Form No. DTMB-3521 (Rev. 4/2012)
AUTHORITY: Act 431 of 1984
COMPLETION: Required
PENALTY: Contract change will not be executed unless form is filed

STATE OF MICHIGAN
DEPARTMENT OF TECHNOLOGY, MANAGEMENT AND BUDGET
PROCUREMENT
P.O. BOX 30026, LANSING, MI 48909
OR
530 W. ALLEGAN, LANSING, MI 48933

July 12, 2013

CHANGE NOTICE NO. 4
to
CONTRACT NO. 071B6200434
between
THE STATE OF MICHIGAN
and

NAME & ADDRESS OF CONTRACTOR:	PRIMARY CONTACT	EMAIL
Michigan State University Contracts & Grant Administration	Lisa A. Somers	somers@osp.msu.edu
301 Administration Building	TELEPHONE	CONTRACTOR #, MAIL CODE
East Lansing, MI 48824	(517) 884-4239	

STATE CONTACTS	AGENCY	NAME	PHONE	EMAIL
CONTRACT COMPLIANCE INSPECTOR	DEQ	Glen Schmitt	517-241-0910	Schmittg1@michigan.gov
BUYER	DTMB	Jim Wilson	517-241-1916	Wilsonj4@michigan.gov

CONTRACT SUMMARY:

DESCRIPTION: **Inland Lakes Sediment Chemistry Trend Monitoring – Dept of Environmental Quality**

INITIAL EFFECTIVE DATE	INITIAL EXPIRATION DATE	INITIAL AVAILABLE OPTIONS	EXPIRATION DATE BEFORE CHANGE(S) NOTED BELOW
September 15, 2006	May 29, 2012	5, one year	May 29, 2013
PAYMENT TERMS	**F.O.B**	**SHIPPED**	**SHIPPED FROM**
N/A	N/A	N/A	N/A

ALTERNATE PAYMENT OPTIONS:	AVAILABLE TO MiDEAL PARTICIPANTS
☐ P-card ☐ Direct Voucher (DV) ☐ Other	☐ Yes ☒ No

MINIMUM DELIVERY REQUIREMENTS:

N/A

DESCRIPTION OF CHANGE NOTICE:

EXTEND CONTRACT EXPIRATION DATE	EXERCISE CONTRACT OPTION YEAR(S)	EXTENSION BEYOND CONTRACT OPTION YEARS	LENGTH OF OPTION/EXTENSION	EXPIRATION DATE AFTER CHANGE
☐ No ☒ Yes	☒	☐	7 months and 2 days	Dec. 31, 2013

VALUE/COST OF CHANGE NOTICE:	ESTIMATED REVISED AGGREGATE CONTRACT VALUE:
$0.00	$855,713.10

Effective immediately, this contract is hereby extended seven months and two days to December 31, 2013. All other terms, conditions, pricing and specifications remain the same. Per vendor and agency agreement and DTMB Procurement approval.

Form No. DTMB-3521 (Rev. 4/2012)
AUTHORITY: Act 431 of 1984
COMPLETION: Required
PENALTY: Contract change will not be executed unless form is filed

STATE OF MICHIGAN
DEPARTMENT OF TECHNOLOGY, MANAGEMENT AND BUDGET
PROCUREMENT
P.O. BOX 30026, LANSING, MI 48909
OR
530 W. ALLEGAN, LANSING, MI 48933

May 17, 2012

CHANGE NOTICE NO. 3

to

CONTRACT NO. 071B6200434

between

THE STATE OF MICHIGAN

and

NAME & ADDRESS OF CONTRACTOR:	PRIMARY CONTACT	EMAIL
Michigan State University Congracts & Grant Administration 301 Administration Building East Lansing, MI 48824	Lisa A. Somers	somers@osp.msu.edu
	TELEPHONE	CONTRACTOR #, MAIL CODE
	(517) 884-4239	

STATE CONTACTS	AGENCY	NAME	PHONE	EMAIL
CONTRACT COMPLIANCE INSPECTOR:	DEQ	Glen Schmitt	(517) 241-0910	SCHMITTG1@michigan.gov
BUYER:	DTMB	Jim Wilson	(517) 241-1916	wilsonj4@michigan.gov

CONTRACT SUMMARY:			
DESCRIPTION: **Inland Lakes Sediment Chemistry Trend Monitoring – Dept of Environmental Quality**			
INITIAL TERM	EFFECTIVE DATE	INITIAL EXPIRATION DATE	AVAILABLE OPTIONS
	September 15, 2006	May 29, 2012	
PAYMENT TERMS	F.O.B	SHIPPED	SHIPPED FROM
N/A	N/A	N/A	N/A
ALTERNATE PAYMENT OPTIONS:			AVAILABLE TO MiDEAL PARTICIPANTS
☐ P-card ☐ Direct Voucher (DV) ☐ Other			☐ YES ☒ NO
MINIMUM DELIVERY REQUIREMENTS:			

DESCRIPTION OF CHANGE NOTICE:		
OPTION EXERCISED: ☐ NO ☒ YES	IF YES, NEW EXPIRATION DATE:	May 29, 2013
Effective immediately, this contract is hereby EXTENDED to May 29, 2013, using a one year option. Please also note that the vendor information has been updated, Lisa Somers replaces Fred Salas as the vendor contact. All other terms, conditions, and pricing remains the same. Per vendor and agency agreement and the approval of DTMB Procurement.		
VALUE/COST OF CHANGE NOTICE:	$0.00	
ESTIMATED AGGREGATE CONTRACT VALUE REMAINS:	$855,713.10	

Form No. DMB 234 (Rev. 1/96)
AUTHORITY: Act 431 of 1984
COMPLETION: Required
PENALTY: Contract will not be executed unless form is filed

STATE OF MICHIGAN
DEPARTMENT OF MANAGEMENT AND BUDGET
PURCHASING OPERATIONS
P.O. BOX 30026, LANSING, MI 48909
OR
530 W. ALLEGAN, LANSING, MI 48933

November 3, 2011

CHANGE NOTICE NO. 2
TO
CONTRACT NO. 071B6200434
between
THE STATE OF MICHIGAN
and

NAME & ADDRESS OF VENDOR	TELEPHONE (517) 355-5040 X250 **Fred Salas**
Michigan State University **Contract & Grant Administration** **301 Administration Bldg.** **East Lansing, MI 48824** **salas@cga.msu.edu**	VENDOR NUMBER/MAIL CODE BUYER/CA (517) 241-1916 **Jim Wilson**
Contract Compliance Inspector: Glen Schmitt **Inland Lakes Sediment Chemistry Trend Monitoring – Department of Environmental Quality**	
CONTRACT PERIOD: From: **September 15, 2006** To: **May 29, 2012**	
TERMS **N/A**	SHIPMENT **N/A**
F.O.B. **N/A**	SHIPPED FROM **N/A**
MINIMUM DELIVERY REQUIREMENTS **N/A**	

NATURE OF CHANGE (S):

This Contract is hereby EXTENDED to May 29, 2012. All other terms, conditions, specifications and pricing remain unchanged.

AUTHORITY/REASON:

Per agency and DTMB Procurement approval.

TTOAL ESTIMATED CONTRACT VALUE REMAINS: $855,713.10

Form No. DMB 234 (Rev. 1/96)
AUTHORITY: Act 431 of 1984
COMPLETION: Required
PENALTY: Contract will not be executed unless form is filed

STATE OF MICHIGAN
DEPARTMENT OF MANAGEMENT AND BUDGET
PURCHASING OPERATIONS
P.O. BOX 30026, LANSING, MI 48909
OR
530 W. ALLEGAN, LANSING, MI 48933

September 15, 2006

CHANGE NOTICE NO. 1
TO
CONTRACT NO. 071B6200434
between
THE STATE OF MICHIGAN
and

NAME & ADDRESS OF VENDOR	TELEPHONE (517) 355-5040 X250 **Fred Salas**
Michigan State University **Contract & Grant Administration** **301 Administration Bldg.** **East Lansing, MI 48824** **salas@cga.msu.edu**	VENDOR NUMBER/MAIL CODE BUYER/CA (517) 241-1916 **Jim Wilson**
Contract Compliance Inspector: Glen Schmitt **Inland Lakes Sediment Chemistry Trend Monitoring – Department of Environmental Quality**	
CONTRACT PERIOD: From: **September 15, 2006** To: **September 19, 2011**	
TERMS **N/A**	SHIPMENT **N/A**
F.O.B. **N/A**	SHIPPED FROM **N/A**
MINIMUM DELIVERY REQUIREMENTS **N/A**	

NATURE OF CHANGE (S):

The correct start date for this Contract is SEPTEMBER 15, 2006. All other terms, conditions, specifications and pricing remain unchanged.

AUTHORITY/REASON:

Per agency request on September 15, 2006, and DMB/Purchasing Operations approval.

TTOAL ESTIMATED CONTRACT VALUE REMAINS: $855,713.10

Form No. DMB 234 (Rev. 1/96)
AUTHORITY: Act 431 of 1984
COMPLETION: Required
PENALTY: Contract will not be executed unless form is filed

STATE OF MICHIGAN
DEPARTMENT OF MANAGEMENT AND BUDGET
PURCHASING OPERATIONS
P.O. BOX 30026, LANSING, MI 48909
OR
530 W. ALLEGAN, LANSING, MI 48933

September 14, 2006

NOTICE
TO
CONTRACT NO. 071B6200434
between
THE STATE OF MICHIGAN
and

NAME & ADDRESS OF VENDOR **Michigan State University** **Contract & Grant Administration** **301 Administration Bldg.** **East Lansing, MI 48824** **salas@cga.msu.edu**	TELEPHONE (517) 355-5040 X250 **Fred Salas** VENDOR NUMBER/MAIL CODE BUYER/CA (517) 241-1916 **Jim Wilson**
Contract Compliance Inspector: Glen Schmitt **Inland Lakes Sediment Chemistry Trend Monitoring – Department of Environmental Quality**	
CONTRACT PERIOD: From: **September 20, 2006** To: **September 19, 2011**	
TERMS **N/A**	SHIPMENT **N/A**
F.O.B. **N/A**	SHIPPED FROM **N/A**
MINIMUM DELIVERY REQUIREMENTS **N/A**	

The terms and conditions of this Contract are those of ITB #071I6200230, this Contract Agreement and the vendor's quote. In the event of any conflicts between the specifications, terms and conditions indicated by the State and those indicated by the vendor, those of the State take precedence.

Estimated Contract Value: $855,713.10

Form No. DMB 234 (Rev. 1/96)
AUTHORITY: Act 431 of 1984
COMPLETION: Required
PENALTY: Contract will not be executed unless form is filed

STATE OF MICHIGAN
DEPARTMENT OF MANAGEMENT AND BUDGET
PURCHASING OPERATIONS
P.O. BOX 30026, LANSING, MI 48909
OR
530 W. ALLEGAN, LANSING, MI 48933

CONTRACT NO. 071B6200434
between
THE STATE OF MICHIGAN
and

NAME & ADDRESS OF VENDOR **Michigan State University** **Contract & Grant Administration** **301 Administration Bldg.** **East Lansing, MI 48824** **salas@cga.msu.edu**	TELEPHONE (517) 355-5040 X250 **Fred Salas** VENDOR NUMBER/MAIL CODE BUYER/CA (517) 241-1916 **Jim Wilson**
Contract Compliance Inspector: Glen Schmitt **Inland Lakes Sediment Chemistry Trend Monitoring – Department of Environmental Quality**	
CONTRACT PERIOD: From: **September 20, 2006** To: **September 19, 2011**	
TERMS **N/A**	SHIPMENT **N/A**
F.O.B. **N/A**	SHIPPED FROM **N/A**
MINIMUM DELIVERY REQUIREMENTS **N/A**	

MISCELLANEOUS INFORMATION:

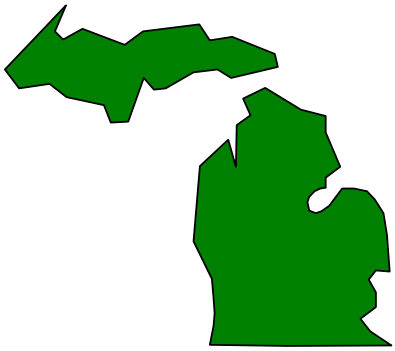
The terms and conditions of this Contract are those of ITB #071I6200230, this Contract Agreement and the vendor's quote. In the event of any conflicts between the specifications, terms and conditions indicated by the State and those indicated by the vendor, those of the State take precedence.

Estimated Contract Value: $855,713.10

THIS IS NOT AN ORDER: This Contract Agreement is awarded on the basis of our inquiry bearing the ITB No. 071I6200230. Orders for delivery may be issued directly by the Department of Environmental Quality through the issuance of a Purchase Order Form.

All terms and conditions of the invitation to bid are made a part hereof.

FOR THE VENDOR:	**FOR THE STATE:**
Michigan State University Firm Name	Signature
Authorized Agent Signature	**Melissa Castro, CPPB, Buyer Manager** Name/Title
Authorized Agent (Print or Type)	**Services Division, Purchasing Operations** Department
Date	Date



STATE OF MICHIGAN
Department of Management and Budget
Purchasing Operations

Contract No. 071B6200434
Inland Lakes Sediment Chemistry Trend Monitoring

Buyer Name: Jim Wilson
Telephone Number: 517-241-1916
E-Mail Address: wilsonj4@michigan.gov

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APPENDICES

Appendix A – Bidder Response to Article 1

Article 1 – Statement of Work (SOW)

1.0 Project Identification

1.001 PROJECT DESCRIPTION

This DEQ project is for technical support to assist with the continuation of all aspects of the inland lakes sediment chemistry trend monitoring program over a five (5) year period. Specifically, the following objectives will be achieved through this project:

- Collection of high-quality sediment cores from inland lake to meet the following objectives:
- Determine historical and current concentrations of metals and persistent organic pollutants in bottom sediments of selected Michigan inland lakes.
- Measure temporal and spatial trends in the loading of heavy metals and organic contaminants to Michigan's inland lakes.
- Determine the contaminant anthropogenic sediment inventory of selected inland lakes.
- Determine whether new chemicals are accumulating in the sediments of inland lakes.
- Provide data to support long term monitoring strategies.
- Provide data to support the Michigan Department of Environmental Quality's (MDEQ) water quality protection programs and evaluate their effectiveness.
- Preparation of an annual inland lakes sediment report, lake-specific fact sheets, and assisting DEQ with reports and presentations, including the production of graphs, tables, and maps as necessary.

1.002 BACKGROUND

In November 1998, Michigan voters approved the Clean Michigan Initiative (CMI), which allocated funding for many environmental programs. One priority of this legislation was the implementation of a 1997 Department of Environmental Quality (DEQ) report, entitled "A Strategic Environmental Quality Monitoring Program for Michigan's Surface Water" (Strategy). This report, which now serves as the basis on the DEQ's water quality monitoring program, outlined several monitoring activities to address four goals. Specifically, these goals include the identification of waters that are not meeting Michigan Water Quality Standards; the measurement of temporal and spatial trends; the evaluation of the effectiveness of existing programs; and the detection of emerging problems.

Each year since 2000, the State Legislature has appropriated CMI funds for the implementation of the Strategy. A major component of the Strategy is to collect sediment core samples from inland lakes, analyze the sediments for organic and inorganic contaminants, provide dates for sediment core slices, and produce an annual report describing the results. This contract will continue the project for five (5) years.

1.1 Scope of Work and Deliverables

1.101 IN SCOPE

The collection of sediment cores as well as laboratory analysis of the cores for chemical parameters, are within the contract scope of work. Study design/planning, statistical data analysis, presentations at conferences and to DEQ, and the development of reports and fact sheets as requested by the DEQ are also "in-scope".

1.102 OUT OF SCOPE

Policy-related decisions and conclusions resulting from the data collection and analysis will be made by the DEQ, and is "out-of-scope" of this contract. Contractor reports will summarize the data, and make recommendations/interpretations as requested, but will not include policy statements.

1.103 ENVIRONMENT

The contractor is expected to use the existing, specially-equipped vessel to sample inland lake sediments. In addition, the contractor is expected to provide the appropriate sampling equipment, including but not limited to GPS units, sediment core processing equipment, and analytical instruments for organic and inorganic contaminant analysis. Sampling often is conducted on remote lakes with few on-shore facilities, so the contractor must be able to work effectively and efficiently in such settings and be able to adapt to unforeseen circumstances.

The contractor must have software compatible with that used by the State of Michigan, primarily Microsoft products (e.g. Word, Excel, spreadsheet, Access database).

1.104 WORK AND DELIVERABLE

Contractor shall provide Deliverables/Services and staff, and otherwise do all things necessary for or incidental to the performance of work, as set forth below:

The following is a preliminary analysis of the major tasks involved for this project. The Contractor is not, however, constrained from supplementing this listing with additional steps, subtasks, or elements deemed necessary to permit the development of alternative approaches or the application of proprietary analytical techniques.

Task 1: Study design/planning
Identify five lakes to be sampled each year, using criteria such as geographic location, accessibility, potential contaminant sources, surrounding land use, historical sampling, and other relevant considerations. Determine which lakes should be re-assessed, and the appropriate reassessment frequency. The contractor will coordinate sampling with MDEQ as appropriate. Demonstrated knowledge of past DEQ and other regional (Great Lakes, inland lakes, and rivers) sediment core sampling projects is desirable, as is familiarity with the effects of land use, geography, and other factors on contaminant accumulation rates in sediments.

Task 2: Sediment core collection/sediment core processing
Collect high-quality sediment cores from five inland lakes per year selected jointly by the contractor and MDEQ. A high-quality sediment core is a core that has not been compacted or otherwise disturbed, ensures the chronological integrity of the core, and captures the sediments that lie at the sediment/water interface. The contractor will use an existing boat and sediment coring device to collect samples. The contractor will provide all other sampling equipment, and will be reimbursed for the cost of supplies and shipping. Samples will generally be collected according to a schedule developed by the MDEQ in consultation with the contractor. The contractor will process the sediment core to meet the objectives of the project and should utilize clean techniques and low-level analysis where applicable. Quality assurance/quality control procedures, to be developed by the MDEQ and the contractor, must be followed.

Task 3: Sediment core analysis
The sediment core samples collected from inland lakes will be analyzed by the contractor or a contractor-selected laboratory that is approved by the MDEQ. The laboratory must have certification for analysis of nutrients (e.g. phosphorus, nitrogen), conventional parameters, organic contaminants (e.g. PCBs, DDT), metals (including mercury), using EPA-approved methods. The contractor also will collect and analyze pore water for these parameters and determine the age of sediments.

Task 4: Statistical data analysis/review
Perform rigorous statistical analysis on the data resulting from Tasks 1-3. Because comparable data will be collected at many inland lakes, the contractor must determine whether statistically significant differences exist among inland lakes, and whether these differences can be correlated with other key variables such as population density, land use, impervious area, atmospheric deposition, etc. Other necessary analyses including sediment aging, sedimentation rates, focusing factors, the effects of mixing zones on sediment dating, and anthropogenic accumulation rates. Other statistical tests also may be necessary. The MDEQ, in consultation with the contractor, will determine the type and format of the output.

Task 5: Report preparation/Presentations
Prepare reports on inland lakes sediment core data to summarize key findings (as determined by the MDEQ in cooperation with the contractor), with the raw data included in appendices. These reports should make effective use of graphs and tables to synthesize data and communicate major findings to technical and non-technical audiences. The report also will include individual fact sheets for each lake. The MDEQ also may require some assistance with the preparation of reports for which the MDEQ is responsible. The assistance will include preparation of tables, graphics, and spreadsheets. The contractor will make reports and other outputs available to MDEQ electronically and hard copy, as necessary. Materials in electronic format must be compatible with MDEQ software, primarily Microsoft products (Word, Excel, and Access), and in a format approved by MDEQ. The contractor will provide at least an annual presentation to MDEQ and other presentations to MDEQ as needed, as well as external conferences/organizations.

Bidder Response: See Appendix A

1.2 Roles and Responsibilities

1.201 CONTRACTOR STAFF, ROLES, AND RESPONSIBILITIES

The contractor must have available staff with a diverse array of expertise in sediment monitoring. Specific staff requirements include expertise in sediment sample collection, sediment analysis, statistical data analysis, data management, and report writing. Key staff in each of these areas should be identified along with relevant experience/qualifications. Contract/financial management expertise also will be required. The contractor should identify its primary contact for this contract to provide overall oversight and serve as a central conduit for information.

1.202 STATE STAFF, ROLES, AND RESPONSIBILITIES

Glen Schmitt, Water Bureau – Surface Water Assessment Section, will serve as the MDEQ project manager for the contract. Responsibilities include reviewing and approving work plans and monthly invoices; reviewing contractor reports and other work products along with the technical contacts; and working with the contractor to identify and resolve any problems. Schmitt will serve as the primary contact with the contractor on all issues, and must approve all proposed project work plans.

1.203 OTHER ROLES AND RESPONSIBILITIES

1.3 Project Plan

1.301 PROJECT PLAN MANAGEMENT

Specific sampling plans will be developed each year, within the scope of work described above. The MDEQ project manager will review individual work plans to ensure they fall within the scope of work. Specific work plans and costs will be regularly reviewed by the MDEQ project manager via the quarterly progress reports and invoices. The work plans and/or budgets may be modified as necessary as the project progresses. Modification decisions will be made by the MDEQ project manager in consultation with the contractor.

Bidder Response: See Appendix A

1.302 REPORTS

Progress reports must be submitted along with the quarterly invoices. The progress reports should describe the activities that occurred during the quarter, as well as any problems that arise. Annual reports summarizing and providing the results for the previous year are required, including fact sheets highlighting key findings for each lake. A Quality Assurance Project Plan (QAPP) is required for the project, and must be approved by MDEQ prior to any sampling collection or analysis.

Bidder Response: See Appendix A

1.4 Project Management

1.401 ISSUE MANAGEMENT- RESERVED

1.402 RISK MANAGEMENT

The primary risk associated with this project is field sampling. It can be expected that, at times, sampling will be affected by inclement weather, lack of access, or equipment problems. The contractor should identify steps that it will take to minimize the potential occurrence of these risks. The contractor will be responsible for resolving any problems with the sediment coring device and other field equipment to ensure the timely collection of samples. The contractor also is responsible for tracking weather patterns to minimize the risk of sampling cancellation due to poor weather. Should sample collection be delayed by inclement weather, the contractor will re-schedule the sampling (in consultation with MDEQ) to ensure all scheduled samples are collected during the year. Lake access should be considered as one important criterion by the contractor during the planning process to prevent the selection of sites with poor access.

Another potential risk is a cost overrun. Generally, the contractor will be expected to complete sample collection and analysis within the specified budget. There is a potential for unexpected events to happen in the field or for specific tasks to take longer than anticipated. The contractor should have a process in place to notify the MDEQ project manager whenever a project cost overrun appears possible, so that a joint decision can be made to increase the project cost or to take steps to modify the work plan so the estimate is not exceeded.

There is always a risk that sample collection and analysis will yield inaccurate results. The contractor should identify the quality assurance/quality control activities that will be employed to minimize the risk of poor data quality.

1.403 CHANGE MANAGEMENT

The process for changing the work plan and budget is described under Section 1.301 above. The DEQ project manager has ultimate responsibility for such changes, in consultation with the contractor.

If a proposed contract change is approved by the Contract Compliance Inspector, the Contract Compliance Inspector will submit a request for change to the Department of Management and Budget, Purchasing Operations Buyer, who will make recommendations to the Director of Purchasing Operations regarding ultimate approval/disapproval of change request. If the DMB Purchasing Operations Director agrees with the proposed modification, and all required approvals are obtained (including State Administrative Board), the Purchasing Operations Buyer will issue an addendum to the Contract, via a Contract Change Notice. **Vendors who provide products or services prior to the issuance of a Contract Change Notice by DMB Purchasing Operations, risk non-payment for the out-of-scope/pricing products and/or services.**

1.5 Acceptance

1.501 CRITERIA

The following criteria will be used by the State to determine Acceptance of the Services and/or Deliverables provided under this SOW.

- Adherence to sampling plan and methods identified in project work plans;
- Adherence to quality assurance requirements identified in a QAPP, if applicable;
- Reasonableness of costs; and
- Production of interim and final reports, and other presentations, consistent with DEQ guidance for format and content.

1.502 FINAL ACCEPTANCE

The MDEQ project manager has final authority to approve/disapprove services and deliverables, and to ensure that work plan and QAPP requirements are followed satisfactorily.

1.6 Compensation and Payment

1.601 COMPENSATION AND PAYMENT

State shall pay Contractor an amount over the five-year contract for the performance of all activities necessary for or incidental to the performance of work as set forth in this SOW. The contractor will itemize costs by labor (# of hours times hourly rates), sample analysis, travel, equipment and supplies, and other categories as appropriate. Travel will be reimbursed at standard DEQ rates. Project-specific invoices will be submitted quarterly.

1.7 Additional Terms and Conditions Specific to this SOW

1.701 ADDITIONAL TERMS AND CONDITIONS SPECIFIC TO THIS SOW-RESERVED

Article 1, Attachment A
Pricing

ARTICLE 1, ATTACHMENT A

Budget Presentation Style

Michigan State University is a non profit institution. The work proposed here will be performed by faculty, graduate students, and undergraduate students, a model that is highly successful not only in other project, but specifically demonstrated for the type of work proposed here. However, because of the nature of the institution, salary structure, personnel involved, and analytical work involved, developing the budget does not lend it self to the design of Article !, Attachment A of the RFP. Therefore we have prepared a budget that hopefully better reflects the distribution of funds for this project throughout the 5 year program.

Budget Explanation

Personnel

We request funds each year for the following:
- one (1) month summer stipend for the principle PI (DTL),
- summer stipend (3 months) for a graduate assistant,
- academic year (12 months) stipend for a graduate assistant,
- hourly monies for an undergraduate assistant, and
- fringes and benefits are based on MSU criteria.

Travel

We request travel funds each year for:
- van rental, and
  - MSU rental van – estimated 2,000 miles per year at $0.35/mile and 12 days at $14 a day. Gas is included.
- per diem.
  - Government rates – food $35/day and lodging $65/day for 12 days

Supplies

We request each sampling year:
- supplies for the boat, coring device, extruding systems, and freeze dryer,
- supplies for the field activities (e.g., sediment sample bottles; porewater bottles; Porex rods, syringes, filters, ultra pure acid for porewater extrusion, and acids for bottle washing),
- miscellaneous supplies for unexpected expenses,
- funds for publications, and
- occasional funds for digestion vessel replacement.

Analytical costs

Funds requested for each analytical year include:
- ICP-MS analyses, Hg analysis, Organic suite analysis, Total N analyses, ^{210}Pb analysis

Budget: Inland Lakes Temporal Monitoring

		year 1	year 2	year 3	year 4	year 5
		2006-2007	2007-2008	2008-2009	2009-2010	2010-2011
Personnel						
	David T. Long (1 mo summer)	10948	11276.44	11614.73	11963.18	12322.07
	Grad Assistant (1/2 time 3 months)	4374	4592.7	4822.335	5063.452	5316.624
	Grad Assistant (1/2 time 12 months)	18500	19055	19626.65	20215.45	20821.91
	U grad assistant	9000	9000	9000	9000	4000
	Fringe DTL (7.5%)	821.1	845.733	871.105	897.2381	924.1553
	Graduate fringe (summer)	1675	1809	1954	2110	2279
	Graduate fringe (12 month)	9443	10199	11016	11896	12849
	total personnel	54761.1	56777.87	58904.82	61145.31	58512.76
Travel						
	Vehicle	868	928.76	993.7732	1063.337	1137.771
	Per Diem	4752	4989.6	5239.08	5501.034	594
	Conference fees and per diem	3500	3500	3500	3500	3500
	Presentations to lake groups per diem		300	300	300	300
Boat supplies		1000	1000	1000	1000	
Corer supplies		1000	500	1000	500	
Extruding systems supplies		1000	500	1000	500	
Freeze dryer supplies		1000	500	1000	500	
Field supplies		5158	5857	5158	5312.74	
Miscellaneous supplies*		1500	1500	1500	1500	1500
Publications			1000	1000	1000	1000
Digestion vessels		3000		3000		
Metal analysis						
	preparation (microwave digestion)	1821	2058	1821	1875.63	
	ICP/MS & AA analyses	14400	17304	15264	15721.92	
Hg analysis		1950	2343.25	2067	2129.01	
Organic analysis						
	Pest/PCB/PAH	26901	32326.04	28515.06	29370.51	
N analysis		2500	1000	1500	1000	
210Pb		28800	33600	30528	31443.84	
Total		153911.1	165984.5	163290.7	163363.3	66544.53
over head (20%)		30782.22	33196.9	32658.15	32672.67	13308.91
Total Requested		184693.3	199181.4	195948.9	196036	79853.44
Total Project Requested						855713.1

Article 1, Attachment B

ARTICLE 1, ATTACHMENT B

Organizational Chart, including Key Personnel
Vendors should include an organizational chart with their bid packet

In discussions with the Michigan State University's Contract and Grants Administration it was suggested that we list the key personnel for the project as the organization chart. It was also suggested that the key personnel be the two principle investigators.

David T. Long

Aqueous & Environmental Geochemistry Laboratory
Dept. of Geological Sciences, Michigan State University
East Lansing, MI 48824-1115
Voice: 517.355.9618 **FAX**: 517.353.8787 **Email**: long@msu.edu

John P. Giesy, Jr.

The Aquatic Toxicology Laboratory
Dept. of Zoology, Michigan State University
East Lansing, MI 48824-1115
Voice: 517.353.2000 **FAX**: 517.432.1984 **Email**: jgeisy@aol.com

Article 2 – General Terms and Conditions

2.010 Contract Structure and Administration

2.011 Definitions

Capitalized terms used in this Contract (including its Exhibits) shall have the meanings given below, unless the context requires otherwise:

(a) "Days" means calendar days unless otherwise specified.
(b) "24x7x365" means 24 hours a day, seven days a week, and 365 days a year (including the 366th day in a leap year).
(c) "Additional Service" means any Services/Deliverables within the scope of the Contract, but not specifically provided under any Statement of Work, that once added will result in the need to provide the Contractor with additional consideration. "Additional Service" does not include New Work.
(d) "Amendment Labor Rates" means the schedule of fully-loaded hourly labor rates attached as **Article 1, Attachment C**.
(e) "Audit Period" has the meaning given in **Section 2.111**.
(f) "Business Day," whether capitalized or not, shall mean any day other than a Saturday, Sunday or State-recognized legal holiday (as identified in the Collective Bargaining Agreement for State employees) from 8:00am EST through 5:00pm EST unless otherwise stated.
(g) "Incident" means any interruption in Services.
(h) "Business Critical" means any function identified in any Statement of Work as Business Critical.
(i) "Deliverable" means physical goods and/or commodities as required or identified by a Statement of Work
(j) "Key Personnel" means any Personnel designated in **Article 1, Section 1.201 and/or Attachment B,** as Key Personnel.
(k) "New Work" means any Services/Deliverables outside the scope of the Contract and not specifically provided under any Statement of Work, that once added will result in the need to provide the Contractor with additional consideration. "New Work" does not include Additional Service.
(l) "Services" means any function performed for the benefit of the State.
(m) "State Location" means any physical location where the State performs work. State Location may include state-owned, leased, or rented space.
(n) "Subcontractor" means a company Contractor delegates performance of a portion of the Services to, but does not include independent contractors engaged by Contractor solely in a staff augmentation role.
(o) "Work in Process" means a Deliverable that has been partially prepared, but has not been presented to the State for Approval.

2.012 Attachments and Exhibits

All Attachments and/or Exhibits attached to any, and all Statement(s) of Work, attached to, or referencing this Contract, are incorporated in their entirety into, and form part of, this Contract.

2.013 Statements of Work

(a) The parties agree that the Services/Deliverables to be rendered by Contractor pursuant to this Contract (and any future amendments of it) will be defined and described in detail in Statements of Work or Purchase Orders (PO) executed under this Contract. Contractor shall not be obliged or authorized to commence any work to implement a Statement of Work until authorized via a PO issued against this Contract, or an amendment to this Contract (see 2.106). Contractor shall perform in accordance with this Contract, including the Statements of Work/Purchase Orders executed under it.
(b) Unless otherwise agreed by the parties, each Statement of Work (as defined in Article 1) will include, or incorporate by reference to the appropriate Contract Article 1 Attachment containing, the following information:
- a description of the Services to be performed by Contractor under the Statement of Work;
- a project schedule (including the commencement and completion dates for all tasks, subtasks (for all projects of sufficient duration and complexity to warrant sub task breakdown), and Deliverables;

- a list of the Deliverables to be provided, if any, including any particular specifications and acceptance criteria for such Deliverables, and the dates on which the Deliverables are scheduled to be completed and delivered to the State;
- all Deliverable price schedules and other charges associated with the Statement of Work, the overall fixed price for such Statement of Work and any other appropriate pricing and payment terms;
- a specification of Contractor's and the State's respective performance responsibilities with respect to the performance or completion of all tasks, subtasks and Deliverables;
- a listing of any Key Personnel of Contractor and/or its Subcontractors for that Statement of Work and any future Statements of Work;
- any other information or provisions the parties agree to include.

(c) Reserved.

(d) The initial Statements of Work, as of the Effective Date, are attached to this Contract.

2.014 Issuing Office

This Contract is issued by the Department of Management and Budget, Purchasing Operations and the Department of Environmental Quality (collectively, including all other relevant State of Michigan departments and agencies, the "State"). Purchasing Operations is the sole point of contact in the State with regard to all procurement and contractual matters relating to the Contract. **Purchasing Operations is the only State office authorized to change, modify, amend, alter or clarify the prices, specifications, terms and conditions of this Contract.** The Contractor Administrator within the Office of Purchasing Operations for this Contract is:

Jim Wilson
Purchasing Operations
Department of Management and Budget
Mason Bldg, 2nd Floor
PO Box 30026
Lansing, MI 48909
Wilsonj4@michigan.gov
517-241-1916

2.015 Contract Compliance Inspector

Upon receipt at Purchasing Operations of the properly executed Contract, it is anticipated that the Director of DMB Purchasing Operations, in consultation with DEQ, will direct that the person named below, or any other person so designated, be authorized to monitor and coordinate the activities for the Contract on a day-to-day basis during its term. However, monitoring of this Contract implies **no authority to change, modify, clarify, amend, or otherwise alter the prices, terms, conditions and specifications of such Contract as that authority is retained by the Office of Purchasing Operations**. The Contract Compliance Inspector for this Contract is:

Glen Schmitt
Department of Environmental Quality – Water Bureau
Constitution Hall, 2nd Floor South
PO Box 30273
Lansing, MI 48909
schmittgp@michigan.gov
Phone: (517) 241-0910

2.016 Project Manager

The following individual will oversee the project:

Glen Schmitt
Department of Environmental Quality – Water Bureau
Constitution Hall, 2nd floor south
PO Box 30273
Lansing, MI 48909
schmittgp@michigan.gov
Phone: (517) 241-0910
Fax: (517) 373-9958

2.020 Contract Objectives/Scope/Background

2.21 Background

Each year since 2000, the State Legislature has appropriated CMI funds for the implementation of the Strategy. A major component of the Strategy is to collect sediment core samples from inland lakes, analyze the sediments for organic and inorganic contaminants, provide dates for sediment core slices, and produce an annual report describing the results. This contract will continue the project for five years.

2.022 Purpose

The purpose of this contract is to collect and analyze inland lake sediments for selected contaminants. Monitoring activities will include sediment core sampling, sediment sample analysis, data analysis, preparation of figures and tables, and writing reports. The contract will be specific to the MDEQ – Water Bureau.

2.023 Objectives and Scope

Contract outcomes will be an annual report, including fact sheets for each lake, summarizing inland lake sediment data. During each year, the contractor (in consultation with MDEQ) will identify five lakes to assess, and will collect and analyze sediment core samples from the selected lakes. The scope of the contract is identified above (Sections 1.101 and 1.102).

2.024 Interpretation

Sections 2.021 through 2.023 are intended to provide background and context for this Contract and are not intended to expand the scope of the obligations under this Contract or to alter the plain meaning of the terms and conditions of this Contract. However, to the extent the terms and conditions of this Contract are unclear or otherwise ambiguous, such terms and conditions are to be interpreted and construed in light of the provisions of this Section.

2.025 Form, Function and Utility

If the Contract is for use of more than one State agency and if the Deliverable/Service does not the meet the form, function, and utility required by that State agency, that agency may, subject to State purchasing policies, procure the Deliverable/Service from another source.

2.030 Legal Effect and Term

2.031 Legal Effect

Except as otherwise agreed in writing by the parties, the State assumes no liability for costs incurred by Contractor or payment under this Contract, until Contractor is notified in writing that this Contract (or Change Order) has been approved by the State Administrative Board (if required), approved and signed by all the parties, and a Purchase Order against the Contract has been issued.

2.032 Contract Term

This Contract is for a period of five (5) years from September 20, 2006 through September 19, 2011. All outstanding Purchase Orders shall also expire upon the termination (cancellation for any of the reasons listed in 2.210) of the Contract, unless otherwise extended pursuant to the Contract. Absent an early termination for any reason, Purchase Orders issued but not expired, by the end of the Contract's stated term, will remain in effect for the balance of the fiscal year for which they were issued.

2.033 Renewal(s)

This Contract may be renewed in writing by mutual agreement of the parties not less than thirty (30) days before its expiration. The Contract may be renewed for up to five (5) additional one (1) year periods. Successful completion of negotiations surrounding the terms of the extension, will be a pre-requisite for the exercise of any option year.

2.040 Contractor Personnel

2.041 Contractor Personnel

(a) Personnel Qualifications. All persons assigned by Contractor to the performance of Services under this Contract shall be employees of Contractor or its majority-owned (directly or indirectly, at any tier) subsidiaries (or a State-approved Subcontractor) and shall be fully qualified to perform the work assigned to them. Contractor shall include a similar provision in any subcontract entered into with a Subcontractor. For the purposes of this Contract, independent contractors engaged by Contractor solely in a staff augmentation role shall be treated by the State as if they were employees of Contractor for this Contract only; however, the State understands that the relationship between Contractor and Subcontractor is an independent contractor relationship.

(b) Key Personnel

(i) In discharging its obligations under this Contract, Contractor shall provide the named Key Personnel on the terms indicated. **Exhibit C** provides an organization chart showing the roles of certain Key Personnel, if any.

(ii) Key Personnel shall be dedicated as defined in **Exhibit C** to the Project for its duration in the applicable Statement of Work with respect to other individuals designated as Key Personnel for that Statement of Work.

(iii) The State will have the right to recommend and approve in writing the initial assignment, as well as any proposed reassignment or replacement, of any Key Personnel. Before assigning an individual to any Key Personnel position, Contractor will notify the State of the proposed assignment, will introduce the individual to the appropriate State representatives, and will provide the State with a resume and any other information about the individual reasonably requested by the State. The State reserves the right to interview the individual before granting written approval. In the event the State finds a proposed individual unacceptable, the State will provide a written explanation including reasonable detail outlining the reasons for the rejection. Additionally, the State's request shall be based on legitimate, good-faith reasons. Proposed alternative for the individual denied, shall be fully qualified for the position.

(iv) Contractor shall not remove any Key Personnel from their assigned roles or the Contract without the prior written consent of the State. If the Contractor does remove Key Personnel without the prior written consent of the State, it shall be considered an unauthorized removal ("Unauthorized Removal"). It shall not be considered an Unauthorized Removal if Key Personnel must be replaced for reasons beyond the reasonable control of Contractor, including illness, disability, leave of absence, personal emergency circumstances, resignation or for cause termination of the Key Personnel's employment. It shall not be considered an Unauthorized Removal if Key Personnel must be replaced because of promotions or other job movements allowed by Contractor personnel policies or Collective Bargaining Agreement(s) as long as the State receives prior written notice before shadowing occurs and Contractor provides thirty (30) days of shadowing unless parties agree to a different time period. The Contractor with the State shall review any Key Personnel replacements, and appropriate transition planning will be established. Any Unauthorized Removal may be considered by the State to be a material breach of the Contract, in respect of which the State may elect to exercise its rights under **Section 2.210**.

(v) It is acknowledged that an Unauthorized Removal will interfere with the timely and proper completion of the Contract, to the loss and damage of the State, and that it would be impracticable and extremely difficult to fix the actual damage sustained by the State as a result of any Unauthorized Removal. Therefore, Contractor and the State agree that in the case of any Unauthorized Removal in respect of which the State does not elect to exercise its rights under **Section 2.210**, the State may assess liquidated damages against Contractor as specified below.

For the Unauthorized Removal of any Key Personnel designated in the applicable Statement of Work, the liquidated damages amount shall be $25,000.00 per individual provided Contractor identifies a replacement approved by the State pursuant to **Section 2.041** and assigns the replacement to the Project to shadow the Key Personnel s/he is replacing for a period of at least thirty (30) days prior to such Key Personnel's removal.

If Contractor fails to assign a replacement to shadow the removed Key Personnel for at least thirty (30) days, in addition to the $25,000.00 liquidated damages for an Unauthorized Removal, Contractor shall pay the amount of $833.33 per day for each day of the thirty (30) day shadow period that the replacement Key Personnel does not shadow the removed Key Personnel, up to $25,000.00 maximum per individual. The total liquidated damages that may be assessed per Unauthorized Removal and failure to provide thirty (30) days of shadowing shall not exceed $50,000.00 per individual.

(c) Re-assignment of non-Key Personnel. Prior to re-deploying to other projects, at the completion of their assigned tasks on the Project, teams of its non-Key Personnel who are performing Services on-site at State facilities or who are otherwise dedicated primarily to the Project, Contractor will give the State at least ten (10) Business Days notice of the proposed re-deployment to give the State an opportunity to object to the re-deployment if the State reasonably believes such team's Contract responsibilities are not likely to be completed and approved by the State prior to the proposed date of re-deployment.

(d) Re-assignment of Personnel at the State's Request. The State reserves the right to require the removal from the Project of Contractor personnel found, in the judgment of the State, to be unacceptable. The State's request shall be written with reasonable detail outlining the reasons for the removal request. Additionally, the State's request shall be based on legitimate, good-faith reasons. Replacement personnel for the removed person shall be fully qualified for the position. If the State exercises this right, and the Contractor cannot immediately replace the removed personnel, the State agrees to an equitable adjustment in schedule or other terms that may be affected by the State's required removal. If any such incident with removed personnel results in delay not reasonable anticipatable under the circumstances and which is attributable to the State, the applicable SLAs for the affected Service will not be counted in **Section 2.076** for a time as agreed to by the parties.

(e) Staffing Levels.

(i) All staff requirements not specified in the applicable Statement of Work or State-approved project plan as State personnel will be supplied by Contractor. This includes secretarial, clerical and Contract administration support staff necessary for Contractor to perform its obligations hereunder.

(ii) Contractor shall provide sufficient personnel resources for the completion of Contract tasks indicated in Contractor's project plan approved by the State. If the level of personnel resources is insufficient to complete any Contractor Contract tasks in accordance with the Contract time schedule as demonstrated by Contractor's failure to meet mutually agreed to time schedules, Contractor shall promptly add additional qualified personnel resources to the performance of the affected tasks, at no additional charge to the State, in an amount sufficient to complete performance of Contractor's tasks in accordance with the Contract time schedule.

(f) Personnel Turnover. The Parties agree that it is in their best interests to keep the turnover rate of employees of Contractor and its Subcontractors who are performing the Services to a reasonable minimum. Accordingly, if the State determines that the turnover rate of such employees is excessive and so notifies Contractor, Contractor will meet with the State to discuss the reasons for the turnover rate and otherwise use commercially reasonable efforts to minimize such turnover rate. If requested to do so by the State, Contractor will submit to the State its proposals for reducing the turnover rate to an acceptable level. In any event, notwithstanding the turnover of personnel, Contractor remains obligated to perform the Services without degradation and in accordance with the State-approved Contract schedule.

(g) Location. All staff assigned by Contractor to work on the Contract will perform their duties either primarily at Contractor's offices and facilities or at State facilities. Without limiting the generality of the foregoing, Key Personnel will, at a minimum, spend at least the amount of time on-site at State facilities as indicated in the applicable Statement of Work. Subject to availability, selected Contractor personnel may be assigned office space to be shared with State personnel.

2.042 Contractor Identification

Contractor employees shall be clearly identifiable while on State property by wearing a State-issued badge, as required. Contractor employees are required to clearly identify themselves and the company they work for whenever making contact with State personnel by telephone or other means.

2.043 Cooperation with Third Parties

Contractor agrees to cause its personnel and the personnel of any Subcontractors to cooperate with the State and its agents and other contractors including the State's Quality Assurance personnel, and, as reasonably requested by the State, to provide to the State's agents and other contractors with reasonable access to Contractor's Project personnel, systems and facilities to the extent they relate to activities specifically associated with this Contract and will not interfere or jeopardize the safety or operation of the systems or facilities and provided Contractor receives reasonable prior written notice of such request. The State acknowledges that Contractor's time schedule for the Contract is very specific and agrees not to unnecessarily or unreasonably interfere with, delay or otherwise impeded Contractor's performance under this Contract with such requests for access.

2.044 Subcontracting by Contractor

(a) Contractor shall have full responsibility for the successful performance and completion of all of the Services and Deliverables. The State will consider Contractor to be the sole point of contact with regard to all contractual matters under this Contract, including payment of any and all charges for Services and Deliverables.

(b) Contractor shall not delegate any duties under this Contract to a Subcontractor unless the Department of Management and Budget, Office of Purchasing Operations has given written consent to such delegation. The State shall have the right of prior written approval of all Subcontractors and to require Contractor to replace any Subcontractors found, in the reasonable judgment of the State, to be unacceptable. The State's request shall be written with reasonable detail outlining the reasons for the removal request. Additionally, the State's request shall be based on legitimate, good-faith reasons. Replacement Subcontractor(s) for the removed Subcontractor shall be fully qualified for the position. If the State exercises this right, and the Contractor cannot immediately replace the removed Subcontractor, the State will agree to an equitable adjustment in schedule or other terms that may be affected by the State's required removal. If any such incident with a removed Subcontractor results in delay not reasonable anticipatable under the circumstances and which is attributable to the State, the applicable SLAs for the affected Work will not be counted in **Section 2.076** for a time agreed upon by the parties.

(c) In any subcontracts entered into by Contractor for the performance of the Services, Contractor shall require the Subcontractor, to the extent of the Services to be performed by the Subcontractor, to be bound to Contractor by the terms of this Contract and to assume toward Contractor all of the obligations and responsibilities that Contractor, by this Contract, assumes toward the State. The State reserves the right to receive copies of and review all subcontracts, although Contractor may delete or mask any proprietary information, including pricing, contained in such contracts before providing them to the State. The management of any Subcontractor will be the responsibility of Contractor, and Contractor shall remain responsible for the performance of its Subcontractors to the same extent as if Contractor had not subcontracted such performance. Contractor shall make all payments to Subcontractors or suppliers of Contractor. Except as otherwise agreed in writing by the State and Contractor, the State will not be obligated to direct payments for the Services other than to Contractor. The State's written approval of any Subcontractor engaged by Contractor to perform any obligation under this Contract shall not relieve Contractor of any obligations or performance required under this Contract. Attached as **Exhibit E** is a list of the Subcontractors, if any, approved by the State as of the execution of this Contract, together with a copy of the applicable subcontract.

(d) Except where specifically approved in writing by the State on a case-by-case basis, Contractor shall flow down the obligations in **Sections 2.040, 2.110, 2.150, 2.160, 2.171(c), 2.172(b), 2.180, 2.260, 2.276, 2.297** in all of its agreements with any Subcontractors.

(e) The Contractor shall select subcontractors (including suppliers) on a competitive basis to the maximum practical extent consistent with the objectives and requirements of the Contract.

2.045 Contractor Responsibility for Personnel

Contractor shall be responsible for all acts and omissions of its employees, as well as the acts and omissions of any other personnel furnished by Contractor to perform the Services.

2.050 State Standards

2.051 Existing Technology Standards- RESERVED

2.052 PM Methodology Standards- RESERVED

2.053 Adherence to Portal Technology Tools- RESERVED

2.054 Acceptable Use Policy

To the extent that Contractor has access to the State computer system, Contractor must comply with the State's Acceptable Use Policy, see http://www.michigan.gov/ditservice/0,1607,7-179-25781-73760--,00.html. All Contractor employees must be required, in writing, to agree to the State's Acceptable Use Policy before accessing the State system. The State reserves the right to terminate Contractor's access to the State system if a violation occurs.

2.060 Deliverables

2.061 Ordering

(a) Any Services/Deliverables to be furnished under this Contract shall be ordered by issuance of written Purchase Orders/Blanket Purchase Order by the State after approval by the Contract Administrator or his/her designee. All orders are subject to the terms and conditions of this Contract. In the event of conflict between an order and this Contract, the Contract shall take precedence as stated in **Section 2.293**. In no event shall any additional terms and conditions contained on a Purchase Order/Blanket Purchase Order be applicable, unless specifically contained in that Purchase Order/Blanket Purchase Order's accompanying Statement of Work.

2.062 Software- RESERVED

2.063 Hardware- RESERVED

2.064 Equipment to be New and Prohibited Products- RESERVED

2.070 Performance

2.071 Performance, In General

The State engages Contractor to execute the Contract and perform the Services/provide the Deliverables, and Contractor undertakes to execute and complete the Contract in its entirety in accordance with the terms and conditions of this Contract and with the participation of State representatives as specified in this Contract.

2.072 Time of Performance

(a) Contractor shall use commercially reasonable efforts to provide the resources necessary to complete all Services and Deliverables in accordance with the time schedules contained in the Statements of Work and other Exhibits governing the work, and with professional quality.

(b) Without limiting the generality of **Section 2.072(a)**, Contractor shall notify the State in a timely manner upon becoming aware of any circumstances that may reasonably be expected to jeopardize the timely and successful completion of any Deliverables/Services on the scheduled due dates in the latest State-approved delivery schedule and, in such event, shall inform the State of the projected actual delivery date.

(c) If Contractor believes that a delay in performance by the State has caused or will cause Contractor to be unable to perform its obligations in accordance with specified Contract time periods, Contractor shall notify the State in a timely manner and shall use commercially reasonable efforts to perform its obligations in accordance with such Contract time periods notwithstanding the State's failure. Contractor will not be in default for a delay in performance to the extent such delay is caused by the State.

2.073 Liquidated Damages - RESERVED

2.074 Bankruptcy

If Contractor shall file for protection under the bankruptcy laws, or if an involuntary petition shall be filed against Contractor and not removed within thirty (30) days, or if the Contractor becomes insolvent, be adjudicated bankrupt, or if it should make a general assignment for the benefit of creditors, or if a receiver shall be appointed due to its insolvency, and Contractor and/or its affiliates are unable to provide reasonable assurances that Contractor and/or its affiliates can deliver the services provided herein, the State may, without prejudice to any other right or remedy, terminate this Contract, in whole or in part, and, at its option, may take possession of the "Work in Process" and finish such Works in Process by whatever appropriate method the State may deem expedient. Contractor will fix appropriate notices or labels on the Work in Process to indicate ownership by the State. To the extent reasonably possible, materials and Work in Process shall be stored separately from other stock and marked conspicuously with labels indicating ownership by the State.

To secure the State's progress payments before the delivery of any services or materials required for the execution of Contractor's obligations hereunder, and any work which Contractor may subcontract in the support of the performance of its obligations hereunder, title shall vest in the State to the extent the State has made progress payments hereunder.

2.075 Time is of the Essence- RESERVED

2.076 Service Level Agreements (SLAs)- RESERVED

2.080 Delivery and Acceptance of Deliverables

2.081 Delivery Responsibilities- RESERVED

2.082 Delivery of Deliverables

(a) Where applicable, the Statements of Work/POs contain lists of the Deliverables to be prepared and delivered by Contractor including, for each Deliverable, the scheduled delivery date and a designation of whether the Deliverable is a document ("Written Deliverable"), a good ("Physical Deliverable") or a Service. All Deliverables shall be completed and delivered for State review and written approval and, where applicable, installed in accordance with the State-approved delivery schedule and any other applicable terms and conditions of the Contract.

2.083 Testing- RESERVED

2.084 Approval of Deliverables, In General

(a) All Deliverables (Physical Deliverables and Written Deliverables) and Services require formal written approval by the State, in accordance with the following procedures. Formal approval by the State requires that the Deliverable be confirmed in writing by the State to meet its specifications, which will include the successful completion of Testing as applicable in **Section 2.083**, to be led by the State with the support and assistance of Contractor. The parties acknowledge that the approval process set forth herein will be facilitated by ongoing consultation between the parties, visibility of interim and intermediate Deliverables and collaboration on key decisions.

(b) The State's obligation to comply with any State Review Period is conditioned on the timely delivery of Deliverables/Services being reviewed.

(c) Prior to commencement of its review or testing of a Deliverable/Service, the State may inspect the Deliverable/Service to confirm that all components of the Deliverable/Service have been delivered without material deficiencies. If the State determines that the Deliverable/Service has material deficiencies, the State may refuse delivery of the Deliverable/Service without performing any further inspection or testing of the Deliverable/Service. Otherwise, the review period will be deemed to have started on the day the State receives the Deliverable or the Service begins, and the State and Contractor agree that the Deliverable/Service is ready for use and, where applicable, certification by Contractor in accordance with **Section 2.083(a)**.

(d) The State will approve in writing a Deliverable/Service upon confirming that it conforms to and, performs in accordance with, its specifications without material deficiency. The State may, but shall not be required to, conditionally approve in writing a Deliverable/Service that contains material deficiencies if the State elects to permit Contractor to rectify them post-approval. In any case, Contractor will be responsible for working diligently to correct within a reasonable time at Contractor's expense all deficiencies in the Deliverable/Service that remain outstanding at the time of State approval.

(e) If, after three (3) opportunities (the original and two repeat efforts), Contractor is unable to correct all deficiencies preventing Final Acceptance of a Deliverable/Service, the State may: (i) demand that Contractor cure the failure and give Contractor additional time to cure the failure at the sole expense of Contractor; or (ii) keep the Contract in force and do, either itself or through other parties, whatever Contractor has failed to do, in which event Contractor shall bear any excess expenditure incurred by the State in so doing beyond the Contract price for such Deliverable/Service and will pay the State an additional sum equal to ten percent (10%) of such excess expenditure to cover the State's general expenses provided the State can furnish proof of such general expenses; or (iii) terminate the particular Statement of Work for default, either in whole or in part by notice to Contractor provided Contractor is unable to cure such breach. Notwithstanding the foregoing, the State shall not use, as a basis for exercising its termination rights under this Section, deficiencies discovered in a repeat State Review Period that could reasonably have been discovered during a prior State Review Period.

(f) The State, at any time and in its reasonable discretion, may halt the testing or approval process if such process reveals deficiencies in or problems with a Deliverable/Service in a sufficient quantity or of a sufficient severity as to make the continuation of such process unproductive or unworkable. In such case, the State may stop using the Service or return the applicable Deliverable to Contractor for correction and re-delivery prior to resuming the testing or approval process.

2.085 Process For Approval of Written Deliverables

The State Review Period for Written Deliverables will be the number of days set forth in the applicable Statement of Work following delivery of the final version of the Deliverable (failing which the State Review Period, by default, shall be five (5) Business Days for Written Deliverables of one hundred (100) pages or less and ten (10) Business Days for Written Deliverables of more than one hundred (100) pages). The duration of the State Review Periods will be doubled if the State has not had an opportunity to review an interim draft of the Written Deliverable prior to its submission to the State. The State agrees to notify Contractor in writing by the end of the State Review Period either stating that the Deliverable is approved in the form delivered by Contractor or describing any deficiencies that must be corrected prior to approval of the Deliverable (or at the State's election, subsequent to approval of the Deliverable). If the State delivers to Contractor a notice of deficiencies, Contractor will correct the described deficiencies and within thirty (30) Business Days resubmit the Deliverable in a form that shows all revisions made to the original version delivered to the State. Contractor's correction efforts will be made at no additional charge. Upon receipt of a corrected Deliverable from Contractor, the State will have a reasonable additional period of time, not to exceed the length of the original State Review Period, to review the corrected Deliverable to confirm that the identified deficiencies have been corrected.

2.086 Process for Approval of Services

The State Review Period for approval of Services is governed by the applicable Statement of Work (failing which the State Review Period, by default, shall be thirty (30) Business Days for Services). The State agrees to notify Contractor in writing by the end of the State Review Period either stating that the Service is approved in the form delivered by Contractor or describing any deficiencies that must be corrected prior to approval of the Services (or at the State's election, subsequent to approval of the Service). If the State delivers to Contractor a notice of deficiencies, Contractor will correct the described deficiencies and within thirty (30) Business Days resubmit the Service in a form that shows all revisions made to the original version delivered to the State. Contractor's correction efforts will be made at no additional charge. Upon implementation of a corrected Service from Contractor, the State will have a reasonable additional period of time, not to exceed the length of the original State Review Period, to review the corrected Service for conformity and that the identified deficiencies have been corrected.

2.087 Process for Approval of Physical Deliverables

The State Review Period for approval of Physical Deliverables is governed by the applicable Statement of Work (failing which the State Review Period, by default, shall be thirty (30) continuous Business Days for a Physical Deliverable). The State agrees to notify Contractor in writing by the end of the State Review Period either stating that the Deliverable is approved in the form delivered by Contractor or describing any deficiencies that must be corrected prior to approval of the Deliverable (or at the State's election, subsequent to approval of the Deliverable). If the State delivers to Contractor a notice of deficiencies, Contractor will correct the described deficiencies and within thirty (30) Business Days resubmit the Deliverable in a form that shows all revisions made to the original version delivered to the State. Contractor's correction efforts will be made at no additional charge. Upon receipt of a corrected Deliverable from Contractor, the State will have a reasonable additional period of time, not to exceed the length of the original State Review Period, to review the corrected Deliverable to confirm that the identified deficiencies have been corrected.

2.088 Final Acceptance

Unless otherwise stated in the Statement of Work or Purchase Order, "Final Acceptance" of each Deliverable shall occur when each Deliverable/Service has been approved by the State following the State Review Periods identified in **Sections 2.080-2.087**. Payment will be made for Deliverables installed and accepted. Upon acceptance of a Service, the State will pay for all Services provided during the State Review Period that conformed to the acceptance criteria.

2.080 Delivery and Acceptance of Deliverables

2.081 Delivery of Deliverables

Exhibit G contains a list of the Deliverables to be prepared and delivered by Contractor including, for each Deliverable, the scheduled delivery date and a designation of whether the Deliverable is a document ("Written Deliverable") or a Custom Software Deliverable. All Deliverables shall be completed and delivered for State review and written approval and, where applicable, installed in accordance with the State-approved delivery schedule and any other applicable terms and conditions of this Contract.

Prior to delivering any Deliverable to the State, Contractor will first perform all required quality assurance activities, and, in the case of Custom Software Deliverables, System Testing to verify that the Deliverable is complete and in conformance with its specifications. Before delivering a Deliverable to the State, Contractor shall certify to the State that (1) it has performed such quality assurance activities, (2) it has performed any applicable testing, (3) it has corrected all material deficiencies discovered during such quality assurance activities and testing, (4) the Deliverable is in a suitable state of readiness for the State's review and approval, and (5) the Deliverable/Service has all Critical Security patches/updates applied.

In discharging its obligations under this Section, Contractor shall be at all times (except where the parties agree otherwise in writing) in compliance with Level 3 of the Software Engineering Institute's Capability Maturity Model for Software ("CMM Level 3") or its equivalent.

2.082 Contractor System Testing

Contractor will be responsible for System Testing each Custom Software Deliverable in Contractor's development environment prior to turning over the Custom Software Deliverable to the State for User Acceptance Testing and approval. Contractor's System Testing shall include the following, at a minimum, plus any other testing required by CMM Level 3 or Contractor's system development methodology:

Contractor will be responsible for performing Unit Testing and incremental Integration Testing of the components of each Custom Software Deliverable.

Contractor's System Testing will also include Integration Testing of each Custom Software Deliverable to ensure proper inter-operation with all prior software Deliverables, interfaces and other components that are intended to inter-operate with such Custom Software Deliverable, and will include Regression Testing, volume and stress testing to ensure that the Custom Software Deliverables are able to meet the State's projected growth in the number and size of transactions to be processed by the Application and number of users, as such projections are set forth in the applicable Statement of Work.

Contractor's System Testing will also include Business Function Testing and Technical Testing of each Application in a simulated production environment. Business Function Testing will include testing of full work streams that flow through the Application as the Application will be incorporated within the State's computing environment. The State shall participate in and provide support for the Business Function Testing to the extent reasonably requested by Contractor. Within ten (10) days before the commencement of Business Function Testing pursuant to this Section, Contractor shall provide the State for State review and written approval Contractor's test plan for Business Function Testing.

Within five (5) Business Days following the completion of System Testing pursuant to **Section 2.080**, Contractor shall provide to the State a testing matrix establishing that testing for each condition identified in the System Testing plans has been conducted and successfully concluded. To the extent that testing occurs on State premises, the State shall be entitled to observe or otherwise participate in testing under this Section as the State may elect.

2.083 Approval of Deliverables, In General

All Deliverables (Written Deliverables and Custom Software Deliverables) require formal written approval by the State, in accordance with the following procedures. Formal approval by the State requires that the Deliverable be confirmed in writing by the State to meet its specifications which, in the case of Custom Software Deliverables, will include the successful completion of State User Acceptance Testing, to be led by the State with the support and assistance of Contractor. The parties acknowledge that the approval process set forth herein will be facilitated by ongoing consultation between the parties, visibility of interim and intermediate Deliverables and collaboration on key decisions.

The State's obligation to comply with any State Review Period is conditioned on the timely delivery of Deliverables being reviewed. If Contractor fails to provide a Deliverable to the State in a timely manner, the State will nevertheless use commercially reasonable efforts to complete its review or testing within the applicable State Review Period.

Before commencement of its review or testing of a Deliverable, the State may inspect the Deliverable to confirm that all components of the Deliverable (e.g., software, associated documentation, and other materials) have been delivered. If the State determines that the Deliverable is incomplete, the State may refuse delivery of the Deliverable without performing any further inspection or testing of the Deliverable. Otherwise, the review period will be deemed to have started on the day the State receives the Deliverable and the applicable certification by Contractor in accordance with **Section 2.080**.

The State will approve in writing a Deliverable upon confirming that it conforms to and, in the case of a Custom Software Deliverable, performs in accordance with, its specifications without material deficiency. The State may, but shall not be required to, conditionally approve in writing a Deliverable that contains material deficiencies if the State elects to permit Contractor to rectify them post-approval. In any case, Contractor will be responsible for working diligently to correct within a reasonable time at Contractor's expense all deficiencies in the Deliverable that remain outstanding at the time of State approval.

If, after three (3) opportunities (the original and two repeat efforts), Contractor is unable to correct all deficiencies preventing State approval of a Deliverable, the State may: (i) demand that Contractor cure the failure and give Contractor additional time to cure the failure at the sole expense of Contractor; or (ii) keep this Contract in force and do, either itself or through other parties, whatever Contractor has failed to do, in which event Contractor shall bear any excess expenditure incurred by the State in so doing beyond the contract price for such Deliverable and will pay the State an additional sum equal to ten percent (10%) of such excess expenditure to cover the State's general expenses without the need to furnish proof in substantiation of such general expenses; or (iii) terminate this Contract for default, either in whole or in part by notice to Contractor (and without the need to afford Contractor any further opportunity to cure). Notwithstanding the foregoing, the State shall not use, as a basis for exercising its termination rights under this Section, deficiencies discovered in a repeat State Review Period that could reasonably have been discovered during a prior State Review Period.

The State, at any time and in its own discretion, may halt the UAT or approval process if such process reveals deficiencies in or problems with a Deliverable in a sufficient quantity or of a sufficient severity as to make the continuation of such process unproductive or unworkable. In such case, the State may return the applicable Deliverable to Contractor for correction and re-delivery prior to resuming the review or UAT process and, in that event, Contractor will correct the deficiencies in such Deliverable in accordance with the Contract, as the case may be.

Approval in writing of a Deliverable by the State shall be provisional; that is, such approval shall not preclude the State from later identifying deficiencies in, and declining to accept, a subsequent Deliverable based on or which incorporates or inter-operates with an approved Deliverable, to the extent that the results of subsequent review or testing indicate the existence of deficiencies in the subsequent Deliverable, or if the Application of which the subsequent Deliverable is a component otherwise fails to be accepted pursuant to **Section 2.080**.

2.084 Process for Approval of Written Deliverables

The State Review Period for Written Deliverables will be the number of days set forth in the applicable Statement of Work following delivery of the final version of the Written Deliverable (failing which the State Review Period, by default, shall be five (5) Business Days for Written Deliverables of one hundred (100) pages or less and ten (10) Business Days for Written Deliverables of more than one hundred (100) pages). The duration of the State Review Periods will be doubled if the State has not had an opportunity to review an interim draft of the Written Deliverable prior to its submission to the State. The State agrees to notify Contractor in writing by the end of the State Review Period either stating that the Written Deliverable is approved in the form delivered by Contractor or describing any deficiencies that must be corrected prior to approval of the Written Deliverable (or at the State's election, subsequent to approval of the Written Deliverable). If the State delivers to Contractor a notice of deficiencies, Contractor will correct the described deficiencies and within five (5) Business Days resubmit the Deliverable in a form that shows all revisions made to the original version delivered to the State. Contractor's correction efforts will be made at no additional charge. Upon receipt of a corrected Written Deliverable from Contractor, the State will have a reasonable additional period of time, not to exceed the length of the original State Review Period, to review the corrected Written Deliverable to confirm that the identified deficiencies have been corrected.

2.085 Process for Approval of Custom Software Deliverables

The State will conduct UAT of each Custom Software Deliverable in accordance with the following procedures to determine whether it meets the criteria for State approval – i.e., whether it conforms to and performs in accordance with its specifications without material deficiencies.
Within thirty (30) days (or such other number of days as the parties may agree to in writing) prior to Contractor's delivery of any Custom Software Deliverable to the State for approval, Contractor shall provide to the State a set of proposed test plans, including test cases, scripts, data and expected outcomes, for the State's use (which the State may supplement in its own discretion) in conducting UAT of the Custom Software Deliverable. Contractor, upon request by the State, shall provide the State with reasonable assistance and support during the UAT process.

For the Custom Software Deliverables listed in **Exhibit G**, the State Review Period for conducting UAT will be as indicated in **Exhibit G**. For any other Custom Software Deliverables not listed in **Exhibit G**, the State Review Period shall be the number of days agreed in writing by the parties (failing which it shall be forty-five (45) days by default). The State Review Period for each Custom Software Deliverable will begin when Contractor has delivered the Custom Software Deliverable to the State accompanied by the certification required by **Section 2.080** and the State's inspection of the Deliverable has confirmed that all components of it have been delivered.

The State's UAT will consist of executing test scripts from the proposed testing submitted by Contractor, but may also include any additional testing deemed appropriate by the State. If the State determines during the UAT that the Custom Software Deliverable contains any deficiencies, the State will notify Contractor of the deficiency by making an entry in an incident reporting system available to both Contractor and the State. Contractor will modify promptly the Custom Software Deliverable to correct the reported deficiencies, conduct appropriate System Testing (including, where applicable, Regression Testing) to confirm the proper correction of the deficiencies and re-deliver the corrected version to the State for re-testing in UAT. Contractor will coordinate the re-delivery of corrected versions of Custom Software Deliverables with the State so as not to disrupt the State's UAT process. The State will promptly re-test the corrected version of the Software Deliverable after receiving it from Contractor.

Within three (3) business days after the end of the State Review Period, the State will give Contractor a written notice indicating the State's approval or rejection of the Custom Software Deliverable according to the criteria and process set out in this **Section 2.080**.

2.086 Final Acceptance

"Final Acceptance" shall be considered to occur when the Custom Software Deliverable to be delivered has been approved by the State and has been operating in production without any material deficiency for fourteen (14) consecutive days. If the State elects to defer putting a Custom Software Deliverable into live production for its own reasons, not based on concerns about outstanding material deficiencies in the Deliverable, the State shall nevertheless grant Final Acceptance of the Project.

2.090 Financial

2.091 Pricing

(a) Fixed Prices for Services/Deliverables
Each Statement of Work/PO issued under this Contract shall specify (or indicate by reference to the appropriate Contract Exhibit) the firm, fixed prices for all Services/Deliverables, and the associated payment milestones and payment amounts. To the extent the parties agree that certain specific Services will be provided on a time and materials basis. The State may make progress payments to the Contractor when requested as work progresses, but not more frequently than monthly, in amounts approved by the Contract Administrator, after negotiation. Contractor must show verification of measurable progress at the time of requesting progress payments.
(b) Adjustments for Reductions in Scope of Services/Deliverables
If the scope of the Services/Deliverables under any Statement of Work issued under this Contract is subsequently reduced by the State, the parties shall negotiate an equitable reduction in Contractor's charges under such Statement of Work commensurate with the reduction in scope unless specifically identified in an applicable Statement of Work.
(c) Services/Deliverables Covered
For all Services/Deliverables to be provided by Contractor (and its Subcontractors, if any) under this Contract, the State shall not be obligated to pay any amounts in addition to the charges specified in this Contract.
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2.092 Invoicing and Payment Procedures and Terms

(a) Invoicing and Payment – In General

(i) Each Statement of Work issued under this Contract shall list (or indicate by reference to the appropriate Contract Exhibit) the prices for all Services/Deliverables, equipment and commodities to be provided, and the associated payment milestones and payment amounts.

(ii) Each Contractor invoice will show details as to charges by Service/Deliverable component and location at a level of detail reasonably necessary to satisfy the State's accounting and charge-back requirements. The charges for Services billed on a time and materials basis shall be determined based on the actual number of hours of Services performed, at the applicable Labor Rates specified in **Article 1, Attachment C**. Invoices for Services performed on a time and materials basis will show, for each individual, the number of hours of Services performed during the billing period, the billable skill/labor category for such person and the applicable hourly billing rate. Prompt payment by the State is contingent on the Contractor's invoices showing the amount owed by the State minus any holdback amount to be retained by the State in accordance with **Section 2.094**.

(iii) Correct invoices will be due and payable by the State, in accordance with the State's standard payment procedure as specified in 1984 Public Act No. 279, MCL 17.51 et seq., within forty-five (45) days after receipt, provided the State determines that the invoice was properly rendered.

(b) Taxes (See Section 2.305 and Article 3, Section 3.022-3.024 for additional)
The State is exempt from Federal Excise Tax, State and Local Sales Taxes, and Use Tax with respect to the sale to and use by it of tangible personal property. Such taxes shall not be included in Contract prices as long as the State maintains such exemptions. Copies of all tax exemption certificates shall be supplied to Contractor, if requested.

(c) Out-of-Pocket Expenses
Contractor acknowledges that the out-of-pocket expenses that Contractor expects to incur in performing the Services/ providing the Deliverables (such as, but not limited to, travel and lodging, document reproduction and shipping, and long distance telephone) are included in Contractor's fixed price for each Statement of Work. Accordingly, Contractor's out-of-pocket expenses are not separately reimbursable by the State unless, on a case-by-case basis for unusual expenses, the State has agreed in advance and in writing to reimburse Contractor for such an expense at the State's current travel reimbursement rates. See http://www.mi.gov/dmb/0,1607,7-150-9141_13132---,00.html for current rates.

(d) Pro-ration
To the extent there are any Services that are to be paid for on a monthly basis, the cost of such Services shall be pro-rated for any partial month.

(e) Antitrust Assignment
The Contractor assigns to the State any claim for overcharges resulting from antitrust violations to the extent that those violations concern materials or services supplied by third parties to the Contractor, toward fulfillment of this Contract.

(f) Final Payment
The making of final payment by the State to Contractor does not constitute a waiver by either party of any rights or other claims as to the other party's continuing obligations under the Contract, nor will it constitute a waiver of any claims by one party against the other arising from unsettled claims or failure by a party to comply with this Contract, including claims for Services and Deliverables not reasonably known until after acceptance to be defective or substandard. Contractor's acceptance of final payment by the State under this Contract shall constitute a waiver of all claims by Contractor against the State for payment under this Contract, other than those claims previously filed in writing on a timely basis and still unsettled.

2.093 State Funding Obligation

The State's obligation under this Contract is payable only and solely from funds appropriated for the purpose of this Contract. Contractor acknowledges and agrees that all funds for payments after the end of the current fiscal year are subject to the availability of a legislative appropriation for the purpose of this Contract. Events of non-appropriation are addressed further in **Section 2.210** of this Contract.

2.094 Holdback

The State shall have the right to hold back, as a retainage, an amount equal to ten percent (10%) of all amounts invoiced by Contractor for Services/Deliverables. The amounts held back shall be released to Contractor after the State has granted Final Acceptance.

2.095 Electronic Payment Availability

Electronic transfer of funds is available to State contractors. Contractor is required to register with the State electronically at http://www.cpexpress.state.mi.us. Public Act 533 of 2004, requires all payments be transitioned over to EFT by October, 2005.

2.100 Contract Management

2.101 Contract Management Responsibility

(a) Contractor shall have overall responsibility for managing and successfully performing and completing the Services/Deliverables, subject to the overall direction and supervision of the State and with the participation and support of the State as specified in this Contract. Contractor's duties will include monitoring and reporting the State's performance of its participation and support responsibilities (as well as Contractor's own responsibilities) and providing timely notice to the State in Contractor's reasonable opinion if the State's failure to perform its responsibilities in accordance with **Article 1, Attachment E** (Project Plan) is likely to delay the timely achievement of any Contract tasks.
(b) The Services/Deliverables will be provided by the Contractor either directly or through its affiliates, subsidiaries, subcontractors or resellers. Regardless of the entity providing the Service/Deliverable, the Contractor will act as a single point of contact coordinating these entities to meet the State's need for Services/Deliverables. Nothing in this Contract, however, shall be construed to authorize or require any party to violate any applicable law or regulation in its performance of this Contract.

2.102 Problem and Contract Management Procedures

Problem Management and Contract Management procedures will be governed by the Contract and the applicable Statements of Work.

2.103 Reports and Meetings

(a) Reports.

Within thirty (30) days after the Effective Date, the parties shall determine an appropriate set of periodic reports to be issued by Contractor to the State. Such reports may include:

(i) separately address Contractor's performance in each area of the Services;

(ii) for each area of the Services, assess the degree to which Contractor has attained or failed to attain the pertinent objectives in that area, including on-time completion and delivery of Deliverables;

(iii) explain the reasons for any failure to achieve on-time completion and delivery of Deliverables and include a plan for corrective action where appropriate;

(iv) describe any circumstances that Contractor anticipates will impair or prevent on-t time completion and delivery of Deliverables in upcoming reporting periods;

(v) include plans for corrective action or risk mitigation where appropriate and describe the status of ongoing problem resolution efforts;

(vi) provide reports setting forth a comparison of actual hours spent by Contractor (including its augmented personnel and Subcontractors) in performing the Project versus hours budgeted by Contractor.

(vii) set forth a record of the material personnel changes that pertain to the Services and describe planned changes during the upcoming month that may affect the Services.

(viii) include such documentation and other information may be mutually agreed to verify compliance with, and meeting the objectives of, this Contract.

(ix) set forth an updated schedule that provides information on the status of upcoming Deliverables, expected dates of delivery (or redelivery) of such Deliverables and estimates on timing for completion of the Project.

(b) Meetings.

Within thirty (30) days after the Effective Date, the parties shall determine an appropriate set of meetings to be held between representatives of the State and Contractor. Contractor shall prepare and circulate an agenda sufficiently in advance of each such meeting to give participants an opportunity to prepare for the meeting. Contractor shall incorporate into such agenda items that the State desires to discuss. At the State's request, Contractor shall prepare and circulate minutes promptly after a meeting.

2.104 System Changes

Contractor is not responsible for and not authorized to make changes to any State systems without written authorization from the State. Any changes Contractor makes to State systems with the State's approval shall be done in accordance with applicable State procedures, including security, access and configuration management procedures.

2.105 RESERVED

2.106 Change Requests

The State reserves the right to request from time to time, any changes to the requirements and specifications of the Contract and the work to be performed by the Contractor under the Contract. During the course of ordinary business, it may become necessary for the State to discontinue certain business practices or create Additional Services/Deliverables. At a minimum, to the extent applicable, the State would like the Contractor to provide a detailed outline of all work to be done, including tasks necessary to accomplish the services/deliverables, timeframes, listing of key personnel assigned, estimated hours for each individual per task, and a complete and detailed cost justification.

If the State requests or directs the Contractor to perform any Services/Deliverables that are outside the scope of the Contractor's responsibilities under the Contract ("New Work"), the Contractor must notify the State promptly, and before commencing performance of the requested activities, that it believes the requested activities are New Work. If the Contractor fails to notify the State before commencing performance of the requested activities, any such activities performed before notice is given by the Contractor shall be conclusively considered to be in-scope Services/Deliverables, not New Work.

If the State requests or directs the Contractor to perform any services or provide deliverables that are consistent with and similar to the Services/Deliverables being provided by the Contractor under the Contract, but which the Contractor reasonably and in good faith believes are not included within the Statements of Work, then before performing such services or providing such deliverables, the Contractor shall notify the State in writing that it considers the services or deliverables to be an Additional Service/Deliverable for which the Contractor should receive additional compensation. If the Contractor does not so notify the State, the Contractor shall have no right to claim thereafter that it is entitled to additional compensation for performing that service or providing that deliverable. If the Contractor does so notify the State, then such a service or deliverable shall be governed by the Change Request procedure in this Section.

In the event prices or service levels are not acceptable to the State, the Additional Services or New Work shall be subject to competitive bidding based upon the specifications.

(a) Change Requests

(i) State Requests

If the State should require Contractor to perform New Work, Additional Services or make changes to the Services that would affect the Contract completion schedule or the amount of compensation due Contractor (a “Change”), the State shall submit a written request for Contractor to furnish a proposal for carrying out the requested Change (a “Change Request”).

(ii) Contractor Recommendations

Contractor shall be entitled to propose a Change to the State, on its own initiative, should it be of the opinion that this would benefit the Contract.

(iii) Upon receipt of a Change Request or on its own initiative, Contractor shall examine the implications of the requested Change on the technical specifications, Contract schedule and price of the Deliverables and Services and shall submit to the State without undue delay a written proposal for carrying out the Change. Contractor’s proposal will include any associated changes in the technical specifications, Contract schedule and price and method of pricing of the Services. If the Change is to be performed on a time and materials basis, the Amendment Labor Rates shall apply to the provision of such Services. If Contractor provides a written proposal and should Contractor be of the opinion that a requested Change is not to be recommended, it shall communicate its opinion to the State but shall nevertheless carry out the Change as specified in the written proposal if the State directs it to do so.

(iv) By giving Contractor written notice within a reasonable time, the State shall be entitled to accept a Contractor proposal for Change, to reject it or to reach another agreement with Contractor. Should the parties agree on carrying out a Change, a written Contract Change Notice shall be prepared and issued under this Contract, describing the Change and its effects on the Services and any affected components of this Contract (a “Contract Change Notice”).

(v) No proposed Change shall be performed until the proposed Change has been specified in a duly executed Contract Change Notice issued by the Department of Management and Budget, Purchasing Operations.

(vi) If the State requests or directs Contractor to perform any activities that Contractor believes constitute a Change, Contractor must notify the State that it believes the requested activities are a Change prior to commencing the performance of the requested activities. If Contractor fails to so notify the State prior to commencing performance of the requested activities, such activities shall be considered to be performed gratuitously by Contractor, and Contractor shall not have any right thereafter to assert any claim for additional compensation or time for the performance of such activities. If Contractor commences performance of gratuitous services outside the scope of this Contract and subsequently elects to stop performing such out-of-scope services, Contractor must, at the request of the State, back out or reverse any changes resulting from such performance that would adversely affect the Contract.

2.107 Management Tools- RESERVED

2.110 Records and Inspections

2.111 Records and Inspections

(a) Inspection of Work Performed. The State's authorized representatives shall at all reasonable times and with ten (10) days prior written request, have the right to enter Contractor's premises, or any other places, where the Services are being performed, and shall have access, upon reasonable request, to interim drafts of Deliverables or work-in-progress. Upon ten (10) Days prior written notice and at all reasonable times, the State's representatives shall be allowed to inspect, monitor, or otherwise evaluate the work being performed and to the extent that such access will not reasonably interfere or jeopardize the safety or operation of the systems or facilities. Contractor must provide all reasonable facilities and assistance for the State's representatives.

(b) Examination of Records. Contractor agrees that the State, including its duly authorized representatives, until the expiration of seven (7) years following the creation of the material (collectively, the "Audit Period"), shall, upon twenty (20) days prior written notice, have access to and the right to examine and copy any of Contractor's books, records, documents and papers pertinent to establishing Contractor's compliance with the Contract and with applicable laws and rules, including the State's procurement rules, regulations and procedures, and actual performance of the Contract for the purpose of conducting an audit, examination, excerpt and/or transcription but the State shall not have access to any information deemed confidential to Contractor to the extent such access would require such confidential information to become publicly available. This provision also applies to the books, records, accounts, documents and papers, in print or electronic form, of any parent, affiliated or subsidiary organization of Contractor, or any Subcontractor of Contractor performing services in connection with the Contract.

(c) Retention of Records. Contractor shall maintain at least until the end of the Audit Period all pertinent financial and accounting records (including time sheets and payroll records, and information pertaining to the Contract and to the Services, equipment, and commodities provided under the Contract) pertaining to the Contract in accordance with generally accepted accounting principles and other procedures specified in this Section. Financial and accounting records shall be made available, upon request, to the State at any time during the Audit Period. If an audit, litigation, or other action involving Contractor's records is initiated before the end of the Audit Period, the records must be retained until all issues arising out of the audit, litigation, or other action are resolved or until the end of the Audit Period, whichever is later.

(d) Audit Resolution. If necessary, the Contractor and the State shall meet to review each audit report promptly after issuance. The Contractor will respond to each audit report in writing within thirty (30) days from receipt of such report, unless a shorter response time is specified in such report. The Contractor and the State shall develop, agree upon and monitor an action plan to promptly address and resolve any deficiencies, concerns, and/or recommendations in such audit report.

2.112 Errors

(a) If the audit demonstrates any errors in the statements provided to the State, then the amount in error shall be reflected as a credit or debit on the next invoice and in subsequent invoices until the amount is paid or refunded in full. However, a credit or debit may not be carried for more than four (4) quarterly statements. If a balance remains after four (4) quarterly statements, then the remaining amount will be due as a payment or refund within forty-five (45) days of the last quarterly statement that the balance appeared on or termination of the contract, whichever is earlier.

(b) In addition to other available remedies, the difference between the payment received and the correct payment amount is greater than ten percent (10%), then the Contractor shall pay all of the reasonable costs of the audit.

2.120 State Responsibilities

2.121 State Performance Obligations

(a) Equipment and Other Resources. To facilitate Contractor's performance of the Services/Deliverables, the State shall provide to Contractor such equipment and resources as identified in the Statements of Work or other Contract Exhibits as items to be provided by the State.

(b) Facilities. The State shall designate space as long as it is available and as provided in the Statement of Work, to house Contractor's personnel whom the parties agree will perform the Services/Deliverables at State facilities (collectively, the "State Facilities"). Contractor shall have reasonable access to, and unless agreed otherwise by the parties in writing shall observe and comply with all rules and regulations relating to, each of the State Facilities (including hours of operation) used by Contractor in the course of providing the Services. Contractor agrees that it will not, without the prior written consent of the State, use any State Facilities or access any State information systems provided for Contractor's use, or to which Contractor otherwise gains access in the course of performing the Services, for any purpose other than providing the Services to the State.

(c) Return. Contractor shall be responsible for returning to the State any State-furnished equipment, facilities and other resources when no longer required for the Contract in the same condition as when provided by the State, reasonable wear and tear excepted.

(d) Except as otherwise provided in **Section 2.220**, the State's failure to perform its responsibilities as set forth in this Contract shall not be deemed to be grounds for termination by Contractor. However, Contractor will not be liable for any default or delay in the performance of its obligations under this Contract to the extent such default or delay is caused by nonperformance of the State's obligations under this Contract, provided Contractor provides the State with reasonable written notice of such nonperformance and Contractor uses commercially reasonable efforts to perform notwithstanding the State's failure to perform. In addition, if the State's nonperformance of its responsibilities under this Contract materially increases the time required for Contractor's performance or Contractor's cost of performance, Contractor shall be entitled to seek an equitable extension via the Change Request process described in **Section 2.106**.

2.130 Security

2.131 Background Checks

The Contractor shall authorize the investigation of its personnel proposed to have access to State facilities and systems on a case by case basis. The scope of the background check is at the discretion of the State and the results will be used to determine Contractor personnel eligibility for working within State facilities and systems. Such investigations will include Michigan State Police Background checks (ICHAT) and may include the National Crime Information Center (NCIC) Finger Prints. Proposed Contractor personnel may be required to complete and submit an RI-8 Fingerprint Card for the NCIC Finger Print Check. Any request for background checks will be initiated by the State and will be reasonably related to the type of work requested.

All Contractor personnel will also be expected to comply with the State's security and acceptable use policies for State IT equipment and resources. See http://www.michigan.gov/ditservice/0,1607,7-179-25781-73760--,00.html. Furthermore, Contractor personnel will be expected to agree to the State's security and acceptable use policies before the Contractor personnel will be accepted as a resource to perform work for the State. It is expected the Contractor will present these documents to the prospective employee before the Contractor presents the individual to the State as a proposed resource. Contractor staff will be expected to comply with all Physical Security procedures in place within the facilities where they are working.

2.140 Reserved

2.150 Confidentiality

2.151 Freedom of Information

All information in any proposal submitted to the State by Contractor and this Contract is subject to the provisions of the Michigan Freedom of Information Act, 1976 Public Act No. 442, as amended, MCL 15.231, et seq (the "FOIA").

2.152 Confidentiality

Contractor and the State each acknowledge that the other possesses and will continue to possess confidential information that has been developed or received by it. As used in this Section, “Confidential Information” of Contractor shall mean all non-public proprietary information of Contractor (other than Confidential Information of the State as defined below) which is marked confidential, restricted, proprietary or with a similar designation. “Confidential Information” of the State shall mean any information which is retained in confidence by the State (or otherwise required to be held in confidence by the State pursuant to applicable federal, state and local laws and regulations) or which, in the case of tangible materials provided to Contractor by the State pursuant to its performance under this Contract, is marked as confidential, proprietary or with a similar designation by the State. In the case of information of either Contractor or the State “Confidential Information” shall exclude any information (including this Contract) that is publicly available pursuant to the Michigan FOIA.

2.153 Protection of Confidential Information

The State and Contractor will each use at least the same degree of care to prevent disclosing to third parties the Confidential Information of the other as it employs to avoid unauthorized disclosure, publication or dissemination of its own confidential information of like character, but in no event less than reasonable care. Neither Contractor nor the State will (i) make any use of the Confidential Information of the other except as contemplated by this Contract, (ii) acquire any right in or assert any lien against the Confidential Information of the other, or (iii) if requested to do so, refuse for any reason to promptly return the other party's Confidential Information to the other party. Each party will limit disclosure of the other party’s Confidential Information to employees and Subcontractors who must have access in order to fulfill the purposes of this Contract. Disclosure to, and use by, a Subcontractor is permissible where (A) use of a Subcontractor is authorized under this Contract, (B) such disclosure is necessary or otherwise naturally occurs in connection with work that is within such Subcontractor's scope of responsibility, and (C) Contractor obligates the Subcontractor in a written Contract to maintain the State’s Confidential Information in confidence. At the State's request, any employee of Contractor and of any Subcontractor having access or continued access to the State’s Confidential Information may be required to execute an acknowledgment that the employee has been advised of Contractor’s and the Subcontractor’s obligations under this Section and of the employee’s obligation to Contractor or Subcontractor, as the case may be, to protect such Confidential Information from unauthorized use or disclosure.

2.154 Exclusions

Notwithstanding the foregoing, the provisions of this Section will not apply to any particular information which the State or Contractor can demonstrate (i) was, at the time of disclosure to it, in the public domain; (ii) after disclosure to it, is published or otherwise becomes part of the public domain through no fault of the receiving party; (iii) was in the possession of the receiving party at the time of disclosure to it without an obligation of confidentiality; (iv) was received after disclosure to it from a third party who had a lawful right to disclose such information to it without any obligation to restrict its further disclosure; or (v) was independently developed by the receiving party without reference to Confidential Information of the furnishing party. Further, the provisions of this Section will not apply to any particular Confidential Information to the extent the receiving party is required by law to disclose such Confidential Information, provided that the receiving party (i) promptly provides the furnishing party with notice of the legal request, and (ii) assists the furnishing party in resisting or limiting the scope of such disclosure as reasonably requested by the furnishing party.

2.155 No Implied Rights

Nothing contained in this Section shall be construed as obligating a party to disclose any particular Confidential Information to the other party, or as granting to or conferring on a party, expressly or impliedly, any right or license to the Confidential Information of the other party.

2.156 Remedies

Each party acknowledges that, if it breaches (or attempts or threatens to breach) its obligations under this Section, the other party may be irreparably harmed. Accordingly, if a court of competent jurisdiction should find that a party has breached (or attempted or threatened to breach) any such obligations, the non-breaching party shall be entitled to seek an injunction preventing such breach (or attempted or threatened breach).

2.157 Security Breach Notification

In the event of a breach of this Section, Contractor shall take (i) prompt corrective action to cure any such deficiencies and (ii) any action pertaining to such unauthorized disclosure required by applicable federal and state laws and regulations. Contractor and the State will cooperate to mitigate, to the extent practicable, the effects of any breach, intrusion, or unauthorized use or disclosure. Contractor shall report to the State in writing any use or disclosure of Confidential Information, whether suspected or actual, other than as provided for by the Contract within ten (10) days of becoming aware of such use or disclosure or such shorter time period as is reasonable under the circumstances.

2.158 Survival

The parties' respective obligations under this Section shall survive the termination or expiration of this Contract for any reason.

2.159 Destruction of Confidential Information

Promptly upon termination or cancellation of the Contract for any reason, Contractor shall certify to the State that Contractor has destroyed all State Confidential Information.

2.160 Proprietary Rights

2.161 Ownership

Ownership of Work Product by State. All Deliverables shall be owned by the State and shall be considered works made for hire by the Contractor for the State. The State shall own all United States and international copyrights, trademarks, patents or other proprietary rights in the Deliverables.

Vesting of Rights. With the sole exception of any preexisting licensed works identified in **Exhibit J**, the Contractor shall assign, and upon creation of each Deliverable automatically assigns, to the State, ownership of all United States and international copyrights, trademarks, patents, or other proprietary rights in each and every Deliverable, whether or not registered by the Contractor, insofar as any such Deliverable, by operation of law, may not be considered work made for hire by the Contractor for the State. From time to time upon State's request, the Contractor and/or its personnel shall confirm such assignment by execution and delivery of the assignments, confirmations of assignment, or other written instruments as the State may request. The State shall have the right to obtain and hold in its own name all copyright, trademark, and patent registrations and other evidence of rights that may be available for Deliverables.

2.162 Source Code Escrow- Reserved

2.163 Rights in Data

(a) The State will be and remain the owner of all data made available by the State to Contractor or its agents, Subcontractors or representatives pursuant to the Contract. Contractor will not use the State's data for any purpose other than providing the Services, nor will any part of the State's data be disclosed, sold, assigned, leased or otherwise disposed of to the general public or to specific third parties or commercially exploited by or on behalf of Contractor, nor will any employee of Contractor other than those on a strictly need to know basis have access to the State's data.

Contractor will not possess or assert any lien or other right against the State's data. Without limiting the generality of this Section, Contractor shall only use personally identifiable information as strictly necessary to provide the Services and shall disclose such information only to its employees who have a strict need to know such information. Contractor shall comply at all times with all laws and regulations applicable to such personally identifiable information.
(b) The State is and shall remain the owner of all State-specific data pursuant to the Contract. The State may use the data provided by the Contractor for any purpose. The State will not possess or assert any lien or other right against the Contractor's data. Without limiting the generality of this Section, the State shall only use personally identifiable information as strictly necessary to utilize the Services and shall disclose such information only to its employees who have a strict need to know such information, except as provided by law. The State shall comply at all times with all laws and regulations applicable to such personally identifiable information. Other material developed and provided to the State shall remain the State's sole and exclusive property.

2.164 Ownership of Materials

State and Contractor will continue to own their respective proprietary technologies developed before entering into the Contract. Any hardware bought through the Contractor by the State, and paid for by the State, will be owned by the State. Any software licensed through the Contractor and sold to the State, will be licensed directly to the State.

2.165 Standard Software- Reserved

2.166 Pre-existing Materials for Custom Software Deliverables- Reserved

2.167 General Skills

Notwithstanding anything to the contrary in this Section, each party, its Subcontractors and their personnel shall be free to use and employ its and their general skills, know-how and expertise, and to use, disclose and employ any generalized ideas, concepts, know-how, methods, techniques or skills gained or learned during the course of performing the Services, so long as it or they acquire and apply the foregoing without disclosure of any confidential or proprietary information of the other party.

2.170 Warranties And Representations

2.171 Warranties and Representations

The Contractor represents and warrants:

(a) It is capable in all respects of fulfilling and shall fulfill all of its obligations under this Contract. The performance of all obligations under this Contract shall be provided in a timely, professional, and workman-like manner and shall meet the performance and operational standards required under this Contract.

(b) The Contract Appendices, Attachments and Exhibits identify the equipment and software and services necessary for the Deliverable(s) to perform and Services to operate in compliance with the Contract's requirements and other standards of performance.

(c) It is the lawful owner or licensee of any Deliverable licensed or sold to the State by Contractor or developed by Contractor under this Contract, and Contractor has all of the rights necessary to convey to the State the ownership rights or licensed use, as applicable, of any and all Deliverables. None of the Deliverables provided by Contractor to the State under this Contract, nor their use by the State, will infringe the patent, copyright, trade secret, or other proprietary rights of any third party.

(d) If, under this Contract, Contractor procures any equipment, software or other Deliverable for the State (including equipment, software and other Deliverables manufactured, re-marketed or otherwise sold by Contractor under Contractor's name), then in addition to Contractor's other responsibilities with respect to such items in this Contract, Contractor shall assign or otherwise transfer to the State or its designees, or afford the State the benefits of, any manufacturer's warranty for the Deliverable.

(e) The contract signatory has the power and authority, including any necessary corporate authorizations, necessary to enter into this Contract, on behalf of Contractor.

(f) It is qualified and registered to transact business in all locations where required.

(g) Neither the Contractor nor any Affiliates, nor any employee of either, has, shall have, or shall acquire, any contractual, financial, business, or other interest, direct or indirect, that would conflict in any manner or degree with Contractor's performance of its duties and responsibilities to the State under this Contract or otherwise create an appearance of impropriety with respect to the award or performance of this Agreement. Contractor shall notify the State within two (2) days of any such interest that may be incompatible with the interests of the State.

(h) Neither Contractor nor any Affiliates, nor any employee of either has accepted or shall accept anything of value based on an understanding that the actions of the Contractor or Affiliates or employee on behalf of the State would be influenced. Contractor shall not attempt to influence any State employee by the direct or indirect offer of anything of value.

(i) Neither Contractor nor any Affiliates, nor any employee of either has paid or agreed to pay any person, other than bona fide employees and consultants working solely for Contractor or such Affiliate, any fee, commission, percentage, brokerage fee, gift, or any other consideration, contingent upon or resulting from the award or making of this Contract.

(j) The prices proposed by Contractor were arrived at independently, without consultation, communication, or agreement with any other bidder for the purpose of restricting competition; the prices quoted were not knowingly disclosed by Contractor to any other bidder; and no attempt was made by Contractor to induce any other person to submit or not submit a proposal for the purpose of restricting competition.

(k) All financial statements, reports, and other information furnished by Contractor to the State as part of its response to the RFP or otherwise in connection with the award of this Contract fairly and accurately represent the business, properties, financial condition, and results of operations of Contractor as of the respective dates, or for the respective periods, covered by such financial statements, reports, other information. Since the respective dates or periods covered by such financial statements, reports, or other information, there have been no material adverse change in the business, properties, financial condition, or results of operations of Contractor.

(m) All written information furnished to the State by or behalf of Contractor in connection with this Contract, including its bid, it true, accurate, and complete, and contains no untrue statement of material fact or omits any material fact necessary to make such information not misleading.

(n) It is not in material default or breach of any other contract or agreement that it may have with the State or any of its departments, commissions, boards, or agencies. Contractor further represents and warrants that it has not been a party to any contract with the State or any of its departments that was terminated by the State or such department within the previous five (5) years for the reason that Contractor failed to perform or otherwise breached an obligation of such contract.

2.172 Software Warranties- RESERVED

2.173 Equipment Warranty- RESERVED

2.174 Physical Media Warranty- RESERVED

2.175 Standard Warranties- RESERVED

2.176 Consequences For Breach

In addition to any remedies available in law, if the Contractor breaches any of the warranties contained in this section, such breach may be considered as a default in the performance of a material obligation of this Contract.

2.180 Insurance

2.181 Liability Insurance

(a) Liability Insurance

The Contractor is required to provide proof of the minimum levels of insurance coverage as indicated below. The purpose of this coverage shall be to protect the State from claims which may arise out of or result from the Contractor's performance of services under the terms of this Contract, whether such services are performed by the Contractor, or by any subcontractor, or by anyone directly or indirectly employed by any of them, or by anyone for whose acts they may be liable.

The Contractor waives all rights against the State of Michigan, its departments, divisions, agencies, offices, commissions, officers, employees and agents for recovery of damages to the extent these damages are covered by the insurance policies the Contractor is required to maintain pursuant to this Contract.

All insurance coverages provided relative to this Contract/Purchase Order are PRIMARY and NON-CONTRIBUTING to any comparable liability insurance (including self-insurances) carried by the State.

The insurance shall be written for not less than any minimum coverage specified in this Contract or required by law, whichever is greater.

The insurers selected by Contractor shall have an A.M. Best rating of A or better, or as otherwise approved in writing by the State, or if such ratings are no longer available, with a comparable rating from a recognized insurance rating agency. All policies of insurance required in this Contract shall be issued by companies that have been approved to do business in the State.
See http://www.mi.gov/cis/0,1607,7-154-10555_22535---,00.html.

Where specific limits are shown, they are the minimum acceptable limits. If Contractor's policy contains higher limits, the State shall be entitled to coverage to the extent of such higher limits.

Before the Contract is signed by both parties or before the purchase order is issued by the State, the Contractor must furnish to the Director of Purchasing Operations, certificate(s) of insurance verifying insurance coverage ("Certificates"). The Certificate must be on the standard "accord" form or equivalent. **THE CONTRACT OR PURCHASE ORDER NO. MUST BE SHOWN ON THE CERTIFICATE OF INSURANCE TO ASSURE CORRECT FILING.** All Certificate(s) are to be prepared and submitted by the Insurance Provider. All Certificate(s) shall contain a provision indicating that coverages afforded under the policies WILL NOT BE CANCELLED, MATERIALLY CHANGED, OR NOT RENEWED without THIRTY (30) days prior written notice, except for ten (10) days for non-payment of premium, having been given to the Director of Purchasing Operations, Department of Management and Budget. The notice must include the Contract or Purchase Order number affected and be mailed to: Director, Purchasing Operations, Department of Management and Budget, P.O. Box 30026, Lansing, Michigan 48909. Failure to provide evidence of coverage, may, at the State's sole option, result in this Contract's termination.

The Contractor is required to pay for and provide the type and amount of insurance checked ☑ below:

☑ 1. Commercial General Liability with the following minimum coverage:

$2,000,000 General Aggregate Limit other than Products/Completed Operations
$2,000,000 Products/Completed Operations Aggregate Limit
$1,000,000 Personal & Advertising Injury Limit
$1,000,000 Each Occurrence Limit
$500,000 Fire Damage Limit (any one fire)

The Contractor must list the State of Michigan, its departments, divisions, agencies, offices, commissions, officers, employees and agents as ADDITIONAL INSUREDS on the Commercial General Liability certificate. The Contractor also agrees to provide evidence that insurance policies contain a waiver of subrogation by the insurance company.

☑ 2. If a motor vehicle is used to provide services or products under this Contract, the Contractor must have vehicle liability insurance on any auto including owned, hired and non-owned vehicles used in Contractor‘s business for bodily injury and property damage as required by law.

The Contractor must list the State of Michigan, its departments, divisions, agencies, offices, commissions, officers, employees and agents as ADDITIONAL INSUREDS on the vehicle liability certificate. The Contractor also agrees to provide evidence that insurance policies contain a waiver of subrogation by the insurance company.

☑ 3. Workers’ compensation coverage must be provided in accordance with applicable laws governing the employees and employers work activities in the state of the Contractor’s domicile. If the applicable coverage is provided by a self-insurer, proof must be provided of approved self-insured authority by the jurisdiction of domicile. For employees working outside of the state of qualification, Contractor must provide appropriate certificates of insurance proving mandated coverage levels for the jurisdictions where the employees’ activities occur.

Any certificates of insurance received must also provide a list of states where the coverage is applicable.

The Contractor also agrees to provide evidence that insurance policies contain a waiver of subrogation by the insurance company. This provision shall not be applicable where prohibited or limited by the laws of the jurisdiction in which the work is to be performed.

☑ 4. Employers liability insurance with the following minimum limits:

$100,000 each accident
$100,000 each employee by disease
$500,000 aggregate disease

☐ 5. Employee Fidelity, including Computer Crimes, insurance naming the State as a loss payee, providing coverage for direct loss to the State and any legal liability of the State arising out of or related to fraudulent or dishonest acts committed by the employees of Contractor or its Subcontractors, acting alone or in collusion with others, in a minimum amount of one million dollars ($1,000,000.00) with a maximum deductible of fifty thousand dollars ($50,000.00).

☐ 6. Umbrella or Excess Liability Insurance in a minimum amount of ten million dollars ($10,000,000.00), which shall apply, at a minimum, to the insurance required in Subsection 1 (Commercial General Liability) above.

☐ 7. Professional Liability (Errors and Omissions) Insurance with the following minimum coverage: three million dollars ($3,000,000.00) each occurrence and three million dollars ($3,000,000.00) annual aggregate.

☐ 8. Fire and Personal Property Insurance covering against any loss or damage to the office space used by Contractor for any reason under this Contract, and the equipment, software and other contents of such office space, including without limitation, those contents used by Contractor to provide the Services to the State, up to the replacement value thereof, where such office space and its contents are under the care, custody and control of Contractor. Such policy shall cover all risks of direct physical loss or damage, including without limitation, flood and earthquake coverage and coverage for computer hardware and software. The State shall be endorsed on the policy as a loss payee as its interests appear.

(b) Subcontractors
Except where the State has approved in writing a Contractor subcontract with other insurance provisions, Contractor shall require all of its Subcontractors under this Contract to purchase and maintain the insurance coverage as described in this Section for the Contractor in connection with the performance of work by those Subcontractors. Alternatively, Contractor may include any Subcontractors under Contractor’s insurance on the coverage required in this Section. Subcontractor(s) shall fully comply with the insurance coverage required in this Section. Failure of Subcontractor(s) to comply with insurance requirements does not limit Contractor’s liability or responsibility.

(c) Certificates of Insurance and Other Requirements
Contractor shall furnish to the Office of Purchasing Operations certificate(s) of insurance verifying insurance coverage or providing satisfactory evidence of self-insurance as required in this Section (the "Certificates"). Before the Contract is signed, and not less than 20 days before the insurance expiration date every year thereafter, the Contractor shall provide evidence that the State and its agents, officers and employees are listed as additional insureds under each commercial general liability and commercial automobile liability policy. In the event the State approves the representation of the State by the insurer's attorney, the attorney may be required to be designated as a Special Assistant Attorney General by the Attorney General of the State of Michigan.

Contractor shall maintain all required insurance coverage throughout the term of the Contract and any extensions thereto and, in the case of claims-made Commercial General Liability policies, shall secure tail coverage for at least three (3) years following the expiration or termination for any reason of this Contract. The minimum limits of coverage specified above are not intended, and shall not be construed, to limit any liability or indemnity of Contractor under this Contract to any indemnified party or other persons. Contractor shall be responsible for all deductibles with regard to such insurance. If Contractor fails to pay any premium for required insurance as specified in this Contract, or if any insurer cancels or significantly reduces any required insurance as specified in this Contract without the State's written consent, at the State's election (but without any obligation to do so) after the State has given Contractor at least thirty (30) days written notice, the State may pay such premium or procure similar insurance coverage from another company or companies; and at the State's election, the State may deduct the entire cost (or part thereof) from any payment due Contractor, or Contractor shall pay the entire cost (or any part thereof) upon demand by the State.

2.190 Indemnification

2.191 Indemnification

(a) General Indemnification
To the extent permitted by law, the Contractor shall indemnify, defend and hold harmless the State from liability, including all claims and losses, and all related costs and expenses (including reasonable attorneys' fees and costs of investigation, litigation, settlement, judgments, interest and penalties), accruing or resulting to any person, firm or corporation that may be injured or damaged by the Contractor in the performance of this Contract and that are attributable to the negligence or tortious acts of the Contractor or any of its subcontractors, or by anyone else for whose acts any of them may be liable.
(b) Code Indemnification
To the extent permitted by law, the Contractor shall indemnify, defend and hold harmless the State from any claim, loss, or expense arising from Contractor's breach of the No Surreptitious Code Warranty.
(c) Employee Indemnification
In any and all claims against the State of Michigan, its departments, divisions, agencies, sections, commissions, officers, employees and agents, by any employee of the Contractor or any of its subcontractors, the indemnification obligation under the Contract shall not be limited in any way by the amount or type of damages, compensation or benefits payable by or for the Contractor or any of its subcontractors under worker's disability compensation acts, disability benefit acts or other employee benefit acts. This indemnification clause is intended to be comprehensive. Any overlap in provisions, or the fact that greater specificity is provided as to some categories of risk, is not intended to limit the scope of indemnification under any other provisions.
(d) Patent/Copyright Infringement Indemnification
To the extent permitted by law, the Contractor shall indemnify, defend and hold harmless the State from and against all losses, liabilities, damages (including taxes), and all related costs and expenses (including reasonable attorneys' fees and costs of investigation, litigation, settlement, judgments, interest and penalties) incurred in connection with any action or proceeding threatened or brought against the State to the extent that such action or proceeding is based on a claim that any piece of equipment, software, commodity or service supplied by the Contractor or its subcontractors, or the operation of such equipment, software, commodity or service, or the use or reproduction of any documentation provided with such equipment, software, commodity or service infringes any United States patent, copyright, trademark or trade secret of any person or entity, which is enforceable under the laws of the United States.

In addition, should the equipment, software, commodity, or service, or its operation, become or in the State's or Contractor's opinion be likely to become the subject of a claim of infringement, the Contractor shall at the Contractor's sole expense (i) procure for the State the right to continue using the equipment, software, commodity or service or, if such option is not reasonably available to the Contractor, (ii) replace or modify to the State's satisfaction the same with equipment, software, commodity or service of equivalent function and performance so that it becomes non-infringing, or, if such option is not reasonably available to Contractor, (iii) accept its return by the State with appropriate credits to the State against the Contractor's charges and reimburse the State for any losses or costs incurred as a consequence of the State ceasing its use and returning it.

Notwithstanding the foregoing, the Contractor shall have no obligation to indemnify or defend the State for, or to pay any costs, damages or attorneys' fees related to, any claim based upon (i) equipment developed based on written specifications of the State; or (ii) use of the equipment in a configuration other than implemented or approved in writing by the Contractor, including, but not limited to, any modification of the equipment by the State; or (iii) the combination, operation, or use of the equipment with equipment or software not supplied by the Contractor under this Contract.

2.192 Continuation of Indemnification Obligations

The Contractor's duty to indemnify pursuant to this Section continues in full force and effect, notwithstanding the expiration or early cancellation of the Contract, with respect to any claims based on facts or conditions that occurred prior to expiration or cancellation.

2.193 Indemnification Procedures

The procedures set forth below shall apply to all indemnity obligations under this Contract.

(a) After receipt by the State of notice of the action or proceeding involving a claim in respect of which it will seek indemnification, the State shall promptly notify Contractor of such claim in writing and take or assist Contractor in taking, as the case may be, any reasonable action to avoid the imposition of a default judgment against Contractor. No failure to notify Contractor shall relieve Contractor of its indemnification obligations except to the extent that Contractor can demonstrate damages attributable to such failure. Within ten (10) days following receipt of written notice from the State relating to any claim, Contractor shall notify the State in writing whether Contractor agrees to assume control of the defense and settlement of that claim (a "Notice of Election"). After notifying Contractor of a claim and prior to the State receiving Contractor's Notice of Election, the State shall be entitled to defend against the claim, at Contractor's expense, and Contractor will be responsible for any reasonable costs incurred by the State in defending against the claim during such period.

(b) If Contractor delivers a Notice of Election relating to any claim: (i) the State shall be entitled to participate in the defense of such claim and to employ counsel at its own expense to assist in the handling of such claim and to monitor and advise the State about the status and progress of the defense; (ii) Contractor shall, at the request of the State, demonstrate to the reasonable satisfaction of the State, Contractor's financial ability to carry out its defense and indemnity obligations under this Contract; (iii) Contractor shall periodically advise the State about the status and progress of the defense and shall obtain the prior written approval of the State before entering into any settlement of such claim or ceasing to defend against such claim and (iv) to the extent that any principles of Michigan governmental or public law may be involved or challenged, the State shall have the right, at its own expense, to control the defense of that portion of such claim involving the principles of Michigan governmental or public law. Notwithstanding the foregoing, the State may retain control of the defense and settlement of a claim by written notice to Contractor given within ten (10) days after the State's receipt of Contractor's information requested by the State pursuant to clause (ii) of this paragraph if the State determines that Contractor has failed to demonstrate to the reasonable satisfaction of the State Contractor's financial ability to carry out its defense and indemnity obligations under this Section. Any litigation activity on behalf of the State of Michigan, or any of its subdivisions pursuant to this Section, must be coordinated with the Department of Attorney General. In the event the insurer's attorney represents the State pursuant to this Section, the insurer's attorney may be required to be designated as a Special Assistant Attorney General by the Attorney General of the State of Michigan.

(c) If Contractor does not deliver a Notice of Election relating to any claim of which it is notified by the State as provided above, the State shall have the right to defend the claim in such manner as it may deem appropriate, at the cost and expense of Contractor. If it is determined that the claim was one against which Contractor was required to indemnify the State, upon request of the State, Contractor shall promptly reimburse the State for all such reasonable costs and expenses.

2.200 Limits of Liability and Excusable Failure

2.201 Limits of Liability

The Contractor's liability for damages to the State shall be limited to two times the value of the Contract or $200,000 which ever is higher. The foregoing limitation of liability shall not apply to claims for infringement of United States patent, copyright, trademarks or trade secrets; to claims for personal injury or damage to property caused by the gross negligence or willful misconduct of the Contractor; to claims covered by other specific provisions of this Contract calling for liquidated damages; or to court costs or attorney's fees awarded by a court in addition to damages after litigation based on this Contract.

The State's liability for damages to the Contractor shall be limited to the value of the Contract.

Neither the Contractor nor the State shall be liable to each other, regardless of the form of action, for consequential, incidental, indirect, or special damages. This limitation of liability shall not apply to claims for infringement of United States patent, copyright, trademark or trade secrets; to claims for personal injury or damage to property caused by the gross negligence or willful misconduct of the Contractor; to claims covered by other specific provisions of this Contract calling for liquidated damages; or to court costs or attorney's fees awarded by a court in addition to damages after litigation based on this Contract.

2.202 Excusable Failure

Neither party will be liable for any default, damage or delay in the performance of its obligations under the Contract to the extent such default, damage or delay is caused by government regulations or requirements (executive, legislative, judicial, military or otherwise), power failure, electrical surges or current fluctuations, lightning, earthquake, war, water or other forces of nature or acts of God, delays or failures of transportation, equipment shortages, suppliers' failures, or acts or omissions of common carriers, fire; riots, civil disorders; strikes or other labor disputes, embargoes; injunctions (provided the injunction was not issued as a result of any fault or negligence of the party seeking to have its default or delay excused); or any other cause beyond the reasonable control of such party; provided the non-performing party and its Subcontractors are without fault in causing such default or delay, and such default or delay could not have been prevented by reasonable precautions and cannot reasonably be circumvented by the non-performing party through the use of alternate sources, workaround plans or other means, including disaster recovery plans.

In such event, the non-performing party will be excused from any further performance or observance of the obligation(s) so affected for as long as such circumstances prevail and such party continues to use its commercially reasonable efforts to recommence performance or observance whenever and to whatever extent possible without delay and provided further that such party promptly notifies the other party in writing of the inception of the excusable failure occurrence, and also of its abatement or cessation.

If any of the above-enumerated circumstances substantially prevent, hinder, or delay Contractor's performance of the Services/provision of Deliverables for more than ten (10) Business Days, and the State determines that performance is not likely to be resumed within a period of time that is satisfactory to the State in its reasonable discretion, then at the State's option: (a) the State may procure the affected Services/Deliverables from an alternate source, and the State shall not be liable for payment for the unperformed Services/ Deliverables not provided under the Contract for so long as the delay in performance shall continue; (b) the State may terminate any portion of the Contract so affected and the charges payable there under shall be equitably adjusted to reflect those Services/Deliverables terminated; or (c) the State may terminate the affected Statement of Work without liability to Contractor as of a date specified by the State in a written notice of termination to Contractor, except to the extent that the State shall pay for Services/Deliverables provided through the date of termination.

Contractor will not have the right to any additional payments from the State as a result of any Excusable Failure occurrence or to payments for Services not rendered/Deliverables not provided as a result of the Excusable Failure condition. Defaults or delays in performance by Contractor which are caused by acts or omissions of its Subcontractors will not relieve Contractor of its obligations under the Contract except to the extent that a Subcontractor is itself subject to an Excusable Failure condition described above and Contractor cannot reasonably circumvent the effect of the Subcontractor's default or delay in performance through the use of alternate sources, workaround plans or other means.

2.203 Disaster Recovery

Contractor and the State recognize that the State provides essential services in times of natural or man-made disasters. Therefore, except as so mandated by Federal disaster response requirements, Contractor personnel dedicated to providing Services/Deliverables under this Contract will provide the State with priority service for repair and work around in the event of a natural or manmade disaster.

2.210 Termination/Cancellation by the State

The State may terminate this Contract without further liability or penalty to the State, its departments, divisions, agencies, offices, commissions, officers, agents and employees for any of the following reasons:

2.211 Termination for Cause

(a) In the event that Contractor breaches any of its material duties or obligations under this Contract (including a Chronic Failure to meet any particular SLA as defined in **Section 2.076**), which are either not capable of or subject to being cured, or are not cured within the time period specified in the written notice of breach provided by the State (such time period not to be less than thirty (30) days), or pose a serious and imminent threat to the health and safety of any person, or the imminent loss, damage or destruction of any real or tangible personal property, the State may, having provided written notice of termination to Contractor, terminate this Contract in whole or in part, for cause, as of the date specified in the notice of termination.

(b) In the event that this Contract is terminated for cause, in addition to any legal remedies otherwise available to the State by law or equity, Contractor shall be responsible for all costs incurred by the State in terminating this Contract, including but not limited to, State administrative costs, reasonable attorneys' fees and court costs, and any reasonable additional costs the State may incur to procure the Services/Deliverables required by this Contract from other sources. Re-procurement costs shall not be considered by the parties to be consequential, indirect or incidental damages, and shall not be excluded by any other terms otherwise included in this Contract, provided such costs are not in excess of fifty percent (50%) more than the prices for such Service/Deliverables provided under this Contract.

(c) In the event the State chooses to partially terminate this Contract for cause, charges payable under this Contract will be equitably adjusted to reflect those Services/Deliverables that are terminated and the State shall pay for all Services/Deliverables for which Final Acceptance has been granted provided up to the termination date. Services and related provisions of this Contract that are terminated for cause shall cease on the effective date of the termination.

(d) In the event this Contract is terminated for cause pursuant to this Section, and it is determined, for any reason, that Contractor was not in breach of contract pursuant to the provisions of this section, that termination for cause shall be deemed to have been a termination for convenience, effective as of the same date, and the rights and obligations of the parties shall be limited to that otherwise provided in this Contract for a termination for convenience.

2.212 Termination for Convenience

The State may terminate this Contract for its convenience, in whole or part, if the State determines that such a termination is in the State's best interest. Reasons for such termination shall be left to the sole discretion of the State and may include, but not necessarily be limited to (a) the State no longer needs the Services or products specified in the Contract, (b) relocation of office, program changes, changes in laws, rules, or regulations make implementation of the Services no longer practical or feasible, (c) unacceptable prices for Additional Services or New Work requested by the State, or (d) falsification or misrepresentation, by inclusion or non-inclusion, of information material to a response to any RFP issued by the State. The State may terminate this Contract for its convenience, in whole or in part, by giving Contractor written notice at least thirty (30) days prior to the date of termination. If the State chooses to terminate this Contract in part, the charges payable under this Contract shall be equitably adjusted to reflect those Services/Deliverables that are terminated. Services and related provisions of this Contract that are terminated for cause shall cease on the effective date of the termination.

2.213 Non-Appropriation

(a) Contractor acknowledges that, if this Contract extends for several fiscal years, continuation of this Contract is subject to appropriation or availability of funds for this Contract. If funds to enable the State to effect continued payment under this Contract are not appropriated or otherwise made available, the State shall have the right to terminate this Contract and all affected Statements of Work, in whole or in part, at the end of the last period for which funds have been appropriated or otherwise made available by giving written notice of termination to Contractor. The State shall give Contractor at least thirty (30) days advance written notice of termination for non-appropriation or unavailability (or such time as is available if the State receives notice of the final decision less than thirty (30) days before the funding cutoff).

(b) If funding for the Contract is reduced by law, or funds to pay Contractor for the agreed-to level of the Services or production of Deliverables to be provided by Contractor are not appropriated or otherwise made available, the State may, upon thirty (30) days written notice to Contractor, reduce the level of the Services or the change the production of Deliverables in such manner and for such periods of time as the State may elect. The charges payable under this Contract will be equitably adjusted to reflect any equipment, services or commodities not provided by reason of such reduction.

(c) In the event the State terminates this Contract, eliminates certain Deliverables, or reduces the level of Services to be provided by Contractor pursuant to this Section, the State shall pay Contractor for all Work-in-Process performed through the effective date of the termination or reduction in level, as the case may be and as determined by the State, to the extent funds are available. For the avoidance of doubt, this Section will not preclude Contractor from reducing or stopping Services/Deliverables and/or raising against the State in a court of competent jurisdiction, any claim for a shortfall in payment for Services performed or Deliverables finally accepted before the effective date of termination.

2.214 Criminal Conviction

The State may terminate this Contract immediately and without further liability or penalty in the event Contractor, an officer of Contractor, or an owner of a 25% or greater share of Contractor is convicted of a criminal offense incident to the application for, or performance of, a State, public or private Contract or subcontract; convicted of a criminal offense, including any of the following: embezzlement, theft, forgery, bribery, falsification or destruction of records, receiving stolen property, attempting to influence a public employee to breach the ethical conduct standards for State of Michigan employees; convicted under State or federal antitrust statutes; or convicted of any other criminal offense which in the sole discretion of the State reflects upon Contractor's business integrity.

2.215 Approvals Rescinded

The State may terminate this Contract without further liability or penalty in the event any final administrative or judicial decision or adjudication disapproves a previously approved request for purchase of personal services pursuant to Constitution 1963, Article 11, § 5, and Civil Service Rule 7-1. Termination may be in whole or in part and may be immediate as of the date of the written notice to Contractor or may be effective as of the date stated in such written notice.

2.216 Rights and Obligations Upon Termination

(a) If this Contract is terminated by the State for any reason, Contractor shall (a) stop all work as specified in the notice of termination, (b) take any action that may be necessary, or that the State may direct, for preservation and protection of Deliverables or other property derived or resulting from this Contract that may be in Contractor's possession, (c) return all materials and property provided directly or indirectly to Contractor by any entity, agent or employee of the State, (d) in the event that the Contractor maintains title in Deliverables that is intended to be transferred to the State at the termination of the Contract, Contractor will transfer title in, and deliver to, the State, unless otherwise directed, all Deliverables intended to be transferred to the State at the termination of the Contract and which are resulting from the Contract (which shall be provided to the State on an "As-Is" basis except to the extent the amounts paid by the State in respect of such items included compensation to Contractor for the provision of warranty services in respect of such materials), and (e) take any action to mitigate and limit any potential damages, or requests for Contractor adjustment or termination settlement costs, to the maximum practical extent, including terminating or limiting as otherwise applicable those subcontracts and outstanding orders for material and supplies resulting from the terminated Contract.

(b) In the event the State terminates this Contract prior to its expiration for its own convenience, the State shall pay Contractor for all charges due for Services provided prior to the date of termination and, if applicable, as a separate item of payment pursuant to this Contract, for Work In Process, on a percentage of completion basis at the level of completion determined by the State. All completed or partially completed Deliverables prepared by Contractor pursuant to this Contract shall, at the option of the State, become the State's property, and Contractor shall be entitled to receive equitable fair compensation for such Deliverables. Regardless of the basis for the termination, the State shall not be obligated to pay, or otherwise compensate, Contractor for any lost expected future profits, costs or expenses incurred with respect to Services not actually performed for the State.

(c) Upon a good faith termination, the State shall have the right to assume, at its option, any and all subcontracts and agreements for services and deliverables provided under this Contract, and may further pursue completion of the Services/Deliverables under this Contract by replacement contract or otherwise as the State may in its sole judgment deem expedient.

2.217 Reservation of Rights

Any termination of this Contract or any Statement of Work issued under it by a party shall be with full reservation of, and without prejudice to, any rights or remedies otherwise available to such party with respect to any claims arising prior to or as a result of such termination.

2.218 Contractor Transition Responsibilities

In the event this contract is terminated, for convenience or cause, dissolved, voided, rescinded, nullified, expires or is otherwise rendered unenforceable, the Contractor agrees to comply with direction provided by the State to assist in the orderly transition of equipment, services, software, leases, etc. to the State or a third party designated by the State. In the event of termination or the expiration of this Contract, the Contractor agrees to make all reasonable efforts to effect an orderly transition of services within a reasonable period of time that in no event will exceed ninety (90) days. These efforts shall include, but are not limited to, the following:

(a) Personnel - The Contractor shall work with the State, or a specified third party, to develop a transition plan setting forth the specific tasks and schedule to be accomplished by the parties, to effect an orderly transition. The Contractor shall allow as many personnel as practicable to remain on the job to help the State, or a specified third party, maintain the continuity and consistency of the services required by this Contract. In addition, during or following the transition period, in the event the State requires the Services of the Contractor's subcontractors or vendors, as necessary to meet its needs, Contractor agrees to reasonably, and with good-faith, work with the State to use the Services of Contractor's subcontractors or vendors. Contractor will notify all of Contractor's subcontractors of procedures to be followed during transition.

(b) Information - The Contractor agrees to provide reasonable detailed specifications for all Services/Deliverables needed by the State, or specified third party, to properly provide the Services/Deliverables required under this Contract. The Contractor will provide the State with asset management data generated from the inception of this Contract through the date on which this Contractor is terminated in a comma-delineated format unless otherwise requested by the State. The Contractor will deliver to the State any remaining owed reports and documentation still in Contractor's possession subject to appropriate payment by the State.

(d) Software. - The Contractor shall reasonably assist the State in the acquisition of any Contractor software required to perform the Services/use the Deliverables under this Contract. This shall include any documentation being used by the Contractor to perform the Services under this Contract. If the State transfers any software licenses to the Contractor, those licenses shall, upon expiration of the Contract, transfer back to the State at their current revision level. Upon notification by the State, Contractor may be required to freeze all non-critical changes to Deliverables/Services.

(e) Payment - If the transition results from a termination for any reason, reimbursement shall be governed by the termination provisions of this Contract. If the transition results from expiration, the Contractor will be reimbursed for all reasonable transition costs (i.e. costs incurred within the agreed period after contract expiration that result from transition operations) at the rates specified by **Exhibit D**. The Contractor will prepare an accurate accounting from which the State and Contractor may reconcile all outstanding accounts.

2.219 State Transition Responsibilities

In the event that this Contract is terminated, dissolved, voided, rescinded, nullified, or otherwise rendered unenforceable, the State agrees to perform the following obligations, and any others upon which the State and the Contractor agree:

(a) Reconciling all accounts between the State and the Contractor;

(b) Completing any pending post-project reviews.

2.220 Termination by Contractor

2.221 Termination by Contractor

If the State materially breaches its obligation to pay Contractor undisputed amounts due and owing under this Contract in accordance with **Section 2.090**, or if the State breaches its other obligations under this Contract to an extent that makes it impossible or commercially impractical for Contractor to perform the Services, and if the State does not cure the breach within the time period specified in a written notice of breach provided to the State by Contractor (such time period not to be less than thirty (30) days), then Contractor may terminate this Contract, in whole or in part based on Statement of Work for cause, as of the date specified in the notice of termination; provided, however, that Contractor must discharge its obligations under **Section 2.250** before any such termination.

2.230 Stop Work

2.231 Stop Work Orders

The State may, at any time, by written stop work order to Contractor, require that Contractor stop all, or any part, of the work called for by the Contract for a period of up to ninety (90) calendar days after the stop work order is delivered to Contractor, and for any further period to which the parties may agree. The stop work order shall be specifically identified as such and shall indicate that it is issued under this **Section 2.230**. Upon receipt of the stop work order, Contractor shall immediately comply with its terms and take all reasonable steps to minimize the incurrence of costs allocable to the work covered by the stop work order during the period of work stoppage. Within the period of the stop work order, the State shall either: (a) cancel the stop work order; or (b) terminate the work covered by the stop work order as provided in **Section 2.210**.

2.232 Cancellation or Expiration of Stop Work Order

If a stop work order issued under this **Section 2.230** is canceled or the period of the stop work order or any extension thereof expires, Contractor shall resume work. The parties shall agree upon an equitable adjustment in the delivery schedule, the Contract price, or both, and the Contract shall be modified, in writing, accordingly, if: (a) the stop work order results in an increase in the time required for, or in Contractor's costs properly allocable to, the performance of any part of the Contract; and (b) Contractor asserts its right to an equitable adjustment within thirty (30) calendar days after the end of the period of work stoppage; provided that, if the State decides the facts justify the action, the State may receive and act upon a Contractor proposal submitted at any time before final payment under the Contract. Any adjustment will conform to the requirements of **Section 2.106.**

2.233 Allowance of Contractor Costs

If the stop work order is not canceled and the work covered by the stop work order is terminated for reasons other than material breach, such termination shall be deemed to be a termination for convenience under **Section 2.212**, and the State shall allow reasonable costs resulting from the stop work order in arriving at the termination settlement. For the avoidance of doubt, the State shall not be liable to Contractor for loss of profits because of a stop work order issued under this **Section 2.230**.

2.240 Reserved

2.250 Dispute Resolution

2.251 In General

Any claim, counterclaim, or dispute between the State and Contractor arising out of or relating to the Contract or any Statement of Work shall be resolved as follows. For all Contractor claims seeking an increase in the amounts payable to Contractor under the Contract, or the time for Contractor's performance, Contractor shall submit a letter executed by Contractor's Contract Administrator or his designee certifying that (a) the claim is made in good faith, (b) the amount claimed accurately reflects the adjustments in the amounts payable to Contractor or the time for Contractor's performance for which Contractor believes the State is liable and covers all costs of every type to which Contractor is entitled from the occurrence of the claimed event, and (c) the supporting data provided with such an affidavit are current and complete to Contractor's best knowledge and belief.

2.252 Informal Dispute Resolution

(a) All operational disputes between the parties shall be resolved under the Contract Management procedures developed pursuant to **Section 2.100**. If the parties are unable to resolve any disputes after compliance with such processes, the parties shall meet with the Director of Purchasing Operations, DMB, or designee, for the purpose of attempting to resolve such dispute without the need for formal legal proceedings, as follows:

(i) The representatives of Contractor and the State shall meet as often as the parties reasonably deem necessary in order to gather and furnish to each other all information with respect to the matter in issue which the parties believe to be appropriate and germane in connection with its resolution. The representatives shall discuss the problem and negotiate in good faith in an effort to resolve the dispute without the necessity of any formal proceeding.

(ii) During the course of negotiations, all reasonable requests made by one party to another for non-privileged information reasonably related to the Contract will be honored in order that each of the parties may be fully advised of the other's position.

(iii) The specific format for the discussions will be left to the discretion of the designated State and Contractor representatives, but may include the preparation of agreed upon statements of fact or written statements of position.

(iv) Following the completion of this process within sixty (60) calendar days, the Director of Purchasing Operations, DMB, or designee, shall issue a written opinion regarding the issue(s) in dispute within thirty (30) calendar days. The opinion regarding the dispute shall be considered the State's final action and the exhaustion of administrative remedies.

(b) This **Section 2.250** will not be construed to prevent either party from instituting, and a party is authorized to institute, formal proceedings earlier to avoid the expiration of any applicable limitations period, to preserve a superior position with respect to other creditors, or pursuant to **Section 2.253**.

(c) The State will not mediate disputes between the Contractor and any other entity, except state agencies, concerning responsibility for performance of work pursuant to the Contract.

2.253 Injunctive Relief

The only circumstance in which disputes between the State and Contractor will not be subject to the provisions of **Section 2.252** is where a party makes a good faith determination that a breach of the terms of the Contract by the other party is such that the damages to such party resulting from the breach will be so immediate, so large or severe and so incapable of adequate redress after the fact that a temporary restraining order or other immediate injunctive relief is the only adequate remedy.

2.254 Continued Performance

Each party agrees to continue performing its obligations under the Contract while a dispute is being resolved except to the extent the issue in dispute precludes performance (dispute over payment shall not be deemed to preclude performance) and without limiting either party's right to terminate the Contract as provided in **Section 2.210** and **2.220**, as the case may be.

2.260 Federal and State Contract Requirements

2.261 Nondiscrimination

In the performance of the Contract, Contractor agrees not to discriminate against any employee or applicant for employment, with respect to his or her hire, tenure, terms, conditions or privileges of employment, or any matter directly or indirectly related to employment, because of race, color, religion, national origin, ancestry, age, sex, height, weight, marital status, physical or mental disability. Contractor further agrees that every subcontract entered into for the performance of this Contract or any purchase order resulting from this Contract will contain a provision requiring non-discrimination in employment, as specified here, binding upon each Subcontractor. This covenant is required pursuant to the Elliot Larsen Civil Rights Act, 1976 PA 453, MCL 37.2101, *et seq*., and the Persons with Disabilities Civil Rights Act, 1976 PA 220, MCL 37.1101, *et seq*., and any breach of this provision may be regarded as a material breach of the Contract.

2.262 Unfair Labor Practices

Pursuant to 1980 PA 278, MCL 423.231, *et seq*., the State shall not award a Contract or subcontract to an employer whose name appears in the current register of employers failing to correct an unfair labor practice compiled pursuant to section 2 of the Act. This information is compiled by the United States National Labor Relations Board. A Contractor of the State, in relation to the Contract, shall not enter into a contract with a Subcontractor, manufacturer, or supplier whose name appears in this register. Pursuant to section 4 of 1980 PA 278, MCL 423.324, the State may void any Contract if, subsequent to award of the Contract, the name of Contractor as an employer or the name of the Subcontractor, manufacturer or supplier of Contractor appears in the register.

2.263 Workplace Safety and Discriminatory Harassment

In performing Services for the State, the Contractor shall comply with the Department of Civil Services Rule 2-20 regarding Workplace Safety and Rule 1-8.3 regarding Discriminatory Harassment. In addition, the Contractor shall comply with Civil Service regulations and any applicable agency rules provided to the Contractor. For Civil Service Rules, see http://www.mi.gov/mdcs/0,1607,7-147-6877---,00.html.

2.270 Litigation

2.271 Disclosure of Litigation

(a) Disclosure. Contractor must disclose any material criminal litigation, investigations or proceedings involving the Contractor (and each Subcontractor) or any of its officers or directors or any litigation, investigations or proceedings under the Sarbanes-Oxley Act. In addition, each Contractor (and each Subcontractor) must notify the State of any material civil litigation, arbitration or proceeding which arises during the term of the Contract and extensions thereto, to which Contractor (or, to the extent Contractor is aware, any Subcontractor hereunder) is a party, and which involves: (i) disputes that might reasonably be expected to adversely affect the viability or financial stability of Contractor or any Subcontractor hereunder; or (ii) a claim or written allegation of fraud against Contractor or, to the extent Contractor is aware, any Subcontractor hereunder by a governmental or public entity arising out of their business dealings with governmental or public entities. Any such litigation, investigation, arbitration or other proceeding (collectively, "Proceeding") must be disclosed in a written statement to the Contract Administrator within thirty (30) days of its occurrence. Details of settlements which are prevented from disclosure by the terms of the settlement may be annotated as such. Information provided to the State from Contractor's publicly filed documents referencing its material litigation will be deemed to satisfy the requirements of this Section.

(b) Assurances. In the event that any such Proceeding disclosed to the State pursuant to this Section, or of which the State otherwise becomes aware, during the term of this Contract would cause a reasonable party to be concerned about:

(i) the ability of Contractor (or a Subcontractor hereunder) to continue to perform this Contract in accordance with its terms and conditions, or

(ii) whether Contractor (or a Subcontractor hereunder) in performing Services for the State is engaged in conduct which is similar in nature to conduct alleged in such Proceeding, which conduct would constitute a breach of this Contract or a violation of Michigan law, regulations or public policy, then Contractor shall be required to provide the State all reasonable assurances requested by the State to demonstrate that:

(A) Contractor and/or its Subcontractors hereunder will be able to continue to perform this Contract and any Statements of Work in accordance with its terms and conditions, and

(B) Contractor and/or its Subcontractors hereunder have not and will not engage in conduct in performing the Services which is similar in nature to the conduct alleged in such Proceeding.

(c) Contractor shall make the following notifications in writing:

(1) Within thirty (30) days of Contractor becoming aware that a change in its ownership or officers has occurred, or is certain to occur, or a change that could result in changes in the valuation of its capitalized assets in the accounting records, Contractor shall notify the Office of Purchasing Operations.

(2) Contractor shall also notify the Office of Purchasing Operations within thirty (30) days whenever changes to asset valuations or any other cost changes have occurred or are certain to occur as a result of a change in ownership or officers.

(3) Contractor shall also notify Purchasing Operations within thirty (30) days whenever changes to company affiliations occur.

2.272 Governing Law

The Contract shall in all respects be governed by, and construed in accordance with, the substantive laws of the State of Michigan without regard to any Michigan choice of law rules that would apply the substantive law of any other jurisdiction to the extent not inconsistent with, or pre-empted by federal law.

2.273 Compliance with Laws

Contractor shall comply with all applicable state, federal, and local laws and ordinances ("Applicable Laws") in providing the Services/Deliverables.

2.274 Jurisdiction

Any dispute arising from the Contract shall be resolved in the State of Michigan. With respect to any claim between the parties, Contractor consents to venue in Ingham County, Michigan, and irrevocably waives any objections it may have to such jurisdiction on the grounds of lack of personal jurisdiction of such court or the laying of venue of such court or on the basis of forum non conveniens or otherwise. Contractor agrees to appoint agents in the State of Michigan to receive service of process.

2.280 Environmental Provision

2.281 Environmental Provision

For the purposes of this Section, "Hazardous Materials" is a generic term used to describe asbestos, ACBMs, PCBs, petroleum products, such construction materials as paint thinners, solvents, gasoline, oil, etc., and any other material the manufacture, use, treatment, storage, transportation or disposal of which is regulated by the federal, state or local laws governing the protection of the public health, natural resources or the environment. This includes, but is not limited to, materials such as batteries and circuit packs, and other materials that are regulated as (1) "Hazardous Materials" under the Hazardous Materials Transportation Act, (2) "chemical hazards" under the Occupational Safety and Health Administration standards, (3) "chemical substances or mixtures" under the Toxic Substances Control Act, (4) "pesticides" under the Federal Insecticide Fungicide and Rodenticide Act, and (5) "hazardous wastes" as defined or listed under the Resource Conservation and Recovery Act. This Contract does not cover the handling, removal, or disposal of all Hazardous Materials.

(a) The Contractor shall use, handle, store, dispose of, process, transport and transfer any material considered a Hazardous Material in accordance with all federal, State and local laws. The State shall provide a safe and suitable environment for performance of Contractor's Work. Prior to the commencement of Work, the State shall advise Contractor of the presence at the work site of any Hazardous Material to the extent that the State is aware of such Hazardous Material. If the Contractor encounters material reasonably believed to be a Hazardous Material and which may present a substantial danger, the Contractor shall immediately stop all affected Work, give written notice to the State of the conditions encountered, and take appropriate health and safety precautions.

(b) Upon receipt of a written notice, the State will investigate the conditions. If (a) the material is a Hazardous Material that may present a substantial danger, and (b) the Hazardous Material was not brought to the site by the Contractor, or does not result in whole or in part from any violation by the Contractor of any laws covering the use, handling, storage, disposal of, processing, transport and transfer of Hazardous Materials, the State shall order a suspension of Work in writing. The State shall proceed to have the Hazardous Material removed or rendered harmless. In the alternative, the State shall terminate the affected Work for the State's convenience.

(c) Once the Hazardous Material has been removed or rendered harmless by the State, the affected Work shall be resumed as directed in writing by the State. Any determination by the Michigan Department of Community Health and/or the Michigan Department of Environmental Quality (whichever is applicable) that the Hazardous Material has either been removed or rendered harmless shall be binding upon the State and Contractor for the purposes of resuming the Work. If any such incident with Hazardous Material results in delay not reasonable anticipatable under the circumstances and which is attributable to the State, the applicable SLAs for the affected Work will not be counted in **Section 2.076** for a time as mutually agreed by the parties.

(d) If the Hazardous Material was brought to the site by the Contractor, or results in whole or in part from any violation by the Contractor of any laws covering the use, handling, storage, disposal of, processing, transport and transfer of Hazardous Material, or from any other act or omission within the control of the Contractor, the Contractor shall bear its proportionate share of the delay and costs involved in cleaning up the site and removing and rendering harmless the Hazardous Material in accordance with Applicable Laws to the condition approved by applicable regulatory agency(ies). If the Contractor fails to take appropriate action pursuant to Applicable Laws and consistent with the State requirements, then the State may take appropriate action.

2.290 General

2.291 Amendments

The Contract may not be modified, amended, extended, or augmented, except by a writing executed by the parties.

2.292 Assignment

(a) Neither party shall have the right to assign the Contract, or to assign or delegate any of its duties or obligations under the Contract, to any other party (whether by operation of law or otherwise), without the prior written consent of the other party; provided, however, that the State may assign the Contract to any other State agency, department, division or department without the prior consent of Contractor and Contractor may assign the Contract to an affiliate so long as such affiliate is adequately capitalized and can provide adequate assurances that such affiliate can perform the Contract. Any purported assignment in violation of this Section shall be null and void. It is the policy of the State of Michigan to withhold consent from proposed assignments, subcontracts, or novations when such transfer of responsibility would operate to decrease the State's likelihood of receiving performance on the Contract or the State's ability to recover damages.
(b) Contractor may not, without the prior written approval of the State, assign its right to receive payments due under the Contract. In the event of any such permitted assignment, Contractor shall not be relieved of its responsibility to perform any duty imposed upon it herein, and the requirement under the Contract that all payments shall be made to one entity shall continue.

2.293 Entire Contract; Order of Precedence

(a) The Contract, including any Statements of Work and Exhibits, to the extent not contrary to the Contract, each of which is incorporated for all purposes, constitutes the entire agreement between the parties with respect to the subject matter and supersedes all prior agreements, whether written or oral, with respect to such subject matter and as additional terms and conditions on the purchase order shall apply as limited by **Section 2.061**.
(b) In the event of any inconsistency between the terms of the Contract and a Statement of Work, the terms of the Statement of Work will take precedence (as to that Statement of Work only); provided, however, that a Statement of Work may not modify or amend the terms of **Sections 2.110 through 2.220** of the Contract, which may be modified or amended only by a formal Contract amendment.

2.294 Headings

Captions and headings used in the Contract are for information and organization purposes. Captions and headings, including inaccurate references, do not, in any way, define or limit the requirements or terms and conditions of the Contract.

2.295 Relationship of the Parties (Independent Contractor Relationship)

The relationship between the State and Contractor is that of client and independent Contractor. No agent, employee, or servant of Contractor or any of its Subcontractors shall be or shall be deemed to be an employee, agent or servant of the State for any reason. Contractor will be solely and entirely responsible for its acts and the acts of its agents, employees, servants and Subcontractors during the performance of the Contract.

2.296 Notices

(a) Any notice given to a party under the Contract shall be deemed effective, if addressed to such party as addressed below, upon: (i) delivery, if hand delivered; (ii) receipt of a confirmed transmission by facsimile if a copy of the notice is sent by another means specified in this Section; (iii) the third (3rd) Business Day after being sent by U.S. mail, postage pre-paid, return receipt requested; or (iv) the next Business Day after being sent by a nationally recognized overnight express courier with a reliable tracking system.

State:
State of Michigan
Purchasing Operations
Attention: Jim Wilson
PO Box 30026
530 West Allegan
Lansing, Michigan 48909

Contractor(s):
Michigan State University
301 Administration Bldg.
East Lansing, MI 48824

Either party may change its address where notices are to be sent by giving notice in accordance with this Section.

(b) Binding Commitments
Representatives of Contractor identified in **Exhibit I** shall have the authority to make binding commitments on Contractor's behalf within the bounds set forth in such table. Contractor may change such representatives from time to time upon written notice.

2.297 Media Releases and Contract Distribution

(a) Media Releases
Neither Contractor nor the State will make any news releases, public announcements or public disclosures, nor will they have any conversations with representatives of the news media, pertaining to the Contract, the Services or the Contract without the prior written approval of the other party, and then only in accordance with explicit written instructions provided by that party. In addition, neither Contractor nor the State will use the name, trademarks or other proprietary identifying symbol of the other party or its affiliates without such party's prior written consent. Prior written consent of the Contractor must be obtained from authorized representatives.
(b) Contract Distribution
Purchasing Operations shall retain the sole right of Contract distribution to all State agencies and local units of government unless other arrangements are authorized by Purchasing Operations.

2.298 Reformation and Severability

Each provision of the Contract shall be deemed to be severable from all other provisions of the Contract and, if one or more of the provisions of the Contract shall be declared invalid, the remaining provisions of the Contract shall remain in full force and effect.

2.299 Consents and Approvals

Except as expressly provided otherwise in the Contract, if either party requires the consent or approval of the other party for the taking of any action under the Contract, such consent or approval shall be in writing and shall not be unreasonably withheld or delayed.

2.300 No Waiver of Default

The failure of a party to insist upon strict adherence to any term of the Contract shall not be considered a waiver or deprive the party of the right thereafter to insist upon strict adherence to that term, or any other term, of the Contract.

2.301 Survival

Any provisions of the Contract that impose continuing obligations on the parties including the parties' respective warranty, indemnity and confidentiality obligations, shall survive the expiration or termination of the Contract for any reason. Specific references to survival in the Contract are solely for identification purposes and not meant to limit or prevent the survival of any other section.

2.302 Covenant of Good Faith

Each party agrees that, in its dealings with the other party or in connection with the Contract, it shall act reasonably and in good faith. Unless stated otherwise in the Contract, the parties will not unreasonably delay, condition or withhold the giving of any consent, decision or approval that is either requested or reasonably required of them in order for the other party to perform its responsibilities under the Contract.

2.303 Permits

Contractor shall obtain and pay any associated costs for all required governmental permits, licenses and approvals for the delivery, installation and performance of the Services. The State shall pay for all costs and expenses incurred in obtaining and maintaining any necessary easements or right of way.

2.304 Website Incorporation

State expressly states that it will not be bound by any content on the Contractor's website, even if the Contractor's documentation specifically referenced that content and attempts to incorporate it into any other communication, unless the State has actual knowledge of such content and has expressly agreed to be bound by it in a writing that has been manually signed by an authorized representation of the State.

2.305 Taxes

Vendors are expected to collect and pay all applicable federal, state, and local employment taxes, including the taxes defined in Section 3.022 for all persons involved in the resulting Contract.

The State may refuse to award a contract to any Vendor who has failed to pay any applicable State taxes. The State may refuse to accept Vendor's bid, if Vendor has any outstanding debt with the State. Prior to any award, the State will verify whether Vendor has any outstanding debt with the State.

2.306 Prevailing Wage

The rates of wages and fringe benefits to be paid each class of individuals employed by the Contractor, its subcontractors, their subcontractors, and all persons involved with the performance of this Contract in privity of contract with the Contractor shall not be less than the wage rates and fringe benefits established by the Michigan Department of Labor and Economic Development, Wage and Hour Bureau, schedule of occupational classification and wage rates and fringe benefits for the local where the work is to be performed. The term Contractor shall include all general contractors, prime contractors, project managers, trade contractors, and all of their contractors or subcontractors and persons in privity of contract with them.

The Contractor, its subcontractors, their subcontractors, and all persons involved with the performance of this contract in privity of contract with the Contractor shall keep posted on the work site, in a conspicuous place, a copy of all wage rates and fringe benefits as prescribed in the contract. You must also post, in a conspicuous place, the address and telephone number of the Michigan Department of Labor and Economic Development, the office responsible for enforcement of the wage rates and fringe benefits. You shall keep an accurate record showing the name and occupation of the actual wage and benefits paid to each individual employed in connection with this contract. This record shall be available to the State upon request for reasonable inspection.

If any trade is omitted from the list of wage rates and fringe benefits to be paid to each class of individuals by the Contractor, it is understood that the trades omitted shall also be paid not less than the wage rate and fringe benefits prevailing in the local where the work is to be performed.

2.307 Call Center Disclosure

Contractor and/or all subcontractors involved in the performance of this Contract providing call or contact center services to the State must disclose the location of its call or contact center services to inbound callers. Failure to disclose this information shall be a material breach of this Contract.

2.308 Future Bidding Preclusion

Contractor acknowledges that, to the extent this Contract involves the creation, research, investigation or generation of a future RFP, it may be precluded from bidding on the subsequent RFP. The State reserves the right to disqualify any bidder if the State determines that the bidder has used its position (whether as an incumbent Contractor, or as a Contractor hired to assist with the RFP development, or as a Vendor offering free assistance) to gain a leading edge on the competitive RFP.

2.310 Reserved

2.320 Extended Purchasing- Reserved

2.330 Federal Grant Requirements

2.331 Federal Grant Requirements

The following links contain certifications and terms which may be required for some purchases paid via Federal funds. They are included here to be utilized as required.

Lobbying Certifications are usually for agreements over $100,000. The debarment certification is required for all agreements. The last link is where you can go and search for debarred or suspended contractors.

http://straylight.law.cornell.edu/uscode/html/uscode31/usc_sec_31_00001352----000-.html
http://www.archives.gov/federal_register/codification/executive_order/12549.html
http://www.archives.gov/federal_register/executive_orders/pdf/12869.pdf
http://www.epls.gov/epls/servlet/EPLSSearchMain/1

APPENDIX A

BIDDER RESPONSE TO ARTICLE 1

Task 1: Study design and planning

Lake selection and competence

Sediment cores shall be retrieved from six to seven lakes during four sampling seasons. Of the six to seven lakes two to three lakes shall be new lakes, those that have not been sampled previously, and two to three lakes shall be of those sampled in previous sampling seasons. New lakes shall be selected based upon evidence of anthropogenic sources near the lake (e.g., coal-fired power plant), geographic location versus lakes previously sampled and knowledge of historical anthropogenic sources in the watershed (e.g., tannery). Lake sampling for the current year will be coordinated with Glen Schmitt and other pertinent MDEQ personnel during the Spring of the sampling year.

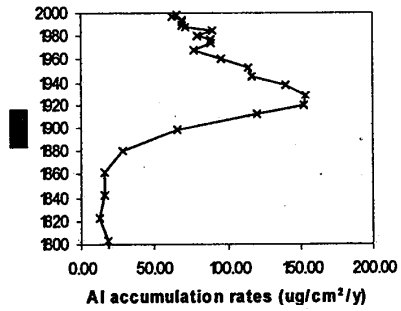


Figure 1. Aluminum accumulation rates in Elk Lake. The increase from the late 1800s until the 1920s is due to extensive logging in the watershed.

- Lake Charlevoix, although located in a region with multiple lakes that had been sampled previously (Torch, Elk, and Mullett lakes) was sampled in 2005 due to historical anthropogenic sources in the

watershed. These sources include a coal fired power plant, tannery, iron works, and logging activities. Influences of logging activities have been identified in a nearby lake, Figure 1(Simpson *et al.*, 2000).

The project team believes that sediments can be collected from nearly every public lake in the State of Michigan.

- The project team has developed techniques to extrude sediment cores on-shore without power equipment enabling us to sample remote lakes. This also improves sample integrity by eliminating the need to transport sediment cores to laboratory facilities for extrusion.
- Due to previous experience, the project team has knowledge of and experience with launching of the sediment collection vessel in remote lakes. Lakes in the Upper Peninsula, due to their remote locales, provide important information on atmospheric transport of contaminants. Consistently, Upper Peninsula lakes do not offer exceptional launch facilities. Imp Lake, located in the western Upper Peninsula, is an example of the flexibility of the project team to improvise launching procedures and collect samples from a remote lake. Figure 2 shows the launch facility at Imp Lake; the lack of a hard surface boat ramp and shallow water did not deter the project team from launching the sediment collection vessel in this lake. Imp Lake provided information about a geographical locale essential to understanding sub-regional scale atmospheric deposition in a watershed with little to no disturbance (e.g., urban development).

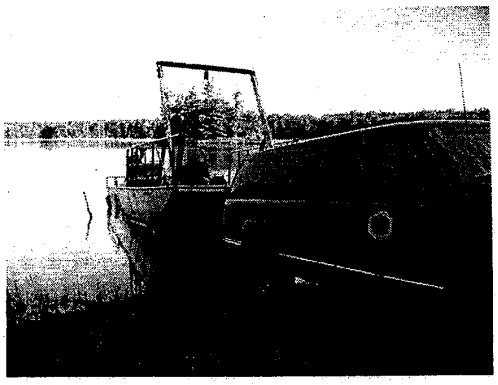


Figure 2. Launching the sediment collection vessel on Imp Lake.

Selection of a site within a lake to sample

Depositional zones (usually the deepest point) within lakes need to be selected for taking sediment cores for chronological and loading studies. These zones are the lowest energy areas of a lake. Two other zones in lakes are erosional and transitional. Erosional zones are characterized by high-energy conditions that remove surface sediments. Sediment removed from the erosional zones is typically moved to the deposition basins. Neither deposition nor erosion occurs in the transitional zones. Transitional zones and depositional zones can occasionally experience high-energy conditions that remove or resuspend sediments, respectively.

Most toxic chemicals are deposited on lake floors adsorbed to particles. Fine-grained particles such as clays have the most reactive surfaces and therefore this portion of sediments in lakes contains the highest concentrations of chemicals. Fine-grained particles accumulate in the depositional zones, therefore containing a better record of contaminant loadings in lakes than more coarse grain particles such as sand.

Selection of inland lakes to sample

Criteria that need to be considered in the selection of the lakes to be sampled include:
(1) depth of the lake,
(2) spatial location in the state,
(3) land use patterns around the lake,
(4) known problems, and
(5) accessibility.

Lakes need to be deep enough, or if shallow, the energy conditions, of the lake low enough, to have a continuous depositional zone. Even if the lake is deep, it does not eliminate the possibly that the sediments have been disturbed in the depositional zone. Assessment of the quality of the sediment core is addressed in Task 4: Statistical data analysis/review.

In selecting lakes to sample, it must be realized that the atmosphere can be a dominant pathway for toxic chemicals to enter Michigan's surface waters. Thus, contaminants in sediment of the lakes may not necessarily be derived from within the state boundaries. Lakes to be sampled need to be located along north-south and east-west transects to evaluate regional trends and near state borders to address the likelihood of long-range atmospheric transport of contaminant to the state. Assessing the role of regional atmospheric transport of chemicals is addressed in the section on sediment focusing found in Task 4: Statistical data analysis/review.

Figure 3. Industrial facilities near the shore of Muskegon Lake

Lakes need to be chosen to reflect the diversity of land uses in the state. Land-use patterns can significantly impact the chemistry of inland lakes. Remote lakes with no motor boat traffic will be expected to have different contaminant loading than urban lakes with diverse recreational uses. Potentially, one of the contaminant problems unique to inland lakes compared to large lakes (e.g., the Great Lakes) is the greater influence of contaminants derived from within the lake from motor traffic.

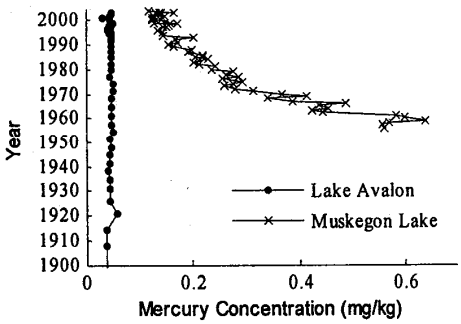


Figure 4. Mercury concentrations in Muskegon and Avalon lakes. Dates for Lake Avalon are truncated for clarity.

Two final criteria for the selection of lakes for sediment chronological study are contaminant issues and accessibility. Lakes with identified issues such as contaminated sediments, biota, or water need to be given high priority. The constraints on lake accessibility will be defined by the sampling equipment to be used for collecting lake sediments and the type of surface vessel.

Revisiting lakes

A critical portion of the Strategy is to revisit lakes to determine current trends of contaminant loading. An overall monitoring strategy should include:

- Lakes of interest: lakes with increasing levels of contaminants to the surface, or concentrations of contaminants higher than most other Michigan lakes
- Background lakes: lakes with low concentrations of contaminants with few point sources in the watershed. These lakes would provide background data on atmospheric deposition and provide a comparison for the lakes of concern. Ideally, these lakes would be spatially dispersed throughout Michigan.

The lakes that have been most affected by anthropogenic activities are classified as lakes of interest. The high percentage of urbanization and industrialization in the Muskegon Lake watershed would suggest that the lake has undergone tremendous anthropogenic impact in recent years, Figure 3. Muskegon Lake sediments reflect the impact of these watershed processes by the high concentrations of contaminants both historically and currently. High rates of sediment deposition are observed in Muskegon Lake. Geochemical background concentrations, due to the high rates of sedimentation, are not reached in this lake and present a limiting factor of the current methodology. For example, sediment collected from Muskegon Lake, sampled in 2003, only reached sediment ages in the 1950s, Figure 4. We are currently implementing the use of a longer coring device to supplement the current sediment collection methods in Muskegon Lake to investigate historical trends of contaminant loadings and reach geochemical background levels. This new methodology would also improve our understanding of other lakes in urban settings (e.g., Cass Lake) as these lakes also have high rates of sedimentation.

Elk Lake has consistently low concentrations of contaminants. Gratiot, Imp and Round lakes also have low anthropogenic accumulation rates. These lakes appear to be the "cleanest" of the lakes sampled. Imp Lake would be particularly useful to sample, as it has little development in the watershed and generally low accumulation rates of contaminants, but rates have been increasing in the past decade (Yohn *et al.*, 2003).

In addition to identifying which lakes need to be revisited is the frequency of sampling a lake. The intent of monitoring is to be able to detect change from when the last sample was taken. Change can be in the concentration of a chemical or a change in the trend of the environmental loading of a chemical. In the first case only the very surface sediment sample would need to be taken. But given the complexities of lake dynamics (e.g., bioturbation) a single sample would not be informative. What is more important is to determine the change in the trend of the chemical inputs. Our current sampling protocol involves taking 0.5 cm samples from the top sediments. Therefore, the accumulation of 2.0 cm of new sediment would be needed to obtain the four samples. The time to deposit 2.0 cm of sediment can be determined from the sedimentation rate, Table 1.

Table 1. Minimum number or years needed to deposit approximately 2 cm of new sediment for seventeen inland lakes in Michigan. *Littlefield estimated

Avalon	Birch	Cadillac	Cass	Crystal B	Crystal M
6 y	5 y	2 y	1 y	4 y	3 y
Elk	Gratiot	Gull	Higgins	Houghton	Imp
10 y	2 y	4 y	6 y	4 y	6 y
Littlefield*	Mullett	Muskegon	Paw Paw	Round	Sand
5 y	3 y	2 y	1 y	3 y	3 y
Shupac	Torch	Whitmore	Witch		
7 y	13 y	1 y	2 y		

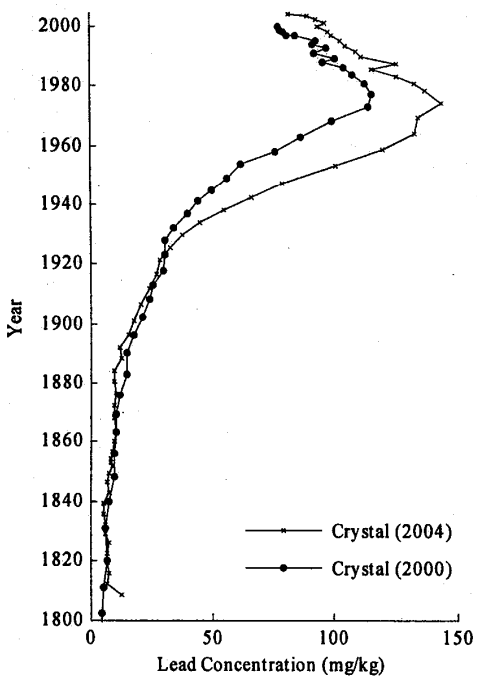


Figure 5. Comparison of Crystal Lake sampled in 2000 and 2004. Some dates are truncated for clarity.

As an example of revisiting lakes, Crystal Lake (Mecosta County) was sampled both in 2000 and 2004. The project team has been able to demonstrate that current sediment concentrations of lead in Crystal Lake (Mecosta County) have continued to decrease and that peak concentrations occur at the same time, Figure 5. These results demonstrate that the methodology put forward by the project team is able to monitoring current trends, a key objective of the Strategy.

The project team has vast experience and knowledge of the procedures and pitfalls of sediment sampling based upon seven years of inland lake sediment collection. Table 2 provides examples of yearly progress reports submitted to MDEQ from 1999 until 2003. An example report is included in Appendix E.

Table 2. Lakes samples and reports submitted during the past seven years.

Report Number	Year	Lakes Sampled
MI/DEQ/SWQ-01/030	1999	Gratiot, Elk, Cass, Higgins, Gull
MI/DEQ/WD-02/115	2000	Crystal (Mecosta County), Littlefield
MI/DEQ/WD-03/052	2001	Crystal (Benzie County), Mullett, Whitmore, Paw Paw, Cadillac
MI/DEQ/WD-04/066	2002	Houghton, Torch, Round (Luce County), Witch, Imp, Hubbard
Submitted	2003	Avalon, Birch, Sand, Muskegon, Shupac

Task 2: Sediment core collection/sediment core processing

Collection of sediments – work platform

Large Lake Experience – The project team has been involved since 199_ in defining the nature of and collecting/analyzing the various sediment layers in the Great Lakes and its bays (Ostrom *et al.*, 1998). The research vessels that we have used include the U.S. EPA R/V Lake Guardian, NOAAs R/V Seward Johnson, NOAAs research submersible Johnson SeaLink, and the University of Michigan's R/V Laurentian. Study areas include Lakes Superior, Michigan, Huron, Ontario; Grand Traverse and Saginaw bays, and the Gulf of Maine (Matty and Long, 1995).

Inland Lake Experience - In 1999, the MDEQ contracted with the project team at Michigan State University to initiate a sediment chemistry trend monitoring program for selected inland lakes in Michigan. The R/V Mudpuppy from the U.S. EPA was contracted and used as the work platform in the initial lake studies. The project team and MDEQ supplied the sampling equipment (see below). An early goal of the monitoring program was to design and build a work platform.

Therefore in 2000, the DTL project team and William Taft of MDEQ Surface Water Quality Division worked to develop such a vessel. They worked with David Schafer of Schafer Boats, L'Anse Michigan, for the boat-building project. Mr. Schafer designed the boat (and trailer) with specifications from the experiences of the DTL project team sediment work, the nature of the coring system already in hand, and the experiences of William Taft working on inland lakes of Michigan. Example specifications included that the boat should:

- be capable of being launched in remote lakes with unimproved launch sites,
- be stable in large waters,
- have an A-frame and winch capable of deploying the coring device,
- have GPS and depth sounding capabilities,
- be capable of carrying a crew of at least four, and
- have a generator, pump, and hose to clean the coring system after recovery.

The boat was completed in 2000 and after initial checkout by the DTL's project team, some modifications were made to the A-frame and trailer. This boat (now known as the Nibi) has been used successfully for the monitoring program.

Collection of sediments – coring device

Needs - The collection of quality cores is an essential portion of the sampling procedure. All the techniques need to be designed to minimize compaction and disturbance of the sediment and to collect a core that provides an accurate record of the depositional history of the lake. The ideal retrieved core should contain mostly sediment, but also about one inch of water at the top of the core. This water helps maintain the integrity at the sediment-water interface. The sediment-water interface is the most important, and easiest to disturb, portion of the core. This sediment boundary layer, a layer of highly unconsolidated sediment typically less than 2 cm thick, lies above the more consolidated sediments and is easily disturbed. The bow waves of rapidly falling coring devices typically blow this layer away. In addition, such falling devices most often compress the sediments. Therefore, sediment-coring techniques that recognize these problems must be used.

Large Lake Experience – In the large lakes, the project team has used gravity cores, piston corers, and large box corers from the surface work platforms and punch corers and small box cores from the manned submersible. The large box corer has the attributes that were considered in selecting a coring device for the Inland Lakes project. The large box core is a container (≈ 4 sq. ft. by 5.5 ft) that is carried inside of a metal frame. The frame and box core are gently lowered to the lake bottom. When the frame hits the bottom, the box core is set free and settles into the sediments. The depth the box core penetrates the sediment is determined by attached weights.

The box core and frame are then retrieved. As the box core is pulled from the sediments, shovels close under the core to contain the sediments. The box core and frame are then brought aboard the surface vessel or platform. If the box core has a glass side, an initial core description is made. Once on board ship, PVC tubes (which are under vacuum) are slowly pushed into the sediment and several cores are retrieved.

Inland Lake Experience – In the development of coring system for the Inland Lakes program, the capabilities of the large box core (e.g., multiple high quality cores) were needed. In addition, the system had to be transportable and be able to be used in remote areas. From advice from one of DTL's colleagues (Dr. Thomas Johnson, director Large Lakes Observatory), the Ocean Instruments MC-400 Lake/Shelf Multi-Corer was selected. Dr. Johnson had successfully used this system in remote lakes in East Africa. This system allows for the collection of four simultaneous high quality cores and is based on the large box corer principles. The advantage of this system is that it is transportable, there is no need for taking sub cores, and the quality of the cores is immediately visible because of the transparent core tubes. The project team worked with Ocean Instruments to facilitate the use of the Multi Corer in the Inland Lakes. This included learning the principles of the system so that adjustments could be made in the field to collect better cores and the development of wooden "feet" to help stabilize the "frame" on the bottom of the lake in an upright position before the corer is released to penetrate the sediments.

The Multi Corer is composed of a frame and a center portion that contains the coring tubes. The frame settles to the lake bottom first, and then the core tubes settle slowly into the sediment. A slow-down cylinder slows the tubes, and the number of lead weights placed in the center portion controls the depth of penetration into the sediment. In order to trigger the rubber stoppers on the top of the tubes and the carpeted portion that caps the bottom of the tube, there needs to be

differential pressure between the tubes and the main center portion of the corer. Initially, the core tubes lower at the same rate as the center portion of the corer. When the cores sink as far as they can (dependant on the amount of weight placed on them and the texture of the lake bottom) they hold firm as the main portion sinks a little bit lower. This allows, for the first time, a tube that is part of the center portion to move against the outside portion attached to the tubes, causing a ring to catch, pull up when the corer is lifted and trigger the release of the caps on the tubes. The important thing to note is that there must be the right amount of weight to cause this differential pressure on the core tubes. Another issue of concern is making sure that the coring device remains in an upright position after taking the cores and does not swing or get tilted these events would cause the water in the top of the core tube to slosh, disturbing the sediment water interface.

A later development in the use of the Multi Corer was the fabrication of aluminum supports to replace the wooden feet. DTL worked with the MSU Physics Shop (Mr. Thomas Palazzolo) to design and build these supports. These supports increased the effectiveness of the coring device in less consolidated bottom sediments.

Some of the inland lakes pose a special problem because of very watery bottom sediments. Retrieval of high quality cores in such situations can be challenging. Recently the project team designed attachments to the Multi Corer (again working with Mr. Palazzolo) to be able to successfully retrieve these "problem" sediments.

The project team also redesigned the core tubes. One of the problems with inland lakes is that they can have high sedimentation rates caused by certain types of land use or by high productivity. As the team learned more about the sampling device, it was determined that the collection tubes could be made longer. Working with Mr. Palazzolo, a new longer set of tubes was developed for the coring system.

Finally, early in the use of the coring system, the project team developed the methodology for initial assessment of the quality of the core and for the removal and maintenance of the integrity of the core prior to extrusion. While the cores are still attached to the Multi Corer, an initial core description is made (e.g., length of core, layers, colors). Evidence for any sediment disturbance including a non level sediment-water interface is gathered. If there is evidence of disturbance, a new set of cores is taken. Once it is determined visually that the core is of high quality it is removed from the Multi Corer. Two to three individuals are necessary for the next steps. One person holds the core tube and removes the holding apparatus. When ready, a second person slides a wide spatula under the core tube (between the core tube and "carpet"). The core is lifted, placed on a plastic stopper, the spatula pulled out, the core tube pushed down on the stopper, and a piece of foil placed on one top of the to tube. The core is then stored in a specially designed holder.

This Multi Corer (now known as the Spider) has been used successfully for the monitoring program. The protocols for taking cores with the Multi Corer are discussed in more detail in Task 2: Sediment core collection/sediment core processing of this RFP and have been approved under the current Quality Assurance Project Plan agreement with MDEQ (please see the section 1.302 Reports of this RFP).

Collection of sediments – sediment processing

Large Lake Experience – In the large lake studies the project team built hydraulic extruders to extract the sediment out of the core tubes. Briefly a rubber stopper is pushed into the bottom of the core tube and the core tube is set on a platform that allows water to push the rubber stopper up the tube. Water was supplied by the ship via a garden hose. The amount of extrusion was determined by a valve. For the top unconsolidated sediments, a short PVC "tube" was fabricated with 0.5 cm increments engraved on the side. The sediments are extruded into the tube, the tube "slid" off of the core, the sediments deposited into a scoop, and then into the sample container.

Inland Lake Experience - In the development of an extruding system for the Inland Lakes program, the project team needed the capabilities of systems used in the large lakes, but able to be used in remote areas. The project team designed and fabricated (with the help of Mr. Palazzolo) an extrusion system. The system consists of a work platform with a system to vertically support the core tube. The original core tubes and the newly fabricated tubes were modified to work with this support system. The sediments are extruded by turning a long threaded rod into the plastic stopper at the bottom of the tube. Specially designed turning handles were made for this process. To collect the top unconsolidated sediments a special collar was made to fit on top of the core tube. The collar has a channel carved into it and a short polycarbonate tube (with depth increments engraved) fits into the collar. Sediment is extruded into the tube and the tube with sediment slid in the channel to the edge of the collar and the sediments deposited into sample containers via a funnel. The advantages of this extrusion technique are that no power or water source is necessary for the extrusion and that increments of the top unconsolidated sediments can be efficiently and accurately collected.

Sediment from three of the core tubes is extruded for the organic, metals, and ^{210}Pb analyses. The thicknesses of the sediment slices are thinner at the top (0.25 to 0.5 cm) and thicker (1 to 2 cm) towards the bottom of the core. Care is taken to remove sediment from around the edges of the extruded sediment (except for the ^{210}Pb core) before a slice is taken to minimize smearing effects. Features of the sediment slices are recorded during the sectioning process.

Sediments are stored in clean containers, the composition of which is reflective of the analysis to be performed. Sediments for organic analysis are placed in solvent-rinsed glass jars with aluminum foil-lined lids. Sediments for inorganic and ^{210}Pb analysis are placed in acid-washed plastic bottles. Sediments for general physical properties can be stored by either method. Samples are frozen or refrigerated (4°C) until analysis.

The protocols for extruding sediment from the cores are discussed in more detail in the current Quality Assurance Project Plan agreement with MDEQ (please see attached).

Collection of sediments – porewater collection and processing

One of the major exposure pathways by which contaminants can enter the ecosystem is through water. Various biogeochemical processes in sediments can cause either the sequestration or the release of inorganic and organic chemicals. The analysis of porewater in sediments provides insight into these processes.

Large Lake Experience – In the large lakes, the project team has used two techniques to extract porewater from sediments, centrifugation and squeezing. The goal of the extraction is to keep the porewater isolated from exposure to air which could result in contamination or oxidation. In the centrifugation method, the sediments are extruded under N_2 (a glove bag is placed over the top of the core). Under N_2, the sediments are placed in N_2 purged centrifuge tubes. The porewater is then separated from the sediment via centrifugation (the project team designed a special gimbled platform to hold the centrifuge on ship. The centrifuge tubes are then brought to a glove bag filled with N_2 and the porewater filtered and stored in appropriate sample bottles. This approach comprises many complicated steps and thus takes time and there is potential for contamination. Also there is significant warming of the sediment during the centrifugation process if a temperature controlled centrifuge is not available. This warming can cause biogeochemical reactions that might influence porewater chemistry.

Although the project team has success with this approach (e.g., (Matty and Long, 1995), a more efficient porewater extraction method needed to be considered. Gaining insight from one of DTL's colleagues (Dr. Yu Pin Chin, Ohio State University) a sediment squeezing system was developed. In this approach, a special tube is used to sub core the large box core. The tube has taped holes spaced and at either one or two cm down the side of the core. When the core is taken, specially designed plungers are pushed into the top and bottom of the core tube. The core is then placed on a rack that allows the plungers to be forced into the core tube via turning with a wrench. Before squeezing, a Porex tube is pushed into the taped holes on the side of the core tube. Attached to the Porex tube is a plastic three way stop cock and to it a plastic syringe. When the core is squeezed, the porewaters are forced into the syringe. Some pre filtration of the water takes place because of the Porex. This system was designed and fabricated with the help of Mr. Palazzolo.

Inland Lake Experience - In the development of a porewater extruding system for the Inland Lakes program, the capabilities of the systems used in the large lakes were considered including its use in remote areas. Working with Mr. Palazzolo, a special platform was designed to hold the core tub to be squeezed. Core tubes with holes necessary for extrusion could not be made compatible with the Multi Corer. Therefore, the platform was designed for two purposes: 1) the extrusion of the sediment into the squeezing tube and 2) the squeezing of the sediment.

When the porewater has been squeezed into the syringes, the syringes are removed from the core, placed in a plastic bag and stored in an iced cooler until final filtration. The filtering of the porewater is done in a glove bag to protect as much as possible from contamination. The porewater is filtered through a Millex 0.45 μm disposal filter. The filtered solution is then acidified with ultra pure nitric acid and stored on ice or 4°C cold room until analysis.

The protocols for extracting porewater from the sediments cores are discussed in more detail in the current Quality Assurance Project Plan agreement with MDEQ (please refer to section 1.302 Reports).

Task 3. Sediment core analysis

All sediment core collection and sediment core analysis, excluding ^{210}Pb dating, are performed by the project team researchers. ^{210}Pb dating will be performed by Paul Wilkinson of the Freshwater Institute; this is consistent with prior sampling years. Below are the methods employed for sediment and porewater collection and metals and organic analysis. The project team has received QAPP certification until 2008 from MDEQ for analysis of the following metals:

Hg, Sc, Mo, Cd, Se, U, Co, V, Cr, Cu, As, Pb, Sr, Ni, Ti, Zn, Ba, Al, Mg, K, Mn, Fe, Sn, P, Si, Ca

and organic chemicals:

polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAH), organochlorine pesticides- DDTs, HCHs, and chlordane.

Methods for the analysis of total nitrogen in sediment shall be developed in conjunction with the MDEQ.

Sediment and porewater collection procedures

Sediment coring occurs aboard the R/V Nibi, a vessel specifically designed to sample remote inland lakes. Organic, metals, ^{210}Pb, and porewater sediment cores are collected simultaneously using the following procedure(s).

The collection of quality cores is an essential portion of the sampling procedure. All the techniques in this procedure are designed to minimize compaction and disturbance of the sediment and to collect a core that provides an accurate record of the depositional history of the lake. The ideal core contains mostly sediment, but also about one inch of water at the top of the core. This water helps maintain the integrity of the sediment-water interface. The sediment-water interface is the most important, and easiest to disturb, portion of the core. This sediment boundary layer is highly unconsolidated, and with a thickness usually less than 2 cm, it's easily disturbed. The bow waves of free falling (gravity) coring devices typically blow this layer away. In addition, "gravity" coring devices most often compress the sediments. Therefore, sediment-coring techniques that recognize these problems must be used.

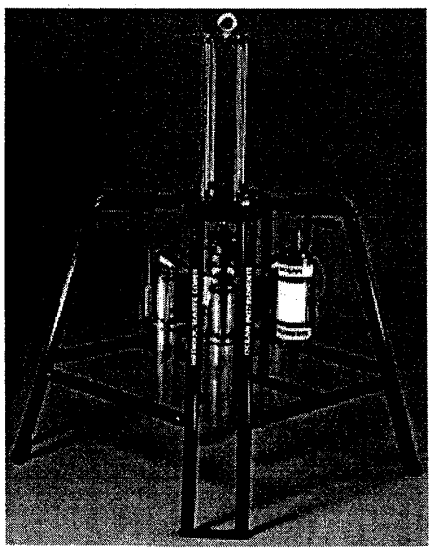


Figure 6. Ocean Instruments Ocean/Shelf Multi Corer

Because of this, the MC-400 Lake/Shelf Multi-Corer, Figure 6, is used to collect samples. The corer is composed of a frame and a center portion that contains the coring tubes. The frame settles to the lake bottom first, and then the core tubes settle slowly into the sediment. A slow-down cylinder slows the tubes, and the number of lead weights placed in the center portion controls the depth that they settle to.

In order to trigger the rubber stoppers on the top of the tubes and the carpeted portion that caps the bottom of the tube, there needs to be differential pressure between the tubes and the main center portion of the corer. Initially, the core tubes lower at the same rate as the center portion of the corer. When the cores sink as far as they can (dependant on the amount of weight placed on them and the texture of the lake bottom) they hold firm as the main portion sinks a little bit lower. This allows, for the first time, a tube that is part of the center portion to move against the outside portion attached to the tubes, causing a ring to catch, pull up when the corer is lifted and trigger the release of the caps on the tubes. The important thing to note is that there must be the right amount of weight to cause this differential pressure on the core tubes.

Another issue of concern is making sure that the coring device remains in an upright position after taking the cores and does not swing or gets tilted. This will cause the water in the top of the core tube to slosh, disturbing the sediment water interface.

Reagents and apparatus

On boat:
core feet, core tubes, spare parts, Multi Corer, holding box, lead bricks
Toolbox
- leather gloves, 9/16" wrench, 3/4" wrench, philips screwdriver, extra bolts / nuts / washers, hammer, knife, oil, drill bits (large for feet), large crescent wrench, screwdriver, wooden rod for removing pistons

Boat tub:
Aluminum foil, beaker (1 L), buoys, bungees, field notebook, electrical tape, garbage bags, lab bags, gloves (bagged), grease (stopcock?), label tape, lake map, paper towels, pens / Sharpies, pistons, squeezer bottoms, paint scraper tool, screwdriver (power), spare parts, syringe (60 mL), tubing for syringe

Coring device was purchased from (and parts and information can be obtained) from John Hedrick of Ocean Instruments (jhedrick@oceaninstruments.com), also see www.oceaninstruments.com for more information.
Core tube information: (Physics shop can make these)
Tube: Polycarbonate
Size: 4"outside diameter, 0.125" wall, 3.75" inside diameter
Bevel: 15 degree inside at top of tube and 15 degrees outside at bottom of tube.

Collecting the cores:

1. Attach either 2 or 4 tubes to the corer with the bolts and wing nut.

2. Pull the knobs on the trip collar out and move the collar down.

3. Cock the tubes:
   a. Unclip the springs from the top rubber stopper.
   b. Hook the lanyard on the lid to the coring device.
   c. Press down on the red ball or pull the bottom carpeted piece down and back. This piece then hooks onto the metal piece attached to the top stopper.
   d. Rehook the springs onto the top stopper.

4. Remove the safety wing nuts.

5. Lower the sampler to the lake bottom. Then provide enough slack that the core tubes can sink into the sediment. Allow at least 5 seconds for collection before pulling the sampler back up.

6. After the corer is on deck, remove the core tubes carefully.

7. It is best to put the safety wing nuts back on before traveling in the boat or working extensively with the corer.

8. If enough sediment is not collected, more lead weights need to be added.
   a. Make sure the safety bolts are on, and the weight is resting on the frame.
   b. Remove the top piece of the corer.
   c. Slide the weights down the two metal rods.
   d. Replace the top of the corer.

Removing the Cores:

1. Carefully unscrew the red ball, and remove the ball and the spring.

2. Open the top rubber stopper, being careful not to disturb the surface sediment.

3. Remove the whole upper portion of the core holder apparatus.

4. Slide the paint scraper between the core tube and the bottom core catcher.

5. Quickly lift the core tube and place on the extruding teflon stopper, remove the paint scraper and push the core tube down onto the stopper.

6. Cover the top of the core with aluminum foil and store out of the sun.

Sectioning

After collection, the cores are sectioned into 0.5 cm and 1 cm increments on the shore of the lake using manual extruders. The sections are collected in sample bottles and taken back to the lab. Cores are sectioned for ^{210}Pb, metals, and organics. The fourth core is squeezed for porewater (see porewater method). Each of the cores is treated slightly differently. Generally, the organics core should only be sectioned using metal (spatula) and glass (bottles) objects. Plastic jars and spatulas should be used for ^{210}Pb and metals cores.

Preparation

1. 120 mL jars (Fisher Scientific) should be cold acid-washed and taped (~60 sections / core, jars are used for metals and ^{210}Pb, therefore ~120 jars are needed per lake)
2. Clean glass jars should be obtained from Dr. John Giesy's group. Our contact is Patrick Bradley, bradl117@msu.edu. Bottle requests should go to him as early as possible before the sampling season.
3. Other materials should be collected / ordered as necessary (see reagents and apparatus needed or to bring list).

Set up

1. Set up screen house, with extruders inside and a table near each extruder.
2. Extruders should be leveled using a level.
3. Each extruder should have a 1 L Nalgene beaker (for waste), a spatula (plastic for ^{210}Pb and metals, metal for organics), bottles (plastic for ^{210}Pb and metals, glass for organics), lab notebook, pen, sharpie, e-pure squirt bottle, ruler, funnel, extra core tube piece, extruder collar and top piece. Additionally, gloves, kimwipes, paper towels, garbage bags, etc. are needed. Buckets are handy for waste.
4. Label bottles before filling. Bottles are labeled with the lake name, the number of the sample, and the reason for collection (Pb for ^{210}Pb, M for metals. Organics is known because of the glass jars. e.g., Whitmore 3 Pb)

Extrusion

1. Very carefully carry cores from the boat to the screen house, trying to disturb the cores as little as possible.
2. Choose which cores should be used for each purpose: the longest, most undisturbed core should be used for ^{210}Pb, then metals, organics and porewater.
3. A photograph should be taken of one of the cores.
4. Carefully place core onto the extruder and push down until the core is seated on the extruder.
5. Put the collar on the core tube and three threaded rods. Put nuts on the three threaded rods and hand tighten only.
6. The cores should be described before they are extruded, including the total length of the core, and the thickness and location of any layers/color changes. Depth of the water column where the core was taken and lat/long coordinates should already have been recorded.
7. Using a piece of tubing, siphon out the water on top of the core,

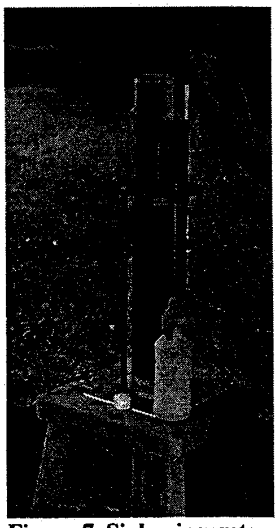


Figure 7. Siphoning water from the core top.

leaving ~1/2 inch of water in the tube, Figure 7. If collecting the top water:

a. Using a clean acid washed 30 mL syringe,. Have a ultra-clean acid washed 30 mL bottle and millex filter ready in the glove bag.
b. Extract approximately 30 mL of topwater from core top.
c. When ~30 mL are in the syringe, place the 30 mL syringe in the glove bag.
d. Filter the topwater sample with the millex filter, wasting the first drops of liquid exiting the syringe, into the ultra-clean acid washed 30 mL bottle.
e. Preserve the sample with 100 uL of 100 ppm gold in concentrated HNO_3 (Optima).
f. The rest of the top water, on top of the sediment core, can be wasted.

8. Extrude core until the water level is at the top of the core, and then remove more water with a short tube attached to a syringe. The eventual goal is to remove enough water from the core top without exposing the surficial sediment.
   a. Leaving some water in the core when extruding up helps to keep the surface layer undisturbed. This is especially important when there is a large water layer.
9. Once the water is removed, place the top piece carefully over the core tube. Set the extra core piece on top of this. Prepare the first bottle and funnel.
10. For the first section, use the increments inscribed on the extra core piece to extrude up 0.5 cm. Making sure you are measuring the top of the sediment layer not the top of the residing water. The organics core should be sectioned in 1 cm increments for the entire core.
11. Carefully pull the extra core piece forward, pulling the sediment into the funnel, Figure 8. The sediment should run down the funnel into the sample bottle. It may be necessary to tap the funnel to get as much sediment as possible into the bottle.
12. Cap the sample jar, rinse funnel and extra core tube piece and dry with kimwipes. Put the extra core tube piece back on the extruder, and then wipe the top piece with a kimwipe.
13. For each section, record in the lab notebook the name of the sample, the thickness of the section, the total depth, and a description of the section (e.g., color, thickness, worms, sticks)
14. Tape a ruler to the core tube lined up with the bottom piston. This will be used in the future to measure the distance to extrude, so choose a line on the piston that is clear to see (e.g., the bottom of the piston).

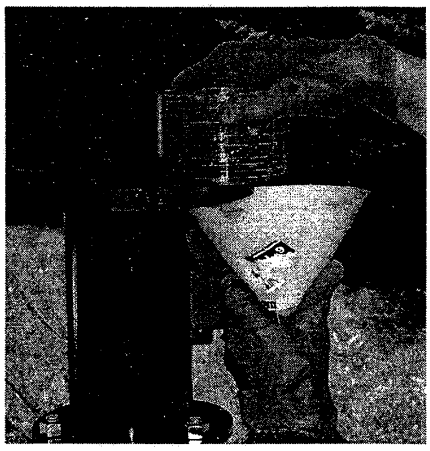


Figure 8. Sectioning at the sediment water interface.

15. Continue extruding until the sediment seems thick enough to not run down the sides of the core tube. Generally, 0.5 cm sections are collected for 10-16 samples. If the core is short, or the lake seems oligotrophic, it is possible that each 0.5 cm will contain many years of deposition, and more 0.5 cm sections should be collected. Be sure that the ^{210}Pb and metals core are sectioned in the same way.
16. When the sediments seem thick enough, remove the top piece.
17. Extrude the core up either 1 or 0.5 cm, using the ruler aligned to the sediment to judge the depth. You cannot use the movement of the piston for this section because the top piece was slightly higher than the top of the core tube.

18. For metals and organics: scrape around the outside of the core where the sediment might have smeared along the tube while extruding. Waste this sediment. (Note: organics analysis requires as much sediment as possible, so waste as little as possible). For ^{210}Pb: try to quantitatively get all of the sediment into the jar. Because of the calculations for dating, there is more error incurred by scraping than smearing.
19. Scrape the sediment carefully off the core tube and into the sample bottle, Figure 9. Do this in small slices at a time to avoid pulling chunks of sediment up from below the current section.
20. Rinse the spatula between sections.
21. After the first section, again use the bottom piston to determine the amount to extrude.
22. After sectioning is complete, double bag samples and put in cooler with ice.

Figure 9. Sectioning sediment core with spatula.

Reagents and apparatus needed:
buckets, coolers, bottles (metals, ^{210}Pb, and organic), DDW carboys, extruders (including tops), table, tent/windscreens, phone list

Extruder tub:
1L beakers (3), bags for sample bottles, E-pure bottles (3), electrical tape, extra core tube pieces, extruder tops, garbage bags, gloves, Kimwipes, label tape, notebooks (3), paper towels, pens and Sharpies, rulers (3), funnels, siphon tubes, spatulas (teflon and rubber), syringes (60 mL w/ tubing), Whirl paks

Porewater

Porewater is collected by squeezing the core and collecting the liquid. The core is first extruded into a core tube with threaded holes in it, then squeezed so that the liquid leave the tube through Porex into syringes. This water is then filtered and preserved. Porewater data may give insight into the mobility of different metals in the sediment.

Note that porewater may have low concentration of some metals, so ultra-clean techniques are needed. Because of this, materials should be washed using ultra-clean techniques. Additionally, if sampling more than one lake on a trip, all materials (e.g., filters, Porex) should be bagged separately for each lake so not to be exposed to the environment more than necessary.

There are 28 holes in the core tubes, the first 10 are 1 cm apart and the remaining 16 are 2 cm apart.

Preparation
1. 30 mL bottles and 30 mL syringes should be ultra-clean acid-washed (~30 / lake)
2. A solution of 100 ppm gold in concentrated HNO_3 should be prepared in the ICP-MS lab.
    a. Add some Optima™ HNO_3 to a 100 mL volumetric flask

   b. Pipette 1 mL of 10,000 ppm Au standard into the flask.
   c. Fill to the line with Optima HNO_3.
   d. Pour into several clean acid washed 30 mL bottles. The Au-acid may be contaminated in the field, so it is best to have a separate bottle for each lake.
3. Cut Porex to the correct length using an X-Acto knife (there should be Porex from the previous year to determine the length, but if not, the length should be ~ ¾ the diameter of the core tube).
4. Wash Porex by soaking in ~10% HNO_3. Because Porex floats, put the acid solution and Porex in one beaker, then put a smaller beaker on top to push the Porex into the acid solution. Soak at least 24 h, then soak in e-pure water for 24 hr, and dry.
5. Drill fittings (connectors) with a 1/8 inch drill bit.
   a. Drill the threaded side by holding the fitting with pliers and drilling straight into the fitting.
6. Wash fittings in HNO_3 in a similar fashion to the Porex.
7. Assemble the Porex (~30 / lake).
   a. Put a small o-ring over the threaded end of the fitting.
   b. Push a Porex rod gently into threaded end of the fitting. The fit will be tight.
   c. Attach a 3-way stopcock to the leur-lok end of the fitting.
   d. Put into a Whirl-Pak bag. Only put ~5 of these / bag to avoid bending the Porex.
   e. Fittings should NOT be reused.
8. Prepare 0.45 µm filters by passing 30 mL of a 10% solution of Optima™ nitric acid followed by 30 mL of Nanopure™ water using an ultra-clean acid-prepped syringe.
9. The two core tubes with holes should have the holes taped over.

Set up

1. A table should be set up for filtering.
2. Place the clean box on the table and cover with two clear plastic bags, one from each direction.
3. All filtration should be done within this clean box. Filtering materials can be set up as the core is being squeezed.

Figure 10. Upper piston, threaded rod and squeezing top assembly.

Squeezing

1. Place core tube on extruder in a fashion similar to that described in the sectioning method. However, this corer should have much longer threaded rods.
2. Place the collar over the core tube, and thread the nuts until touching the collar. Hand tighten only.
3. Place the core tube with holes in it on top of the core on the extruder, using the plastic fitting to hold the core tubes together. Tighten the fitting carefully, and use a level to make sure that the core tubes are both vertical.
4. Extrude the core from the lower tube to the upper tube. Make sure the core is fully in the upper core tube, and then remove this core carefully.

5. Remove the empty core tube currently on the extruder, and replace it with the sediment core.
6. Take the upper piston (with a release valve in it), make sure the valve is loose and push slowly into the water at the top of the core until the piston is sitting on the top of the sediment. Tighten the valve so that water will no longer pass through.
7. Place the threaded rod on top of the piston. Adjust the nut so that it is aligned with the top of the core tube. Put the top piece on top of this, allowing the rod to pass through the hole in the top piece. The nut should be just touching the top piece so that the piston will not be able to move upwards. Thread and hand tighten the wing nuts on the three threaded rods to hold the top piece fast to the core tube, see Figure 10 for an example of squeezer top assembly.

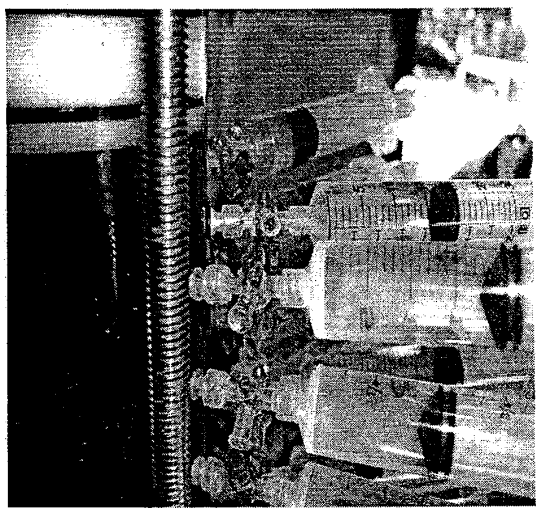


Figure 11. Closeup of Porex assembly inserted into sediment core.

8. Remove one of the assembled Porex (Porex, fitting and 3-way stopcock), and make sure the stopcock is turned to off.
9. Remove the tape for one of the holes and quickly insert the Porex, screwing the fitting into the core tube.
10. Put a 30 mL syringe onto the fitting, Figure 11.
11. Repeat for all holes.
12. For each hole, open the stopcock and allow a small amount of water to rinse out.
13. Put 30 mL syringes on each of the stopcocks, open and begin squeezing.
14. Squeeze slowly and allow time for the water to leave the core before squeezing more.
15. Once squeezing is complete, close the stopcocks and remove the stopcock and syringe from the core tube and take over to the glove box, Figure 12. The syringes should be labeled with which hole the water was collected from.
16. Transfer the syringe from the stopcock to a millex filter with the minimum exposure to air as possible. Filter into a 30 mL bottle, wasting the first few drops of liquid.
17. Preserve the sample with 50 µL of 100 ppm Au in concentrated HNO_3.

Figure 12. Glove box for filtering porewater samples.

Reagents and apparatus needed

100 uL Eppendorf and tips, pipette tips – 100, top rods (threaded), bolts, fittings to hold tubes together, holders for old squeezers, syringes (30 mL), 3 way stopcocks, small o-rings, prepped porex, spare fittings, spare porex, 30 mL bottles (hot acid), prepped filters, teflon tape, bags for clean box, tub for washing, bag holder, Teflon™ screws, $AuHNO_3$ solution (100 ppm Au in conc. HNO_3)

Analytical procedures

Total mercury sediment samples will be analyzed using EPA Method 7473.

Inductively Coupled Plasma Mass Spectroscopy (ICP-MS) will be used to analyze total metal sediment samples, other than mercury, following nitric acid digestion. These methods are described below.

Nitric Acid Microwave Digestion of Inland Lake Sediments

Preparation

1. 0.4µm Nuclepore filters should be acid washed and stored in DDW. Acid wash by adding 10 mL nitric acid to ~ 500 mL of DDW. Add filters and allow to soak for 24 h. Then drain the water and rinse 3x with DDW. Fill the beaker with DDW, cover with a watch glass and store until use.

2. Prepare 100 ppm $HAuCl_4$ solution (For mercury analysis ONLY). Dilute 1 mL stock Au solution (10,000 mg/L $HAuCl_4$) to 100 mL with 2.5% nitric acid in a volumetric flask. (do this at the ICP lab). Store solution in acid-washed plastic bottles in the refrigerator.

Method

Two sets of triplicates should be performed for each core. If separate replicates have been freeze-dried, there is no need to split any samples. If replicates have not been freeze dried, two samples must be split and triplicates of them digested. A blank and SRM must be digested with each run (12 vessels/run = 10 samples + blank + SRM)

1. Prior to starting a digestion, all vessels should be cleaned (liners washed with nitric acid, lids scrubbed with DDW; both soaked for at least 24 h in DDW bath).

2. Place rupture membrane in the gray top of each digestion vessel. Set the membrane in place with a pipette tip. Screw the gray top firmly onto the white Teflon top for all the digestion vessels with the exception of the vessel with the pressure gauge.

3. Samples should be freeze-dried prior to analysis. Examine the sample – if there are chunks in the sample they must be broken up. An effective method to doing this is by rolling a pen or similar object over the Whirl-pak bag until the sample is a fine powder.

4. Carefully weigh out approximately 0.50 g (~0.45 – 0.55 g) of ground sample into a Teflon digestion vessel. BE SURE TO RECORD THE EXACT WEIGHT, SAMPLE NAME AND VESSEL NUMBER OF THE SAMPLE. Repeat this for 10 of the 12 digestion vessels.

5. Weigh out ~ 0.50 g of SRM (Buffalo River Sediment) into a Teflon digestion vessel liner. Record the exact weight.

6. To each sample add 10 ml of 15N HNO_3. Make sure no sample remains on the side of the vessel. Use one vessel as an acid blank, containing only 10 mL of acid with no sample. Screw caps on. Pressure monitor lead should be attached to the sample with the highest organic content (often nearer the top of the core).

7. A CEM MDS-81D microwave with pressure regulation is used for digestions. If the microwave has not been used recently, it is necessary to flush the microwave. Align the valve on the pressure gauge with the "flush" direction. Place pressure hose into the beaker of DDW. Using syringe, inject DDW 3 times into the syringe. Leave syringe full. Return valve to neutral position.

8. Place digestion vessels into rotary tray inside microwave. Attach the hose to the pressure monitor. Make sure the hose is pushed all the way into the Teflon lead.

9. Set up the microwave: fix the exhaust hose in the fume hood, make sure that it is secure. Plug microwave into outlet. Switch the microwave and pressure gauge "on". Make sure that the valve on the pressure gauge is set to "neutral."

10. Check that the vessels turn smoothly and that the hose does not get caught by turning on the turntable and watching for problems, moving the vessel with the pressure monitor into a different position if necessary (if this is necessary, be sure to remember that the sample order changed so not to switch samples)

11. Set the program as follows:
    <1500> for time (15 min)
    <enter>
    <100> for % power
    <enter>
    <program>
    <2000> for cooling time (20 min)
    <enter>
    <0> for % power
    <enter>
    <reset>
    <start>

12. After the digestion ends, allow the vessels to continue cooling until the pressure in the vessels fall below 10 psig.

13. Remove the hose from the pressure monitor and remove the vessels from the microwave.

14. To each sample add 90 ml of DDW (using a graduated cylinder) after digestion and cool down period. Be sure to do this step in the fume hood.

15. Prepare Swinex filters:
    a. Remove an acid-rinsed 0.4µm Nuclepore filter with tweezers and place shiny side up on the bottom portion of the filter holder. Smooth out any wrinkles and make sure the filter is centered on the holder.
    b. Screw on the top portion of the filter holder.
    c. Attach a 30 mL syringe to the bottom portion of the filter holder. Pull the plunger and release it. If the filter is properly seated in the filter holder the plunger will move back to its original position. Repeat this three times. If the plunger does not go back to its original position, unscrew the filter holder and try again.
    d. Screw the gray piece onto the top of the syringe holder.
    e. Repeat these steps until 12 filters have been prepared.

16. Attach a 60 mL syringe onto the top of the filter. Allow ~ 5 mL of sample to run into a waste beaker, then filter ~ 40 mL of sample into an acid-washed 60 mL bottle for Hg analysis. Filter the rest of the sample into a second bottle. Use a new filter with each new sample.
    - Note: Only samples 1-16 are required to be preserved for mercury.

17. After all the samples have been filtered, add ~100 µL 100 ppm $HAuCl_4$ solution to each Hg sample (20 µL/10.0 mL sample, then round up to 100µL).

18. Place vessels immediately into DDW bath. Place syringes and filter heads into separate DDW bath.

19. At the end of the digestion, flush the microwave. Align the valve on the pressure gauge with the "flush" direction. Place pressure hose into the beaker of DDW. Using syringe, inject DDW 3 times into the syringe. Leave syringe full. Return valve to neutral position.

20. Remove exhaust hose from fume hood and unplug microwave.

Hewitt A.D., and Reynolds C.M. (1990). Dissolution of metals from soils and sediments with a microwave-nitric digestion technique. *Atomic Spectroscopy*. 11: 187-192.

ICP-MS Metals Analysis
Making standards and other preparatory lab work
Introduction

A typical suite of elements that are analyzed in water and digested sediments (sample preparation details given in another document) include: Sc, Mo, Cd, Se, U, Co, V, Cr, Cu, As, Pb, Sr, Ni, Ti, Zn, Ba, Al, Mg, K, Mn, Fe, Sn, P, Si and Ca. These include some of the common, important environmental elements and the first row transition metals.

Elements present in high concentrations (100s ppm), like calcium, have severe effects on the response of the instrument, causing matrix effects, especially in digested sediment samples. The calcium may increase the background concentration for some elements (e.g. 80 Se, 88Sr), or suppress the signal for other elements. Because of this, if Ca concentrations are above 5 ppm, a concentration similar to that of the samples should be added to the standards to provide a similar matrix. High concentrations of sodium will also cause significant matrix effects. Because of potential matrix effects, and to determine which elements might be of interest, a full mass scan should be preformed on representative samples before a new experiment is carried out. These concentrations can be used to matrix match the standards.

The standards made for the ICP-MS must be multi-elemental (if carrying out multi-element analysis), however, not all the elements should cover the same concentration ranges (e.g., arsenic concentrations may be in the low ppb, while iron may be in the ppm range). Therefore elements are grouped according to their concentration ranges, with each group representing a different standard curve. For example:

Final concentrations of standards in ppb.

Concentration groups:	Standard 1	Standard 2	Standard 3	Standard 4	Standard 5
Sc, Mo, Cd, Hg, Se, U, Co	0.2	0.5	1.0	5.0	10.0
V, Cr, Cu, As, Pb, Sr, Ni	0.5	1.0	10.0	50.0	100.0
Ti, Zn, Ba	1.0	5.0	50.0	200.0	500.0
Al, Mg, K, Mn, Fe	50.0	100.0	500.0	1000.0	2000.0

Concentrations of ICP-MS standards (ppb to low ppm range) are much lower than the purchased original standards (1,000 ppm). Because of this it is not possible to dilute from the original standards to the ICP-MS standards. Therefore *solutions* are made, and these solutions are used to make the *standards*. A *solution* is a lower concentration solution of all the elements in one group (e.g. a 1 ppm solution of V, Cr, Cu, As, Pb, Sr and Ni). This solution is then diluted to different extents to make the five different standards.

To obtain the greatest accuracy, the concentration range of the standards will differ for each type of sample, and therefore will likely be different for each project. The standards given in this method are merely examples of standards for the Inland Lakes project.

To choose concentration ranges for the standards it is best to first do a preliminary analysis of some samples. By looking at the minimum and maximum concentration for each of the elements, elements should be grouped into several ranges of concentration (e.g. one group may be 0.2 to 10 ppb, while another may be 500 to 2,000 ppb – see above for example groupings). Things to consider: (1) the smaller the range of concentrations the more accurate the curve is (a curve from 0.2-10 ppb will be much better for analyzing a 2 ppb solution than a curve from 0.2-100 ppb) - however – the more concentration groups of elements, the more work it is to make the standards; (2) 0.05 ppb is reaching near detection limits and/or the concentrations in the blank – this varies for each element and the clean methods used – but as a general guide, low

concentrations should not go below 0.05 ppb unless discussed with Lina; (3) The upper limit of the mass spectrometer is reached by saturating the detector, which occurs around 2000 ppb (again, this varies some with each element), so the high standard should not exceed 2000 ppb. Some elements can go much higher, but this is a good general rule.

Five standards plus a blank is the minimum number of standards that should be used. Currently, 7 to 10 standards are typical. More points allow for greater flexibility in the range of concentration in the metal without losing accuracy, and therefore it is often worth the extra work in preparing the standards. There should be more points near the low concentration end of the curve than the high (see example above). For better examples of standard curves with more than five points, see David Szymanski.

From each of these concentration groupings at least one *solution* is made. This solution contains all the elements in the group and is needed because the purchased standards are too high to dilute directly to the ppb range. The dilutions are typically done in 100 mL volumetric flasks, and the volume that can be accurately pipetted limits the size of the dilution. The solution should be transfered to a Nalgene bottle soon after it is prepared to avoid contamination from the volumetric flask. As a general rule, volumes ~<50 µL begin to be less accurate, and we cannot pipette <10 µL. Also, the larger pipettes (> 1 mL) often leave significant volume in the pipette tip and should not be used to make ICP-MS standards. Because of these constraints, it is sometimes necessary to use two solutions for one group of elements (e.g., 1 ppm and 100 ppb) either because the low concentration is too low to reach in two dilutions (e.g., 0.05 ppb), or the range of concentrations is too great (e.g., 1-500 ppb).

Nitric acid is added to each standard to both prevent precipitation and to create a similar matrix to the sample. Nitric acid will enhance the ionization of different elements; therefore the concentration of nitric acid in the standards should be as close as possible to the concentration in the sample.

Samples in the ICP-MS vial include 1 mL of internal standard – a 20 ppb solution of indium and bismuth (indium is used for low mass elements, and bismuth for higher mass elements) in HNO_3 and 1 mL of sample.

Digested sediments are run at a dilution of 1:10 (not including the internal standard dilution) so that most elements do not saturate the detector (e.g., 1 mL internal standard + 900 µL 2% nitric acid + 100 µL sample). Additionally, the matrix effects may be too significant for concentrated digested sediment samples. Water samples can often be run without dilution.

Three rinses of 2% nitric acid are run before and after each set of standards. For some elements, the high standard may contaminate the next sample if the sample has a low concentration. Rinses are used to eliminate this possibility. It is a good idea to check for samples that have high concentrations of some elements to make sure that the next sample is not contaminated.

The ICP-MS should be conditioned to the type of sample before the run (e.g., digested sediments have a very different matrix than the solutions used to tune the machine). A vial should be prepared with 3 times the normal volume of a sample (including internal standard) to use as the conditioning solution (e.g., 3 mL internal std, 3 mL sample).

Concentrations are determined by the standards run before and after each group of ~ 30 samples. Therefore the run should be organized as follows: standards, 3 rinses, ~30 samples, 3 rinses, another set of standards, 3 rinses, ~30 samples, 3 rinses, standards. Typically runs have up to ~60 samples, though longer runs can be done.

ICP-MS Analytical Procedure

1. Prepare solutions for standards:
   a. Add 2% nitric acid and appropriate volumes of 1,000 ppm standards to 100 mL volumetric flasks. For example:

      Solution A: 1 ppm – Sc, Mo, Cd, Hg, Se, Co, U (100 µL of each in 100 mL)

      Solution A2: 100 ppb – Solution A (10 mL:100 mL)

      Solution B: 1 ppm – V, Cr, Cu, As, Pb, Sr, Ni (100 µL of each in 100 mL)

      Solution C: 10 ppm – Ti, Zn, Ba (1000 µL of each in 100 mL)

      Solution C2: 100 ppb – solution C (1000 µL: 100 mL)

      Solution D: 50 ppm – Al, Mg, K, Mn, Fe, Ca if appropriate (5000 µL: 100 mL)

2. Prepare standards from solutions:
   a. Add 2% nitric acid, appropriate amount of ultra pure nitric acid, appropriate matrix match, and appropriate amounts of each solution to the standards. A blank should be prepared with water, matrix match, and acid. The concentration of nitric acid in the standard should be as close as possible to the concentration in the sample (or the diluted sample if a dilution is used). Matrix match includes any very high concentration elements, often Ca, Na, Mg or other elements. These elements should be added to the standards in concentrations similar to what is found in the samples. If relatively high concentration elements are being analyzed for (e.g., ~10 ppm) and are already in the standards, this in itself helps matrix match. But if only one element is being analyzed for, it may be necessary to add more elements to matrix match (e.g.. not just Ca, but perhaps also Mg, K, Al and Fe).

Amount of solution to add to each standard in µL.

Component	Standard 1	Standard 2	Standard 3	Standard 4	Standard 5
Solution A	---	---	---	500	1,000
Solution A2	200	500	1,000	---	---
Solution B	50	100	1,000	5,000	10,000
Solution C	---	---	500	2,000	5,000
Solution C2	1,000	5,000	---	---	---
Solution D	100	200	1,000	2,000	4,000

Final concentrations of standards in ppb

Component / conc ppb	Standard 1	Standard 2	Standard 3	Standard 4	Standard 5
Sc, Mo, Cd, Hg, Se, U, Co	0.2	0.5	1.0	5.0	10.0
V, Cr, Cu, As, Pb, Sr, Ni	0.5	1.0	10.0	50.0	100.0
Ti, Zn, Ba	1.0	5.0	50.0	200.0	500.0
Al, Mg, K, Mn, Fe	50.0	100.0	500.0	1000.0	2000.0

3. Standards may be stored in acid-washed Nalgene bottles, and should be refrigerated to prevent evaporation. Do NOT store ANY solution in volumetric flasks or any glass container.
4. Prepare internal standard (20 ppb In, Bi in 2% nitric acid): (there is a 1 L bottle of this in the hood. Make more when necessary.)
   a. Dilute 1000 µL of 1,000 ppm standard In and Bi to 100 mL in a volumetric flask to make a 10 ppm solution of In and Bi
   b. Dilute 2000 µL of 10 ppm solution and ~28.5 mL nitric acid to 1000 mL in a 1000 mL volumetric flask to make internal standard (20 ppb In and Bi, 2% nitric acid). (Concentrated nitric is 70%).
5. All ICP-MS vials should be taped with less than one full rotation at the very top of the vial (if there is excess tape it is harder to get the vials into the auto sampler).
6. Pipette samples:
   a. For standards: pipette 1 mL of internal standard and 1 mL of standard
   b. For samples: pipette 1 mL of internal standard and a total of 1 mL of straight or diluted sample (e.g. 100 µL sample + 900 µL water for a 1:10 dilution).
   c. For rinses: pipette 2 mL of 2% HNO_3.
   d. For SRMs: pipette 1 mL internal standard and 1 mL of aqueous SRM (1643e). Liquid SRMs should be run even if digested SRMs are run. The SRMs are used for quality

control. The digested SRMs do not represent total digestions and it is harder to compare obtained values with known concentrations.

7. Prepare a conditioning solution:
   a. To an ICP-MS vial add 3 mL of internal standard and 3 mL of appropriately diluted sample (if samples are not diluted, add 3 mL of sample: if a 1:10 dilution is used, add 30 µL of sample and 270 µL of water)
8. Organize samples in the test tube holder:
   a. one set of blank and standards
   b. 3 rinses
   c. ~ 30 sample
   d. 3 rinses
   e. blank and standards, etc.
   f. Conditioning solution may be set aside on the rack
9. List down a column in Excel the labels of all the samples (including standards) in order. This is cut and pasted into the ICP-MS software to provide the labels on the data that is returned. This file should be e-mailed to Lina (patinol@msu.edu) or given to her on a Zip disk. Also send or give Lina a chart of the standards used.
10. When the data are returned, there may be columns for area, response, concentration and flags. The area is the actual counts by the mass spec, the response is the area normalized to the internal standard, and the concentration is in ppb. The flags apply only to the standards. Each standard curve is examined, and if any points are anomalous, they are not considered in the calculation of the concentrations. Standards that are not used are flagged.
11. Check for samples that saturated the detector (therefore concentrations are not valid):
    a. Select the entire "area" column in Excel and format for scientific notation.
    b. Any sample with an area $x10^8$ has saturated the detector and the concentration is not valid.
12. Graph the indium areas (indium area as y, arbitrary sample number as x). Indium should remain relatively constant throughout the run. Rinses will have much lower concentrations because they have no internal standard, these samples can be ignored.

Mercury Analysis

Mercury analysis is performed on the Lumex RA-915+ Zeeman Corrected Atomic Absorption (AA) analyzer with the Thermal Decomposition (TD) R-91C attachment. This allows for the analysis of mercury in freeze-dried sediment rather than liquid analysis. Precautions should be taken to perform this analysis in as clean an environment as possible to avoid contamination of samples.

Instrument calibration may take place by employing one of two methods 1) using Standard Reference Materials (SRM) that span the range of the samples needed to be analyzed or 2) a single SRM varying the mass to contain the range of the samples. The second method is preferred. Multiple SRM's are available for calibration. SRM1515 Apple Leaves has shown to be a useful reagent in that it spans the range of most inland lake sediment mercury concentrations encountered thus far. However, it may be necessary to use SRMs with higher mercury concentrations to calibrate peak mercury values.

Instrument Start-up

The instrument must be powered on including the oven, instrument and air pump a minimum of two hours prior to the start of analysis. The lamp must be lit approximately one half hour prior to analysis.

Sample Boat Cleaning

Prior to sample analysis and after individual sample runs the sample boats require a methanol cleaning.

1. In a 250-mL beaker pour 200-mL of fresh methanol.
2. Rinse sample boat in methanol.
3. Shake off excess methanol and wipe down with a fresh kimwipe.
4. Place the sample boat in the TD oven for at least 90 seconds.
5. Remove the sample boat from the TD oven and allow to cool to room temperature.
6. Proceed with sample analysis.

Baseline Determination

Baseline should be determined prior to the start of analysis and periodically during the run. It is convenient to baseline the instrument every ten samples, but if noticeable drift is occurring it may be more appropriate at more frequent intervals.

Calibration (Single SRM Method)

Calibrations must be run prior to and following sample analysis. Calibrations should be performed to enclose the anticipated range of sample concentrations.

1. Using a clean sample boat, tare the sample boat using a four decimal point balance.
2. Remove the boat from the balance and add the appropriate amount of SRM.
3. Replace the boat onto the tared balance; record the sample mass to four decimal places in the lab notebook.
4. Press start on the integration window inside the Lumex software.
5. Place the sample boat into the TD oven and close the sample door.
6. Observe the output on the computer screen; be careful to catch the end of the sample peak. Zoom levels may be adjusted inside the output screen.
7. Once the peak has terminated, press end on the integration window inside the Lumex software.
8. While in the **EDIT MODE**: Enter the sample name; the identical name should be placed in the lab notebook, into the data entry window.
9. Repeat to achieve a minimum of five calibration points. Let the instrument stabilize for 60 seconds between analyses.
10. Once all the calibration points have been recorded run a blank using a clean sample boat. Blank runs should be no less than 90 seconds.

11. While in the **SELECT MODE**: To create the calibration curve, highlight the five or more calibration points and depress the calibration icon in the data entry window.
12. Create an excel spreadsheet file from the calibration information and determine the correlation coefficient; this should be no less than 0.99. If the correlation coefficient is below 0.99 the calibration must be rerun. Once an acceptable correlation coefficient is achieved save the calibration in the Lumex software.

Sample Analysis

- Samples that extend beyond the range of the calibration curve must be rerun at a lower mass until the integration area falls within the calibration range.
- After every ten samples a blank and an SRM must be run. If the SRM does not fall within the accepted limits the instrument must be recalibrated and the previous ten samples must be rerun.
- Wait a minimum of 60 seconds between sample analyses.
- Save the data file after every tenth analysis.

1. Using a clean sample boat, tare the sample boat using a four decimal point balance.
2. Remove the boat from the balance and add the appropriate amount of SRM.
3. Replace the boat onto the tared balance; record the sample mass to four decimal places.
4. Press start on the integration window inside the Lumex software.
5. Place the sample boat into the TD oven and close the sample door.
6. Observe the output on the computer screen; be careful to catch the end of the sample peak.
7. Once the peak has terminated, press end on the integration window inside the Lumex software.
8. While in the **EDIT MODE**: Enter the sample name and mass in the data entry window.
9. Record the sample name and mass in the lab notebook.
10. While in the **SELECT MODE**: To calculate the concentration of mercury; highlight the sample (or by holding down the ctrl key multiple samples) and press calculate.

Organics analysis

Quality control measures in the analysis of organic contaminants include the use of a standard reference material, matrix spike, matrix spike duplicates, surrogate standards and reagent blanks. Calibration of the instrument will be checked periodically using calibration standards.

Standard reference material (SRM)

SRM is used to assess accuracy because it has "certified" concentrations of the analytes of interest, as determined through replicate analysis by a reputable certifying agency using two independent techniques for verification.

<u>Precision criteria:</u> Laboratory maintains control charts for use by analysts in monitoring the overall precision of the SRM analyses. Upper and lower control chart limits (e.g., control limits and warning limits) should be updated at regular intervals; control limits based on 3 standard deviations of the mean generally are recommended. Following the analysis of all samples, an

RSD (relative standard deviation, or coefficient of variation) will be calculated for each analyte of interest in the SRM. For each analyte having an SRM concentration ≥ 10 times the laboratory's MDL, an overall RDS > 30% will be considered acceptable precision. Failure to meet this goal will result in a thorough review of the laboratory's control charting procedures and analytical methodology to determine if improvements in precisions are possible.

Accuracy criteria: The "absolute" accuracy of an analytical method can be assessed using SRM only when certified values are provided for the analysis of interest. The laboratory values should be within ± 30% of the true value on average for each combined group of organic compounds, and the laboratory's value should be within ± 35% of either the upper and lower 95% confidence limit for at least 70% of the individual compound in each group

Continuing Calibration Checks

The initial instrument calibration performed prior to the analysis of each batch of samples is checked through the analysis of calibration check samples (i.e., calibration standard solutions) inserted as a part of the sample stream. Calibration standard solutions used for the continuing calibration check should contain all analytes of interest. If the control limit for analysis of the calibration check standard is not met, the initial calibration will have to be repeated. If possible, the samples analyzed before the calibration check sample that failed the control limit criteria should be reanalyzed following the recalibration. The laboratory should begin by reanalyzing the last sample analyzed before the calibration standard which failed. If the relative percent difference (RPD) between the results of this reanalysis and the original analysis exceeds 30%, the instrument is assumed to have been out of control during the original analysis. If possible, reanalysis of samples should progress in reverse order until it is determined that there is less than 30 RPD between initial and reanalysis results. Only the reanalysis results should be reported by the laboratory.

Internal Standards

Internal standards (commonly referred to as "surrogates," or "surrogate spikes") are compounds chosen to simulate the analytes of interest in organic analyses. The internal standards represent a reference analyte against which the signal from the analytes of interest is compared directly for the purpose of quantification. Internal standards must be added to each sample including QA/QC samples prior to extraction. The reported concentration of each analyte should be adjusted to correct for the recovery of the internal standard, as is done in the NOAA National Status and Trends Program. The internal standard recovery data therefore should be carefully monitored; the percent recovery of the internal standards is reported along with the target analytes data for each sample.

Matrix Spike and Matrix Spike Duplicates

A laboratory-fortified sample matrix (commonly called a matrix spike, or MS) and a laboratory-fortified sample matrix duplicate (commonly called a matrix spike duplicate, or MSD) will be used both to evaluate the effect of the sample matrix on the recovery of the compounds of interest and to provide an estimate of analytical precision. A minimum of 5% of the total number of samples submitted to the laboratory in a given year should be selected at random for analysis as matrix spike/matrix spike duplicates. Each MS/MSD sample is first homogenized and then

split into three subsamples. Two of these subsamples are fortified with the matrix spike solution and the third subsample is analyzed as is to provide a background concentration for each analyte of interest. The matrix spike solution should contain all the analytes of interest. The final spiked concentration of each analyte in the sample should be at least 10 times that of the MDL for that analyte, as previously calculated by the laboratory.

Recovery data for the fortified compounds ultimately will provide a basis for determining the prevalence of matrix effects in the sediment samples analyzed during the project. If the percent recovery for any analyte in the MS or MSD is less than the recommended warning limit of 50%, the chromatograms and raw data quantification reports should be reviewed. If an explanation for a low percent recovery value is not discovered, the instrument response may be checked using a calibration standard. Low matrix spike recoveries may be result of matrix interferences and further instrument response checks may not be warranted, especially if the low recovery occurs in both MS and MSD and the other QC samples in the batch indicate that the analysis was "in control." An explanation for low percent recovery values for MS/MSD results should be discussed in a cover letter accompanying the data package. Corrective actions taken and verification of acceptable instrument response must be included.
Analysis of the MS/MSD also is useful for assessing laboratory precision. The relative percent difference (RPD) between the MS and MSD results should be less than 30 for each analyte of interest.
The RPD is calculated as follows:

$$RPD = (C1 - C2)/(C1 + C2) \times 100$$

where: C1 is the larger of the duplicate results for a given analyte
C2 is the smaller of the duplicate results for a given analyte

If results for any analytes do not meet the RPD ≤ 30% control limit criteria, calculations and instruments should be checked. A repeat analysis may be required to confirm the results. Results which repeatedly fail to meet the control limit criteria indicate poor laboratory precision. In this case, the laboratory is obligated to halt the analysis of samples and eliminate the source of the imprecision before proceeding.

Task 4: Statistical data analysis/review

Results from Tasks 1-3 shall be subject to QA/QC using rigorous statistical methodology including process control and stochastic watershed modeling. The purpose of process control is to identify processes that have become out of statistically defined control limits so that measures can be taken to correct possible malfunctions in analytical equipment or laboratory methodology. Process control methodology applied to these data includes but are not limited to calculation of process control limits, descriptive statistics, analytical quantification limits, and instrument detection limits. Stochastic watershed modeling has been investigated by the project team to help identify how change in land use/land cover over time, defined by GIS delineated watershed attributes, affects the anthropogenic accumulation of contaminants in lakes.

Process control

Descriptive Statistics

The definitions and equations described below shall be utilized in the examination of error in both mercury and major and trace element analysis. Equations presented below were found in Skoog and Leary (Skoog and Leary, 1992). Absolute error, E_a, is defined as the deviation of the sample mean, $\bar{x}$ from the known analyte value, x_t,

$$E_a = \bar{x} - x_t \tag{1}$$

where the right hand side of the equation includes both random and systematic components. Random error, E_r, for a small set of data can be estimated using:

$$E_r = \bar{x} - \mu \tag{2}$$

where μ is the population mean. In general the population mean is determined, and assumed to be free of random error, by replicating the measurement 20 to 30 times and is calculated by:

$$\mu = \lim_{N \to \infty} \frac{\sum_{i=1}^{N} x_i}{N} \tag{3}$$

where x_i is the value for the ith measurement and N is the number of measurements. The standard deviation, σ, of the population is calculated as follows:

$$\sigma = \sqrt{\lim_{N \to \infty} \frac{\sum_{i=1}^{N} (x_i - \mu)^2}{N}}. \tag{4}$$

The standard deviation of a set of samples differs from the population standard deviation by replacing σ with s, μ with $\bar{x}$, and N by N-1:

$$s = \sqrt{\frac{\sum_{i=1}^{N} (x_i - \bar{x})^2}{N-1}} \tag{5}$$

The arithmetic mean, $\bar{x}$, will be used for sample means. The value of the population and sample mean may differ. The sample mean usually represents a subset of the population or a smaller set of measurements intended for comparison to the population. Standard errors shall also be calculated to demonstrate the fluctuation in the standard deviation based upon the number of samples:

$$s_m = \frac{s}{\sqrt{N}}. \tag{6}$$

The coefficient of variation, *CV*,

$$CV = \frac{s}{\bar{x}} \times 100\% \tag{7}$$

provides information on the magnitude of the standard deviation as a percentage of the mean and is generally more useful than the standard deviation alone.

Table 3 shows an example of descriptive statistics, of in-run SRMs, broken down by lake for mercury analysis. SRM is the NIST standard reference material used for the lake; the noted

value of mercury in SRM 1515 is 44 ± 4 ng/g. These results demonstrate both the precision and accuracy of the project team methods.

Table 3. Descriptive Sample Statistics

Lake	SRM	N	df	Average (ng/g)	Std. dev (ng/g)	CV (%)	s_m
Gull	1515	3	2	47.0	1.66	3.54	0.96
Higgins	1515	11	10	43.5	1.86	4.29	0.56
Cass	1515	4	3	43.3	1.50	3.47	0.75
Crystal-M	1515	5	4	44.0	1.87	4.25	0.84
Littlefield	1515	9	8	46.6	2.55	5.49	0.85
Cadillac	1515	5	4	43.2	2.05	4.74	0.92
Crystal-B	1515	5	4	43.6	1.67	3.84	0.75
Hubbard	1515	5	4	43.8	1.30	2.98	0.58
Mullett	1515	6	5	44.3	1.75	3.95	0.71
Whitmore	1515	6	5	43.5	2.17	4.98	0.89
Imp	1515	7	6	42.4	1.62	3.81	0.61
Paw Paw	1515	7	6	43.0	2.08	4.84	0.79
Torch	1515	6	5	42.3	0.82	1.93	0.33
Witch	1515	6	5	44.3	2.07	4.66	0.84

Detection Limits

The quantification limit of an analytical method, determined here as the minimum distinguishable signal, S_m, is a function of average signal of the blank, $\bar{S}_{bl}$, and a multiple, k, of the blank signal, s_{bl}

$$S_m = \bar{S}_{bl} + ks_{bl}. \tag{8}$$

Where blank data are available totaling a minimum of 20 to 30 measurements Equation 9 will result in the detection limit, c_m, as

$$c_m = \frac{S_m - \bar{S}_{bl}}{m}, \tag{9}$$

where m is the slope of the calibration line at the concentration of interest.

Detection limits for mercury analysis, given in Table 4, were calculated using Equations 8 and 9 using the average blank signal obtained during sample runs. Slope was determined from plots of mass Hg vs. Area of standard reference material ran every tenth sample in accordance with EPA Method 7473, where the mass of Hg is the mass, in picograms, of the calibration standard and Area is the integrated area of instrument response. In Equation 8, k was assigned a value of three. Detection limit concentrations are calculated using the population average. Detection limits will vary based upon the mass of sample analyzed and three different detection limits have been defined here for illustration.

Table 4. SRM 1515 LOD

	Mass Hg (pg)	Hg (fmoles)	
Mean	141.8	706.9	
Standard Deviation	20.3	101.2	
	250 mg	125 mg	10 mg
Detection Limit (ng/g)	0.687	1.37	17.2

Quantification Limits

Linear regressions on calibration standard concentration vs. instrument response using SYSTAT10's linear regression module were calculated to determine the quantification limit for major and trace element data (SPSS, 2000). Results of the regression including: y-intercept, slope, and the standard error of the estimate were used to calculate the quantification limit. Table 5 lists the quantification limits of major elements from Avalon and Birch lakes sampled in 2003.

Table 5. Quantification limits for major elements

Lake	Regression	Slope	Intercept	N	Sy/x	yLOD	xLOD (ppb)	Element
Avalon	0.9998	0.0184	-0.0214	26	0.1920	0.5547	31.4	Mg
	0.9986	0.0297	0.0676	24	0.5472	1.7091	55.3	Al
	0.9988	0.0417	4.6025	16	0.5695	6.3112	41.0	K
	0.9996	0.0012	0.0310	32	0.1589	0.5078	404.1	Ca
	0.9994	0.0526	-0.0233	21	0.3261	0.9550	18.6	Mn
	0.9998	0.0024	0.1883	31	0.2375	0.9009	298.2	Fe
Birch	0.9996	0.0128	0.0044	30	0.5888	1.7708	137.9	Mg
	1.0000	0.0153	0.1007	29	0.2121	0.7370	41.6	Al
	0.9999	0.0315	2.7129	17	0.2893	3.5808	27.6	K
	0.9995	0.0011	-0.0301	26	0.1919	0.5456	523.4	Ca
	0.9993	0.0635	-0.1462	24	0.7960	2.2419	37.6	Mn
	0.9993	0.0030	0.0472	27	0.1735	0.5678	175.9	Fe

Statistical Process Control

The project team will visually inspect and use statistical box plots to extract data outliers. If outliers are found in the data, samples will be rerun to determine statistical validity of the previous analysis. If the sample concentration still results in an outlier, statistical evidence of validity will be supplied. In addition, standard reference materials, analyzed during ICP-MS and mercury runs, shall be used to create process control sheets to evaluate method control.

Stochastic watershed modeling

Stochastic watershed modeling, defined here, is the statistical modeling of the impacts of watershed attributes and their impact on anthropogenic accumulation of contaminants. This type of analysis can be helpful in identifying possible sources of contaminants to inland lakes. The

following example demonstrates the project team's capabilities in correlating watershed attributes such as population density, land use, and atmospheric deposition to anthropogenic accumulation of contaminants; this section was taken from the 2002-2003 final report (Yohn *et al.*, 2003).

Focusing corrected anthropogenic accumulation rates were compared to watershed characteristics for two time periods, 1970-1980 (1975) and 1990-2000 (1995). This comparison was performed to help determine possible influences on metal inputs to inland lakes throughout Michigan. The watershed characteristics examined include population density, %land cover, atmospheric deposition of sulfate, erodibility of the watershed, lake size, watershed size, and watershed:lake area ratio. None of these watershed characteristics portray one particular source, but rather represent a variety of sources and processes that may influence metal inputs to a lake. The sources and processes that each watershed characteristic represents are described below.

Population density within the watershed represents many different human sources, including releases from wear of automobile parts (Rice, 1999), car emissions (Callender and vanMetre, 1997, Rice, 1999), zinc from road dust and vehicle exhaust (Shahin *et al.*, 2000), wastewater (Callender and Rice, 2000), and household and yard waste (Callender and Rice, 2000). Metals from these sources may enter the lake through direct overland flow from the watershed to the lake, from stream or sewer input, or from local atmospheric input and deposition (e.g., vehicle exhaust). Previous studies have found some correlation between the sum of copper, lead, mercury, and zinc concentrations in stream sediments and population density (Rice, 1999), and that population density strongly correlates to traffic density and is a predictor of Pb and Zn concentrations in the environment derived from anthropogenic activities (Callender and Rice, 2000).

Land use and land cover within a watershed have the potential to significantly influence metal inputs to a lake (Cohen *et al.*, 2004). Metals such as cadmium, chromium, copper, lead, mercury, nickel and zinc have been found to occur at higher levels in urban areas than rural areas in stream sediments (Rice, 1999), reservoir sediments (Callender and vanMetre, 1997), and soils (Parker et al., 1978). Agricultural land use may also contribute not only increased nutrient inputs to the environment, but also increased metal inputs such as arsenic, copper, mercury, lead, selenium and zinc from pesticides and fertilizers (Rice, 1999).

The importance of atmospheric deposition of metals to freshwater systems has been well documented (e.g., Callender and vanMetre, 1997, Gatz, 1975, e.g., Hillery *et al.*, 1998, Winchester and Nifong, 1971). However, while some studies have been done in the Great Lakes region, accurate metal deposition rates throughout Michigan are not well defined. It is likely that there is a spatial gradient of atmospheric deposition in Michigan, with the highest rates occurring near and downwind of major urban and industrial centers, such as Chicago, IL, Gary, IN, and Detroit, MI. Because sufficient data for metal deposition were not available, sulfate deposition data were used instead. Sulfate is released into the atmosphere as a result of the burning of fossil fuels, and deposition of sulfate is monitored as part of the National Atmospheric Deposition Program (NADP) (NADP, 2003). The burning of fossil fuels is a source of metals to the environment (Goodarzi *et al.*, 2001, Rice, 1999, Simonetti *et al.*, 2000, Souch *et al.*, 2003, Winchester and Nifong, 1971), and sulfate deposition may represent deposition of metals from this source. Sulfate deposition will not represent deposition of specific metals from sources such

as copper smelters. Wet deposition of sulfate has previously been found to correlate with lead and cadmium deposition (Gatz, 1975).

Many of the above described inputs of metals to lakes rely on erosion of soils containing contaminants and subsequent transport to the lake. Sources relating to land cover, such as application of pesticides and fertilizer to agricultural land, are not input directly to the lake, but to the land, and must be transported to the lake to act as a source. Additionally, atmospheric deposition occurs not only directly to the lake, but also to soils within the watershed, which may then be transported to the lake (Callender and vanMetre, 1997, Sanudo-Wilhelmy and Gill, 1999). Because of this, it may be necessary to represent not only possible sources of metals within the lake, but also the pathways in which those metals reach the lake. Therefore, the susceptibility of each watershed to erosion was calculated using the average K factor and slope of soils within the watershed. The K factor is the "relative index of susceptibility of bare, uncultivated soil to particle detachment and transport by rainfall," (United States Division of Soil Survey, 1993). This value is standardized to a slope of 9%. Because slope does influence erosion, the K factor was adjusted to include the influence of slope.

Several characteristics of the lake and watershed were also included into the data analysis, including lake size, watershed size, and watershed:lake area ratio. The lake size should not influence the focusing corrected anthropogenic accumulation rates, but this variable was included to test this hypothesis. The size of the watershed and watershed:lake area ratio may provide information about transport of contaminants.

Data collection and analysis methods

Spatial data were collected from secondary sources, and were in, or were projected into the Michigan GEOREF coordinate system: oblique Mercator projection, datum NAD83, spheroid GRS 1980. Sources for data included the United States Geological Survey, Michigan Maps and Information (TIGER base data), and Michigan Department of Natural Resource's spatial data library. The digital elevation models (DEMs) used to delineate watersheds were obtained from the Shuttle Radar Topography Mission (SRTM) dataset (National Aeronautics and Space Administration, 2002) with 30 m grid cells and $\leq$ 16 m absolute vertical height accuracy.

Watersheds were delineated around each of the eighteen lakes of interest (Yohn, 2003) using Arc/INFO. In further analyses, the lake is not considered part of the watershed. Cass and Whitmore Lake watersheds were defined using 90 m SRTM data because 30 m data were not available for this region of the state. If the watershed of a lake contained another lake (e.g., Mullett Lake watershed contains Burt Lake), the watershed of the second lake was removed from the watershed of the study lake. Lakes are effective sediment traps (Wetzel, 2001), and outflow from a lake is likely to have very low concentrations of metals. Therefore, it is likely that the watershed of a lake within the watershed of a study lake is unlikely to significantly contribute metals to the study lake.

Census data at the census tract scale were used for population density calculations. Population data from one data set was used for population density calculations from 1870-1990, and a separate data set was used for 2000 (Michigan Center for Geographic Information, 2002). Because of this, census tracts are different for 2000, and some population densities changed significantly from 1990 to 2000 due to this. Watersheds generally only encompassed a portion

of each census tract; therefore, to determine population densities within the watershed, it was essential to estimate as accurately as possible where people were living within the township. Thus, dasymetric mapping was used to estimate population distribution. Areas that are state owned (Michigan Department of Natural Resources, 2000) or areas covered by lakes (Michigan Department of Natural Resources, 1992) were considered as non-livable areas. It was assumed that the population was evenly distributed throughout the remaining livable area within each census tract. The preference of people to live near a lake (Stewart, 1994) was not accounted for, causing a possible underestimation of population densities within watersheds. Additionally, no attempt was made to account for seasonal increases in population, which may be significant around some lakes. Census data from 1970 and 1980 were averaged to represent the 1975 time period, and data from 1990 and 2000 were averaged to represent the 1995 time period. The number of people within the watershed was divided by the area of the watershed (not including the lake area) to determine the population density of the watershed (people/km^2).

Land use/cover data were collected for 1978 (Michigan Department of Natural Resources, 1999) and 1997-2001 (MIchigan Department of Natural Resources, 2003). Land cover groupings were different for the two time periods, therefore the Level 1, or coarsest, land cover groupings were used so that the two time periods could be compared, Table 6. The Level 1 land cover groupings were generally comparable between time periods, with the exception of the forested and wetland land covers. The 1978 dataset includes lowland forest in the forested land cover, whereas the 1997-2001 dataset includes lowland forest in the wetlands land cover, and categorizes upland forest separately. The 1997-2001 dataset was modified to include lowland forest into a new forest category (instead of upland forest), thus making the two time periods more comparable. Percentage land covers were calculated for each watershed (not including the lake) for each of the two time periods.

Table 6. Level 1 land cover groupings from two time periods. The 1997-2001 dataset was modified to correspond better to the 1978 dataset by moving the lowland forest land cover from the wetlands category to the forest category.

1978	1997-2001
Urban	Urban
Agriculture	Agriculture
Rangeland	Upland openland
Forested	Forest = upland forest + lowland forest
Water	Water
Wetland	Wetland (not including lowland forest)
Barren	Bare/sparsely vegetated

Sulfate deposition data (kg/ha/y) were collected for 10 sites from Michigan, Wisconsin and Illinois from the National Acid Deposition Program database (NADP, 2003). Data were collected from all available years from each site, but final data are from 1990-2000. Very few stations collected data from 1970-1980, making it difficult to estimate sulfate deposition values for this time period. However, the patterns of sulfate deposition appear to remain the same within the state over time, therefore the 1990-2000 data were also used to represent the spatial gradient of atmospheric deposition from 1970-1980. Inverse distance weighting was used to estimate sulfate deposition values for each watershed.

K factors to estimate soil erodibility were calculated from the State Soil Geographic (STATSGO) database (U.S. Department of Agriculture, 1994). Area weighted averages were used to determine the average slope and K factor for each watershed. The K factor is standardized to a 9% slope. To create a variable that included both slope and the K factor, the K factor was multiplied by the slope divided by 9%. For slopes greater than 9%, the K factor increases when slope is included, indicating higher erosion potential. Slopes less than 9% would result in a lower K factor, and a lower erosion potential. Unfortunately, the STATSGO database defines very broad groupings of soils for large spatial areas, and may not be detailed enough for this analysis.

All of these watershed characteristics were then compared to focusing corrected anthropogenic accumulation rates. Witch Lake was not included in the analyses because of difficulties in calculating anthropogenic inputs, and the influence of local mining activities. A high correlation between accumulation rates of a metal (e.g., cadmium) and a watershed characteristic (e.g., percent agricultural land use within the watershed) suggests that the characteristic is somehow related to a source or process influencing that metal. This may provide insight into the important sources and processes influencing metal inputs to inland lakes throughout Michigan.

Stochastic watershed modeling results

Population densities were much higher for the Cass Lake watershed than any other watershed, Figure 13. Population densities for Witch, Paw Paw, and Cadillac Lake watersheds were also

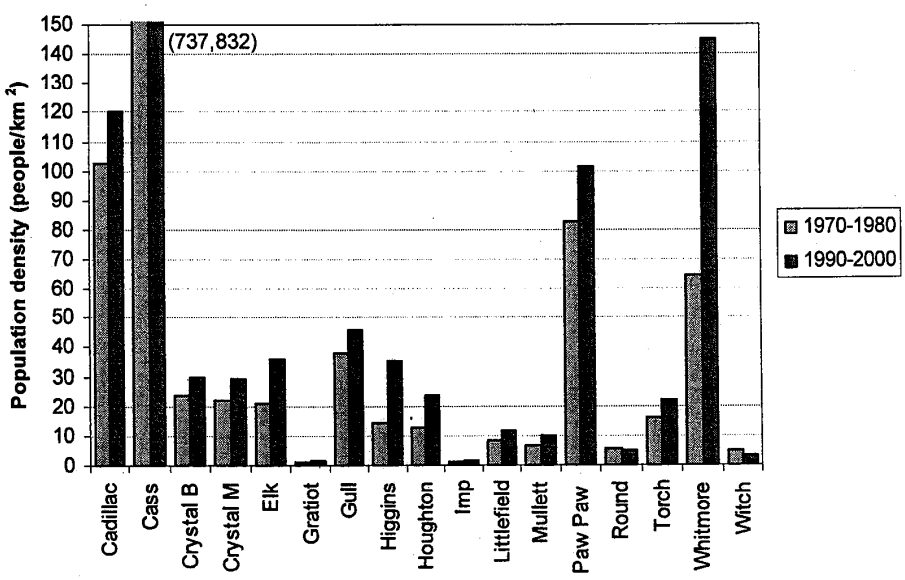


Figure 13. Population densities (people/km2) for the watersheds of the 17 Michigan study lakes.

high. The much higher population density in 1995 than 1975 in Whitmore Lake watershed is probably partly due to differences in census tracts between the two time periods. The Upper Peninsula lakes (Gratiot, Imp, Round and Witch) have the lowest watershed population densities.

The proportion of land uses within each watershed varied greatly among lakes and over time, Figure 14 and Figure 15. There are also significant changes in land cover seen over time. Unfortunately, changes over time may reflect differences in the datasets more than actual land cover changes. The resolution of the 1975 dataset is much coarser than that of the 1995 dataset, Figure 14. As a result, where large areas may be grouped as one land cover in 1975 (e.g., urban in Cass Lake watershed), these areas are divided into several land covers in 1995 Figure 15. Because of this, it will be difficult to compare land cover data over time.

None of the watersheds had a significant percentage of the land use as water or barren barely/sparsely vegetated, therefore, these land covers were not included in further analysis (Fig. 68). The watershed around Cass Lake has the highest percentage of urban land cover, while Gull, Paw Paw, Cadillac, and Crystal M watersheds have the highest proportions of agricultural land cover. Many lakes have high percentages of forested land cover within their watersheds, including all of the Upper Peninsula lakes.

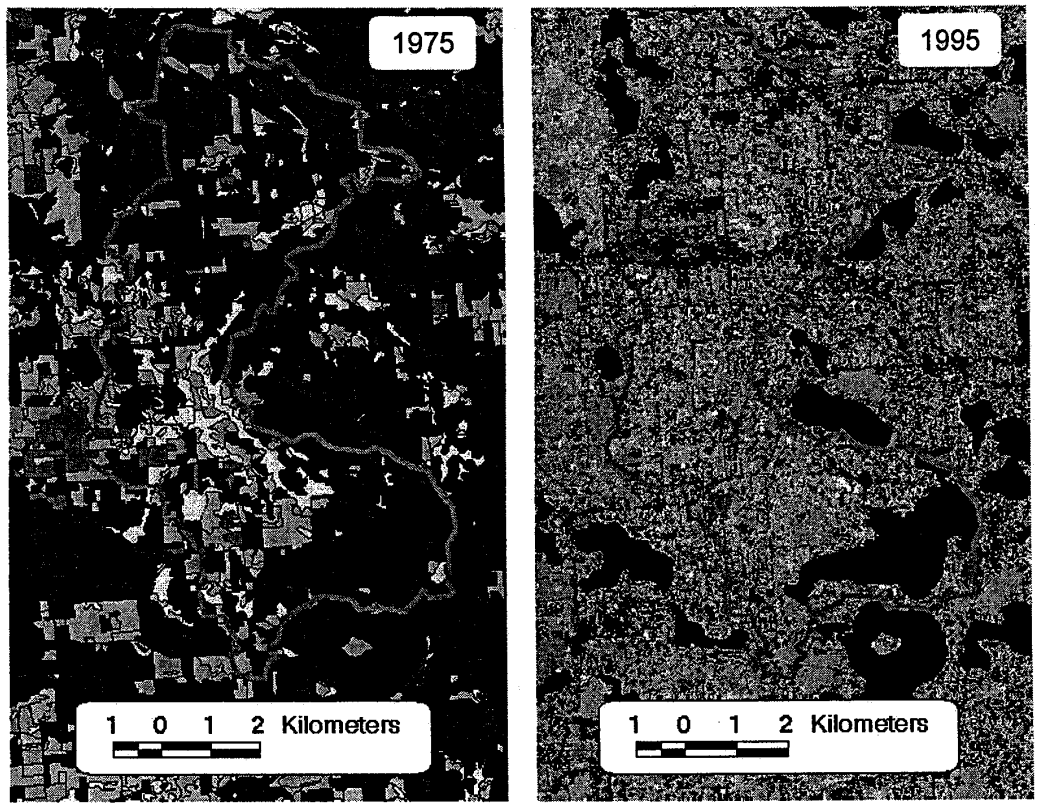


Figure 14. Urban land cover in the Cass Lake watershed in 1975 and 1995. Urban land cover is in red, and water is in blue. Land covers of the other colors vary between years. The watershed is outlined in green.

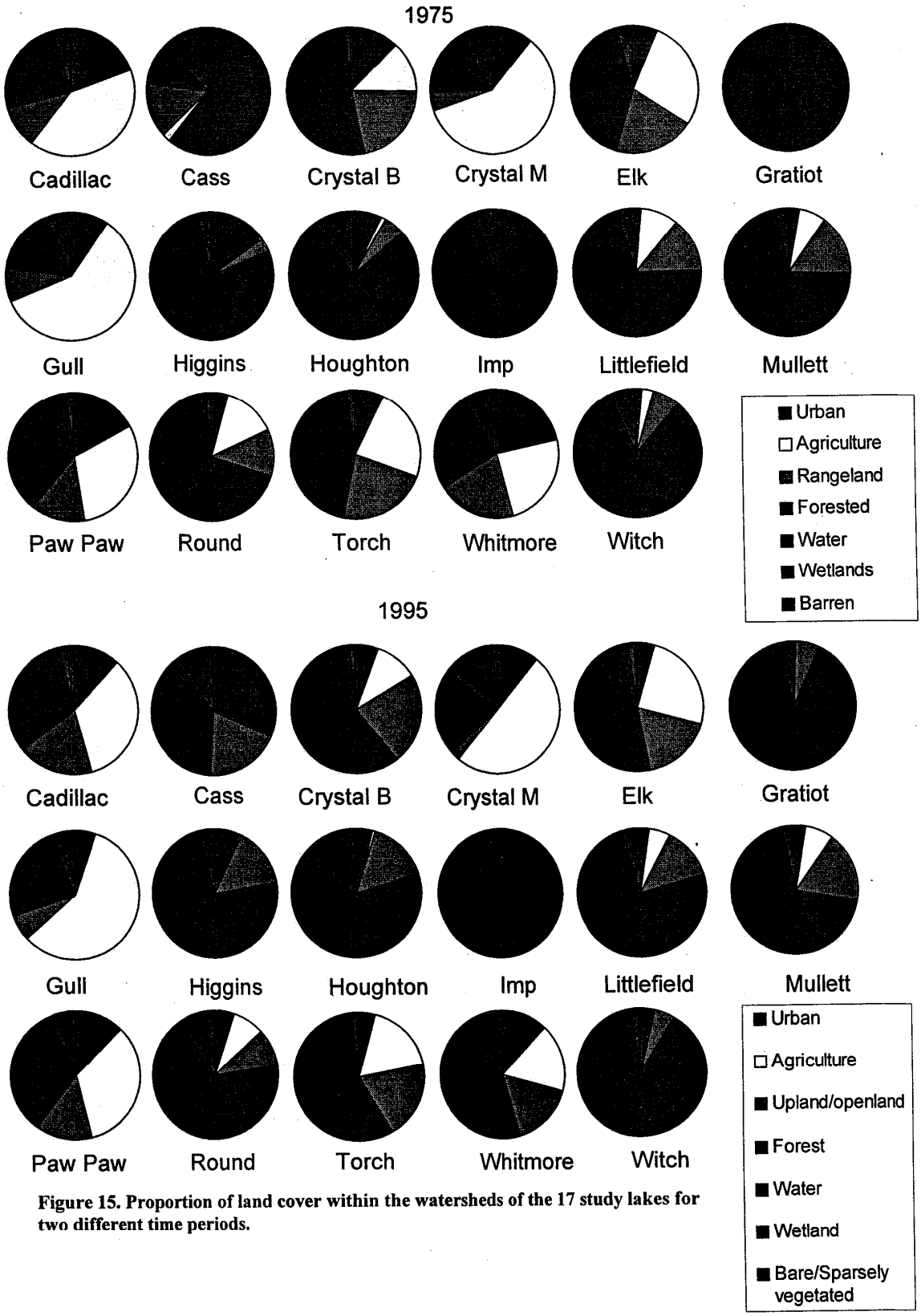


Figure 15. Proportion of land cover within the watersheds of the 17 study lakes for two different time periods.

Sulfate deposition values varied among lakes, with the lowest values in the Upper Peninsula, and highest values near the southwest corner of Michigan (e.g., Gull and Paw Paw lakes), Figure 16.

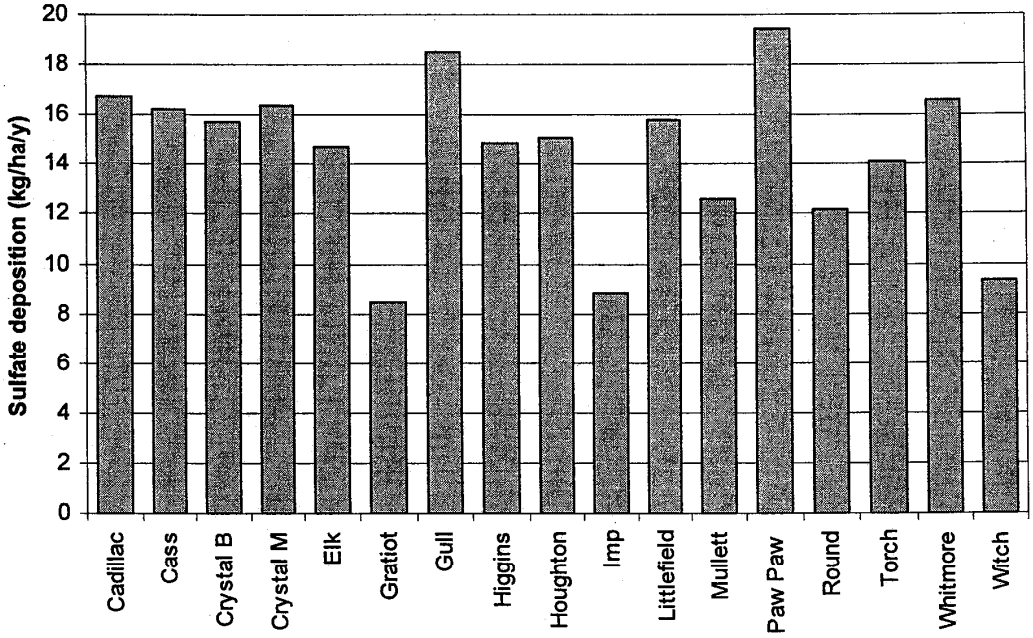
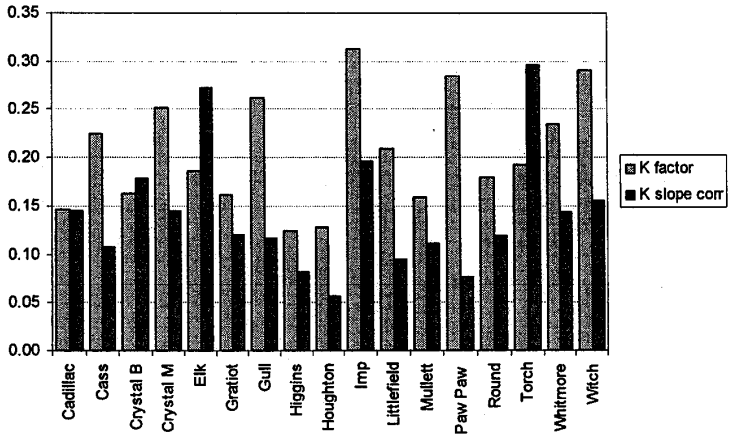


Figure 16. Average estimated rates of sulfate deposition (kg/ha/y) for the watersheds of the study lakes from 1990-2000.

The prevailing winds in the southern Lower Peninsula are westerly, and carry acid deposition from the Chicago, IL, and Gary, IN, industrial and urban centers (Perkins *et al.*, 2000, Souch *et al.*, 2003, Winchester and Nifong, 1971).



K factors were highest in Imp, Paw Paw and Whitmore Lake watersheds, and low in Higgins and Houghton lakes, Figure 17. Accounting for slope changed the K factor significantly, with Elk, Torch and Imp lakes having the highest slope corrected K factors, Figure 17.

Figure 17. K factors (light grey) and slope corrected k factors (k factor * slope/9) (dark grey) for the watersheds of the study lakes.

Each of the watershed characteristics described above was plotted versus the anthropogenic input rates for each of the metals, and a correlation coefficient was determined. Additionally, correlation among the different elements was examined. Most variables were unevenly distributed, with many low values and few high values. To improve the distribution, all variables, including landscape characteristics and metals, were log transformed. Copper data for Cadillac and Houghton lakes were removed for the calculation of R values, because the source of copper to these lakes was unique and local (addition of copper sulfate). Copper data for Witch and Gratiot lakes was also removed, because the source of copper to these lakes is probably related to local mining activities. Copper was also removed for Littlefield Lake because log accumulation rates were much lower than all other lakes.

There are relatively high positive correlations among copper, cadmium, lead, and zinc during both time periods, Table 7. Correlations between lead and zinc, and cadmium and zinc have particularly high values.

Lake size, watershed size, watershed:lake area and erodibility measures do not correlate with metal inputs, except lake area and slope corrected K-factor correlate negatively with copper in 1995.

Sulfate deposition is correlated with all metals in the 1970s, but less so in the 1990s, Table 7 and Figure 18. This supports previous conclusions that atmospheric deposition was a more important source in the 1970s, while more localized sources were more influential in the 1990s (Yohn, 2003, Yohn *et al.*, 2002). Lead and zinc may still have had important atmospheric sources in the 1990s.

Table 7. Pearson's correlations (R value) between focusing corrected anthropogenic accumulation rates and watershed characteristics. Values greater than 0.6 are shown. All variables and metals have been log transformed. Bold indicates the highest correlation

	1970-1980				1990-2000			
	Cd	Cu	Pb	Zn	Cd	Cu	Pb	Zn
Watershed area								
Lake area		-0.607						
Watershed:lake								
SO4	**0.835**	0.657	0.778	0.821			0.728	0.751
K factor								
K factor, slope corr		-0.628						
Pop dens	*0.813*	**0.855**	**0.825**	**0.905**	*0.616*	*0.856*	*0.851*	**0.919**
% urban	0.720	*0.740*	0.627	*0.874*	**0.725**	**0.899**	**0.899**	**0.918**
% ag								
% range, openland				0.637				
% forest	-0.688		*-0.782*	-0.778			-0.642	
% wetlands	0.673		0.683	0.734				
Cu		0.604	0.802	0.802			0.652	0.860
Cd			0.880	0.882			0.843	0.739
Pb				0.980				0.950
Zn								

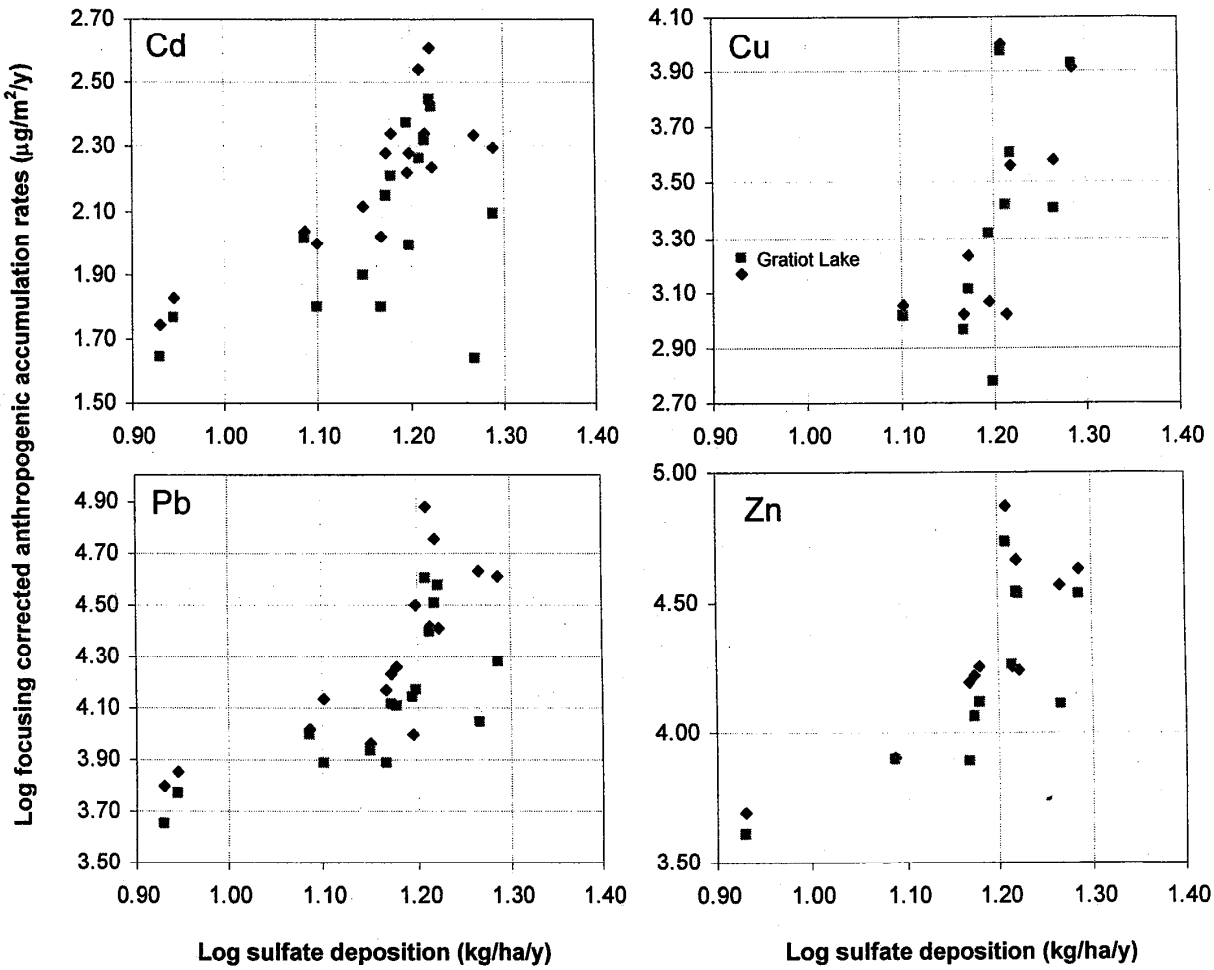


Figure 18. Log focusing corrected anthropogenic rates of cadmium (Cd), copper (Cu), lead (Pb), and zinc (Zn) from 1970-1980 (black) and 1990-2000 (grey) versus average log sulfate deposition (kg/ha/y).

Anthropogenic inputs of metals had the most number of correlations and highest correlation values with population density and percentage of urban land cover in the watershed, Table 7 and Figure 19 and Figure 20. For lead, copper, and zinc, correlations are higher in 1995 than 1975 for both urban land cover and population density. Population densities in both 1995 and 1975 are positively correlated to the % urban land cover in the watershed (1975: 0.845, 1995: 0.918). It is likely that these two variables represent similar sources, such as release of metals from wear of automobile parts (Rice, 1999), car emissions (Callender and vanMetre, 1997, Rice, 1999, Shahin *et al.*, 2000), wastewater (Callender and Rice, 2000), and household and yard waste (Callender and Rice, 2000).

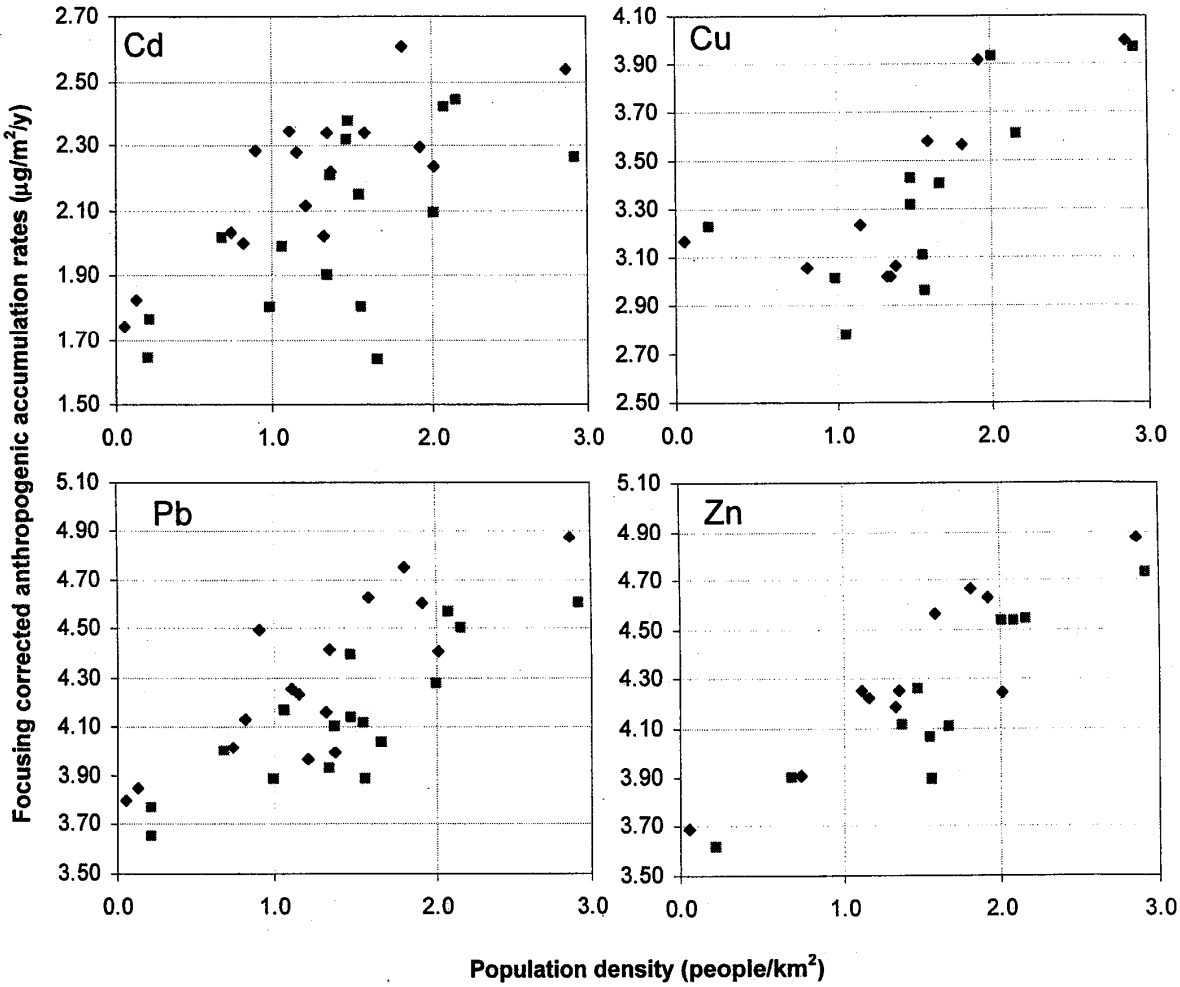


Figure 19. Log focusing corrected anthropogenic accumulation rates of cadmium (Cd), copper (Cu), lead (Pb) and zinc (Zn) (µg/m2/y) versus log watershed population densities.

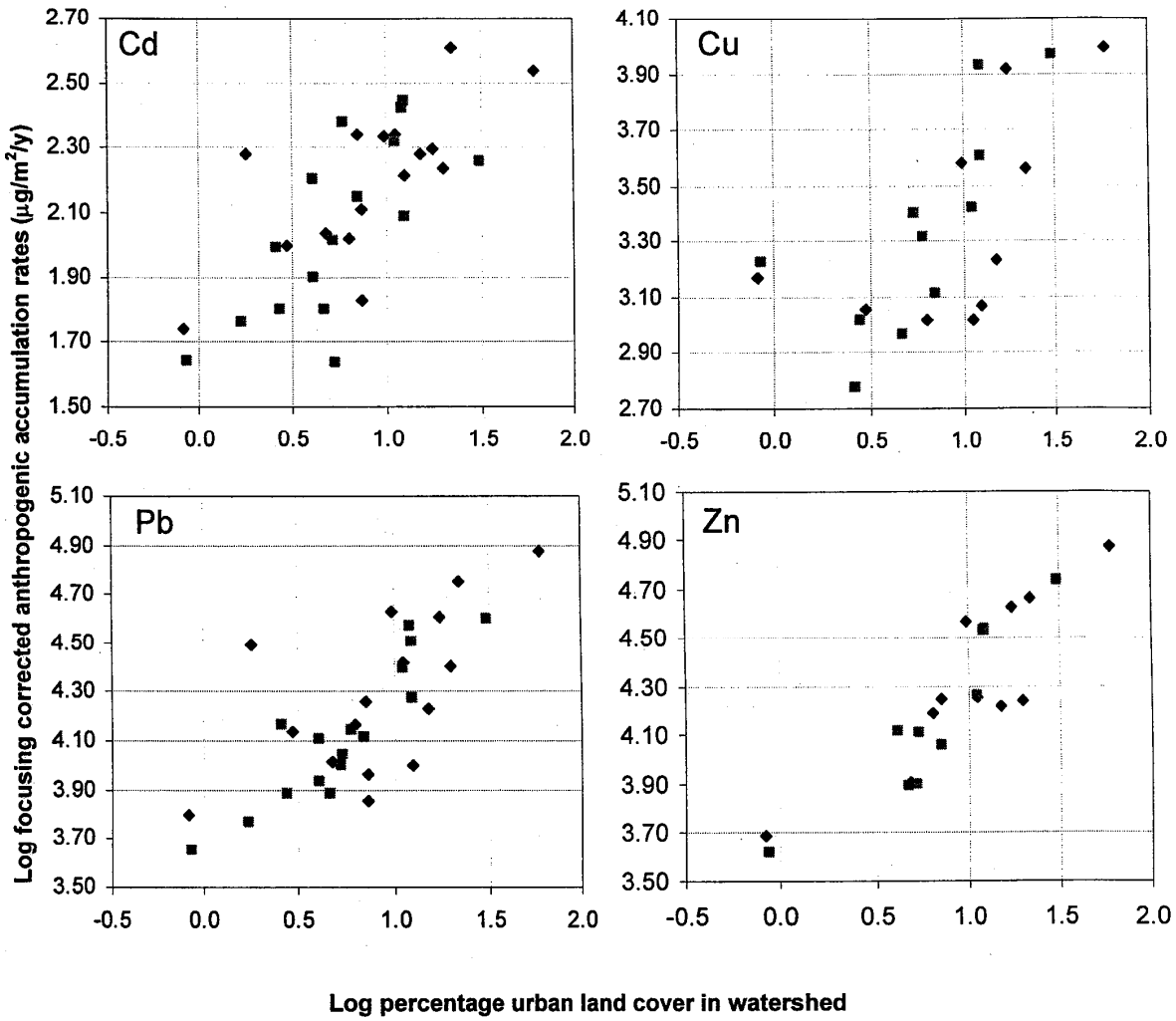


Figure 20. Log focusing corrected anthropogenic accumulation rates of cadmium (Cd), copper (Cu), lead (Pb) and zinc (Zn) (µg/m2/y) versus log percentage of urban land cover within the watersheds.

Percent forest is negatively correlated with cadmium, lead and zinc in the 1970s, and lead in the 1990s. This is a result of % forest being negatively correlated with both population density and % urban.

There is also a positive correlation between the percentage of wetlands and accumulation rates of cadmium lead and zinc from 1970-1980, Table 7 and Figure 21. This result is surprising, as typically wetlands act as sediment traps, and should reduce the input of metals (Cohen *et al.*, 2004). Additionally, the percentage of wetlands within the watershed does not correlate highly or moderately with any other variable. The reason for this positive correlation is unclear.

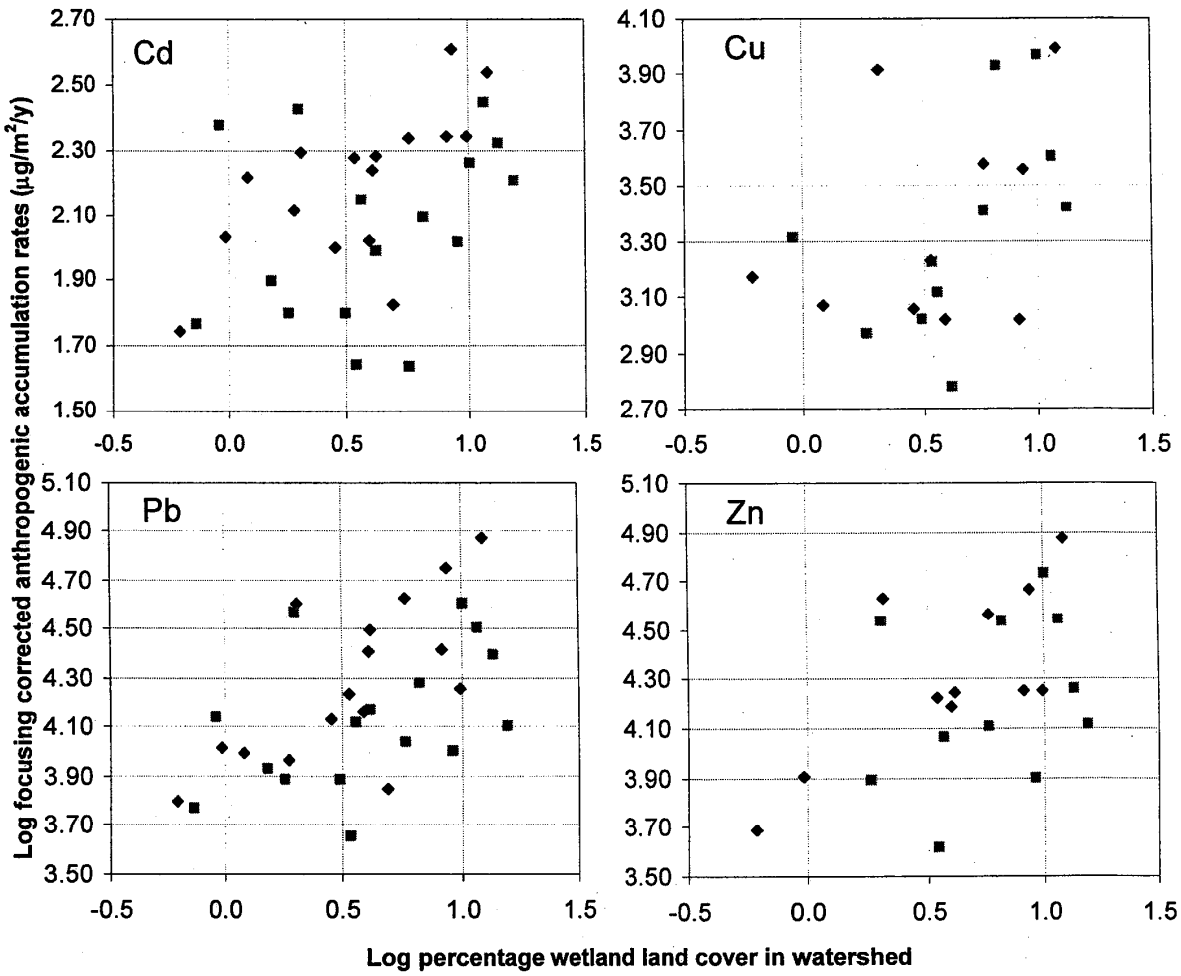


Figure 21. Log focusing corrected anthropogenic accumulation rates of cadmium (Cd), copper (Cu), lead (Pb) and zinc (Zn) (µg/m2/y) versus log percentage of wetland land cover within the watersheds.

Overall, it is apparent that the presence of humans within the watershed of a lake, represented either by percentage of urban land cover or population density within the watershed, results in greater inputs of copper, cadmium, lead and zinc to the lake. Additionally, atmospheric deposition, as represented by sulfate deposition, also appears to be an important source of metals in the 1970s. The physical characteristics of the watershed (e.g., erodibility) do not have a dominant role in determining rates of metal inputs.

Determination of sedimentation rates and age of sediments

The radionuclide ^{210}Pb is measured in one of the subcores from each sampling site to determine rates of sedimentation and sediment ages. Typically a modification of the method of Eakins and Morrison (1978) is used (Wong *et al.*, 1995) for the analysis.

The calculations and considerations in deriving ^{210}Pb dates are involved, but a conceptualization of the technique is relatively straightforward. The atmospheric deposition of ^{210}Pb is considered to be relatively constant. Newly deposited sediments bury older sediments in lakes. ^{210}Pb in the older sediments decays and therefore its concentration (activity) in the sediments decreases with depth. A plot of ^{210}Pb activity in the sediments versus depth produces a curve from which sedimentation rates can be obtained. From the sedimentation rates the ages of the individual layers are estimated.

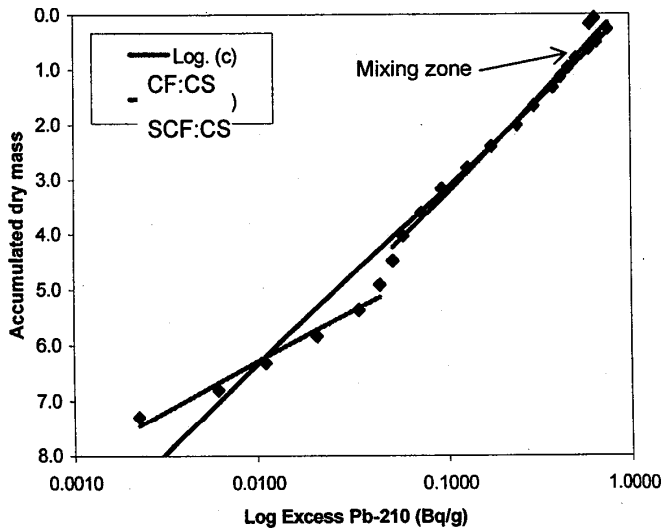


Figure 22. Log of 210Pb activity (Bq/g) versus accumulated dry mass. Regression lines for the CF:CS model (blue) and the SCF:CS model are shown.

Various models are used to date the sediments such as the constant flux, constant sedimentation rate model (CF:CS) (and a modification of this method, the segmented CF:CS), and the constant rate of supply model (CRS). The CF:CS model assumes a constant flux of ^{210}Pb to the sediment and a constant rate of sedimentation over some period of time. Generally, the rate of sedimentation is assumed to stay the same throughout the length of the core but the segmented CF:CS (SCF:CS) model may be used if there is a clear change in sedimentation rate, Figure 22 (Heyvaert *et al.*, 2000). The CRS model also assumes constant flux of ^{210}Pb to the sediment, but does not assume that the sedimentation rate remains the same. Instead, the CRS model determines a different sedimentation rate between each depth. Some authors prefer the CRS model, finding that it gives more insight into changes in sedimentation rates (Fritz *et al.*, 1993, Gottgens *et al.*, 1999). However, the CRS method is particularly vulnerable to noisy data, as errors are propagated to date assignments(Heyvaert *et al.*, 2000).

For all models, sediment deeper than the presence of excess ^{210}Pb cannot be dated. Dates for these older sediments are were determined by extrapolation, using the assumption that sedimentation rates remain constant below this depth. For the RSSM, CF:CS, and SCF:CS models, the sedimentation rate in the lower portion of the core is used to extrapolate dates. For the CRS model, the average sedimentation rate in the last five samples is used. The sedimentation rate chosen to use for extrapolation has a significant effect on the resulting dates,

and all dates older than 1850 should be considered estimations that are reported primarily for graphing purposes.
Sedimentation rates in each lake are determined using all models possible for that lake, and then the models evaluated to ascertain which was the most appropriate to use in determining sediment ages. There is no consensus as to which model is more appropriate in all cases (Oldfield and Appleby, 1984), and several factors are considered when choosing a model. Visual examination of the ^{210}Pb profile provides some insight into the most appropriate model to be used. The RSSM or CRS models are more appropriate for lakes with large mixing zones, and the SCF:CS or CRS models are more appropriate for lakes with clear changes in sedimentation. Additionally, this study will use two other indicators to determine the most appropriate model to use: profiles of ^{137}Cs activity and stable lead concentration profiles. ^{137}Cs is an artificial radionuclide that was produced by atmospheric testing of nuclear weapons in the late 1950s and early 1960s. The peak level of fallout occurred in 1963, and therefore the peak activity in the sediment should occur in the early 1960s (Walling and Qingping, 1992). The second indicator is the stable lead peak. Stable lead has an historical pattern of deposition that is very consistent among lakes, with lead concentrations increasing from the mid-1800s to the early to mid-1970s, and decreasing to the present. The peak in lead concentrations in the mid-1970s due to the removal of lead from gasoline is consistent enough to use for dating verification (Alfaro-De la Torre and Tessier, 2002, Callender and vanMetre, 1997). Therefore the dating method with both the most appropriate date for the ^{137}Cs peak (1963-64) and stable lead peak (early to mid-1970s) is chosen.

^{210}Pb data can also give insight into mixing of sediment focusing and mixing of surface sediments. Sediment focusing is the process by which fine-grained sediment and associated contaminants is redistributed laterally moving from shallow nearshore (erosional) regions to more quiescent (depositional) areas by currents and episodic storm events. The concept of sediment focusing is discussed further in the next section. Bioturbation can mix surface sediment. A constant ^{210}Pb activity with depth in near surface sediments gives an indication of the depth of the biologically reactive zone, Figure 23. Consideration of sediment mixing is discussed in a subsequent section.

Sediment focusing and the sediment focusing factor

There are various aspects of the project objectives that need to make use of the concept of sediment focusing. For example, we need to know:

- the anthropogenic sediment burden of a contaminant for each lake as a whole,
- how the sediment inventories and trends compare among lakes, and
- the role of the atmosphere in contaminant loadings in lakes.

The anthropogenic sediment burden of a contaminant is defined as the total mass of a contaminant in the lake sediments that is due to human inputs. To make this calculation, many cores throughout a lake would need to be retrieved and the contaminant concentrations measured. Concentrations in the cores would be spatially averaged to determine whole lake burdens. Such a strategy would take much time and money.

An alternative approach would be to use the concept of sediment focusing to make calculations on anthropogenic sediment burdens from a single core in an inland lake. The total mass of an anthropogenically-derived contaminant in a sediment core is known as the contaminant

inventory. Dividing by a focusing factor, the inventory can be corrected for the amount of sediment focusing that has occurred at the collection site. The focusing factor is calculated as the ratio of the integrated ^{210}Pb inventory measured in the sediment to the expected inventory from ^{210}Pb deposition from the atmosphere (15.5 pCi cm^{-2}; from Kada and Heit, 1992). The whole lake burden is then calculated by multiplying the focusing corrected inventory times the surface area of the lake.

Focusing corrected inventories (as well as focusing corrected concentration trends) can be compared among lakes (locally and regionally) to determine spatial trends in contaminant loadings. If inventories for a contaminant are different among all lakes with the state and no regional trend is evident, then local sources dominate contaminant loadings in the lakes. Regional patterns in inventories could indicate the roles of land use in contaminant loadings. If the dominant source for a contaminant is from the atmosphere, then regional patterns should reflect this also. For example, the chemical inventories among sites might be similar.

Understanding the effects of mixing zones on sediment dating

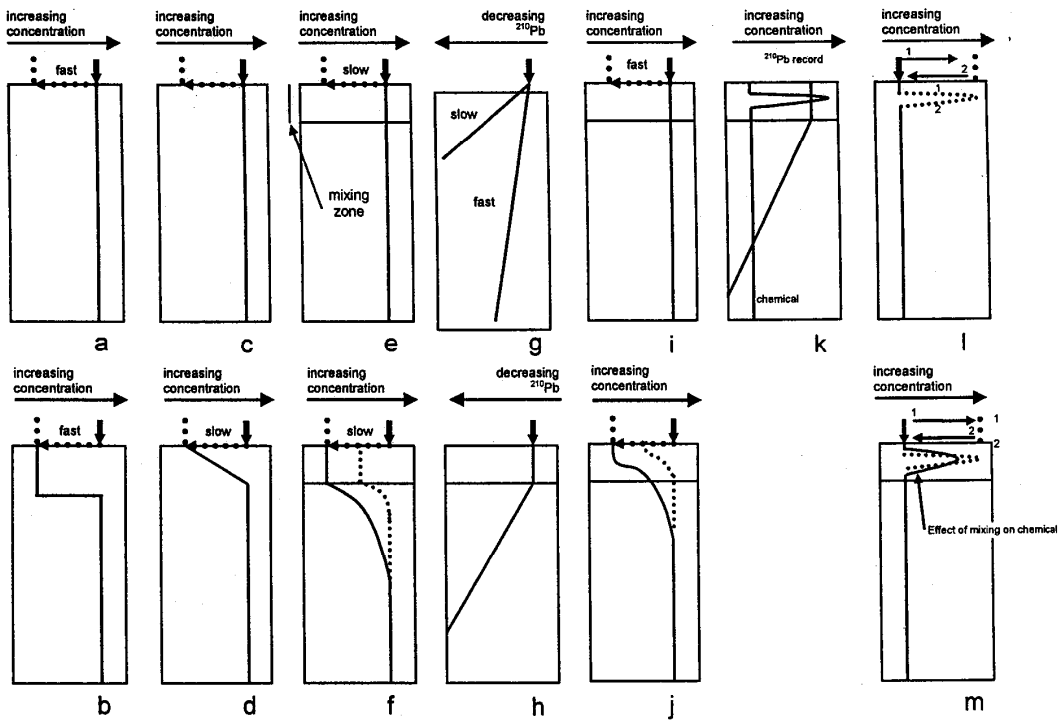


Figure 23. Schematic representation of the effects of bioturbation where the vertical axis represents depth below the sediment-water interface, and the x-axis represents concentration. Sediment conditions and resultant 210Pb or chemical profiles are a) no mixed zone, fast chemical change; b) resultant profile for a; c) no mixed zone, slow chemical change; d) resultant profile for c; e) mixed zone, slow chemical change; f) resultant profile for e, with the dotted and solid lines representing earlier and later time periods, respectively; g) 210Pb profiles for no mixing, slow and fast sedimentation rates; h) mixing zone, 210Pb profile; i) mixing zone, fast chemical change; j) resultant profile for I, with the dotted and solid lines representing earlier and later time periods, respectively; k) record of chemical change in mixed zone with constant 210Pb activity; l) no mixed zone increase and decrease in chemical input; m) influence of mixed zone on chemical record in l.

Resuspension of top layers of sediment and bioturbation by zoobenthos will cause the top few centimeters of sediment at the bottom of lakes to become mixed. A question that frequently arises is, "how can sediments maintain chemical trends if mixing of the top layers of sediment occurs?" It is important to understand that mixing can disturb, but not necessarily destroy the depositional record of chemical input in the sediments (Robbins, 1982; Wong et al., 1995). The degree of disturbance is a function of changes in rates of chemical inputs, the amount of bioturbation, and the sedimentation rate. For example, in the case of no mixing and a rapid change in the amount of chemical input from high to low , Figure 23, there would be a sharp change in concentration recorded in the sediments, Figure 23b. If the change were slow rather than rapid, Figure 23c, then a more gradual change in sediment concentrations would be recorded, Figure 23d.

Now, take the case in which extensive mixing occurs and that the change of rate in chemical input is slow, Figure 23e. In this case it is possible that chemistry of the sediments in the mixed zone could be completely homogenized. At any one time the chemical concentration of the different sediment layers in the mixed zone would be the same, Figure 23f. However, the sediments below the mixed zone would record the changes in chemical input.

The case just described is often observed for the profiles of ^{210}Pb activity in the sediments. ^{210}Pb is generally considered to have a constant rate of input to the sediments. Once in the sediments it is away from its source (the atmosphere), and the ^{210}Pb decays. If mixing did not occur, then the amount of ^{210}Pb in the sediment would decrease from the surface sediments. The rate of decrease would be a function of sedimentation rate, Figure 23g. Because the decay rate of ^{210}Pb can be relatively slow compared to the degree of mixing, then it is quite possible that the ^{210}Pb activities in sediment layers of the mixed zone could be similar, Figure 23h. In fact, the shape of the ^{210}Pb profile in the upper sediments is one way of identifying the mixing zone.

Finally, consider the condition in which the rate of change of chemical input is relatively rapid compared to the degree of mixing, Figure 23i. In this case, the degree of mixing is not sufficient to completely homogenize the chemical record in the sediment. Thus, the sediments in the mixed zone record changes in chemical inputs, Figure 23j. Records of chemical change in layers of sediment in the mixed zone and no change in ^{210}Pb activity are frequently observed in cores taken from inland lakes and large lakes (Fritz et al., 1993; Golden et al., 1993; Simick et al., 1996; Wong et al., 1995), Figure 23k. It should be pointed out that while the chemical record in the mixed zone would not be obscured, it would be altered. For example, if no mixing were to occur, a change in chemical inputs might look like the example shown in Figure 23l. Mixing will tend to spread out or "smear" the record and decrease the peak concentration, Figure 23m.

In sum, while mixing tends to affect the record of chemical trends in lake sediments, it is still possible to obtain information about trends in chemical input within the mixing zone.

Calculation of anthropogenic inventories (Inv), anthropogenic sediment burden (ASB), and anthropogenic sediment accumulation rates (SAR)

Three important calculations to assess historical trends, current conditions, and future expectations are anthropogenic inventories and sediment burden, and anthropogenic accumulation rates.

Anthropogenic inventories and sediment burden – Focus corrected anthropogenic sediment inventories and whole lake burdens will be determined from the following equations:

$$\text{Inventory}\,(\mu\text{g/cm}^2) = \sum_{i}\left[\text{Csed}^* \times (1 - \phi \times \rho \times \text{d})\right]$$

where:
Csed* = background corrected concentration of metal in sediment (µg/g dry wt.)
ϕ = porosity
ρ = sediment dry density (g/cm^3)
d = thickness of sediment increment (cm)
i = number of depth increment.

$$\text{Focus-corrected inventory}\,(\mu\text{g/cm}^2) = \frac{\text{Inv}}{\text{FF}}$$

where:
Inv = inventory of the metal
FF = focusing factor

$$\text{ASB}_i^l(\text{kg}) = \frac{\sum_{l}^{j}\text{Invc}_i^j}{n_j} \times \text{SA}_l$$

where:
i = metal,
j = site for sediment core,
l = lake,
n_j = number of sites,
$\mathbf{ASB}^l_i$ = anthropogenic sediment burden for ith metal in lth lake (kg),
Invc^j_i = focusing corrected inventory (µg/cm^2) for ith metal in the sediment core at jth site,
SA_l = surface area of lth lake (m^2).

Anthropogenic sediment accumulation rates – Focusing corrected anthropogenic sediment accumulation rates (the loading rate of a chemical to a lake at a depth increment or year) will be determined from the following equation:

$$\text{SAR}\,(\mu\text{g/m}^2 yr) = \left(\text{C}_\text{i} \times W \times 10^4\right) / FF$$

where:
C_i = background corrected concentration of metal in sediment at a particular depth (µg/g dry wt.)
W = mass sedimentation rate at depth I (g/cm^2/yr)
FF = focusing factor (see above)

Task 5: Report preparation/presentations

The project team will prepare a yearly report on the inland lakes sediment core data to summarize key findings (as determined by the MDEQ in cooperation with the contractor), with the raw data included in appendices. These reports will make effective use of graphs and tables to synthesize data and communicate major findings to technical and non-technical audiences. (please see Appendix E). The report also will include individual fact sheets for each lake (please see Appendix A).

The project team will assist the MDEQ with the preparation of reports for which the MDEQ is responsible. The assistance will include preparation of tables, graphics, and spreadsheets. They will also make reports and other outputs available to MDEQ electronically and hard copy, as necessary.

The project team will provide at least an annual presentation to MDEQ and other presentations to MDEQ as needed (please see Appendix E), as well as external conferences/organizations (please see Appendix B).

Applications of the Strategy to other issues

(1) Provides a unique database for the Great Lakes region and can be integrated into trends of the Great Lakes.
(2) Can be used to study any contaminated sediments.
(3) Can be used to study chemistry of sediment boundary layer.
(4) Can be used to examine associations of contaminant burdens in biota with sediment concentrations.
(5) Can be used to explore chemistry of porewater in sediments.

1.201 Contractor staff, roles, and responsibilities

The key contact for this contract shall be:

David T. Long
Michigan State University
206 Natural Science
East Lansing, Michigan 48824
Phone: (517) 353-9618
Email: long@msu.edu

Please refer to the qualifications sections 1B.201, 1B.202, and 1B.203 for prior experience and relevant qualifications of contractor staff.

1.301 Project plan management

Please refer to *EXHIBIT G – DELIVERABLES* for project plan and management

1.302 Reports

Progress reports shall be submitted quarterly along with quarterly invoices. An example of a quarterly progress report submitted to MDEQ and the MSU project team's letter of QAPP approval are included below.

QAPP approval letter

STATE OF MICHIGAN
DEPARTMENT OF ENVIRONMENTAL QUALITY
LANSING

JENNIFER M. GRANHOLM
GOVERNOR

STEVEN E. CHESTER
DIRECTOR

April 7, 2005

Dr. David T. Long
Department of Geological Sciences
Michigan State University
206 Natural Science
East Lansing, Michigan 48344

Dear Dr. Long:

We have reviewed the Inland Lakes Sediment Trends Monitoring Program - Quality Assurance Project Plan (QAPP) for 2005 through 2008 that you e-mailed to Glen Schmitt of my staff on March 30, 2005. The QAPP objectives are consistent with the contract work plan. The framework and procedures for how the environmental data will be collected to achieve the objectives are adequate. Therefore, we approve the QAPP.

If you have any questions, please contact Glen Schmitt at 517-241-0910, or you may contact me.

Sincerely,

Gerald Saalfeld, Chief
Upper Peninsula Unit
Surface Water Assessment Section
Water Bureau
517-335-4201

cc: Gary Kohlhepp/Grant Files, WB
Glen Schmitt, SWAS, WB

Progress report

GRANTEE NAME: Michigan State University

PROJECT NAME: A Strategic Environmental Quality Monitoring Program for Michigan's Surface Waters: Sediments PROJECT #: 480502-01

PERIOD COVERED: January 1 – March 31, 2003 DATE SUBMITTED: April 7, 2003

A. Progress made/tasks completed this period:

- analyzed Standard Reference Material for 25 elements,
- conferred with DEQ to determine feasibility of sampling Lake St Clair,
- ordered sampling bottles and other supplies necessary for summer 2003 sampling season,
- began washing, preparing sample bottles for summer 2003 sampling season,
- submitted paperwork for long term lease vehicle,
- investigated new pore water sampling methods,
- replaced old winch on boat trailer,
- submitted "Regional versus local influences on lead and cadmium loading to the Great Lakes region", Sharon Yohn, David Long, Joel Fett, Lina Patino to the journal Applied Geochemistry
-
-

B. Work to be accomplished next reporting period (April 1 – June 30, 2002):

- finalize 2002-2003 Report,
- further Investigation of porewater sampling methods,
- finalize lakes to be sampled in 2003 summer sampling season,
- begin collecting watershed and population density data for 2003 Lakes,
- wire trailering vehicle for new winch set up

C. Problems encountered (Identify any problems real or anticipated which has or may result in any deviation from previously agreed upon work plans):

- none.

Signed: _____

Grantees Representative Date

1.402 Risk management

Field sampling

Inclement weather – Our approach to this problem is relatively straightforward and is based on our prior experience. First inland lake sampling is generally initiated after the spring storm season. Dates are picked and the weather channel is monitored to track weather patterns ahead of time. Extra sampling days are added in as a buffer. We have sampled in light rain with no problems; the real problem is wind. For many of the lakes it is not possible to anchor the boat. We solve this problem by getting on the lake as early as possible (typically we start setting up at sunrise) when the winds are low. Once the cores are collected, the onshore work takes up to 5 hours. We work in a tent and when there is inclement weather we have sides that can be added. We have been able to process the cores in relatively harsh weather. Again, the real problem is wind. Although we try to go out after the storm season, there are still some lakes that need to be sampled early. For example, because of the weed problem in Houghton Lake, it needs to be sampled in May. When this is the case, our protocols do not change, but there is the risk of having to reschedule the sampling.

Lack of access – We have designed the sampling system (boat and coring device) to be used in remote lakes. However, there are some lakes that do not have any access or the available access is too primitive. Our approach to solve this problem is to gain as much information about the lake from 1) published lake maps, 2) knowledge from MDNR and MDEQ representatives, and 3) on site visits. Thus, before final selection of a lake, access typically has been confirmed. However, there is always the possibility that the boat can not be launched for unforeseen circumstances. Therefore, we typically have "backup" lakes designated for a particular area. We have found that this approach works well.

Equipment problems – There are three concerns for equipment problems 1) the boat, 2) the coring system and 3) the extruding system. For the boat, we request maintenance funds for the duration of the project. If problems arise in the field, we will work with MDEQ to solve the problems. If the problems can not be resolved, we will reschedule the sampling. For the coring system, we request maintenance funds for the duration of the project. We have good familiarity with the coring system and have made many modifications to it. Most of the problems that might arise will be with the wearing of the core tubes and core tube holders, and loss of small parts. We solve this problem by working with the MSU Physics Shop to keep the core tubes in proper shape and with the manufacturer of the coring system for extra supplies.

Other field related problems – There are two other types of field problems not identified in the RFP that need to be highlighted. From our previous work on the inland lakes in Michigan we have found that each lake reveals its own "surprises." As best as possible we try to anticipate what we might expect for the types of lakes sediments to be encountered. We gain this knowledge for example, from the glacial and geologic maps of Michigan, land use, published lake maps, or what we have found from nearby lakes. Still, there can be unanticipated problems. The two most common are sand bottoms or highly unconsolidated bottoms. In the first situation the coring device will not penetrate the sand. There are coring devices that would be able to penetrate (e.g., vibra-corer), but these devices do not yield acceptable cores and the environmental record from such sediments is poor. In the second case, the corer does has not

problems with penetration and the opposite is true, the coring systems go too far into the sediment. We have developed attachments to the coring device to stop this penetration as best as possible. Even so, with very "watery" sediment the device itself can malfunction. The malfunction is caused by the lack of sediment resistance that the device needs to operate properly. We have developed some attachments to the corer to be used in this situation. However, even with these modifications, some lake sediments are too unconsolidated for this device to work properly. Thus, the inclusion of "backup" lakes to the sampling schedule is again is helpful. The other risk associated with the field work is in the processing of the cores (both sediment and pore water extrusion). There are always problems that can arise (e.g., core tubes falling over), this is particularly true for the porewater extrusion. The methodology developed for the extrusion of the porewater is relatively straight forward, but does involve a series of steps that allow for the possibility of impacting the quality of the samples obtained. We attempt to solve this problem by retrieving a duplicate set of four cores and if there is a problem we use one of these cores to supplement one of the originals. If this happens it is recorded in the log books.

Cost Overrun – We have to the best of our abilities constructed a budget for the project that will allow us to complete the tasks. The costs were developed based on our experiences in this type of work and working with the State in the past. Unexpected events do happen. For example, a power outage could severely impact the analytical devices or cost for supplies or gas could increase dramatically. The best solution to work with these issues is to have a strong working relationship with the MDEQ project manager. This is in part accomplished with continuing lines of communication (e.g., email, phone including cell) and updates as necessary.

In Accurate Results – Throughout the proposal we have outlined our approaches to assure the best results possible (please refer to section 1.001 Introduction and Objectives). These approaches start in the field with attempting to collect the highest quality core through laboratory analyses. As stated elsewhere, we have on file a QAPP with MDEQ for this type of work until 2008. After this time we will renew this agreement.

EXHIBIT G – DELIVERABLES

This project is designed as a five (5) year program as per the RFP. As indicated in the RFP, there are to be five (5) lakes sampled per year, which would yield 25 lakes. However, in order for the project to be completed in five years, lakes cannot be sampled in the last year of the program. Therefore, to sample the requisite number of lakes, the approach will be to sample six (6) lakes in the first year, seven (7) in the second year, and six (6) lakes in the subsequent years.

The expected time line and deliverables on a yearly basis for the project are as follows:

1. Core collection ***(May to September)***. Sediment cores will be collected (Task 2) from five lakes. Sediment cores will be sectioned and stored for further analysis. Porewater samples will also be collected from each lake.
2. Chronology of sampled lakes ***(September to August)***. Cores will be analyzed for ^{210}Pb, metals (including mercury), and organic chemicals. ^{210}Pb analysis includes porosity, accumulated dry weight, percent water, activity of ^{210}Pb and calculation of sedimentation rates and sediment ages. (Tasks 3).
3. Inland lake data ***(October to September).*** Spatial data will be collected for the inland lakes sampled and selected lakes for future study. These data will include: shape, area, depth of lakes; location of lake, area and shape of surrounding watershed. These data will be entered into a GIS database. Temporal data from library research and databases either purchased (e.g., MSU Center for Remote Sensing) or obtained (e.g., U.S.G.S.) will be collected on the history of the watershed in terms of population changes, land use change, events (e.g., logging), and changes in weather. Data collected will be related to each lake (Task 4).
4. Outreach ***(January to September).*** This task will be to design and implement outreach activities (Task 5). Informational workshops will be held as needed for individual lake associations. A web page will be created and maintained that will provide information on the purpose of the project, which lakes have been sampled, and include the fact sheets about those lakes.
5. Workshops ***(January to September)***. A series of workshops will be held between MSU and MDEQ for the purposes of identification of lakes to be sampled, exchange of data, design of outreach activities, and discussion of project results (Tasks 1 and 5).
6. Annual Reports ***(October)***. A report detailing the activities and findings of each year of the program will be submitted to the MDEQ at the end of that project year. At a minimum, this report will include sedimentation rates for each lake, interpretation of "background concentrations," selected contaminant chronological profiles for each lake, selected anthropogenic sediment accumulation rates, preliminary interpretations of trends based on spatial and temporal data collected for each lake, and a summary fact sheet for each lake. Additional items for inclusion in the report may be added at a later date upon agreement by both parties.
7. Final report ***(October)***. A final report detailing the activities and findings of the final year will be submitted to the MDEQ at the end of the project period. At a minimum, this report will include sedimentation rates for each lake, interpretation of "background concentrations," selected contaminant chronological profiles for each lake, selected anthropogenic sediment accumulation rates, preliminary interpretations of trends based on spatial and temporal data collected for each lake, and a summary fact sheet for each lake. Additional items for inclusion in the report may be added at a later date upon agreement by both parties.