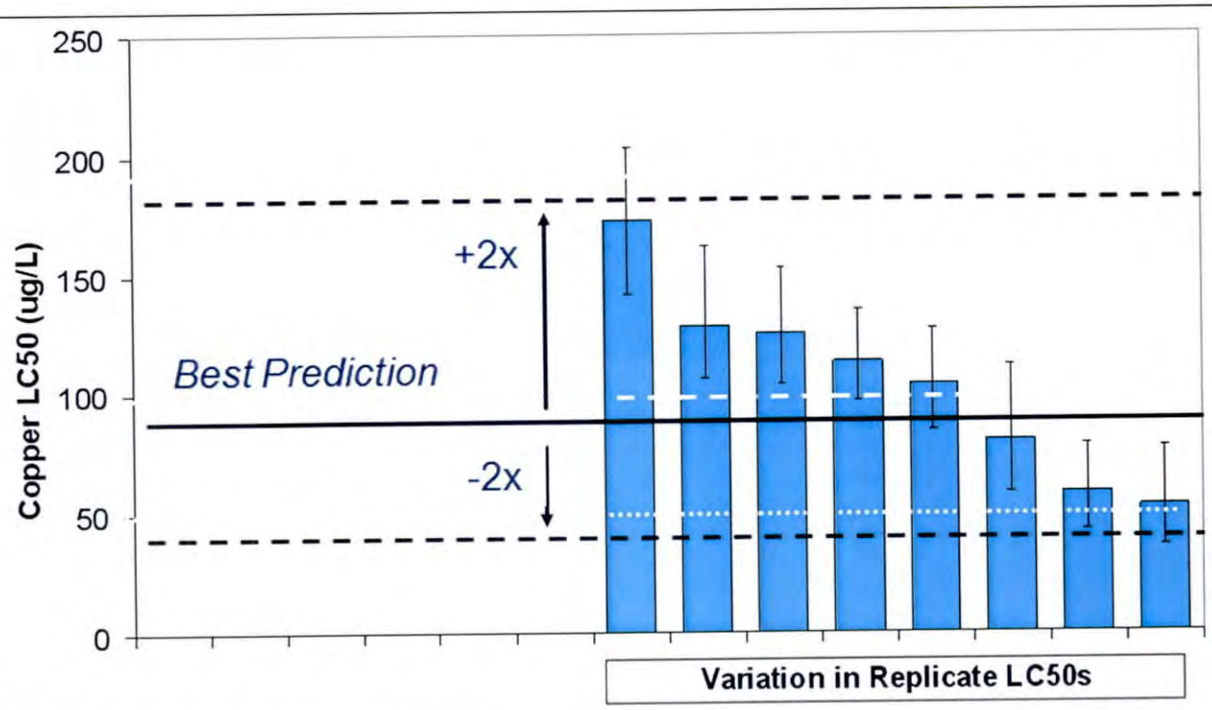

Figure 3. Variation in replicate measurements of LC50 of copper to fathead minnow in Lake Superior water tends to fall in an envelope of plus or minus 2 times the geometric mean value (date from Erickson et al., 1996). The dark solid line labeled "Best Prediction" is shown at the geometric mean of the measured values. The dashed lines correspond to an envelope showing plus or minus a factor of two. Since all of these measured values are from water samples with the same chemistry, the BLM would predict the same LC50 in every case.

IV. CALCULATED WER WITH PREDICTED TOXICITY TO *DAPHNIA MAGNA*

As discussed in Section II of this report, the BLM for Nickel can be used to calculate a site specific WQC by using the model to calculate a WER for the receiving water downstream of the Main Plant. Samples were collected at two locations downstream of the Main Plant discharge, and chemical analyses for BLM input parameters were measured on these samples. Similar analyses were made on samples taken from the Main Plant effluent, although these were not used in the WER analysis. Measured chemical parameters used as input parameters to the Nickel BLM are shown in Table 1.

The BLM for Nickel was run with these input data to determine Nickel toxicity to *D. magna*, which is a sensitive invertebrate recommended for use in WER testing for Nickel (USEPA, 1994b, Appendix I). For calculation of WER values, the predicted toxicity in these site waters was compared with toxicity in a reference water sample. According to the WER guidance document, suitable reference water must have a hardness concentration close to, but not in excess of, the measured hardness in the site water (US EPA, 1994b). The US EPA's recipe for "very hard" water with a hardness of 317 mg/L as Calcium Carbonate ("CaCO3"), compared with hardness in the site water of 347, would be a suitable choice for use as a reference water for WER testing at the site. Calculated LC50 values for site and reference water are shown in Table 2.

Table 1. Input chemistry used for BLM analyses. For site waters, Sangamon River samples collected at the Rock Springs Trail bridge approximately one-half mile downstream (RD at Rock Springs) and at the South Lincoln Memorial Parkway bridge approximately six miles downstream (RD at Lincoln) were used to characterize the chemistry of the receiving 1water downstream of the plant. The presence of NOM was characterized by the dissolved organic carbon ("DOC") concentration. For calculation of WER, the US EPA's "very hard" water recipe was used as a reference sample. Variation of an assumed DOC in the reference water sample from 0.5 to 2.0 mg C/L was included in the BLM analysis.

Sample Description		Temp	pH	DOC	Ca	Mg	Na	K	SO4	Cl	Alk
		°C		mg C/L		----------	----------	mg / L	----------	----------	
RD at Rock Springs	8/26/2010	23	8.00	12	56	53	396	86	298	446	365
RD at Rock Springs	9/9/2010	21	8.09	10	64	48	286	53	214	304	341
RD at Lincoln	8/26/2010	25	8.00	10	58	46	296	60	225	450	321
RD at Lincoln	9/9/2010	21	8.10	7.9	65	43	192	35	146	202	315
Final Effluent	8/26/2010	30	8.09	13	56	62	504	112	374	558	400
Final Effluent	9/9/2010	28	7.90	14	62	62	474	91	328	477	399
US EPA Very Hard	DOC=0.5	20	8.20	0.5	47	48	105	8	304	8	229
US EPA Very Hard	DOC=1.0	20	8.20	1	47	48	105	8	304	8	229
US EPA Very Hard	DOC=2.0	20	8.20	2	47	48	105	8	304	8	229

Table 2. Predicted toxicity to *D. magna* by the Nickel BLM in site and reference water samples used in WER analysis. For calculation of WER values, the average LC50 determined in site water was divided by the average LC50 in the reference water. The US EPA's "very hard" recipe for synthetic water was chosen as the reference water due to the good correspondence between the hardness in this recipe and at the site.

Sample Description		Ni LC50 mg/L	Average Ni LC50 mg/L	Average WER
RD at Rock Springs	8/26/2010	32.38	28.89	2.92
RD at Rock Springs	9/9/2010	25.61		
RD at Lincoln	8/26/2010	25.55	22.84	2.31
RD at Lincoln	9/9/2010	20.13		
Final Effluent	8/26/2010	44.52	43.78	4.42
Final Effluent	9/9/2010	43.04		
US EPA Very Hard	DOC=0.5	9.82	9.90	
US EPA Very Hard	DOC=1.0	9.88		
US EPA Very Hard	DOC=2.0	10.00		

Site water was characterized by performing two separate sampling events at both Rock Springs B and Lincoln Homestead. The BLM calculated LC50 values to *D. magna* in site-waters downstream of the Main Plant ranged from 22.84 mg/L to 28.89 mg/L (Table 2). For comparison, the calculated LC50 for reference water based on the US EPA's "very hard" water recipe was 9.9 mg/L. The WER values for each sampling location, calculated by dividing site water LC50 by the reference water LC50, correspond to 2.31 and 2.92 for Rock Springs B and Lincoln Homestead. Since these values are similar, an overall WER for the site can be determined by averaging to obtain an overall WER for the site of 2.62.

Predicted toxicity in the Final Effluent and the resulting WER value is also shown for comparison in Table 2, but these values were not averaged into the overall WER for the site. The predicted average LC50 in effluent samples was 43.78 mg/L, which is considerably higher than in downstream receiving water samples. The chemistry for the effluent shown in Table 1 indicates that effluent samples had higher concentrations of cations, such as Ca, Mg, and Sodium ("Na"), as well as a higher concentration of NOM (measured as DOC). All of these factors would tend to further mitigate against nickel toxicity to aquatic organisms, which is why the predicted LC50 in effluent samples is higher. As a result, Nickel toxicity would be lower in any areas that are poorly mixed downstream of the discharge, and the resulting WER would be protective for these areas as well.

V. SENSITIVITY TO VARIATION IN WATER CHEMISTRY

Since relatively few samples were used in the BLM analysis summarized in Tables 1 and 2, an additional analysis was conducted to see what effect natural variation in downstream water chemistry would have on the predicted toxicity. Additional monitoring data were used to characterize variation in measured chemistry corresponding to BLM input parameters. Monitoring data describing the variability in downstream chemistry was collected by the Sanitary District of Decatur, and combined with monitoring data for the Sangamon River collected by *Eastern Illinois University. Samples collected for these monitoring studies were obtained at a number of different stations downstream of the plant, including Lincoln, Rock Springs, and Wyckles Bridge, as well as unnamed stations 100 yards and 600 yards downstream. Variability in measured chemistry in the pooled data from these sampling stations includes both spatial and temporal variation. From these available data, the 10th, 25th, 75th, and 90th percentiles were estimated for key water quality parameters that are known to affect nickel bioavailability, including pH, DOC, Ca, Mg, Na, and Alkalinity (Table 3). A set of base case conditions was established as the median value for all parameters. Variation in K, SO4, and Cl was not considered since these parameters are not important in determining the bioavailability of nickel.*

Table 3. Variation in water quality parameters that affect nickel bioavailability was characterized as the 10th, 25th, 75th, and 90th percentile estimated from a dataset of pooled measurements are stations downstream of the Decatur Plant. The values for the base case were based on median values from the same dataset.

Test	Temp. C	pH SU	DOC mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	SO4 mg/L	Cl mg/L	Alk mg/L
base	17.78	8.14	9.99	70.00	84.25	244.00	47.4	185.5	326.0	279.00
10th		7.96	3.7	48.0	29.9	202.4				151.2
25th		8.03	6.4	57.6	38.0	218.0				223.0
75th		8.29	14.8	138.9	122.4	270.0				321.0
90th		8.47	28.2	159.0	140.1	285.6				451.2

These data correspond to pre-existing monitoring studies and were not specifically collected for BLM analyses. Consequently, not all BLM parameters were measured in every sample. For the purposes of conducting a sensitivity analyses, these data are suitable for showing the expected downstream variation in individual parameters. Available data are plotted in Figure 4 for river samples and Figure 5 for effluent samples.

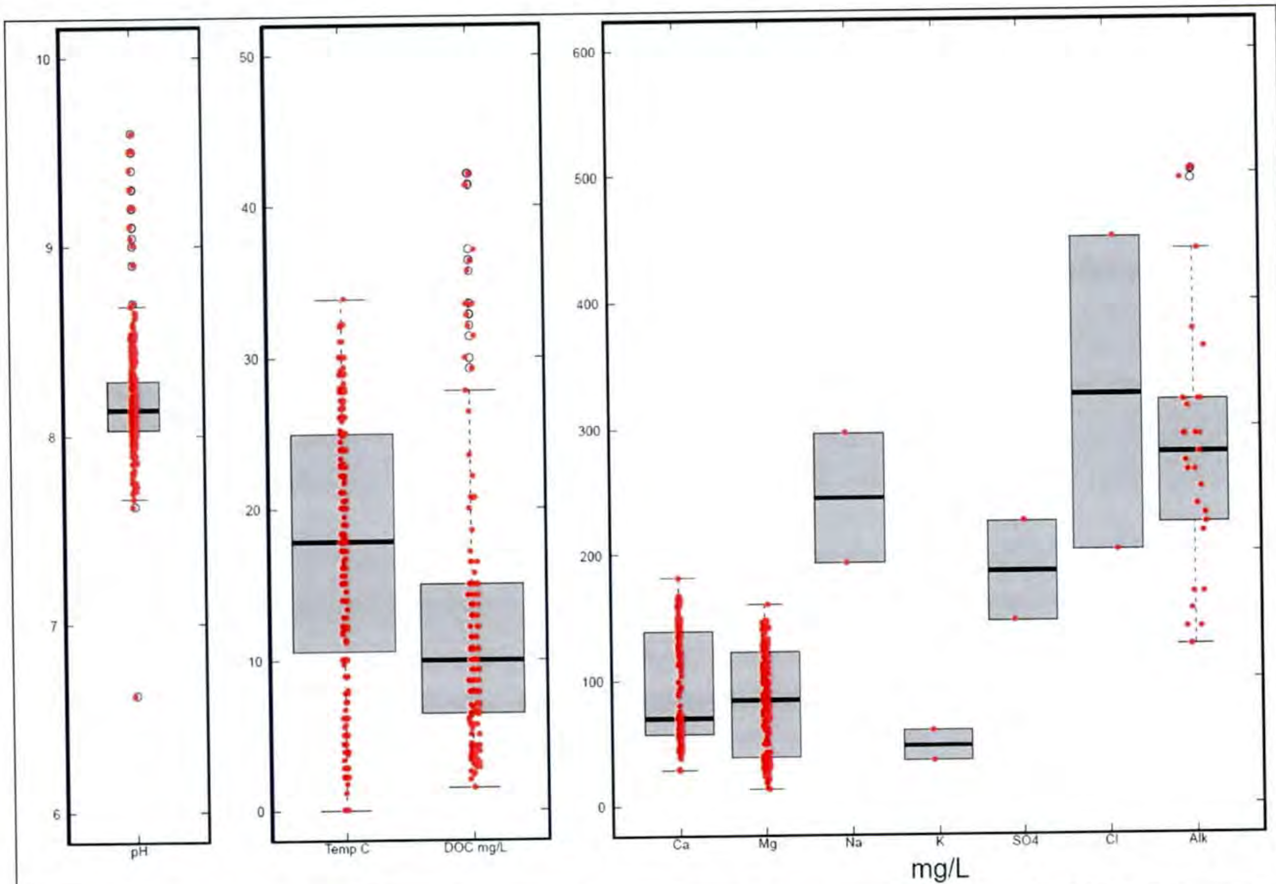

Figure 4. Box and whisker plots showing distributions of measured values for BLM input parameters in river samples. Average values are shown by a black line in the middle of each box and represent mean (pH, Temp, DOC) or geometric mean (Ca, Mg, Na, Potassium ("K"), Sulfate ("SO4"), Chlorine ("Cl"), Alkalinity ("Alk")) depending on whether parameters are expected to be normally or log-normally distributed. For each box, the lower edge of the box represents the 25th percentile, the upper edge of the box represents the 75th percentile, and whiskers extend to minimum and maximum values exclusive of extreme values. Individual observations are shown as small red circles.

The distribution of values for each parameter are shown as box and whisker diagrams constructed so that the lower edge of the box represents the 25th percentile, the upper edge of the box represents the 75th percentile, and whiskers extend to minimum and maximum values exclusive of extreme values. Median values are shown as the solid black horizontal line in the middle of each box. Individual observations are shown as small red circles. For river samples, there was a large amount of data characterizing pH, alkalinity, DOC, and hardness cations (Ca and Mg), which are the bioavailability factors that are the most important for determining nickel toxicity (Figure 4). There were relatively few samples characterizing K, and SO4, but these parameters have little to no effect on nickel toxicity and do not need to be considered in the uncertainty analysis. There were also relatively few observations for Na, but the estimated variation in Na concentrations is similar to that seen for Ca and Mg and is therefore, likely to be a reasonable characterization of variation in downstream chemistry. For effluent samples there were many more measurements of anion concentrations (Figure 5), and in comparison with river