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**William A. Schoenlein**
*Manager Hydro and Renewable Generation*

September 25, 2017

Kimberly D. Bose, Secretary
Nathaniel J. Davis, Sr., Deputy Secretary
Federal Energy Regulatory Commission
Dockets Room, Room 1A
888 First Street, NE
Washington, D.C. 20426

**RE: LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT (FERC PROJECT NO. 2680-113)**

**RESPONSE TO JULY 27, 2017 STAFF COMMENTS ON FINAL LICENSE APPLICATION**

Dear Ms. Bose,

On June 28, 2017 Consumers Energy Company ("Consumers Energy") and DTE Electric Company ("DTEE") (collectively, "Licensees") co-Licensees of the Ludington Pumped Storage Hydroelectric (FERC Project No. P-2680), filed an Application for new license. By letter dated July 27, 2017, FERC Staff ("Staff") provided a deficiency and Additional Information Request ("AIR"): (1) Schedule A - Application deficiencies and (2) Schedule B - request for additional information for the Application for new license for the Ludington Pump Storage Project ("Project"). Responses to Staff's request were to be provided within 60 days of issuance of the letter, or by September 25, 2017.

This letter provides the Licensees' responses to Staff's requests.

During the preparation of the responses, the Licensees determined that several values discussed in Exhibits D and E of the Application were not correctly defined based on the co-ownership of the Project. The values for estimated average cost of the Project, property taxes, Project revenue, cost of pumping, and production cost provided in the license Application are estimated values that were utilized on a total project basis. However, since these values are split between the two Project owners, the values provided in the exhibits were determined to be applicable only to Consumers Energy, and did not include DTEE's values. Property taxes are split 51% / 49% according to the Ownership Agreement between Consumers Energy and DTEE. Additionally, Consumers Energy and DTEE dispatch their three units according to the needs of each respective company. Revenue from generation and the electrical energy cost for pumping are determined separately for each company. The discrepancy was determined late in the AIR's 60-day response period and the DTEE values were not available in time to be included with this response. The Licensees respectfully request a 30-day extension for Schedule B items numbers 9, 18, and 19 (i.e., by October 25, 2017). This extension will permit Licensees to provide complete and accurate responses to these questions without undue delay.

Attached to this letter are:

Enclosure 1 July 27, 2017 Schedule A - Deficiencies - Responses
Enclosure 2 July 27, 2017 Schedule B - Additional Information - Responses
Enclosure 3 Revised Exhibit F drawings – (Sheets 1-6 CEII, Sheet 7 Public)
Enclosure 4 Revised Exhibit G drawings.

Questions regarding the Licensees' responses should be directed to David McIntosh of my staff at (231) 779-5506.

/s/ William A. Schoenlein
William A. Schoenlein

Copy to: Mailing List (attached)

CC: Shana Wiseman <Shana.Wiseman@FERC.GOV>

# Enclosure 1

Responses to Schedule A – Deficiencies

## Schedule A

## DEFICIENCIES

Following is a list of deficiencies that the Federal Energy Regulatory Commission ("FERC" or the Commission") Staff identified after review of the license application.

**Exhibit B**

(1) Section 4.51(c)(1) of the Commission's regulations requires a statement of whether the operation of the project is manual or automatic. Please provide this information and specific details on how the project is operated.

**Response:**

In either the pumping mode or generating mode, the operation of each unit is initiated by a local manual action. The units cannot be operated (started or stopped) remotely and rely upon an Operator being in the Plant's Control Room to initiate the start or stop function in either operating mode. When a generation order or a pumping order is received by the Control Room, the Operator selects the proper mode of operation and provides the required input, to generate or pump (i.e., the Operator pushes the respective generate start or pump start button). An automatic sequence of actions then takes control of the selected unit(s) to initiate pumping, or generating (generation and synchronization to the transmission system, herein called online generating). Once a unit is online generating, the unit is then placed in Automatic Generation Control ("AGC") whereby the load setpoint (i.e., the number of megawatts being requested of the unit) is controlled by the Owner's Electric Sourcing and Trading Department in Jackson, MI. The AGC allows the unit's governor to automatically adjust the wicket gate opening to match the actual unit output (MW) to the load setpoint that is being sent. When a unit is online pumping, the wicket gate opening is automatically controlled by the unit's governor system according to the manufacturer's net head curve. The net head curve is programmed into the governor's computer system. The governor's computer system automatically adjusts the wicket gate opening on the unit as the net head changes with the increasing upper reservoir water level in order to maximize the efficiency of and minimize vibration on the unit. Pumping and generation are terminated by a manual action (i.e. the Operator pushes the stop button) or by automatic protective trip.

**Exhibit D**

(2) Section 4.51(e)(4)(iv) of the Commission's regulations requires information on operation and maintenance expenses, including the cost of insurance and administrative and general expenses. Please provide this information.

**Response:**

Cost of insurance, administrative, and general expenses for the Ludington Pump Storage Project ("Project") are incorporated into costs of the Consumers Energy Company ("Consumers

Energy") and DTE Electric Company ("DTEE") (collectively, "Licensees") consolidated business and are not separated out for the Project.

**Exhibit F**

(3) Section 4.39(a) of the Commission's regulations requires that each drawing must have a numerical and graphical scale and the project number in the upper half of the lower right hand corner of each sheet. Please provide this information for each Exhibit F sheet.

**Response:**

The Exhibit F drawings have been revised to include a project number and numerical and graphical scales have been added or revised. The Revised Exhibit F drawings are filed separately as they contain CEII.

**Exhibit G**

(4) Section 4.39(b)(1) of the Commission's regulations requires each Exhibit G map to show the true and magnetic meridians. Please provide this information.

**Response:**

Revised Exhibit G maps are attached. Each sheet now includes the required true and magnetic meridians as required.

**Exhibit H**

(5) Section 5.18(c)(1)(C)(2)(iv) of the Commission's regulations requires data showing the need, cost, and availability of alternative power sources including new capacity at existing units, new construction, off-system power purchases, and load management measures. Please provide the total annual cost of each alternative source of power to replace project power, the basis for the determination of projected annual cost, a discussion of the relative merits of each alternative, including the issues of the period of availability and dependability of purchased power, average life of alternatives, relative equivalent availability of generating alternatives, and relative impacts on the applicant's power system reliability and other system operating characteristics, and the effect on the direct providers (and their immediate customers) of alternate sources of power.

**Response:**

The electricity generated by the LPSP is generally used to meet daily peak electrical demand. The electrical output from the plant is sold wholesale into the Midcontinent Independent System Operator ("MISO") administered wholesale market. During the term of the new license, the Project's authorized capacity following completion of the unit upgrades is 1,785 MW, at the time of filing the license Application the authorized capacity of the Project was 1,700 MW, with three of the six unit upgrades completed. The annual generation from the LPSP over the most recent five years of history (2012 through 2016) has averaged 1,724,458 MWh.

Consumers Energy's share of project generation is 51%, and the average annual share of production over this five-year period is 879,474 MWh. Consumers Energy's total generation requirements are approximately 36,000,000 MWh, which means Ludington provides approximately 2% of customer needs. Additionally, Ludington is expected to provide over 1,100 Zonal Resource Credits[1] ("ZRC") to serve customer need of 7,800 ZRCs. That means the Project provides approximately 15% of CE's Planning Reserve Margin Requirement ("PRMR").

DTEE's share of the project generation is 49% and the average annual share of production over the five year period is 844,984 MWh. DTEE's total generation requirements are approximately 46,000,000 MWh, which means the Ludington provides approximately 2% of customer needs. Additionally, Ludington is expected to provide approximately 1,050 ZRCs to serve customer need of 11,000 ZRCs. That means the Project provides approximately 10% of DTEE's PRMR.

## Consumers Energy:

### Alternative Sources of Power

To replace the energy and capacity provided by Ludington, construction of a new generating facility would be required. Replacement of Ludington would most likely require a Combined Cycle ("CC") natural gas plant (H class or F class) or four Combustion Turbine ("CT") natural gas plants, both of which would be expected to have a life of 30 years and are sized at approximately 1,100 MW and 400 MW, respectively. A CC or CT plant's availability is quite high, generally expected to exceed 95%. Regarding economic commitment and dispatch, a CC is currently projected to operate at a 67% capacity factor, while each CT is projected to have a capacity factor of 7%. To replace the lost energy and capacity provided by Ludington, one CC would be required, while four CTs would be required.

Table 1 compares the costs (in 2017 dollars) of building a CC versus four CT plants to replace the energy and capacity currently provided by the Project.
The capital expenses provided in Table 1 include the installed costs and gas infrastructure values, while the operating cost represents the total fuel cost and variable Operation and Maintenance ("O&M"). Table 2 provides the breakdown of the operating costs provided in Table 1.

[1] ZRCs are MW units of Planning Resources that have been converted into a credit that is eligible to be offered by a market participant into the Planning Resource Auction, or to be sold bilaterally, or to be submitted through a Fixed Resource Adequacy Plan. (FERC Docket ER14-990-000; also MISO, FERC Electric Tariff Module A, Sections 1.L. 1.P. (0.0.0)).

| Table 1 Breakdown of cost of CC and CT units | | | | |
|---|---|---|---|---|
| **Units** | | **Total Capital Expense ($/kW)** | **Operating Cost ($/MWh)** | **Total Annual Revenue Requirement ($K)** |
| **Combined Cycle** | H Class 2x1 | $1,066 | $29.40 | $208,493 |
| | F Class 2x1 | $1,086 | $30.52 | |
| **Combustion Turbine** | J class 1x0 (4 units) | $825 | $53.26 | $205,113 |

| Table 2 Breakdown of Operating Costs | | | | |
|---|---|---|---|---|
| **Units** | | **Variable O&M - including LTSA ($/MWh)** | **Net Fuel Costs ($/MWh)** | **Operating Cost ($/MWh)** |
| **Combined Cycle** | H Class 2x1 | $2.27 | $27.12 | $29.40 |
| | F Class 2x1 | $2.16 | $28.36 | $30.52 |
| **Combustion Turbine** | J class 1x0 | $15.54 | $37.71 | $53.26 |

LTSA – Long Term Service Agreement

The total annual revenue requirement provided in Table 1 consists of the levelized capital investment cost, fixed O&M, fuel costs, and variable O&M that would be required to replace the energy otherwise provided by Ludington. The value of each component for both the units is elaborated in Table 3.

| Table 3: Breakdown of Total Annual Revenue Requirement | | | | | |
|---|---|---|---|---|---|
| **Units** | **Levelized Capital Revenue Requirement ($1000)** | **Fixed O&M – Including LTSA ($1000)** | **Fuel Cost ($1000)** | **Variable O&M – Excluding LTSA ($1000)** | **Total Annual Revenue Requirement ($1000)** |
| **Combined Cycle (H class)** | $156,194 | $26,240 | $25,810 | $249 | $208,493 |
| **Combustion Turbines (4 units)** | $161,506 | $35,067 | $34,711 | $129 | $205,113 |

The Consumers Energy average cost of producing power at Ludington was $22.16/MWh in 2016, which indicates that either of these units would likely be more expensive to operate than the Ludington units.

**Availability of Alternative Sources of Power**

The lead time required to secure replacement energy and capacity for Ludington is significant. During the time period between the loss of license at Ludington and an expected commercial operating date of a new generating facility, the capacity and energy loss would likely have to be replaced with market purchases. To replace the energy otherwise provided by Ludington, market purchases from the MISO would be leveraged. Current monthly average forward prices for power for year 2019 and beyond are approximately $30/MWh, up to nearly $40/MWh. However, the impact on Locational Marginal Prices due to the loss of Ludington has not been quantified but may be significant. Impacts on electric reliability are also possible. An assessment of the impact on the electric transmission system would be required and may result in significant transmission system cost increases.

Additionally, Consumers would have to rely on the purchase of ZRCs from either the annual Planning Resource Auction ("PRA") or a Request for Proposal to replace the capacity. It can be expected that the price of the ZRCs would reach the Cost of New Entry, which is exceeds $90,000/ZRC-year.

Besides replacing the Project with a CC or CT units, other possible sources of energy and capacity are described below:

1. Wind Power: Wind power is not a viable option for replacement of Ludington because of the relatively small amount of ZRCs received per installed MW. MISO currently awards new wind projects a capacity credit of only 15.6% of installed capacity. Wind could be used to replace the energy produced by Ludington, but wind capital cost is expected to be in excess of $1,400/kW, which is significantly higher than the CC or CT units discussed above. The availability of vast amounts of land is also a concern with wind units in Michigan. Furthermore, moratoriums on wind development have been instituted in several areas of the state.

2. Battery: Energy storage is a powerful energy source with continuously declining costs, however, it is not a viable replacement for the 1,100 ZRCs provided by the Project. The limited life cycle of one battery unit (average of 10 years), the relatively high capital cost, and the expected degradation related to dispatch of storage devices result in an uneconomic position for batteries to be utilized as a replacement option. For a Lithium-ion battery with a one-hour dispatch time, the cost ranges between $700/kW to $1000/kW (2015$). However, for storage capabilities between four to eight hours (similar to Ludington usage), the cost ranges between $1600/kW - $4000/kW.

3. Solar: Much like wind, solar installations require vast area of land to install the panels that would be required. Additionally, MISO currently awards new solar generators a capacity credit of only 50% of installed capacity. This means replacement of Ludington with Solar would require approximately 2,200 MWs of new solar installations. The capital cost for solar ranges between $1400/kW-$1800/kW

depending on the type of panels used (Single axis/tilted axis) meaning this would be a far more significant cost than the CC or CT units discussed above.

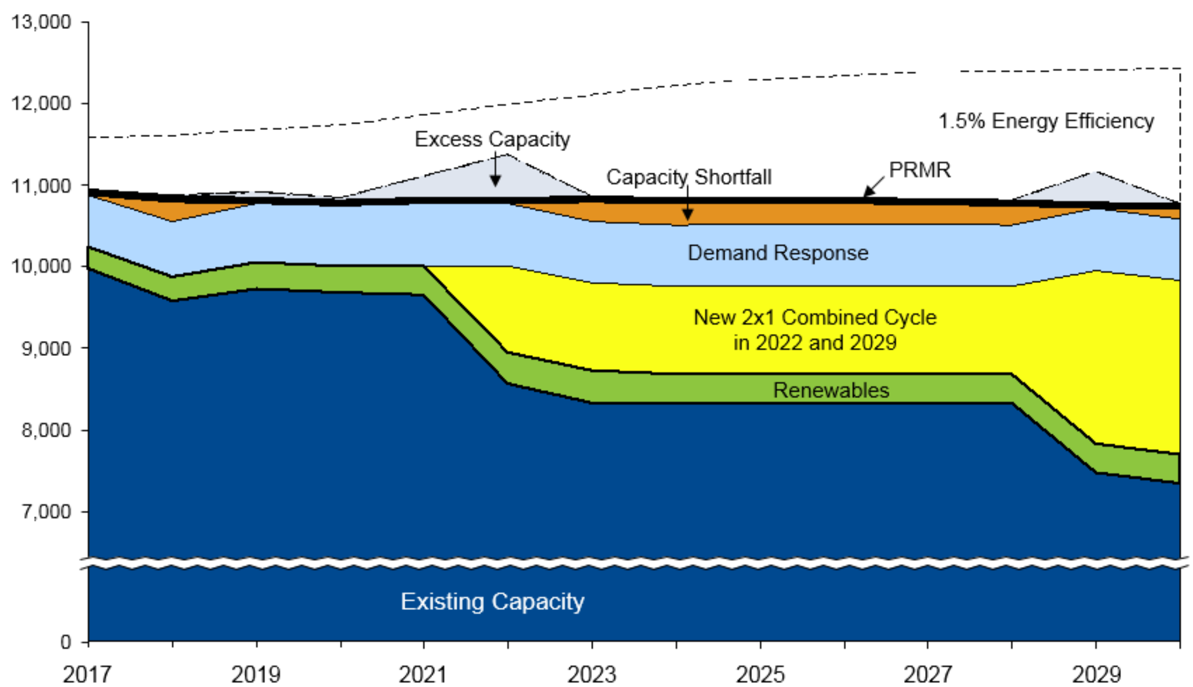
4. Energy Efficiency: Consumers Energy is currently targeting energy efficiency savings of 1.5% in its service territory. However, energy efficiency is not a viable option as it cannot replace the entire 1,100 ZRCs and the 880,000 MWh of energy that would otherwise be provided by the Project. Additionally, the energy efficiency programs would need significant time to build up sufficient savings to replace Ludington.

5. Demand Response: The uncertainty and limited potential of Demand Response programs make it an insufficient option to consider as a replacement for Ludington. The uncertainty is due to dependency on customers to commit to the program. Additionally, Demand Response programs can only account for the capacity needs and not the energy requirements created by loss of Ludington. This would result in a greater reliance on the MISO energy markets. Finally, like energy efficiency, these programs take significant amounts of time to implement.

**DTEE**

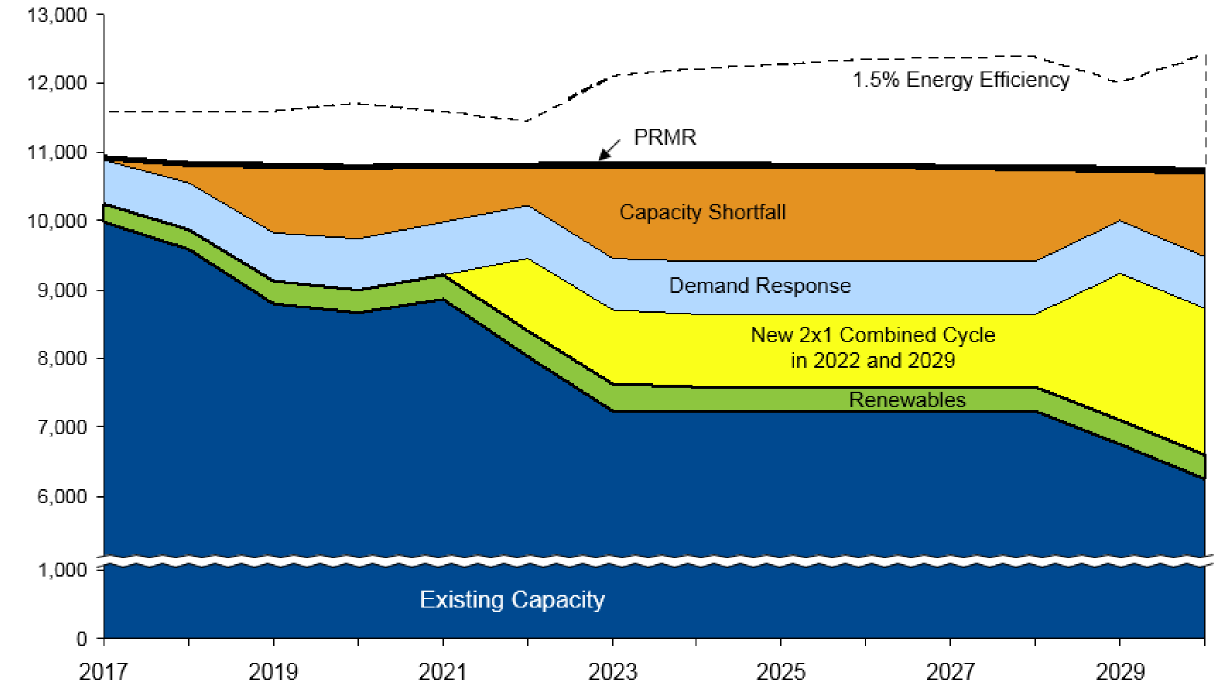
Currently, DTEE has sufficient capacity and energy to meet the need of customer demand which includes Ludington as a vital resource. Below, the 2017 Integrated Resource Plan ("IRP") is shown with Ludington included in the Existing Capacity.

**2017 DTEE IRP CAPACITY POSITION**



If Ludington was not relicensed, it would put DTEE in a significant capacity shortage position starting in 2019. The projected capacity shortfall in 2019 without Ludington would be 930 MW. With 2019 being close in the horizon, there is not a suitable replacement that could be implemented within the timeframe. (The PRMR, used in the graphs, identifies the total capacity needed to meet the MISO reserve requirements for DTEE.) Below is a depiction of how DTEE's capacity position would change if Ludington was no longer in operation.

**2017 DTEE CAPACITY POSITION WITHOUT LUDINGTON**




## Cost and Availability of Alternative Power Sources

If a license to operate the Project is not received, the Licensees, and its customers, would incur short-term and long-term increased costs resulting from the necessary acquisition of replacement capacity and energy. The DTEE average cost of producing electricity at the Project was $22.39/MWh in 2016. Production costs are expected to change annually by the change in Consumer Price Index. This estimate is based on historical routine O&M expense, including Commission fees, property taxes, labor costs, and routine/repetitive non-labor costs. It also includes an estimate of annual depreciation expenses non-routine construction and maintenance and license initiatives. The estimate assumes annual generation of approximately 2,357,066 MWh, which is an average annual generation produced by the Project between October 1999 and September 2016.

The following chart identifies alternative new construction power sources, including the cost and availability associated with each one. The sources shown below cannot be built and operational between now and 2019 to replace Ludington.

**ALTERNATIVE POWER SOURCES (NEW CONSTRUCTION)**

| | *Combined Cycle* | *Combustion Turbine* | *Wind* | *Solar* | *Biomass* | *Nuclear* | *Pulverized Coal w CCS* |
|---|---|---|---|---|---|---|---|
| *Capital Cost ($/kW)*[1] | $1,055 | $917 | $2,162 | $2,277 | $5,328 | | $7,341 |
| *Levelized cost of energy ($/MWh)* | $65 | $166 | $69 | $125 | $189 | $178 | $183 |
| *Availability (%)* | < 90% | < 90% | > 40% | > 20% | < 90% | < 90% | < 90% |

Other alternative power sources such as new capacity at existing units, off-system power purchase, and load management measures are explained in further detail below:

- Battery is another new construction alternative power source. Similar to Ludington, battery can store energy produced during periods of low demand and prices and sell during periods of higher demand and prices. Energy Storage Systems ("ESSs") can also increase the value of renewable energy systems by storing and shifting renewable energy output to times of greater system need or to avoid curtailment. Despite the benefits of battery, it is not a suitable replacement for an approximate 1,000 MW replacement for Ludington. Lithium-ion battery has a large block size of 100 MW, dispatch of four hours and only has a projected service life of ten years. The estimated capital cost is $600/kW.

- New capacity at existing units is not feasible due to the aging infrastructure of the facilities. Since the Company is planning to retire its Tier 2 coal units by 2023, the current spend of those plants are only sufficient to maintain the operations, reliability, and safety until the planned retirements and does not allot for additional investments. Any other potential up-rates would not be substantial enough to replace Ludington or cost effective to even consider for analysis.

- Off system power purchases is not a reliable alternative power source. Based on the recent MISO 2017/2018 PRA results, Zone 7 does not have sufficient capacity to meet its PRMR without relying on imported capacity from the rest of MISO. Considering MISO as a whole, there is great uncertainty concerning the continued operation of capacity resources owned by Independent Power Producers, MISO capacity market construct and declining generator unit performance. The amount of off system power purchases needed to replace Ludington is significant and with the projected tightening of the market, there will not be availability or the market cost would be extremely high.

- Demand Response is not a viable resource to replace Ludington. The amount of Demand Response needed to support the loss of capacity if Ludington was not relicensed is not feasible. There is uncertainty around the ramp up of the programs, including customer commitment rates and customer retention. Additionally, Demand Response programs are suitable replacements for capacity and not energy. Any replacement for Ludington would also have to support the loss of generation.

- Energy Efficiency is not a viable replacement for Ludington. An energy efficiency potential study was conducted in 2016 and is the basis for the 2017 DTEE IRP for energy efficiency implementation. In the 2017 DTEE IRP, an annual energy efficiency savings target of 1.5% will be implemented, capturing all the potential energy efficiency in its service territory.

Ludington reduces Power Supply Cost Recovery expense for customers by taking advantage of the price arbitrage between on and off peak energy prices. Ludington can store energy during periods of low demand and supply energy during periods of high demand.

ESSs are expected to provide balance to intermittent generation supplied from renewable energy resources. ESSs can increase the value of renewable energy by storing renewable energy or avoiding curtailment. Benefits of Ludington include fast start capability, frequency regulation, and providing spinning and supplemental reserve. Off system power purchases serves as the only feasible alternative to replacing Ludington generation by 2019, but is an unreliable long-term solution for meeting future energy demand.

There is value in the relicense of an existing resource in that there is no need for a large capital expenditure that would be required for new technologies.

**Table 4: Annual Cost of Alternatives Sources**

| | Combined Cycle | Combustion Turbine | Wind | Solar | Biomass | Nuclear | Pulverized Coal w CCS |
|---|---|---|---|---|---|---|---|
| *Capital cost ($/kW-yr)* | $97 | $102 | $122 | $154 | $456 | $761 | $599 |
| *Fuel costs ($/kW-yr)* | $253 | $258 | $0 | $0 | $509 | $110 | $349 |
| *Fixed O&M ($/kW-yr)* | $43 | $52 | $22 | $15 | $118 | $166 | $73 |
| *Variable O&M ($/kW-yr)* | $25 | $15 | $5 | $0 | $80 | $0 | $104 |
| *Insurance ($/kW-yr)* | $0 | $0 | $1 | $1 | $2 | $3 | $3 |
| *Emissions costs ($/kW-yr)* | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| *Taxes ($/kW-yr)* | $38 | $40 | $39 | $41 | $161 | $410 | $312 |
| *Levelized cost of energy ($/kW-yr)* | $456 | $467 | $188 | $211 | $1,325 | $1,451 | $1,440 |
| | | | | | | | |
| *Useful Life (Years)* | 30 | 30 | 27 | 20 | 30 | 40 | 40 |
| *Availability (%)* | < 90% | < 90% | > 40% | > 20% | < 90% | < 90% | < 90% |
| *Concerns* | T | T | A, T | A, T | C, T | C, T | C, T |

Values represented in Table 4 are consolidated assumptions from a third-party engineering study and internal subject matter experts.

**<u>Concerns Key:</u>**

A – Availability: Intermittent resources, may not be available during peak demand. Does not provide significant ancillary service benefit;

C – Cost: Cost of project is significantly higher than alternative options; and

T – Timeline: Timing constraints with implementing project by 2019.

**Enclosure 2**

Responses to Schedule B – Additional Information

**Schedule B**

**ADDITIONAL INFORMATION**

**Exhibit A – Project Description**

(1) Exhibit A, table A-1-1 of the final license application (FLA), provides the rated capacities of the pump/turbines and the motor/generators but does not provide the type of the pump/turbines (i.e., Francis, Kaplan, etc.) and the make of the motor/generator (i.e., General Electric, etc.) and their corresponding specifications. Please provide this information.

**Response:**

The new pump/turbine runners are Francis type manufactured by Toshiba Corporation of Tokyo, Japan having an authorized installed hydraulic capacity of 12,715 cubic feet per second as a turbine. The rebuilt motor/generators consist of new stator components (i.e., the frame, core, windings, and air coolers) also manufactured by Toshiba and refurbished rotor field poles having an authorized installed capacity of 297.5 MW with a nameplate (maximum) rating of 60 cycle, 455 mva at 40C and unity (1) power factor.

(2) Exhibit A, page A-2-1 of the FLA gives the Lake Michigan water surface elevation as 581 feet National Geodetic Vertical Datum (NGVD) 29, but Exhibits F2 and F4 state this elevation as 579.5 feet. The Exhibit Fs do not contain a note specifying which datum is used, although we assume it is also NGVD 29. Please reconcile this difference throughout the application as necessary.

**Response:**

The license exhibits were searched for reference to National Geodetic Vertical Datum ("NGVD") for consistency. Exhibits A, B and E all refer to NGVD 29, with Section 4.1.3 of Exhibit E the only exception where only NGVD is included in the statement. This Section is revised to read as follows:

4.1.3 Topography

The Project is located on the eastern shoreline of Lake Michigan, near Ludington, Michigan. Topography in the Project area ranges from less than 600 feet NGVD 29 along the shore of Lake Michigan to over 950 feet along the upper reservoir; natural topography in the Project vicinity ranges from less than 600 feet above sea level to approximately 850 feet above sea level (USGS 2016). The Project Area is characterized by rolling hills and dunes generated by lake-driven winds (Kost 2007).

The Exhibit F drawings have been revised. Lake Michigan water level elevation references have been revised to elevation 581.0 ft to be consistent with the text included in the other exhibits. Exhibit F drawings (F1 through F6) provided with the Final License Application ("FLA") included a note (located above the title block in the lower right hand corner) indicating that all elevations were based on NGVD 29. The only exception being Exhibit F sheet F7, depicting the barrier net details, this drawing does not refer to specific elevations and thus does not require the note to be added. Revised Exhibit F drawings are filed separately as they contain CEII.

(3) Exhibit A, page A-5-1 of the FLA identifies nine step-up transformers as existing equipment at the Ludington Pumped Storage Project (Ludington Project) without giving their specifications. Please provide the transformer specifications including the power from which it steps-up to the power it steps-up (i.e., step-up from 13.8-kilovolts (kV) to 345-kV).

**Response:**

There are nine single phase 60Hz, 65°C rise, Oil Forced Air Forced, 310MVA step-up transformers, 19,500V to 199,200V manufactured by Mitsubishi Electric Power Products, Inc.

**Exhibit B**

(4) Exhibit B, page B-2-1 of the FLA states that the dependable capacity of the project is 1,785 megawatts. Please provide the value of the Ludington Project dependable capacity in dollars per kilowatt-year.

**Response:**

The value of capacity for any resource within the utility's portfolio can be estimated based on current market rates for capacity. The Midcontinent Independent System Operator ("MISO") Planning Resource Auction ("PRA") is an annual capacity auction in which load serving entities secure sufficient capacity to cover their Planning Reserve Margin Requirement on behalf of their customers. Simultaneously, owners of supply resources sell their capacity into the PRA. Clearing prices are determined accordingly and indicate the value of capacity on the open market. Additionally, parties may conduct bilateral transactions for the purchase of capacity in advance of the annual PRA. Both of these mechanisms provide an indication the value of capacity.

Consumers Energy Company's ("Consumers Energy" or the "Company") point of view is that the value of capacity will fall somewhere between 50% and 75% of the Cost of New Entry ("CONE") as filed by MISO with the Federal Energy Regulatory Commission ("FERC" or the "Commission"). The latest filing made by MISO to the FERC indicated a CONE value for planning year 2018 of $90,740/ Zonal Resource Credits ("ZRC")-year. That means, Consumers Energy expects Ludington to provide a capacity value between $45,370/ZRC-year and $68,062/ZRC-year.

While the Ludington Pumped Storage Project's ("Project") dependable capacity is 1,785 MW, it should be noted that the Project is expected to provide over 2,200 ZRCs.

A ZRC represents 1,000 KW of capacity, discounted for the resource's equivalent forced outage rate on demand. Based on the above values expressed in ZRCs, the dollars per kilowatt-year ("kW-yr") equivalent is $45.37/kW-yr to $68.06/kW-yr.

(5) Exhibit B, page B-3-1 of the FLA provides information on how the power generated at the project would be used. To assist us in determining the need for power, please provide a statement of the system and regional power needs.

**Response:**

Power generated at Ludington is used for a number of applications. Energy produced at Ludington serves customers in both Consumers Energy's and DTE Electric Company's ("DTEE") (collectively, "Licensees") systems and within the regional market. Specifically, Consumers Energy's annual generation requirements total approximately 36,000 GWh, of that need, Ludington serves approximately 1,000 GWh annually. DTEE's annual generation requirements total about 46,000 GWh, of that need Ludington serves approximately 960 GWH annually. Within the MISO footprint generation requirements in 2016 totaled approximately 690,000,000 GWh, of which, Ludington generated nearly 2,000 GWh.

Ludington can store energy during periods of low demand and supply energy during periods of high demand. More information regarding capacity is provided in Exhibit H.

**Exhibit D**

(6) Exhibit D, page D-3-1 of the FLA provides a capital cost for additional maintenance upgrades of $264,000,000 and an additional capital cost of $76,300,000 unrelated to maintenance upgrades. Please give an itemized breakdown of these costs.

**Response:**

Table AIR 6-1 provides the requested breakdown of the expected non-upgrade capital costs from 2017 to 2021. The annual total was included in Exhibit D Table D-3.2-1.

Table Air 6-2 provides the requested breakdown of the expected remaining capital costs attributable for the completion of the unit upgrades. Note that this table does not include Allowance of Funds Used During Construction[1] ("AFUDC"), which reflects the capital carrying costs of these capital projects. These were not included as it is difficult to address these for the two Licensees, representing two separate companies which have differing accounting treatments and reporting.

[1] AFUDC is an accounting practice whereby the cost of debt and equity funds used to finance a construction project are credited on the statement of income and charged to a construction in progress on the balance sheet.

**Table AIR #6 -1 Balance of Plant Planned Capital Projects**

| Plant Project Title | 2017 ($1000) | 2018 ($1000) | 2019 ($1000) | 2020 ($1000) | 2021 ($1000) |
|---|---|---|---|---|---|
| Ludington Pumped Storage Relicensing | $986 | $150 | $150 | $0 | $0 |
| Replace Barrier Net Panels | $647 | $686 | $725 | $784 | $808 |
| Small Valves and Instrumentation | $98 | $98 | $98 | $98 | $98 |
| LPS Barrier Net Anchors | $135 | $141 | $0 | $0 | $0 |
| Small Tools & Equipment | $196 | $196 | $196 | $196 | $196 |
| LPS 16-422 Replace Potential Transformer Cabinets | $361 | $369 | $376 | $0 | $0 |
| LPS Step Up Transformer Replacement/Refurbishment | $14,300 | $11,718 | $10,200 | $0 | $0 |
| LPS Fire/Service Water Pressure Surge Correction | $49 | $588 | $0 | $0 | $0 |
| LPS 17-402 Governor Air Compressor Replacement | $147 | $0 | $0 | $0 | $0 |
| Small Pumps & Motors | $98 | $98 | $98 | $98 | $98 |
| LPS 16-402 Cooling Water Strainer Replacement | $151 | $1,671 | $0 | $0 | $0 |
| LPS 17-401 House Air Compressor Replacement | $471 | $0 | $0 | $0 | $0 |
| LPS 16-423 Replace Pony Motor Reactors | $71 | $745 | $75 | $776 | $0 |
| LPS 17-403 Depressing Air Compressor Controls Upgrade | $61 | $235 | $0 | $0 | $0 |
| LPS 15-301 Unit #1 Pony Motor Breaker Replacement | $0 | $0 | $645 | $0 | $0 |
| LPS 15-304 Unit #6 Pony Motor Breaker Replacement | $39 | $671 | $0 | $0 | $0 |
| LPS 14-305 Emergency Diesel Generator Overhaul/Replacement | $0 | $100 | $392 | $0 | $0 |
| LPS RTU Replace and Upgrade | $0 | $0 | $0 | $0 | $0 |
| LPS 16-424 HVAC Replacement | $524 | $2,663 | $2,718 | $2,773 | $2,827 |
| LPS16-401 Sequence of Events Recorder Replacement | $0 | $202 | $335 | $0 | $0 |
| LPS 19-420 Station Battery Replacement | $0 | $0 | $131 | $1,149 | $0 |
| LPS 14-303 Online Thrust Bearing Oil Moisture Analyzers | $0 | $0 | $0 | $0 | $39 |
| LPS-13-104 480 Volt Motor Control Centers for DLC | $0 | $0 | $0 | $0 | $5,294 |
| LPS 18-422 DLC Control Cable Replacement | $0 | $0 | $0 | $0 | $3,061 |

| | | | | | |
|---|---|---|---|---|---|
| LPS 18-401 CO2 Fire Protection System Replacement | $0 | $0 | $0 | $0 | $1,294 |
| LPS 20-420 Spare Station Power Transformer | $0 | $0 | $0 | $0 | $1,157 |
| LPS 16-420 Plant Lighting Upgrade | $0 | $0 | $0 | $0 | $722 |
| LPS 17-420 Bulk Turbine Oil Delivery Pipe | $0 | $0 | $0 | $0 | $98 |
| Annual Capital Estimates | $18,333 | $20,330 | $16,140 | $5,875 | $15,692 |

**Table AIR # 6-2 Overhaul Project Remaining Capital Estimates ($1000)**

| | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|
| **2017-2021 Long-Term Financial Plan** | 100,013 | 73,990 | 46,545 | 30,580 |
| **Engineering**<br>Contracted Engineering | 1,843 | 2,200 | 818 | 150 |
| **Major Contracted Work with Toshiba**<br>Major purchase orders with Toshiba to complete the primary work scope. | 65,571 | 44,153 | 17,356 | 250 |
| **Site Infrastructure Construction**<br>Site fabrication shop work, plant electrical systems upgrades, miscellaneous contracts, overhaul extra work. | 11,336 | 9,621 | 6,970 | 10,405 |
| **Owner Costs**<br>Plant security, project management, DTEE Support Services, corporate capital loadings. | 14,113 | 12,204 | 10,763 | 3,528 |
| **Risk Based Contingency** | 7,150 | 5,812 | 10,638 | 16,247 |

(7) Exhibit D, page D-4-1 of the FLA provides the average cost of the Ludington Project as $20,715,617 annually “based on 8-year period of analysis.” Please provide the 8 years used for this analysis and explain why the period of analysis is 8 years and not a longer or shorter period.

**Response:**

The years used for the analysis were 2009 through 2016. These years were used because Consumers Energy’s corporate accounting system was updated eight years ago and this data is readily available. Data prior to 2009 is not readily available. Table Air 7-1 provides the annual breakdown of the average costs (the values presented are in millions of dollars).

**Table AIR #7-1 Annual Breakdown of Average Costs**

| | 2009 (millions) | 2010 (millions) | 2011 (millions) | 2012 (millions) | 2013 (millions) | 2014 (millions) | 2015 (millions) | 2016 (millions) | Total (millions) | 8 Year Average (millions) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Direct Plant dollars** | $11.25 | $12.23 | $10.83 | $11.23 | $12.79 | $12.50 | $13.33 | $11.53 | $95.69 | $11.96 |
| **Net Maintenance & Effectiveness** | $1.92 | $2.16 | $2.17 | $2.24 | $2.43 | $2.26 | $2.40 | $3.04 | $18.62 | $2.33 |
| **Property Taxes Consumers Energy** | $5.87 | $5.86 | $5.97 | $6.10 | $6.20 | $6.52 | $6.93 | $7.95 | $51.40 | $6.43 |
| **DTEE** | $5.66 | $5.69 | $5.76 | $5.87 | $5.97 | $6.28 | $6.71 | $7.68 | $49.58 | $6.20 |
| **Total** | $24.70 | $25.89 | $24.73 | $25.45 | $27.39 | $27.56 | $29.38 | $30.19 | $215.3 | $26.92 |

(8) Exhibit D, section 4.0 of the FLA states that the average cost of the Ludington project includes operation and maintenance (O&M), the cost related to the seasonal barrier net, and local property and real estate taxes. Section 4.4 gives the O&M cost as $18,500,000, table D-4.6-2 gives the cost of the net as $3,285,000, and section 4.2 gives the property taxes as 7,945,529 in 2016. These costs add up to $29,730,529, excluding the real estate taxes which is not given in the FLA. Please explain why this figure differs from $20,715,614 given in section 4.0, and provide the cost of the real estate taxes, income taxes, depreciation, and costs of financing for each of the 8 years of analysis.

**Response:**

The costs that FERC summed cannot be simply added together because some costs are based on historical averages and other are anticipated costs for the current year. We address these issues in the comments below:

- In Exhibit D, Section 4.4, the $18.5 million is the estimated 2017 annual direct Operation and Maintenance ("O&M") cost. While not explicitly stated, this cost:
  - includes the expected 2017 barrier net costs for install/removal/cleaning and storage, and
  - does not include costs for taxes, depreciation or corporate support.
- In table D-4.6-2, the annual cost of the barrier net of $3.285 million is the 2016 annual cost of the barrier net. This cost contains an 11-year average barrier net panel replacement cost rather than the actual 2016 panel replacement cost.
- Property taxes were provided in Exhibit D, section 4.2 as $7.945 million. This value has been determined to represent only the Consumers property taxes. The actual 2016 local property taxes paid should be a sum of both the Consumers and DTEE property taxes. The DTEE property taxes for 2016 were $7.68 million. The total property taxes paid was $15.63 million. Table AIR 7-1 shows the Consumers and DTEE property tax payments from 2009 to 2016.

The above items cannot be directly totaled as they are a mix of estimated 2017 costs and actual 2016 costs. Comparing the total of $29.73 million to the $20.71 million is comparing a mix of 2016 actual and 2017 estimated costs to the eight-year average O&M cost that includes the barrier net cost and local taxes (the $20.71 million value has been determined to be a Consumers only value it will be revised to include the DTEE tax portion). Revision to the information discussed in Exhibit D will be provided in a separate filing. See the cover letter for the Licensees' request for an extension of time to properly account for Consumers and DTEE specific values.

The difficulty of estimating these numbers is related to dealing with two separate companies as owners and Licensees, and the fact that the costs are incorporated in the Licensees' consolidated businesses. Since the cost of taxes, depreciation, and financing for the Project are incorporated into costs of the Licensees' consolidated business and are not separated out for the Project, these are therefore not available for the eight year analysis (local property taxes are provided in AIR Table 7-1). A weighted average estimate can be made for capital costs and depreciation for the Project based on the percent ownership applied to the cost of capital and depreciation, then applied to the Project investment. Using this analysis we can estimate the cost of following:

**Table AIR 8-1 Weighted average cost of capital and depreciation**

| | Consumers (51%) (%) | DTEE (49%) (%) | Weighted average (%) |
|---|---|---|---|
| Cost of Capital | 8.58 | 7.98 | 8.29 |
| Depreciation | 3.42 | 3.22 | 3.32 |

Table 8-2 is based on the information in Table AIR 7-1, Table AIR 8-1 and total plant value (Exhibit D, Table D-2.2-1).

**Table AIR 8-2 Summary of Capital Costs, taxes, depreciation and O&M**

| | Dollars (millions $) | Notes |
|---|---|---|
| Capital costs (8.29%) | 51.81 | Based on a plant value of $624,991,472 (Exhibit D, Table D-2.2-1) |
| Property taxes<br>Consumers – $6.43 million<br>DTE electric – $6.2 million | 12.63 | 8 year average (per Table AIR 7-1, above) |
| Average annual Depreciation (3.32%) | 20.75 | Based on a plant value of $624,991,472 (Exhibit D, Table D-2.2-1) |
| O&M | 14.29 | 8 year average total of all direct plant costs and barrier net costs (per Table AIR 7-1, above) |

Note: See the cover letter for the Licensee's request for an extension of time to properly account for Consumers and DTEE specific values.

(9) Exhibit D, page D-4-1 provides the estimated cost for O&M as $18,500,000 in 2017 and states that the average cost of pumping was $22.01/megawatt per hour (MWh) in 2016. Multiplying the average pumping energy of 3,258,698 MWh (provided in table B-1.4-1) with the average cost of pumping of $22.01/MWh results in pumping energy cost of $71,723,943. This cost does not appear to be included in the calculation of the O&M cost and implicitly the estimated average cost of the total project provided in section 4 of Exhibit D. Please explain why the pumping cost is not included in the total project cost.

**Response:**

The cost of pumping for the Project is incorporated into the costs of the Licensees' consolidated business and is not separated out. When preparing a response it was discovered that the average cost of pumping, used as an overall project cost, was actually only the cost associated with Consumers Energy's pumping. At the time this response was prepared the cost of pumping associated with DTEE was not available, therefore revision to the information supplied in Exhibit D will be provided in a separate filing. See the cover letter for the Licensees request for an extension of time to properly account for the Consumers and DTEE specific values.

(10) Exhibit D, page D-5-1 estimates a total annual energy production of 2,658,200 MWh once all the upgrades are complete. Please provide an estimate of the average annual pumping energy needed once the upgrades are complete. Also, please give an estimate of the number of hours of generation and pumping for a typical week after all upgrades are complete.

**Response:**

There are no changes planned in how the project is currently operated, therefore, the hours of genertion and pumping will be similar to the historic average.

Based on the capacity factor of 17% (Exhibit B Section 1) and the increased authorized capacity of 297.5 MW the estimated annual production with all six units upgraded was provided in Exhibit D Section 5.0 as 2,658,200 MWH.

Exhibit B Table B-1.4- 1 provides the average annual generation and pumping energy based on the annual reports from October 1999 thru September 2016 as follows: annual generation of 2,375,066 MWH and annual pumping energy of 3,258,098 MWH.

The percent increase in generation would be 12% (2,658,200MWH/2,375,066MWH).

The corresponding increase in average pumping energy would be 3,649,742 MWH (or a similar 12% increase from 3,258,098 MWH).

On a weekly basis the generation would be 51,119 MWH (2,658,200MWH/52 weeks) and weekly pumping energy would be 70,187 MWH (3,258,742MWH/52 weeks).

It is difficult to estimate the number of hours per week that the units are either generating or pumping. Project unit operation depends on several factors including seasonal electric demand, electric transmission and distribution system conditions, and the Licensees differing generating and pumping demands for the units. Generation typically occurs during daytime hours Monday to Friday when system demands are high. Pumping typically occurs in the evenings and overnight hours during the week to recover some of the water used during generation during the day and on the weekends the reservoir is refilled in preparation for the next week's generation.

**Exhibit E**

***Aquatic Resources***

(11) Exhibit E, page E-4-20 of the final license application (FLA) provides data on the minisondes that continuously monitored water quality at two locations within Lake Michigan and one location within the project reservoir. Please clarify the depths at which each of the minsondes were deployed during data collection efforts in 2013.

**Response:**

Table 1 of the GLEC 2013 Water Quality Report, included as Appendix E-4 of Exhibit E contains the deployment information of the sondes utilized for the study, and is reproduced below. As shown the two sondes deployed in Lake Michigan were at a depth of about 11 meters while the sonde in the reservoir was at a depth of about 20 meters.

**Table 1. Description of Sampling Stations and Minisonde Locations.**

| Station | Latitude | Longitude | Depth (m)* |
|---|---|---|---|
| Lake Michigan 1 | 43.850000 | -86.455556 | 13.6 |
| Lake Michigan 2 | 43.879167 | -86.447222 | 5.9 |
| Lake Michigan 3 | 43.883350 | -86.455533 | 11.1 |
| Lake Michigan 4 | 43.891667 | -86.483333 | 19.0 |
| Lake Michigan 5 | 43.905556 | -86.459722 | 11.3 |
| Lake Michigan 6 | 43.913889 | -86.452778 | 6.1 |
| Reservoir 1R | 43.877180 | -86.423330 | 20.0 |
| Reservoir 2R | 43.886040 | -86.425060 | 19.9 |
| Reservoir 3R | 43.901890 | -86.431700 | 24.8 |
| Lake Michigan NW minisonde | 43.904050 | -86.461170 | 11.0 |
| Lake Michigan SW minisonde | 43.884570 | -86.458230 | 11.0 |
| Reservoir 1R minisonde | 43.877180 | -86.423330 | 20.0 |

*For Lake Michigan and Reservoir sites, depth is an average based on maximum depth measured during profiles. For minisonde sites, depth is based on one measurement taken at minisonde deployment.

(12) Exhibit E, page E-4-34 of the FLA states that a bathymetric survey was conducted for the licensees in April 2010; however, the results of this survey were not included in the FLA. Please provide a copy of this document.

**Response:**

A copy of the bathymetric survey results of the tailrace area is included as Attachment 1.

(13) Exhibit E, table E-4.3.3-8 of the FLA provides a cost comparison (in 2015 dollars) of feasible entrainment abatement technologies that were evaluated as part of the Ludington Pumped Storage Project Fish and Aquatic Resources Study-Evaluation of Entrainment Abatement Technologies (Phase 2). However, Exhibit E, table E-4.3.3-9 of the FLA provides a cost comparison (in 2016 dollars) of evaluated engineering alternatives that were analyzed as part of the Evaluation of Engineering Alternatives for Entrainment Reduction Study (Phase 3). To facilitate comparisons of these two tables, please provide a copy of table E-4.3.3-8 in 2016 dollars. Additionally, please ensure footnote 4 in table E-4.3.3-8 is attributed to a column within the table.

**Response:**

Table E-4.3.3-8 has been revised to show the costs as 2016 dollars. The Total Annual Costs (2016) table heading has been revised to include foot note 4. Additionally, footnote 5 was added providing a reference for updating the original 2015 cost estimates to 2016 values. The revised table is provided as Attachment 2

(14) Exhibit E, tables E-4.3.3.8 and E-4.3.3.9 of the FLA both contain a footnote no. 2 which states, "includes existing operation and maintenance effort required to maintain the barrier nets *when applicable*." Please clarify what is meant by "when applicable" and whether this statement applies to each row in both of the respective tables.

**Response:**

This footnote means that if the existing barrier net is compatible with an alternative and will remain in place (i.e. Existing Barrier Net with a Full-Scale Ultrasonic Deterrent System , in Phase II and Alternatives 20a and 20b in Phase III) then the costs to maintain the existing barrier net were included in the costs for that alternative.

(15) Exhibit E, page E-4-61 and table E-4.3.3.9 of the FLA state that the total annual cost for the proposed annual deployment/removal, operation, maintenance, and monitoring of the barrier net (i.e., barrier net program) is $3,200,000 (in 2016 dollars). However, Exhibit D, page D-4-6.2 provides a detailed breakdown of the various components of the proposed barrier net program and states that the total annual cost of the proposed barrier net program is $3,285,000 (in 2016 dollars). In addition, in table E-4.3.3-9, the sum of the annual operation and maintenance costs (including energy, labor, and component replacement) for the proposed barrier net program do not yield the total presented in the table (i.e., $3,200,000). Please clarify if the cost information presented in table E-4.3.3.9 is accurate and provide the total annual cost of the proposed barrier net program, including any revisions to table E-4.3.3-9, as necessary.

**Response:**

Exhibit D, Table D-4.6-1 was revised to reflect the actual total of the values in the table of $6,073,148 (a math error was discovered in the table included in the FLA). Exhibit E was revised to reflect the results from Exhibit D (the FLA values were based on using the actual 2016 panel replacement cost of $244,000 where-as Exhibit D utilized the 11-year average $300,000 panel replacement cost). Table E-4.3.3-9 (all barrier net costs were revised to reflect a total of $3,285,000 and the incremental changes were recalculated, on page E-4-61 $3,200,000 was revised to $3,285,000, Table E-5.3-1 is revised to show the 2016 annual cost of $6,073,148. The text in Sections 5.2.2 and 5.3 are revised to reflect the total 2016 cost of $6,073,148. The $/MWH in Section 5.3 would be changed to $2.58 $/MWH

**Table D-4.6-1: Summary of PME costs**

| Proposed Environmental Measure | Initial cost | Annual costs | Notes |
|---|---|---|---|
| Historic Properties Management Plan | $25,000 | $20,000 | $10,000 each for preparation of National Registry of Historic Places nomination forms estimated at $10,000 and an estimated $10,000 to provide protection of the two potentially eligible sites |
| Recreation Plan | $20,000 | $40,000 | $30,000 to Mason County for maintenance and $10,000 to maintain Port Sheldon |
| Barrier Net Program | | $3,285,000 | The details are provided |

| **Proposed Environmental Measure** | **Initial cost** | **Annual costs** | **Notes** |
|---|---|---|---|
| | | | below. |
| Periodic study of fish protection technology | | $6,000 | $30,000 every 5 years |
| Annual payments to GLFT | | $2,722,148 | Based on 2016 payment to GLFT; the annual payment would be adjusted by a scalar that is a composite of: (25%) CE increase in electric rates from the base case year of 1994, (25%) DTEE increase in electric rates from the base case year of 1994, and (50%) the cumulative implicit GNP deflator from 1994 through the year preceding the adjustment annual increases. |
| TOTAL | $45,000 | ~~$6,097,148~~ $6,073,148 | |

**<u>Exhibit E - page 4-61, Section 4.3.3.3</u>**

- Costs for the proposed fish protection measures in 2016 dollars are:
  - Annual deployment/removal, operation, maintenance, and monitoring of the barrier net - $~~3,200,000~~ $3,285,000.

**<u>Exhibit E page – 5.2, Section 5.2.2</u>**

The cost of all proposed PME measures at the Project is estimated to be $~~6.142~~ 6.118 million (in 2016 $) in the first year and $~~6.097~~ 6.073 million (in 2016 $) annually thereafter during the term of the license.

**<u>Exhibit E page – 5.2, Section 5.3</u>**

The cost of proposed PMEs total $~~6.097~~ 6.073 million annually with an additional one-time cost of $45,000 (occurring in 2019). (Exhibit D Section 4.6 and Table D-4.6-1 <u>and</u> Table E-5.3-1)

Based on expected annual generation of 2,357,000 MWH per year, the annual cost of the PMEs is $~~2.59~~ 2.58/MWH.

**Table E-5.3-1: Summary of PME costs**

| Proposed Environmental Measure | Initial cost (To Occur in 2019, using 2016 $) | Initial cost per MWH (2016 $) | Annual costs (2016 $) | Annual PME costs per MWH (2016 $) |
|---|---|---|---|---|
| Historic Properties Management Plan | 25,000 | 0.011 | 20,000 | 0.009 |
| Recreation Plan | 20,000 | 0.008 | 40,000 | 0.017 |
| Barrier Net Program | - | | 3,285,000 | 1.394 |
| Periodic study of fish protection technology (every 5 years) | - | | 6,000 | 0.003 |
| Annual payments to GLFT | - | | 2,722,148 | 1.155 |
| TOTAL | 45,000 | 0.019 | ~~6,097,148~~ 6,073,148 | 2.578 |

(16) Exhibit E, pages E-4-58 and E-4-60 of the FLA state that the licensees propose to continue funding the Great Lakes Fisheries Trust (GLFT) via mitigation payments for unavoidable fish entrainment losses at the project.[2] Under the licensees' proposal, annual funding of the GLFT would vary based on estimated fish entrainment losses each year, estimated at approximately $2,722,000 per year. Under the licensees' proposal, as described on pages E-4-46 through 47 of the FLA, the GLFT would continue its current functions, including allocating funds provided by the licensees to various entities to protect and restore the Great Lakes fishery. Specifically, the FLA states that the GLFT allocates the funds provided by the licensees to nonprofit organizations, educational institutions, and government agencies to enhance, protect, and rehabilitate Great Lakes fishery resources with grants giving preference to Lake Michigan projects with a focus on: (1) research directed at increasing the benefits associated with Great Lakes fishery resources; (2) rehabilitation of lake trout, lake sturgeon, and other native fish populations; (3) protection and enhancement of fisheries habitat, including Great Lakes wetlands; (4) public education concerning the Great Lakes fisheries; and (5) acquisition of real property for the above purposes, or to provide access to the Great Lakes fisheries.

The Commission in its Policy Statement on Hydropower Licensing Settlements[3] (Settlement Policy Statement) notes that it is the Commission's preference that there should be specific protection, mitigation, and enhancement measures that have a clear nexus to the project (i.e., a relationship between project effects or purposes and a proposed measure must be established) rather than broad funding measures. The Commission also noted that it prefers that measures are physically or geographically as close to the project as possible. The Commission noted that without specific measures that meet these criteria, Commission staff cannot evaluate the environmental effects of a measure or its nexus to the project. The Commission also noted in its Settlement Policy Statement that the Commission prefers measures that are within the scope of its jurisdiction, as the Commission has no jurisdiction over any party (e.g., the GLFT) to a hydroelectric licensing proceeding other than the licensee. Therefore, typically the Commission requires the licensee to undertake particular measures that it determines are necessary to fulfill a project purpose.

Accordingly, please describe how your proposal to provide annual funding to the GLFT is consistent with the Commission's policy described above.
Alternatively, please revise your proposal to include specific measures that fulfill a project purpose. Should you decide to revise your proposal, it may require revisions to other exhibits in the license application. Therefore, if your proposal changes, please revise the necessary pages of the license application and submit the revised pages with

[2] A 1995 "State Settlement Agreement" reached by the courts and non-FERC agencies provided for the establishment of the Great Lakes Fisheries Trust ("GLFT") and annual compensation payments from the licensee to the GLFT.
[3] *See* the Commission's Policy Statement on Hydropower Licensing Settlements. 116 FERC ¶ 61,207 (2006).

your response. Also, please provide the capital and annual costs associated with any revised proposed measures.

**<u>Response:</u>**

In the FLA, the Licensees' proposed as mitigation continued payments to the Great Lakes Fisheries Trust ("GLFT"). At the time of FLA filing, no settlement agreement had been reached and the mitigation proposal assumed that the current payments of $2,722,000 to the GLFT would continue under a new license. Absent a settlement agreement, these payments would no longer be tied to the payments for continuing impacts to fish, as directed under the existing state Settlement Agreement. In order to conform to the Commission's policies, the Licensees would stipulate that, with regards to future funding, the GLFT include them in the decision-making for fund allocation and the payments would be made with the stipulation that the fund be used specifically for fish and aquatic resources habitat improvements and enhancements in the vicinity of the Project. Since the payments would no longer represent payments for fish impacts, the GLFT should be able to allow the Licensees to participate in decisions about the fund disbursement. Should a new settlement agreement be reached and filed with FERC, this proposed mitigation would be replaced by the conditions of the settlement agreement.

***<u>Terrestrial Resources</u>***

(17) Exhibit E, page E-4-129 of the FLA states that tree clearing is conducted as a maintenance activity, but only when northern long-eared bats are hibernating. Please specify the months in which tree clearing is suspended.

**<u>Response:</u>**

Tree cutting (for protection of northern long eared bats) will normally be conducted between October 1 and May 1, cuttings outside of this time period, if necessary, may be conducted following consultation with the United States Fish and Wildlife Service ("USFWS").

***Developmental Analysis***

(18) Exhibit E, page E-5-1 of the FLA states under the current annual costs of operation, maintenance, and administration the project revenue is $100,125,360 based on the average generation in table B-1.4-1 (2,357,066 MWh) and the "average production cost" is $52,231,120, which includes O&M costs, property taxes, and annual cost of capital and depreciation. Also, a pumping cost of $71,730,590 is provided in this section but there is no explanation of how it is figured in the calculation of project costs and benefits. Please provide a breakdown of each component item (O&M, taxes, capital and depreciation) and explain why this "average production cost" figure is different from the "estimated average cost of the total Project" of $20,715,617 provided in section 4.0 of Exhibit D. In addition, please provide an explanation of how the pumping cost is figured into the calculation of project costs and benefits.

**Response:**

The cost of pumping for the Project is incorporated into the costs of the Licensees' consolidated business and is not separated out. When preparing a response, it was discovered that the average cost of pumping, revenue and production costs (all in $/MWH) were used as an overall project cost, the values provided were determined to be associated with Consumers Energy only. At the time this Response was prepared, the values associated with DTEE were not available, therefore revision to the information supplied in Exhibits D and E will be provided in a separate filing. See the cover letter for the Licensees' request for an extension of time to properly account for the Consumers and DTEE specific values.

(19) Exhibit E, page E-5-2 of the FLA states "Under the Proposed Action the average value of Project power is expected to remain the same as the No-Action Alternative, valued at $100.1 million." However, after all upgrades are done, based on the estimate of total annual generation of 2,658,200 MWh as given in section 5.0 of Exhibit D, the value of project power should be $112,920,336 if the 2016 energy value of $42.48/MWh is used. Please explain why the No-Action Alternative generation was used in the calculation of the value of power for the Proposed Action Alternative.

**Response:**

Under the No Action Alternative, the assumptions were that the Licensees would "continue Project operations under the terms and conditions of the current license, including maintaining the current Project boundary, facilities, existing PME measures listed below, and operation and maintenance procedures." Under the Proposed Action, "the Licensees would continue to operate the Project as it currently does under the current license. The unit upgrades will be completed as will several other planned capital projects. (Table D-3.2-1) The total capital expenditures planned for 2019 to 2021 are $67.1 million in 2019, $36.9 million in 2020 and $15.7 million in 2021." Later in this section Consumers Energy states that: "Under the Proposed Action the average annual value of Project power is expected to remain the same as the No-Action Alternative, valued at $100.1 million."

The reason the average annual value of generation would remain the same under both scenarios is because the unit upgrades were approved under the current license and are not proposed as a developmental increase under a new license.

FERC is correct in its statement in AIR 19 that the value of the energy produced would be based on a higher estimate of total annual generation and should have been identified as $112,920,336, and not $110.1 million. Exhibit E should be corrected to state that:

> Under the Proposed Action the average annual value of Project power is expected to remain the same as the No-Action Alternative, valued at $112,920,336.

It should be noted here that the average annual generation value was calculated using a Consumers Energy-only revenue rather than overall Project revenue (Consumers Energy plus DTEE). Section 5.0 will be revised to include the DTEE values and provided in a separate filing. Revision to the information supplied in Exhibits D and E will be provided in a separate filing. See the cover letter for the Licensees' request for an extension of time to properly account for the Consumers and DTEE specific values.

***Appendices***

(20) Appendix E-4, *GLEC Water Resources Report*, includes a list and description of appendices (A through E) in the table of contents that were cited throughout the report. However, these appendices were not included as part of the FLA. Please provide a copy of these appendices.

**Response:**

The Appendices to the GLEC -2013 are included as electronic files as Attachment 3. The files consisting of:

Appendix A;
Appendix B;
Appendix C;
Appendix D; and
Appendix E.

(21) Appendix E-5, *Response to Draft License Application Comments* (response no. 22), states that additional information on lake sturgeon stocking efforts in the Lake Michigan within 100 miles of the project is provided in Exhibit E, section 4.3.3; however, this information is not present in Exhibit E. Please provide this information.

**Response:**

Table AIR 21-1 displays the Lake Sturgeon stocking history from 2004 to 2016 in the Lake Michigan drainage within approximately 100 miles of the Project as provided by the Michigan Department of Natural Resources ("Michigan DNR") database. Additional information was also provided by the Little River Band of Ottawa Indians ("LRBOI") who conduct streamside rearing and stocking efforts on the Manistee River.

While not specifically requested by the Commission at this time, the Licensees are providing additional Lake Sturgeon information that was requested during evaluation of the Draft License Application and was inadvertently omitted from the FLA.

Personal communication with Mr. Robert F. Elliot (USFWS, Green Bay Fish and Wildlife) has confirmed that there is no lake sturgeon stocking planned for Mason County, Michigan (Personal Communication via email.) According to Mr. Elliot: "*There is no lake sturgeon stocking going on in Mason County, Michigan, and most if not all lake sturgeon stocking going on in Michigan involves fall fingerling (6-8") size fish reared in streamside rearing facilities, no stocking of "fry." In general, the only place that "fry" are periodically stocked is into the Black River, tributary to Black Lake (a large inland lake), not a L. Michigan tributary. Restoration or reintroduction stocking into Michigan's Great Lakes waters is or has only occurred in 6 rivers in Michigan (4 in L. Michigan, 2 in L. Superior, and potential plans for 1 in L. Huron), but none is occurring in Mason County. The closest is in the Manistee River, north of Mason County that the Little River Band of Ottawa Indians (LRBOI) has been leading for over 10 years.*"

Scott Heintzelman (Unit Manager Central Lake Michigan Management Unit) and James Dexter (Division Chief) of the Michigan DNR have also indicated that there are no current plans for lake sturgeon stocking in Mason County (Personal Communication via emails on 4/21/2017).

It is also noteworthy that additional efforts are made to protect Young of Year ("YOY") lake sturgeon in tributaries where spawning and rearing occurs. The YOY lake sturgeon are susceptible to mortality from sea lamprey control efforts where lampricide is used. Late summer and early fall is the time of year that the YOY lake sturgeon are gradually moving down stream and out of the rivers. Therefore, to minimize risk to these fish, lampricide applications in rivers that have lake sturgeon are generally conducted as late in the season as possible (e.g. applications made in September) to give the YOY lake sturgeon more time to leave the river before the treatment (Personal Communication via email from Mr. Robert Elliot, 9/11/17). To further protect these fish, the LRBOI, with support from the USFWS and others, has implemented efforts to collect YOY lake sturgeon prior to lampricide treatments. These fish are then placed in on-shore holding facilities until the potential effects of the treatment have expired and are then released back into the river from which they were collected. These efforts occurred on the

Manistee River in 2016 and the Muskegon River (approximately 60 miles south of LPSP) in 2017.

Entrainment of lake sturgeon at the LPSP is likely low. Fingerling and larger sturgeon are physically excluded by the barrier net (mesh size of ½ in near shore and ¾ in in deeper areas). While Sturgeon fry would not be excluded by the net, they would be expected to be located near spawning areas. Spawning area habitat primarily includes tributary streams, which are not located in the immediate vicinity of the LPSP. While spawning habitat can occur within the lake environment, it has not been documented near the LPSP. Therefore, the potential for entrainment of lake sturgeon fry is low. During the cold weather season, the barrier net is not deployed and therefore does not protect lake sturgeon from entrainment. Lake sturgeon movement during this time of year however is expected to be limited[4]. This behavior combined with the fact that relatively few sturgeon are present results in a low likelihood of entrainment during the cold weather season.

[4] Carlander, K Handbook of Freshwater Fishery Biology. Vol 1, 1969, Iowa State University Press
http://www.nrcresearchpress.com/doi/abs/10.1139/z97-048#.WcEd_LKGOvE
https://www.fws.gov/midwest/sturgeon/documents/mcleod-debruyne-namakan-river-2009.pdf

**Table AIR 21-1: Lake Sturgeon Stocking Data for the Lake Michigan drainage within approximately 100 miles of the LPSP (2004 – 2016)**

| Stocking Location | Distance from LPSP | County | Operation | Date Stocked | Number Stocked | Average Length of Fish (in) |
|---|---|---|---|---|---|---|
| Kalamazoo River | ~100 miles south | Allegan | State Plant | 9/6/2011 | 30 | 8.26 |
| | | | State Plant | 9/24/2011 | 76 | 9.36 |
| | | | State Plant | 6/26/2013 | 2 | 3.07 |
| | | | State Plant | 9/6/2014 | 34 | 9.45 |
| | | | Tribal/DNR Coop | 7/28/2015 | 12 | 5.83 |
| Manistee River Rainbow Bend or Highbridge Sites | ~45 Miles North | Manistee | LRBOI* | 8/19/2004 | 3 | 6.06 |
| | | | LRBOI | 8/26/2005 | 11 | 5.00 |
| | | | LRBOI | 9/28/2005 | 40 | 6.50 |
| | | | LRBOI | 9/18/2006 | 51 | 8.07 |
| | | | LRBOI | 9/26/2006 | 35 | 8.58 |
| | | | LRBOI | 10/2/2006 | 3 | 9.53 |
| | | | LRBOI | 10/2/2006 | 3 | 9.72 |
| | | | LRBOI | 9/21/2007 | 29 | 8.86 |
| | | | LRBOI | 9/20/2008 | 41 | 7.20 |
| | | | LRBOI | 9/20/2008 | 6 | 7.40 |
| | | | LRBOI | 9/19/2009 | 34 | 6.77 |
| | | | LRBOI | 9/25/2010 | 74 | 6.34 |
| | | | LRBOI | 9/17/2011 | 23 | 7.52 |
| | | | LRBOI | 9/22/2012 | 28 | 9.17 |
| | | | LRBOI | 9/14/2013 | 363 | 5.9 |
| | | | LRBOI | 9/23/2013 | 8 | 4.57 |
| | | | LRBOI | 9/13/2014 | 91 | 6.57 |
| | | | LRBOI | 9/12/2015 | 241 | 7.24 |

*LRBOI is an acronym for the Little River Band of Ottawa Indians

**Exhibit F – General Design Drawings**

(22) The Exhibit F drawings provided in the FLA do not reference the vertical datum. Please show a vertical datum on each sheet that depicts a section or profile drawing. The datum should match the one referenced throughout the FLA.

**Response:**

The Exhibit F drawings have been revised. Lake Michigan water level elevation references have been revised to elevation 581.0 ft to be consistent with the text included in the other exhibits. Exhibit F drawings (F1 through F6) provided with the FLA included a note (located above the title block in the lower right hand corner) indicating that all elevations were based on NGVD 29. The only exception being Exhibit F sheet F7, depicting the barrier net details, this drawing does not refer to specific elevations and thus does not require the note to be added. Revised Exhibit F drawings are filed separately as they contain CEII.
(Refer to Schedule B Item Number 2.)

**Exhibit G – Project maps**

(23) Exhibit G-1 shows the project boundary for the Upper Reservoir and powerhouse. However, in the area depicted on Exhibit G-1, land near the removed right-of-way for the Ludington Project's switchyard and the 345 kV transmission lines, the project boundary is unclear. Please clearly identify the project boundary in this area on your Exhibit G-1 and provide the rationale for the boundary line.

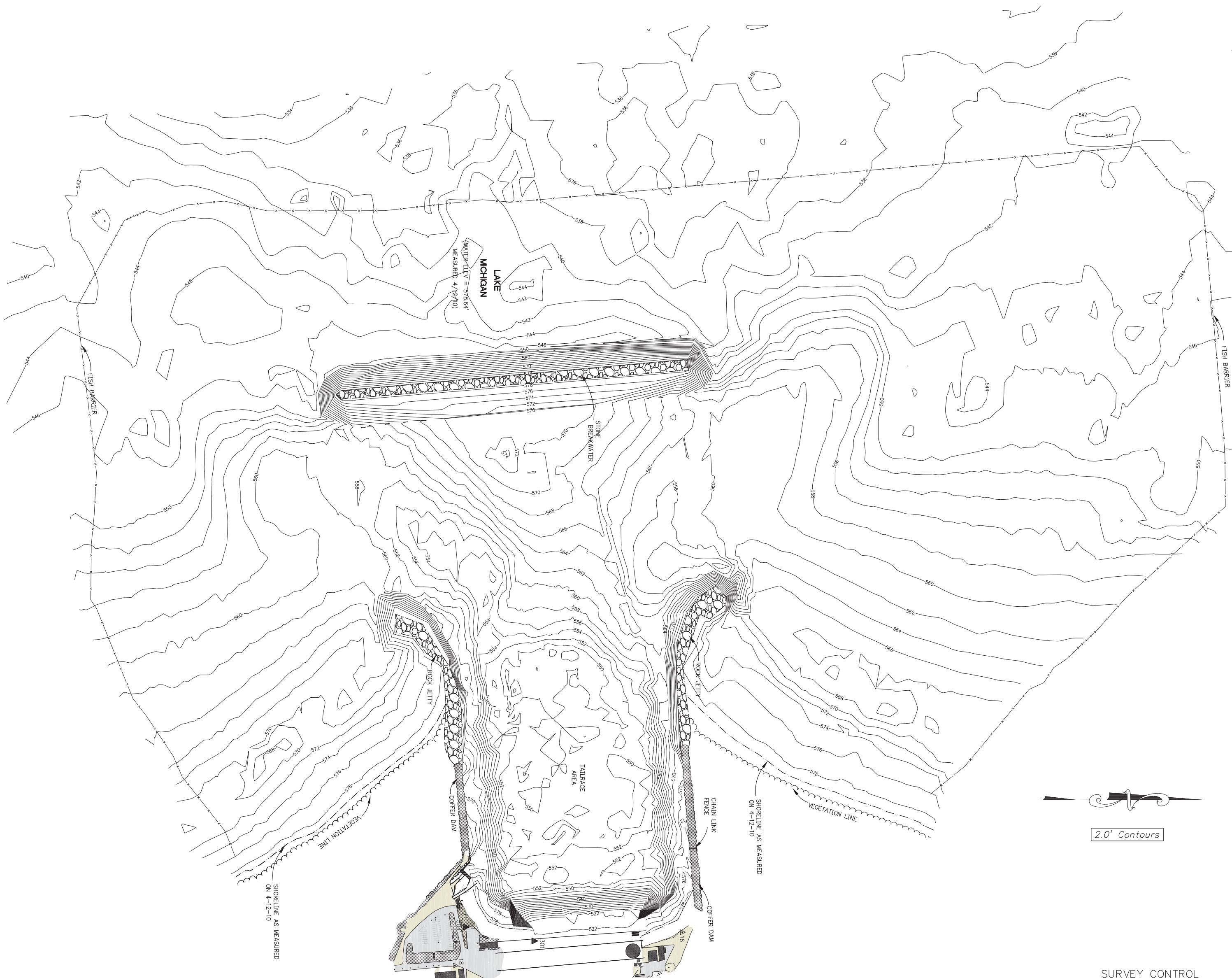
**Response:**

The area excluded from the project boundary for the transmission corridor has been more clearly defined on the revised Exhibit G-1 drawing. The transmission line corridor is a strip of land 350 feet wide centered along the transmission line pathway as depicted on the revised Exhibit G-1 drawing. Ordering paragraph F(b) of the February 1,2001 FERC Order ( 94 FERC ¶ 62, 122) approving the removal of the transmission line from the project boundary states:

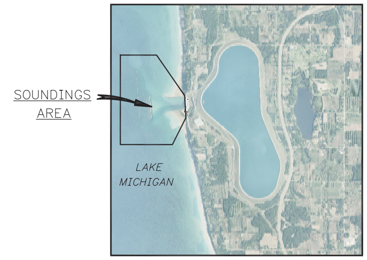
> The revised exhibit drawings shall show labels of "Non-Project Transmission Lines" and an indication added, describing that the switchyard and transmission strip are excluded from the project license by this Order.

**Schedule B - Attachment 1**

Schedule B Item 12 – Tailrace Bathymetric Survey Results




## LUDINGTON PUMP STORAGE FACILITY




## LOCATION MAP

NOT TO SCALE

Section 3 Town 17 North, Range 18 West,
Pere Marquette Township, Mason County, Mi.

## BASIS OF BEARING

The Ludington Pumped Storage Plant Coordinate System
(See Drawing 1140-G-0130, Sht. 1, Rev. 4)

## BASIS OF ELEVATION

PBM-1 – Found 3" brass monument inside 4" capped pipe surrounded by a 5' guard post enclosure, 73.5'± south of the soiuthern most storage building, 43'± east of the easterly edge of the main drive.
**Elev. = 610.373' (NGVD 29)**

## SURVEYORS REPORT

The purpose of the survey was to determine the existing bottom contour elevations within the waters of Lake Michigan in the area of the Tailrace channel and that portion encompassed by the Fish Barrier netting on the same coordinate system as the existing mapping for the Pump Storage Facility as mapped by Consumers Energy personal.

The Coordinate system was established by occupying (5) control positions (points 16, 17, 18, 301 and 5041) with published values as supplied by Consumers Energy. These points were observed using Leica System 1200 geodetic GPS receivers with real-time correction to the Michigan HARN system, establishing State Plane coordinates (NAD-83 Horizontal and NAVD-88 vertical) for these points. Using the newly established NAD-83 (the Coordinate system used to gather the sounding values) a transformation was performed to convert the NAD-83 values to the existing local Ludington Pumped Storage Plant Coordinate System.
The maximum residual between the 5 locations between the existing system and the NAD-83 and NAVD-88 systems were 0.05 feet in the Horizontal values and 0.01 feet in the vertical values. The shift in the vertical resulted in +0.36 feet between NAVD-88 and the Local system with a rotation angle of -0 deg 19' 40" in the Horizontal between NAD-85 and the Local system.

The Sounding data was gather using an Interspace Technology model 455 single beam echo sounder with a 8 deg 208 kHz transducer linked to a GPS receiver for Horizontal positioning. This system was configured to gather depths tagged with the horizontal coordinates in the Michigan NAD-83 horizontal positions and NAVD-88 elevations values at the transducer position. The data was acquired running lines on 50 foot spacing within the tailrace channel and 100 foot spacing in the open water area along lines parallel with the Tailrace wall at the plant. For quality assurance a bar check (a method of verifying the sounder is reporting the correct sounding depth) was performed at the start of the sounding day and at a maximum of 4 hour intervals and at the completion of the day. Additional checks were made by running transecting sounding lines a right angles to the parallel lines to verity the same depth values.
The depth elevations were derived by adding the sounding value to the transducer elevation value, resulting in NAVD-88 elevations. These sounding values in NAD-83 with NAVD-88 were than rotated and translated using the above correction values to agree with the Local Grid System.

Equipment used
Interspace Technology 455 XPE Hydrograph Echo Sounder Serial No. 242
Leica system 1200 GPS Receiver Serial No. 184136

## SURVEY NOTES:

1. Acquired sounding data was performed on a 50 foot grid system within the tailrace channel, and a 100 foot grid in the Lake Michigan portion of the project.
The grid system originated approximately 15 feet Westerly of and parallel with the tailrace wall, therefore the changes in grade may not be accurately delineated without a cross check between grid lines, especially in the area close to the tailrace end of the channel.

2. The location of the fish barrier depicted on this drawing was taken from aerial photography, and was not measured at the time of this survey.

3. The uplands portion of the Topographic survey provided by Consumers Energy, File No.SG 20467

## LEGEND

-- Section Corner
-- Survey Monument (As Noted)
-- Traverse Point
(R) -- Record
(M) -- Measured
-- Coffer Dam
-- Rock Jetty
-- Vegetation Line
-- Shoreline

## SURVEY CONTROL

| Number | Northing | Easting | Elevation | Desc. |
|---|---|---|---|---|
| 16 | 25966.0400 | -26971.9440 | 599.24 | TRAV PT |
| 17 | 25852.5040 | -26773.3000 | 599.66 | TRAV PT |
| 18 | 24868.4590 | -26810.5910 | 600.15 | TRAV PT |
| 301 | 25249.8480 | -26929.8080 | 600.65 | CONC MON |
| 5041 | 24918.5600 | -26996.9640 | 601.16 | GPS CONT. |

GRAPHIC SCALE

200 0 100 200 400 600

( IN FEET )
1 inch = 200 ft.

| | | | |
|---|---|---|---|
| DRAWING NO. | FIELD BOOK # | REFERENCE DRAWINGS | REV. DATE DESCRIPTION BY APP. REV. DATE DESCRIPTION BY |
| | F.B.# 1555 | SG-20467 Sheets 1-3 | |

| | | DATE |
|---|---|---|
| DR. | W.E. KEANE | 4-26-2010 |
| FLD. | TJM/ JW | 4-12-2010 |
| CHKD. | G.WILSON P.S. | 4-26-10 |
| APP. | | |
| APP. | DEPARTMENT HEAD | |

Consumers Energy

PH 231.946.5874
FAX 231.946.3703
WWW.gourdiefraser.com
123 W Front Street
Traverse City, MI 49684

Gourdie-Fraser
Municipal | Development | Transportation

# BATHYMETRIC SURVEY

CHARGE NO. 13448434

Sec. 3 T.17N., R.18W.,
Pere Marquette Township, Mason County, Mi.

| SCALE: 1" = 200' | DRAWING NO. | SHEET | REV. |
|---|---|---|---|
| ConEn FILE NAME: 20467bathymetric.dwg<br>GFA FILE NAME: 10080 | SG-20467Sheets 4-? | 4 | A |

**Schedule B - Attachment 2**

Schedule B Item 13 – Revised Exhibit E Table E-4.3.3-8

**Table E-4.3.3-8: Cost comparison of feasible entrainment abatement technologies (Alden 2015b)**

| Alternative | Initial Capital Costs[5] | | | Annual Costs[5] | | | | |
|---|---|---|---|---|---|---|---|---|
| | Total Project Construction Costs (2016 $) | Replacement Power During Construction (2016 $)[1] | Total Capital Costs (2016$) | Energy (2016 $)[1,2] | Labor (2016 $)[2] | Component Replacement (2016 $)[2,3] | Total Annual Costs (2016 $)[2,4] | Incremental Annual Costs (2016 $) |
| Existing Barrier Net | NA | NA | NA | $442,200 | $2,063,265 | $325,620 | $2,831,085 | $0 |
| Modified Barrier Net | $3,785,835 | $2,211,000 | $5,996,835 | $663,300 | $2,269,290 | $358,785 | $3,291,375 | $460,290 |
| Modified Barrier Net with Ultrasonic Anti-biofouling | $6,231,000 | $442,000 | $10,653,000 | $1,332,630 | $2,285,370 | $402,000 | $4,020,000 | $1,188,915 |
| Longer Barrier Net with ½-inch Bar Mesh | $10,630,890 | $4,569,735 | $15,200,625 | $0 | $4,4221,000 | $444,210 | $4,665,210 | $1,834,125 |
| Existing Barrier Net with a Full-Scale Ultrasonic Deterrent System | $16,000,605 | $2,947,665 | $18,948,270 | $889,425 | $2,153,715 | $665,310 | $3,708,450 | $877,365 |

1. Assumes 1,000 Mwh per day per Unit and a cost of $55 per MWh.
2. Includes existing O&M effort required to maintain the barrier net for the Existing Barrier Net with a Full-Scale Ultrasonic Deterrent System technology.
3. For the existing barrier net, net replacement is considered a capital cost by the owners.
4. Does not include annual fisheries compensation costs.
5. Original costs provided in Alden 2015b were provided in 2015 $. Cost presented here have been converted to 2016 $ based on conversion provided in: RSMeans Company Inc. (RSMeans). 2016. 2016 Heavy Construction Cost Data 30th Annual Edition. Copyright 2015. ISSN 0893-5602.

**Schedule B - Attachment 3**

Schedule B Item 20 – Water Quality Report Appendices

(Appendices A through D are provided in Excel)

# Water Quality Report Appendix E

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

Station: R1
Date/Time: 6/21/2013 / 8:30
GPS Coordinates: N 43.87118 , W 86.42333°
Crew: J. STRICKO , A. REITZ

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 11.34 | 11.64 | |
| 1.0 | 11.62 | 11.26 | X |
| 2.0 | 11.61 | 11.35 | |
| 3.0 | 11.33 | 11.58 | |
| 4.0 | 11.32 | 11.56 | |
| 5.0 | 11.34 | 11.56 | |
| 6.0 | 11.34 | 11.55 | |
| 7.0 | 11.29 | 11.55 | |
| 8.0 | 11.24 | 11.53 | |
| 9.0 | 11.26 | 11.53 | |
| 10.0 | 11.32 | 11.53 | |
| 11.0 | 11.30 | 11.51 | |
| 12.0 | 11.26 | 11.51 | |
| 13.0 | 11.25 | 11.51 | |
| 14.0 | 11.31 | 11.46 | |
| 15.0 | 11.31 | 11.45 | |
| 16.0 | 11.24 | 11.44 | |
| 17.0 | 11.30 | 11.45 | |
| 18.0 | 11.29 | 11.44 | |
| 19.0 | 11.28 | 11.42 | |
| 20.0 | 11.26 | 11.39 | |

| | Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|---|
| | 21.0 | 11.30 | 11.35 | |
| | 22.0 | 11.29 | 11.33 | |
| | 23.0 | 11.28 | ~~11.33~~ | 11.22 |
| | 24.0 | 11.37 | 11.15 | |
| | 25.0 | 11.36 | 11.06 | |
| | 26.0 | 11.27 | 11.02 | |
| | 27.0 | 11.35 | 11.02 | X |
| ~~27.5~~ | ~~28.0~~ | 11.35 | 11.01 | |
| 28.0 | | | | |
| | | | | |
| | | | | |
| DUP | 16.0 | 11.24 | 11.46 | |
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DO and Temp measurements are taken every 1 meter
turbidity samples are taken 1 meter below surface and 1 meter above bottom

LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT
2244-00

Station: R2
Date/Time: 6/21/2013 9:20am
GPS Coordinates: N 43.88604, W 86.42506°
Crew: J.STRICKO, A.REITZ

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 11.67 | 11.59 | |
| 1.0 | 11.59 | 11.60 | X |
| 2.0 | 11.36 | 11.60 | |
| 3.0 | 11.34 | 11.61 | |
| 4.0 | 11.32 | 11.59 | |
| 5.0 | 11.28 | 11.56 | |
| 6.0 | 11.26 | 11.56 | |
| 7.0 | 11.26 | 11.54 | |
| 8.0 | 11.26 | 11.53 | |
| 9.0 | 11.26 | 11.50 | |
| 10.0 | 11.24 | 11.49 | |
| 11.0 | 11.30 | 11.50 | |
| 12.0 | 11.25 | 11.50 | |
| 13.0 | 11.28 | 11.49 | |
| 14.0 | 11.30 | 11.50 | |
| 15.0 | 11.27 | 11.47 | |
| 16.0 | 11.26 | 11.47 | |
| 17.0 | 11.28 | 11.47 | |
| 18.0 | 11.31 | 11.46 | |
| 19.0 | 11.29 | 11.45 | |
| 20.0 | 11.27 | 11.44 | |

| | Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? | |
|---|---|---|---|---|---|
| | 21.0 | 11.25 | 11.43 | | |
| | 22.0 | 11.28 | 11.32 | | |
| | 23.0 | 11.26 | 11.27 | | |
| | 24.0 | 11.26 | 11.18 | | |
| | 25.0 | 11.31 | 11.14 | | |
| | 26.0 | 11.31 | 11.09 | X | DUP TURBIDITY |
| | 27.0 | 11.29 | 11.01 | | |
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| DUP | 7.0 | 11.22 | 11.53 | | |
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DO and Temp measurements are taken every 1 meter 27.5 m to BOTTOM
turbidity samples are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

| | |
|---|---|
| Station: | R3 |
| Date/Time: | 6/21/2013 10:03 |
| GPS Coordinates: | N 43.90189°, W 86.43170° |
| Crew: | |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 11.67 | 11.62 | |
| 1.0 | 11.59 | 11.63 | X |
| 2.0 | 11.52 | 11.64 | |
| 3.0 | 11.45 | 11.65 | |
| 4.0 | 11.42 | 11.57 | |
| 5.0 | 11.43 | 11.56 | |
| 6.0 | 11.40 | 11.55 | |
| 7.0 | 11.38 | 11.54 | |
| 8.0 | 11.37 | 11.55 | |
| 9.0 | 11.36 | 11.55 | |
| 10.0 | 11.30 | 11.56 | |
| 11.0 | 11.34 | 11.55 | |
| 12.0 | 11.31 | 11.52 | |
| 13.0 | 11.30 | 11.53 | |
| 14.0 | 11.31 | 11.53 | |
| 15.0 | 11.32 | 11.52 | |
| 16.0 | 11.32 | 11.52 | |
| 17.0 | 11.34 | 11.51 | |
| 18.0 | 11.27 | 11.49 | |
| 19.0 | 11.28 | 11.49 | |
| 20.0 | 11.30 | 11.48 | |

| | Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|---|
| | 21.0 | 11.27 | 11.49 | |
| | 22.0 | 11.28 | 11.49 | |
| | 23.0 | 11.26 | 11.49 | |
| | 24.0 | 11.27 | 11.49 | |
| | 25.0 | 11.25 | 11.49 | |
| | 26.0 | 11.28 | 11.49 | |
| | 27.0 | 11.27 | 11.49 | |
| | 28.0 | 11.26 | 11.49 | |
| | 29.0 | 11.23 | 11.49 | |
| | 30.0 | 11.26 | 11.49 | |
| | 31.0 | 11.25 | 11.49 | |
| | 32.0 | 11.23 | 11.50 | |
| | | | | |
| | | | | |
| DUP | 5.0 | 11.33 | 11.58 | |
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DO and Temp measurements are taken every 1 meter

DEPTH = 32 M

turbidity samples are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** Lake MI 1
**Date/Time:** 6/20/13 1523
**GPS Coordinates:**
**Crew:** JS, MLV, DJ, AR

| | Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|---|
| | Surface | 11.51 | 14.16 | |
| | 1.0 | 11.52 | 12.69 | X |
| | 2.0 | 11.62 | 11.92 | |
| | 3.0 | 11.58 | 11.54 | |
| | 4.0 | 11.67 | 11.19 | |
| | 5.0 | 11.90 | 10.71 | |
| | 6.0 | 11.87 | 10.54 | |
| | 7.0 | 11.99 | 9.60 | |
| | 8.0 | 12.48 | 7.64 | |
| | 9.0 | 12.52 | 7.28 | |
| | 10.0 | 12.64 | 7.02 | |
| | 11.0 | 12.50 | 6.87 | X |
| Bottom | 12.0 | 12.62 | 6.58 | |
| | 12.5 | | | |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| | | | |

DO and Temp measurements are taken every 1 meter
turbidity samples are taken 1 meter below surface and 1 meter above bottom

LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT
2244-00

Station: Lake MI - Station 2
Date/Time: 6/20/13 1546
GPS Coordinates:
Crew: MLV, JS, AR, DJ

| | Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|---|
| | Surface | 11.45 | 15.01 | |
| | 1.0 | 11.76 | 12.46 | X |
| | 2.0 | 11.71 | 11.96 | |
| | 3.0 | 12.19 | 11.16 | |
| | 4.0 | 12.45 | 10.86 | X |
| Bottom | 4.96 ~~5.0~~ | 12.51 | 10.85 | |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| | | | |

DO and Temp measurements are taken every 1 meter
turbidity samples are taken 1 meter below surface and 1 meter above bottom

## LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT
## 2244-00

**Station:** Lake MI – Station 3
**Date/Time:** 6/20/13 1601
**GPS Coordinates:**
**Crew:** JS, MLV, DJ, AR

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 11.98 | 11.36 | |
| 1.0 | 11.93 | 11.27 | |
| 2.0 | 11.88 | 11.25 | |
| 3.0 | 11.84 | 11.25 | |
| 4.0 | 11.85 | 11.24 | |
| 5.0 | 11.87 | 11.22 | |
| 6.0 | 11.83 | 11.22 | |
| 7.0 | 11.84 | 11.21 | |
| 8.0 | 11.85 | 11.22 | |
| 9.0 | 11.84 | 11.21 | |
| 10.0 | 11.83 | 11.19 | |
| 10.5 | 11.78 | 11.19 | |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
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DO and Temp measurements are taken every 1 meter
turbidity samples are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** Lake MI - Station 4
**Date/Time:** 6/20/13 1612
**GPS Coordinates:**
**Crew:** MLV, JS, DJ, AR

| | Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|---|
| | Surface | 11.64 | 13.97 | |
| | 1.0 | 11.69 | 12.84 | X |
| | 2.0 | 11.82 | 12.05 | |
| | 3.0 | 11.82 | 11.65 | |
| | 4.0 | 11.85 | 11.32 | |
| | 5.0 | 11.80 | 11.24 | |
| | 6.0 | 11.81 | 11.06 | |
| | 7.0 | 11.90 | 10.76 | |
| | 8.0 | 11.95 | 10.40 | |
| | 9.0 | 12.08 | 9.91 | |
| | 10.0 | 12.37 | 8.19 | |
| | 11.0 | 12.67 | 7.01 | |
| | 12.0 | 12.56 | 6.19 | |
| | 13.0 | 12.64 | 5.93 | |
| | 14.0 | 12.71 | 5.80 | |
| | 15.0 | 12.60 | 5.75 | |
| | 16.0 | 12.66 | 5.71 | X |
| | 17.0 | 12.79 | 5.71 | |
| Bottom | 17.5 | 12.78 | 5.72 | |
| | | | | |
| | Dup 4.0 | 11.70 | 11.31 | |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| | | | |

DO and Temp measurements are taken every 1 meter
turbidity samples are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** Lake MI- Station 5
**Date/Time:** 6/20/13 1632
**GPS Coordinates:**
**Crew:** JS, MLV, AR, DJ

| | Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|---|
| | Surface | 11.70 | 11.08 | |
| | 1.0 | 11.78 | 10.99 | X |
| | 2.0 | 11.88 | 16.35 | |
| | 3.0 | 11.84 | 10.23 | |
| | 4.0 | 11.78 | 16.29 | |
| | 5.0 | 11.96 | 10.16 | |
| | 6.0 | 11.95 | 10.14 | |
| | 7.0 | 11.92 | 10.08 | |
| | 8.0 | 12.02 | 10.07 | |
| | 9.0 | 11.94 | 10.07 | |
| | 10.0 | 12.07 | 9.83 | |
| Bottom | 10.5 | 12.14 | 9.69 | |
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| | DUP 8.0 | 11.85 | 10.14 | |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
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DO and Temp measurements are taken every 1 meter
turbidity samples are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-0U**

**Station:** Lake MI-Station 6
**Date/Time:** 6/20/13 1646
**GPS Coordinates:**
**Crew:** MLV, JS, AR, DJ

| | Depth (m) XX.X | O2 (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|---|
| | Surface | 10.30 | 14.56 | |
| | 1.0 | 11.35 | 11.86 | |
| | 2.0 | 11.46 | 11.76 | |
| | 3.0 | 11.47 | 11.63 | |
| | 4.0 | 11.73 | 10.46 | |
| | 5.0 | 11.82 | 10.43 | |
| Bottom | 5.2 | 11.81 | 10.43 | |
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| | Dup surf. | 11.09 | 13.49 | |
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| Depth (m) XX.X | O2 (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| | | | |

DO and Temp measurements are taken every 1 meter
turbidity samples are taken 1 meter below surface and 1 meter above bottom

LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT
2244-00

Station: R 1

Date/Time: 7/1/2013 18:00

GPS Coordinates: N 4387718, W086.42333

Crew: J. STRICKO, A. REITZ

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 9.9 | 16.4 | |
| 1.0 | 9.9 | 16.3 | X |
| 2.0 | 9.8 | 16.2 | |
| 3.0 | 9.8 | 16.1 | |
| 4.0 | 9.8 | 15.7 | |
| 5.0 | 9.8 | 15.6 | |
| 6.0 | 9.8 | 15.4 | |
| 7.0 | 10.0 | 14.4 | |
| 8.0 | 10.2 | 14.0 | |
| 9.0 | 10.2 | 13.8 | |
| 10.0 | 10.2 | 13.5 | |
| 11.0 | 10.1 | 13.5 | |
| 12.0 | 10.1 | 13.3 | |
| 13.0 | 10.1 | 13.2 | |
| 14.0 | 10.1 | 13.2 | |
| 15.0 | 10.0 | 13.1 | |
| 16.0 | 10.0 | 13.0 | |
| 17.0 | 10.0 | 13.0 | |
| 18.0 | 10.0 | 12.9 | |
| 19.0 | 10.0 | 12.9 | |
| 20.0 | 9.9 | 12.9 | X |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| 21.0 | 9.9 | 12.8 | |
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| DUP 1.0 | 9.6 | 16.3 | |
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DO and Temp measurements are taken every 1 meter
turbidity samples are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

Station: R2
Date/Time: 7/1/2013 17:30
GPS Coordinates: N 43.88604 , W 086.42506
Crew: J. STRICKO, A. REITZ

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 9.9 | 16.0 | |
| 1.0 | 9.9 | 16.0 | X |
| 2.0 | 9.8 | 16.0 | |
| 3.0 | 9.8 | 15.7 | |
| 4.0 | 10.0 | 14.8 | |
| 5.0 | 10.0 | 14.7 | |
| 6.0 | 9.9 | 14.5 | |
| 7.0 | 10.0 | 14.3 | |
| 8.0 | 10.0 | 14.3 | |
| 9.0 | 10.0 | 14.1 | |
| 10.0 | 10.0 | 14.0 | |
| 11.0 | 10.0 | 13.9 | |
| 12.0 | 10.0 | 13.8 | |
| 13.0 | 10.0 | 13.6 | |
| 14.0 | 10.0 | 13.4 | |
| 15.0 | 10.0 | 13.3 | |
| 16.0 | 10.0 | 13.3 | |
| 17.0 | 10.0 | 13.2 | |
| 18.0 | 10.0 | 13.0 | |
| 19.0 | 9.9 | 13.0 | |
| 20.0 | 10.0 | 13.0 | X |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| 21.0 | 9.8 | 13.0 | |
| | | | |
| DUP 3.0 | 9.8 | 15.8 | |

DO and Temp measurements are taken every 1 meter
turbidity samples are taken 1 meter below surface and 1 meter above bottom

21.5 meters deep

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

Station: R3
Date/Time: 7/1/2013 16:45
GPS Coordinates: 43.90189°, 086.43170°
Crew: J. STRICKO, A. REITZ

| Depth (m) XX.X | O2 (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 10.3 | 15.6 | |
| 1.0 | 10.3 | 15.5 | X |
| 2.0 | 10.1 | 15.4 | |
| 3.0 | 10.2 | 15.1 | |
| 4.0 | 10.2 | 14.3 | |
| 5.0 | 10.0 | 14.2 | |
| 6.0 | 10.0 | 14.1 | |
| 7.0 | 10.0 | 13.8 | |
| 8.0 | 10.0 | 13.8 | |
| 9.0 | 10.0 | 13.8 | |
| 10.0 | 10.0 | 13.6 | |
| 11.0 | 10.0 | 13.5 | |
| 12.0 | 10.1 | 13.4 | |
| 13.0 | 10.0 | 13.4 | |
| 14.0 | 10.0 | 13.4 | |
| 15.0 | 10.0 | 13.4 | |
| 16.0 | 9.9 | 13.4 | |
| 17.0 | 9.9 | 13.1 | |
| 18.0 | 10.0 | 13.0 | |
| 19.0 | 9.9 | 13.0 | |
| 20.0 | 9.9 | 13.0 | |

| Depth (m) XX.X | O2 (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| 21.0 | 9.9 | 12.9 | |
| 22.0 | 9.9 | 12.9 | |
| 23.0 | 9.8 | 12.9 | |
| 24.0 | 9.9 | 12.9 | |
| 25.0 | 9.8 | 12.9 | |
| 26.0 | 9.8 | 12.9 | X |
| 27.0 | 9.7 | 12.8 | |
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| DUP 4.0 | 9.8 | 14.5 | |
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DO and Temp measurements are taken every 1 meter
turbidity samples are taken 1 meter below surface and 1 meter above bottom

DEPTH IS 27.5 meters
WATER LEVEL IN POND IS SIGNIFICANTLY LOWER THAN PREVIOUS SAMPLING EVENT

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** LM1
**Date/Time:** 7/1/2013
**GPS Coordinates:** N 43°51.000', W 86° 27.533'
**Crew:** J. STRICKO, A. REITZ

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 11.4 | 9.56 | |
| 1.0 | 11.4 | 9.5 | X |
| 2.0 | 11.5 | 9.2 | |
| 3.0 | 11.5 | 8.8 | |
| 4.0 | 11.5 | 8.6 | |
| 5.0 | 11.5 | 8.5 | |
| 6.0 | 11.6 | 7.8 | |
| 7.0 | 11.5 | 7.5 | |
| 8.0 | 11.5 | 7.2 | |
| 9.0 | 11.4 | 6.2 | |
| 10.0 | 11.4 | 6.0 | |
| 11.0 | 11.3 | 6.0 | |
| 12.0 | 11.3 | 6.0 | |
| 13.0 | 11.3 | 6.0 | X |
| 14.0 | 11.3 | 6.0 | |
| | | | |
| DUP 2.0 | 11.3 | 9.2 | |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
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DO and Temp measurements are taken every 1 meter
turbidity samples are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

| | | |
|---|---|---|
| **Station:** | LM3 | LMZ |
| **Date/Time:** | 7/1/2013 12:00 | 7/1/2013 |
| **GPS Coordinates:** | N 43°53.001', W 86° 27.332' | N 43° 52.750', W 86° 26.833' |
| **Crew:** | J. Strecko, A. Reitz | J. Strecko, A. Reitz |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 11.6 | 9.1 | |
| 1.0 | 11.6 | 8.9 | X |
| 2.0 | 11.5 | 8.7 | |
| 3.0 | 11.5 | 8.3 | |
| 4.0 | 11.5 | 7.8 | |
| 5.0 | 11.5 | 7.7 | |
| 6.0 | 11.5 | 7.6 | |
| 7.0 | 11.5 | 6.6 | |
| 8.0 | 11.6 | 6.6 | |
| 9.0 | 11.6 | 5.9 | |
| 10.0 | 11.6 | 5.8 | X |
| 11.0 | ~~5.8~~ 11.6 | 5.8 | |
| | | | |
| DUP 3.0 | 11.2 | 8.3 | |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| SURFACE | 11.0 | 7.9 | |
| 1.0 | 11.0 | 7.9 | X |
| 2.0 | 11.1 | 7.4 | |
| 3.0 | 11.2 | 6.4 | |
| 4.0 | 11.4 | 6.3 | |
| 5.0 | 11.4 | 6.2 | X |
| 6.0 | 11.4 | 6.3 | |
| | | | |
| DUP SURFACE | 11.0 | 7.8 | |

DO and Temp measurements are taken every 1 meter
turbidity samples are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

Station: LM 4
Date/Time: 7/1/2013 11:00
GPS Coordinates: N 43° 53.500', W86° 29.000'
Crew: J. Stricko, A. Reitz

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 11.1 | 12.1 | |
| 1.0 | 11.1 | 12.1 | X |
| 2.0 | 11.1 | 12.0 | |
| 3.0 | 11.1 | 11.5 | |
| 4.0 | 11.2 | 11.3 | |
| 5.0 | 11.2 | 11.2 | |
| 6.0 | 11.2 | 11.1 | |
| 7.0 | 11.2 | 10.8 | |
| 8.0 | 11.2 | 10.7 | |
| 9.0 | 11.3 | 10.5 | |
| 10.0 | 11.3 | 10.4 | |
| 11.0 | 11.3 | 10.3 | |
| 12.0 | 11.3 | 9.7 | |
| 13.0 | 11.4 | 9.0 | |
| 14.0 | 11.5 | 6.0 | |
| 15.0 | 11.5 | 5.5 | |
| 16.0 | 11.4 | 5.3 | |
| 17.0 | 11.3 | 5.3 | |
| 18.0 | 11.3 | 5.2 | |
| 19.0 | 11.3 | 5.2 | X |
| ~~20.0~~ | JPS | | |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| | | | |
| DUP 5.0 | 11.0 | 10.9 | |

DO and Temp measurements are taken every 1 meter
turbidity samples are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

| | | |
|---|---|---|
| Station: | Lm 5 | LM6 |
| Date/Time: | 07/01/2013 10:00 | 7/1/2013 10:31 |
| GPS Coordinates: | N 43° 54,333', W 86° 27.583' | N 43° 54,833' W 86° 27.167' |
| Crew: | Jim, Adam | JIM STRICKO, ADAM REITZ |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 11.3 | 10.7 | |
| 1.0 | 11.1 | 10.7 | X |
| 2.0 | 11.1 | 10.6 | |
| 3.0 | 11.1 | 10.5 | |
| 4.0 | 11.2 | 9.3 | |
| 5.0 | 11.3 | 8.6 | |
| 6.0 | 11.3 | 8.1 | |
| 7.0 | 11.4 | 8.0 | |
| 8.0 | 11.3 | 7.8 | |
| 9.0 | 11.4 | 7.7 | |
| 10.0 | 11.4 | 7.6 | |
| 11.0 | 11.4 | 7.4 | X |
| 11.5 | 11.5 | 7.3 | |
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| DUP 1.0 | 11.0 | 10.7 | |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| SURFACE | 11.9 | 8.5 | |
| 1.0 | 11.9 | 8.4 | X |
| 2.0 | 11.8 | 7.6 | |
| 3.0 | 11.9 | 7.0 | |
| 4.0 | 11.9 | 6.8 | |
| 5.0 | 11.9 | 6.8 | X |
| 6.0 | 11.8 | 6.8 | |
| ~~7.0~~ JPS | | | |
| ~~8.0~~ JPS | | | |
| | | | |
| DUP 3.0 | 11.8 | 7.0 | |
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DO and Temp measurements are taken every 1 meter
turbidity samples are taken 1 meter below surface and 1 meter above bottom

LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT
2244-00

**Station:** R1
**Date/Time:** 7/15/2013 1730
**Crew:** J. STRICKO, D. JOHNS

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 10.13 | 19.45 | |
| 1.0 | 10.14 | 19.44 | X |
| 2.0 | 10.11 | 19.24 | |
| 3.0 | 10.18 | 18.91 | |
| 4.0 | 10.26 | 17.94 | |
| 5.0 | 10.25 | 17.61 | |
| 6.0 | 10.22 | 17.48 | |
| 7.0 | 10.22 | 17.42 | |
| 8.0 | 10.12 | 17.39 | |
| 9.0 | 10.23 | 17.36 | |
| 10.0 | 10.22 | 17.32 | |
| 11.0 | 10.13 | 17.30 | |
| 12.0 | 10.13 | 17.29 | |
| 13.0 | 10.10 | 17.29 | |
| 14.0 | 10.04 | 17.28 | |
| 15.0 | 10.09 | 17.27 | |
| 16.0 | 10.13 | 17.26 | |
| 17.0 | 10.12 | 17.25 | |
| 18.0 | 10.17 | 17.25 | |
| 19.0 | 10.16 | 17.24 | X |
| 20.0 | 10.12 | 17.24 | |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
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| DUP SURF | 10.06 | 19.55 | |
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**Total Depth:** 20.5 meters

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** R2

**Date/Time:** 7/15/2013 18:15

**Crew:** J. STRICKO, D. JOHNS

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 10.19 | 19.56 | |
| 1.0 | 10.18 | 19.47 | X |
| 2.0 | 10.29 | 18.39 | |
| 3.0 | 10.35 | 17.92 | |
| 4.0 | 10.35 | 17.82 | |
| 5.0 | 10.45 | 17.55 | |
| 6.0 | 10.37 | 17.47 | |
| 7.0 | 10.41 | 17.43 | |
| 8.0 | 10.29 | 17.41 | |
| 9.0 | 10.26 | 17.40 | |
| 10.0 | 10.27 | 17.39 | |
| 11.0 | 10.22 | 17.37 | |
| 12.0 | 10.18 | 17.33 | |
| 13.0 | 10.25 | 17.30 | |
| 14.0 | 10.22 | 17.28 | |
| 15.0 | 10.22 | 17.27 | |
| 16.0 | 10.17 | 17.25 | |
| 17.0 | 10.12 | 17.24 | |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
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| DUP SURF | 9.97 | 19.94 | |
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**Total Depth:** 17.5

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

# LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT
## 2244-00

**Station:** R3

**Date/Time:** 7/15/2013 18:45

**Crew:** J. STRICKO D. JOHNS

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 10.48 | 18.30 | |
| 1.0 | 10.48 | 18.26 | |
| 2.0 | 10.46 | 18.15 | |
| 3.0 | 10.49 | 17.68 | |
| 4.0 | 10.47 | 17.41 | |
| 5.0 | 10.43 | 17.36 | |
| 6.0 | 10.39 | 17.33 | |
| 7.0 | 10.38 | 17.32 | |
| 8.0 | 10.16 | 17.27 | |
| 9.0 | 10.27 | 17.26 | |
| 10.0 | 10.30 | 17.23 | |
| 11.0 | 10.15 | 17.22 | |
| 12.0 | 10.21 | 17.21 | |
| 13.0 | 10.10 | 17.22 | |
| 14.0 | 10.24 | 17.21 | |
| 15.0 | 10.24 | 17.20 | |
| 16.0 | 10.25 | 17.19 | |
| 17.0 | 10.23 | 17.19 | |
| 18.0 | 10.09 | 17.17 | |
| 19.0 | 10.18 | 17.15 | |
| 20.0 | 10.10 | 17.15 | X |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| 21.0 | 10.11 | 17.14 | |
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| DUP SURF | 10.22 | 18.28 | |
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**Total Depth:** 21.5

**DO and Temp** measurements are taken every 1 meter

**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT
2244-00

**Station:** LM1

**Date/Time:** 7/15/2013 14:15

**Crew:** J. Strkco, D. Johns

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 9.43 | 21.96 | |
| 1.0 | 9.43 | 21.64 | x |
| 2.0 | 9.45 | 21.10 | |
| 3.0 | 9.47 | 20.73 | |
| 4.0 | 9.49 | 20.30 | |
| 5.0 | 9.83 | 19.12 | |
| 6.0 | 10.39 | 17.56 | |
| 7.0 | 11.73 | 14.58 | |
| 8.0 | 12.23 | 13.01 | |
| 9.0 | 12.22 | 12.30 | |
| 10.0 | 12.51 | 11.34 | |
| 11.0 | 12.55 | 11.01 | |
| 12.0 | 12.60 | 9.90 | x |
| 13.0 | 12.46 | 9.70 | |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
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| DUP 1.0 | 9.28 | 21.90 | |
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**Total Depth:** 42 ft (12.8m)

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** LM2
**Date/Time:** 7/16/2013 ~~1200~~ 1400
**Crew:** J. STRICKO, D. JOHNS

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 9.73 | 21.21 | |
| 1.0 | 9.50 | 21.22 | X |
| 2.0 | 9.67 | 20.20 | |
| 3.0 | 9.85 | 19.66 | |
| 4.0 | 9.96 | 19.63 | |
| 5.0 | 9.92 | 19.60 | |
| 6.0 | 10.09 | 19.41 | |
| 6.5 | 10.66 | 18.92 | |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
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| DUP SURF | 9.52 | 21.18 | |
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**Total Depth:** 19 ft 5.79

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT
2244-00

**Station:** LM3

**Date/Time:** 7/15/2013 13:30

**Crew:** J. Strickd, D. Johns

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? | Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|---|---|---|---|
| Surface | 9.99 | 20.76 | | | | | |
| 1.0 | 9.93 | 20.67 | x | | | | |
| 2.0 | 10.02 | 19.62 | | | | | |
| 3.0 | 10.12 | 19.11 | | | | | |
| 4.0 | 10.16 | 18.68 | | | | | |
| 5.0 | 10.30 | 18.38 | | | | | |
| 6.0 | 10.24 | 18.31 | | | | | |
| 7.0 | 10.47 | 16.19 | | | | | |
| 8.0 | 10.99 | 14.34 | | | | | |
| 9.0 | 11.81 | 13.29 | | | | | |
| 10.0 | 11.84 | 12.53 | x | | | | |
| ~~11.0~~ | ~~11.85~~ | ~~12.61~~ | | | | | |
| 11.0 | 11.99 | 11.00 | | | | | |
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| | | | | DUP 3.0 | 9.97 | 19.20 | |
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**Total Depth:** 34 Ft (10.36)

**DO and Temp** measurements are taken every 1 meter

**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** LM4
**Date/Time:** 7/15/2013 12:30
**Crew:** J. Streicko, D. Johns

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| **Surface** | 9.77 | 22.22 | |
| 1.0 | 9.60 | 21.35 | x |
| 2.0 | 9.73 | 20.61 | |
| 3.0 | 9.69 | 20.54 | |
| 4.0 | 9.67 | 20.45 | |
| 5.0 | 9.70 | 20.42 | |
| 6.0 | 9.98 | 19.55 | |
| 7.0 | 10.10 | 18.34 | |
| 8.0 | 10.88 | 16.41 | |
| 9.0 | 11.13 | 14.49 | |
| 10.0 | 12.57 | 10.84 | |
| 11.0 | 12.77 | 9.95 | |
| 12.0 | 12.64 | 9.49 | |
| 13.0 | 12.42 | 9.36 | |
| 14.0 | 12.32 | 9.16 | |
| 15.0 | 12.48 | 8.87 | |
| 16.0 | 12.21 | 8.44 | |
| 17.0 | 11.80 | 8.23 | |
| 18.0 | 11.76 | 8.19 | |
| 19.0 | 11.80 | 8.12 | |
| 19.5 | 11.73 | 8.10 | |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
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| **DUP** 5.0 | 9.60 | 20.10 | |
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**Total Depth:** 61 ft (18.59)

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** LM5
**Date/Time:** 7/15/2013
**Crew:** J. Streicko D. Johns

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 9.62 | 22.08 | |
| 1.0 | 9.95 | 19.50 | x |
| 2.0 | 10.20 | 18.93 | |
| 3.0 | 10.18 | 18.63 | |
| 4.0 | 10.26 | 18.07 | |
| 5.0 | 10.35 | 17.66 | |
| 6.0 | 10.50 | 16.75 | |
| 7.0 | 10.62 | 15.15 | |
| 8.0 | 11.47 | 10.53 | |
| 9.0 | 12.35 | 10.13 | |
| 10.0 | 12.41 | 9.81 | |
| 11.0 | 12.48 | 9.80 | x |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
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| DUP SURF | 9.61 | 21.92 | |
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**Total Depth:** 35 ft (10.67)

DO and Temp measurements are taken every 1 meter
turbidity samples are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** LM6
**Date/Time:** 7/15/2013 12:15
**Crew:** J. STRICKO, D. JOHNS

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 9.96 | 21.37 | |
| 1.0 | 9.96 | 20.79 | x |
| 2.0 | 10.10 | 19.49 | |
| 3.0 | 10.14 | 19.32 | |
| 4.0 | 10.10 | 19.03 | |
| 5.0 | 10.18 | 18.54 | |
| 6.0 | 10.52 | 17.23 | |
| ~~7.0~~ 6.5 | 10.67 | 16.97 | |
| ~~8.0~~ | JPS | | |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
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| DUP 1.0 | 9.63 | 21.21 | |
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**Total Depth:** 19 Ft (5.79)

**DO and Temp** measurements are taken every 1 meter
**turbidity** samples are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** 1R
**Date/Time:** 7/30/2013 16:30
**Crew:** J. STRICKO, D. JOHNS

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 8.70 | 16.47 | |
| 1.0 | 8.71 | 16.36 | X |
| 2.0 | 8.72 | 15.88 | |
| 3.0 | 8.80 | ~~15.66~~ 15.50 | |
| 4.0 | 8.77 | 15.40 | |
| 5.0 | 8.72 | 15.39 | |
| 6.0 | 8.80 | 15.30 | |
| 7.0 | 8.81 | 15.21 | |
| 8.0 | 8.70 | 15.18 | |
| 9.0 | 8.66 | 15.13 | |
| 10.0 | 8.71 | 15.01 | |
| 11.0 | 8.71 | 14.95 | |
| 12.0 | 8.70 | 14.92 | |
| 13.0 | 8.70 | 14.91 | |
| 14.0 | 8.70 | 14.90 | |
| 15.0 | 8.69 | 14.89 | |
| 16.0 | 8.63 | 14.85 | |
| 17.0 | 8.61 | 14.82 | |
| 18.0 | 8.66 | 14.78 | |
| 19.0 | 8.66 | 14.77 | |
| 20.0 | 8.67 | 14.78 | X |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| 21.0 | 8.69 | 14.78 | |
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| DUP SURF | 8.59 | 16.44 | |
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**Total Depth:** 21.8 meters

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT
2244-00

**Station:** 2R

**Date/Time:** 7/30/2013 16:00

**Crew:** J.Stricko, D.Johns

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 8.60 | 16.60 | |
| 1.0 | 8.62 | 16.48 | |
| 2.0 | 8.64 | 16.03 | |
| 3.0 | 8.40 | 15.81 | |
| 4.0 | 8.54 | 15.60 | |
| 5.0 | 8.65 | 15.51 | |
| 6.0 | 8.66 | 15.46 | |
| 7.0 | 8.67 | 15.39 | |
| 8.0 | 8.69 | 15.34 | |
| 9.0 | 8.69 | 15.31 | |
| 10.0 | 8.71 | 15.28 | |
| 11.0 | 8.75 | 15.18 | |
| 12.0 | 8.63 | 15.03 | |
| 13.0 | 8.71 | 14.95 | |
| 14.0 | 8.72 | 14.89 | |
| 15.0 | 8.67 | 14.88 | |
| 16.0 | 8.63 | 14.88 | |
| 17.0 | 8.50 | 14.87 | |
| 18.0 | 8.59 | 14.87 | |
| 19.0 | 8.62 | 14.86 | |
| 20.0 | 8.60 | 14.85 | |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| 21.0 | 8.59 | 14.82 | |
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| DUP SURF | 8.52 | 16.71 | |
| | | | |

**Total Depth:** 21.9 meters

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** 3R

**Date/Time:** 7/30/2013 1530

**Crew:** J. Stricko, D. Johns

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 9.02 | 15.78 | |
| 1.0 | 9.04 | 15.73 | X |
| 2.0 | 9.07 | 15.56 | |
| 3.0 | 9.03 | 15.47 | |
| 4.0 | 9.08 | 15.39 | |
| 5.0 | 9.04 | 15.40 | |
| 6.0 | 9.03 | 15.36 | |
| 7.0 | 9.00 | 15.34 | |
| 8.0 | 8.97 | 15.30 | |
| 9.0 | 8.87 | 15.29 | |
| 10.0 | 8.89 | 15.25 | |
| 11.0 | 8.88 | 15.21 | |
| 12.0 | 8.96 | 15.18 | |
| 13.0 | 8.92 | 15.10 | |
| 14.0 | 8.93 | 15.09 | |
| 15.0 | 8.91 | 15.05 | |
| 16.0 | 8.89 | 15.03 | |
| 17.0 | 8.91 | 15.05 | |
| 18.0 | 8.91 | 15.02 | |
| 19.0 | 8.90 | 15.00 | |
| 20.0 | 8.91 | 14.97 | |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| 21.0 | 8.90 | 14.90 | |
| 22.0 | 8.89 | 14.85 | |
| 23.0 | 8.89 | 14.73 | |
| 24.0 | 8.87 | 14.67 | |
| 25.0 | 8.80 | 14.65 | |
| 26.0 | 8.86 | 14.65 | X |
| 27.0 | 8.80 | 14.59 | |
| * ~~28.0~~ | ~~8.74~~ | ~~14.59~~ | |
| * ~~29.0~~ | ~~8.74~~ | ~~14.59~~ | |
| * ~~30.0~~ | ~~8.51~~ | ~~14.59~~ | |
| * ~~31.0~~ | ~~8.50~~ | ~~14.60~~ | |
| * ~~32.0~~ | ~~8.50~~ | ~~14.60~~ | |
| * ~~33.0~~ | ~~8.45~~ | ~~14.60~~ | |
| * ~~34.0~~ | ~~8.46~~ | ~~14.60~~ | |
| * ~~35.0~~ | ~~8.49~~ | ~~14.60~~ | |
| * ~~36.0~~ | ~~8.44~~ | ~~14.60~~ | |
| * ~~37.0~~ | ~~8.44~~ | ~~14.60~~ | |
| * ~~38.0~~ | ~~8.50~~ | ~~14.60~~ | |
| * ~~39.0~~ | | | |
| DUP SURF | 8.89 | 16.01 | |
| | | | |

**Total Depth:** 27.8 m

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

* FALSE READINGS, SONDE LAYING ON BOTTOM 7/30/2013 JPS

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** LM1

**Date/Time:** 7/30/2013 13:40

**Crew:** J. Strecko, D. Johns

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 9.17 | 16.11 | |
| 1.0 | 9.14 | 16.15 | X |
| 2.0 | 9.10 | 16.00 | |
| 3.0 | 9.09 | 15.64 | DS |
| 4.0 | 9.09 | ~~15.67~~ | 15.57 |
| 5.0 | 9.14 | 15.07 | |
| 6.0 | 9.18 | 14.80 | |
| 7.0 | 9.27 | 14.55 | |
| 8.0 | 9.34 | 14.08 | |
| 9.0 | 9.42 | 13.90 | |
| 10.0 | 9.53 | 13.52 | DS |
| 11.0 | 9.99 | ~~13.52~~ | 12.61 |
| 12.0 | 9.97 | 11.72 | X |
| 13.0 | 10.61 | 8.74 | |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
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| DUP SURF | 9.01 | 16.12 | |
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**Total Depth:** 13.1 meters

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** LM2
**Date/Time:** 7/30/2013 13:15
**Crew:** J. STRICKO, D. JOHNS

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 9.27 | 15.36 | |
| 1.0 | 9.23 | 15.29 | X |
| 2.0 | 9.22 | 14.94 | |
| 3.0 | 9.27 | 14.43 | |
| 4.0 | 9.33 | 14.43 | |
| 5.0 | 9.31 | 14.42 | X |
| 6.0 | 9.54 | 14.21 | |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
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| DUP SURF | 9.10 | 15.47 | |
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**Total Depth:** 6.1 meters

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT
2244-00

**Station:** LM3

**Date/Time:** 7/30/2013 13:00

**Crew:** J. Stricko, D. Johns

| **Depth (m) XX.X** | **$O_2$ (mg/L) XX.X** | **Temp (°C) XX.X** | **Turbidity Sample Taken?** | **Depth (m) XX.X** | **$O_2$ (mg/L) XX.X** | **Temp (°C) XX.X** | **Turbidity Sample Taken?** |
|---|---|---|---|---|---|---|---|
| **Surface** | 9.05 | 15.98 | | | | | |
| 1.0 | 9.12 | 15.71 | X | | | | |
| 2.0 | 9.09 | 15.62 | | | | | |
| 3.0 | 9.18 | 14.90 | | | | | |
| 4.0 | 9.23 | 14.81 | | | | | |
| 5.0 | 9.18 | 14.49 | | | | | |
| 6.0 | 9.21 | 14.40 | | | | | |
| 7.0 | 9.25 | 14.05 | | | | | |
| 8.0 | 9.31 | 13.93 | | | | | |
| 9.0 | 9.34 | 13.77 | | | | | |
| 10.0 | 9.80 | 12.99 | X | | | | |
| 11.0 | 10.80 | 8.36 | | | | | |
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| | | | | | **DUP** SURF | 8.89 | 16.09 | |
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**Total Depth:** 11.1 meters

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

# LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT
# 2244-00

**Station:** LM4

**Date/Time:** 7/30/2013 12:15

**Crew:** J. Strickco, D. Johns

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 9.36 | 15.86 | |
| 1.0 | 9.22 | 15.84 | X |
| 2.0 | 9.14 | 15.83 | |
| 3.0 | 9.09 | 15.69 | |
| 4.0 | 9.14 | 15.45 | |
| 5.0 | 9.23 | 15.00 | |
| 6.0 | 9.28 | 14.52 | |
| 7.0 | 9.39 | 13.85 | |
| 8.0 | 9.51 | 13.30 | |
| 9.0 | 9.57 | 13.10 | |
| 10.0 | 9.75 | 12.08 | |
| 11.0 | 10.32 | 9.91 | |
| 12.0 | 10.86 | 6.90 | |
| 13.0 | 11.01 | 6.58 | |
| 14.0 | 10.96 | 6.43 | |
| 15.0 | 10.88 | 6.32 | |
| 16.0 | 10.87 | 6.36 | |
| 17.0 | 10.86 | 6.35 | |
| 18.0 | 10.82 | 6.28 | |
| 19.0 | 10.84 | 6.30 | X |
| 20.0 | 10.82 | 6.32 | |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
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| DUP SURF | 9.03 | 15.87 | |
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**Total Depth:** 20.1 meters

**DO and Temp** measurements are taken every 1 meter

**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** LM5
**Date/Time:** 7/30/2013 11:30
**Crew:** J. Stricko, D. Johns

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 9.34 | 15.03 | |
| 1.0 | 9.31 | 15.07 | X |
| 2.0 | 9.21 | 14.81 | |
| 3.0 | 9.37 | 14.03 | |
| 4.0 | 9.90 | 12.31 | |
| 5.0 | 10.44 | 10.77 | |
| 6.0 | 11.00 | 8.53 | |
| 7.0 | 10.99 | 7.58 | |
| 8.0 | 10.94 | 7.34 | |
| 9.0 | 11.03 | 7.28 | |
| 10.0 | 10.94 | 7.21 | |
| 11.0 | 10.88 | 7.20 | X |
| 12.0 | | | |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| DUP Surf | 9.17 | 14.96 | |

**Total Depth:** ~~12.1 meters~~ 11.5 METERS

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** CM6
**Date/Time:** 7/30/2013 11:45
**Crew:** J. STRICCO, D. JOHNS

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? | Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|---|---|---|---|
| Surface | 9.42 | 15.17 | | | | | |
| 1.0 | 9.18 | 15.11 | | | | | |
| 2.0 | 9.08 | 16.02 | | | | | |
| 3.0 | 9.14 | 14.13 | | | | | |
| 4.0 | 10.26 | 11.52 | | | | | |
| 5.0 | 10.76 | 9.64 | | | | | |
| 6.0 | 10.97 | 9.47 | | | | | |
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| | | | | DUP 1.0 | 9.13 | 15.10 | |
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**Total Depth:** 6.1 METERS

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** R1
**Date/Time:** 8/13/2013 ~~08~~0900
**Crew:** J. Stricko, D. Johns

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 9.05 | 17.78 | |
| 1.0 | 9.14 | 17.78 | X |
| 2.0 | 9.10 | 17.81 | |
| 3.0 | 9.06 | 17.80 | |
| 4.0 | 9.07 | 17.79 | |
| 5.0 | 8.93 | 17.80 | |
| 6.0 | 8.99 | 17.79 | |
| 7.0 | 9.05 | 17.79 | |
| 8.0 | 9.07 | 17.78 | |
| 9.0 | 9.01 | 17.77 | |
| 10.0 | 9.02 | 17.78 | |
| 11.0 | 9.01 | 17.75 | |
| 12.0 | 9.01 | 17.73 | |
| 13.0 | 9.03 | 17.72 | |
| 14.0 | 8.99 | 17.72 | |
| 15.0 | 8.91 | 17.71 | |
| 16.0 | 8.93 | 17.70 | |
| 17.0 | 8.98 | 17.66 | |
| 18.0 | 8.96 | 17.65 | |
| 19.0 | 8.98 | 17.62 | |
| 20.0 | 8.98 | 17.57 | |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| 21.0 | 9.03 | 17.54 | |
| 22.0 | 8.93 | 17.51 | |
| 23.0 | 8.96 | 17.48 | |
| 24.0 | 8.97 | 17.48 | |
| 25.0 | 8.98 | 17.39 | |
| 26.0 | 8.97 | 17.37 | X |
| 27.0 | 8.97 | 17.36 | |
| ~~28.0~~ | UPS | | |
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| DUP SURF | 9.00 | 17.78 | |
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**Total Depth:** 27.5 m

DO and Temp measurements are taken every 1 meter
turbidity samples are taken 1 meter below surface and 1 meter above bottom

## LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT
## 2244-00

**Station:** R2
**Date/Time:** 8/13/2013 10:00
**Crew:** J. STRICKO, D. JOHNS

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? | Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|---|---|---|---|
| **Surface** | 9.08 | 17.78 | | 21.0 | 9.06 | 16.94 | |
| 1.0 | 9.10 | 17.78 | X | 22.0 | 9.09 | 16.91 | |
| 2.0 | 9.07 | 17.77 | | 23.0 | 9.09 | 16.92 | |
| 3.0 | 9.07 | 17.77 | | 24.0 | 9.08 | 16.91 | |
| 4.0 | 9.04 | 17.75 | | 25.0 | 9.04 | 16.91 | ✓ |
| 5.0 | 8.99 | 17.75 | | 26.0 | 9.07 | 16.89 | |
| 6.0 | 9.02 | 17.73 | | | | | |
| 7.0 | 9.02 | 17.71 | | | | | |
| 8.0 | 9.03 | 17.69 | | | | | |
| 9.0 | 9.02 | 17.68 | | | | | |
| 10.0 | 9.00 | 17.65 | | | | | |
| 11.0 | 9.01 | 17.65 | | | | | |
| 12.0 | 8.96 | 17.61 | | | | | |
| 13.0 | 8.99 | 17.62 | | | | | |
| 14.0 | 8.95 | 17.61 | | | | | |
| 15.0 | 8.92 | 17.52 | | | | | |
| 16.0 | 8.95 | 17.59 | | | | | |
| 17.0 | 8.94 | 17.48 | | | | | |
| 18.0 | 8.98 | 17.45 | | | | | |
| 19.0 | 9.00 | 17.35 | | DUP SURF | 9.01 | 17.68 | |
| 20.0 | 8.94 | 17.34 | | | | | |

**Total Depth:** 26.7 meters

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** R3
**Date/Time:** 8/13/2013 1030
**Crew:** J. STRICKO, D. JOHNS

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 9.05 | 17.62 | |
| 1.0 | 9.07 | 17.63 | x |
| 2.0 | 9.06 | 17.63 | |
| 3.0 | 9.05 | 17.61 | |
| 4.0 | 9.00 | 17.64 | |
| 5.0 | 8.98 | 17.49 | |
| 6.0 | 9.00 | 17.34 | |
| 7.0 | 9.01 | 17.38 | |
| 8.0 | 9.04 | 17.36 | |
| 9.0 | 9.02 | 17.31 | |
| 10.0 | 9.00 | 17.14 | |
| 11.0 | 9.04 | 17.09 | |
| 12.0 | 8.99 | 17.14 | |
| 13.0 | 9.07 | 17.10 | |
| 14.0 | 9.08 | 17.03 | |
| 15.0 | 9.05 | 17.15 | |
| 16.0 | 9.04 | 16.99 | |
| 17.0 | 9.06 | 17.00 | |
| 18.0 | 9.05 | 16.98 | |
| 19.0 | 9.01 | 16.97 | |
| 20.0 | 9.02 | 16.96 | |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| 21.0 | 8.97 | 16.97 | |
| 22.0 | 8.96 | 16.97 | |
| 23.0 | 8.96 | 17.00 | |
| 24.0 | 8.98 | 16.98 | |
| 25.0 | 8.97 | 16.97 | |
| 26.0 | 8.95 | 16.97 | |
| 27.0 | 8.99 | 16.97 | |
| 28.0 | 8.94 | 16.95 | |
| 29.0 | 8.96 | 16.94 | |
| 30.0 | 9.03 | 16.93 | |
| 31.0 | 9.00 | 16.93 | x |
| 32.0 | 8.97 | 16.92 | |
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| DUP SURF | 8.95 | 17.52 | |
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**Total Depth:** 32.4 meters

DO and Temp measurements are taken every 1 meter
turbidity samples are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** LM1
**Date/Time:** 8/12/2013 1600
**Crew:** J. STRICKO, D. JOHNS

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 8.42 | 20.18 | |
| 1.0 | 8.41 | 20.18 | X |
| 2.0 | 8.39 | 19.95 | |
| 3.0 | 8.40 | 19.65 | |
| 4.0 | 8.67 | 18.41 | |
| 5.0 | 8.69 | 18.05 | |
| 6.0 | 8.85 | 17.32 | |
| 7.0 | 8.90 | 16.98 | |
| 8.0 | 9.06 | 16.42 | |
| 9.0 | 9.28 | 15.13 | |
| 10.0 | 9.59 | 14.27 | |
| 11.0 | 9.76 | 13.41 | |
| 12.0 | 9.80 | 12.50 | x |
| 13.0 | 9.66 | 11.50 | |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| DUP SURF | 8.22 | 20.24 | |

**Total Depth:** 13.0 meters

DO and Temp measurements are taken every 1 meter
turbidity samples are taken 1 meter below surface and 1 meter above bottom

COLLECTED 2 PONAR SAMPLES FOR MACROINVERTEBRATES

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** LM2

**Date/Time:** 8/12/2013 1530

**Crew:** J. STRICKO, D. JOHNS

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 8.25 | 19.65 | |
| 1.0 | 8.33 | 19.62 | X |
| 2.0 | 8.40 | 19.58 | |
| 3.0 | 8.33 | 19.35 | |
| 4.0 | 8.40 | 18.86 | X |
| 5.0 | 8.47 | 18.59 | |
| 5.5 | 9.25 | 17.64 | |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| DUP SURF | 8.28 | 19.56 | |

**Total Depth:** 5.9 meters

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

COLLECTED 2 PONAR SAMPLES FOR MACROINVERTEBRATES. SAMPLES CONSIST OF FINE SAND AND ZEBRA MUSSEL SHELLS

LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT
2244-00

Station: LM3
Date/Time: 8/12/2013 1445
Crew: J. STECKO, D. JOHNS

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 860 | 18.69 | |
| 1.0 | 8.60 | 18.96 | X |
| 2.0 | 8.60 | 18.46 | |
| 3.0 | 8.65 | 18.36 | |
| 4.0 | 8.65 | 18.14 | |
| 5.0 | 8.54 | 18.03 | |
| 6.0 | 8.68 | 17.36 | |
| 7.0 | 8.73 | 17.05 | |
| 8.0 | 8.77 | 16.85 | |
| 9.0 | 8.95 | 16.55 | |
| 10.0 | 9.55 | 14.02 | X |
| 11.0 | 9.80 | 13.67 | |
| ~~12.0~~ | | | |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
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| DUPSURF | 8.40 | 19.07 | |
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Total Depth: 11.1 meters

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

COLLECTED 2 PONAR SAMPLES FOR MACROINVERTEBRATES
SAMPLES CONSIST OF FINE SAND AND ZEBRA MUSSEL SHELLS.

LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT
2244-00

**Station:** LM4

**Date/Time:** 1330 8/12/2013

**Crew:** J. STRICKO, D. JOHNS

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 8.23 | 20.37 | |
| 1.0 | 8.26 | 20.34 | X |
| 2.0 | 8.28 | 19.65 | |
| 3.0 | 8.29 | 19.60 | |
| 4.0 | 8.29 | 19.53 | |
| 5.0 | 8.29 | 19.47 | |
| 6.0 | 8.31 | 19.37 | |
| 7.0 | 8.43 | ~~19.26~~ 19.04 | |
| 8.0 | 8.56 | 18.52 | |
| 9.0 | 8.75 | 18.02 | |
| 10.0 | 8.96 | 17.64 | |
| 11.0 | 9.13 | 17.19 | |
| 12.0 | 9.29 | 16.56 | |
| 13.0 | 9.46 | 15.07 | |
| 14.0 | 9.58 | 13.72 | |
| 15.0 | 9.48 | 11.82 | |
| 16.0 | 9.46 | 10.42 | |
| 17.0 | 9.43 | 10.13 | |
| 18.0 | 9.51 | 9.84 | X |
| 19.0 | 9.49 | 9.83 | |
| ~~20.0~~ JS | | | |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
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| DUP SURF | 8.13 | 20.28 | |
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**Total Depth:** 19.1 meters

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

COLLECTED 2 PONAR SAMPLES FOR MACROINVERTEBRATES
SAMPLES CONSISTED OF FINE SAND, FILLAMENTOUS ALGAE, AND
CLUMPS OF LIVE ZEBRA MUSSELS

LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT
2244-00

**Station:** CM5
**Date/Time:** 8/12/2013 12:15
**Crew:** J. STRICKO, D. JOHNS

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 8.25 | 20.05 | |
| 1.0 | 8.26 | 19.85 | X |
| 2.0 | 8.25 | 19.51 | |
| 3.0 | 8.33 | 19.46 | |
| 4.0 | 8.35 | 19.41 | |
| 5.0 | 8.30 | 19.32 | |
| 6.0 | 8.33 | 19.20 | |
| 7.0 | 8.38 | 19.08 | |
| 8.0 | 8.67 | 18.65 | |
| 9.0 | 9.08 | 18.10 | |
| 10.0 | 9.12 | 16.95 | X |
| 11.0 | 9.23 | 15.60 | |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
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| DUP SURF | 8.17 | 20.06 | |
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**Total Depth:** ~~11.7~~ 11.5 METERS

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

2 PONAR GRABS FOR MACROINVERTEBRATES
SAMPLE CONSISTS OF VERY FINE SAND, ZEBRA MUSSEL SHELLS, OLIGOCHATES, AND CHIRONOMIDS.

# LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT
## 2244-00

**Station:** LM6

**Date/Time:** 8/12/2013 13:00

**Crew:** J. STRICKO, D. JOHNS

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 8.31 | 19.86 | |
| 1.0 | 8.32 | 19.84 | X |
| 2.0 | 8.33 | 19.39 | |
| 3.0 | 8.37 | 19.31 | |
| 4.0 | 8.44 | 19.28 | |
| 5.0 | 8.46 | 19.24 | X |
| 6.0 | 8.53 | 19.24 | |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
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| DUP SURF | 8.26 | 19.77 | |
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**Total Depth:** 6.1 meters

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

COLLECTED 2 PONAR SAMPLES FOR MACRO INVERTEBRATES
VERY FINE SAND, SMALL MIDGES IN BOTH SAMPLES

LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT
2244-00

**Station:** Reservoir - R1
**Date/Time:** 8/29/13 1608
**Crew:** MLV + DJ

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 8.79 | 21.44 | |
| 1.0 | 8.79 | 21.43 | X |
| 2.0 | 8.81 | 21.37 | |
| 3.0 | 8.43 | 21.28 | |
| 4.0 | 8.52 | 21.14 | |
| 5.0 | 8.63 | 21.11 | |
| 6.0 | 8.40 | 21.11 | |
| 7.0 | 8.47 | 21.07 | |
| 8.0 | 8.64 | 21.05 | |
| 9.0 | 8.51 | 21.03 | |
| 10.0 | 8.42 | 21.02 | |
| 11.0 | 8.33 | 21.02 | |
| 12.0 | 8.47 | 21.02 | |
| 13.0 | 8.48 | 21.02 | |
| 14.0 | 8.37 | 21.01 | |
| 15.0 | 8.43 | 21.00 | |
| 16.0 | 8.48 | 21.00 | |
| 17.0 | 8.41 | 20.99 | |
| 18.0 | 8.44 | 20.98 | |
| 19.0 | 8.54 | 20.98 | |
| 20.0 | 8.61 | 20.97 | X |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| 20.8 | 8.50 | 20.97 | |
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| DUP 1.0 | 8.70 | 21.41 | |
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**Total Depth:** 20.8m

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** Reservoir - R2
**Date/Time:** 8/29/13 1638
**Crew:** MLV & DJ

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 8.94 | 21.58 | |
| 1.0 | 8.81 | 21.58 | X |
| 2.0 | 8.80 | 21.55 | |
| 3.0 | 8.75 | 21.47 | |
| 4.0 | 8.78 | 21.24 | |
| 5.0 | 8.83 | 21.16 | |
| 6.0 | 8.75 | 21.15 | |
| 7.0 | 8.77 | 21.10 | |
| 8.0 | 8.80 | 21.08 | |
| 9.0 | 8.79 | 21.04 | |
| 10.0 | 8.64 | 21.02 | |
| 11.0 | 8.69 | 21.01 | |
| 12.0 | 8.67 | 20.99 | |
| 13.0 | 8.50 | 20.98 | |
| 14.0 | 8.56 | 20.98 | |
| 15.0 | 8.49 | 20.97 | |
| 16.0 | 8.54 | 20.97 | |
| 17.0 | 8.49 | 20.97 | |
| 18.0 | 8.45 | 20.96 | X |
| 19.0 | 8.48 | 20.96 | |
| 19.0 | 8.43 | 20.96 | |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
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| DUP 1.0 | 8.66 | 21.55 | |
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**Total Depth:** 19.1 m

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** Reservoir - R3
**Date/Time:** 8/29/13 1700
**Crew:** MLV & DJ

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| **Surface** | 8.95 | 21.62 | |
| 1.0 | 8.81 | 21.52 | X |
| 2.0 | 8.67 | 21.29 | |
| 3.0 | 8.68 | 21.30 | |
| 4.0 | 8.69 | 21.13 | |
| 5.0 | 8.69 | 21.10 | |
| 6.0 | 8.70 | 21.11 | |
| 7.0 | 8.70 | 21.11 | |
| 8.0 | 8.65 | 21.09 | |
| 9.0 | 8.66 | 21.09 | |
| 10.0 | 8.59 | 21.08 | |
| 11.0 | 8.66 | 21.07 | |
| 12.0 | 8.68 | 21.07 | |
| 13.0 | 8.58 | 21.07 | |
| 14.0 | 8.58 | 21.09 | |
| 15.0 | 8.56 | 21.08 | |
| 16.0 | 8.55 | 21.08 | |
| 17.0 | 8.48 | 21.08 | |
| 18.0 | 8.57 | 21.08 | |
| 19.0 | 8.49 | 21.08 | |
| 20.0 | 8.54 | 21.07 | |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| 21.0 | 8.50 | 21.07 | |
| 22.0 | 8.40 | 21.07 | X |
| 22.9 | 8.24 | 21.04 | |
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| DUP 1.0 | 8.32 | 21.45 | |
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**Total Depth:** 22.9 m

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** Lake MI 1
**Date/Time:** 8/29/13 1352
**Crew:** MLV & DJ

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 9.13 | 21.72 | |
| 1.0 | 9.03 | 21.67 | X |
| 2.0 | 8.83 | 21.62 | |
| 3.0 | 8.79 | 21.33 | |
| 4.0 | 8.83 | 21.16 | |
| 5.0 | 8.76 | 21.11 | |
| 6.0 | 8.87 | 21.10 | |
| 7.0 | 8.82 | 21.10 | |
| 8.0 | 8.86 | 21.06 | |
| 9.0 | 8.75 | 20.87 | |
| 10.0 | 8.87 | 20.61 | |
| 11.0 | 9.13 | 20.16 | |
| 12.0 | 9.69 | 18.17 | |
| 13.0 | 10.17 | 15.98 | X |
| 13.7 | 10.30 | 15.19 | |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
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| DUP 1.0 | 8.74 | 21.65 | |
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**Total Depth:** 13.7 m

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT
2244-00

**Station:** Lake MI 2
**Date/Time:** 8/29/13 1335
**Crew:** MLV & DJ

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 9.19 | 22.80 | |
| 1.0 | 8.91 | 22.49 | X |
| 2.0 | 8.83 | 21.28 | |
| 3.0 | 8.85 | 21.21 | |
| 4.0 | 8.89 | 21.19 | |
| 5.0 | 8.82 | 21.19 | X |
| 6.0 | 8.57 | 21.20 | |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
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| DUP 1.0 | 8.84 | 2201 | |
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**Total Depth:** 6.0 m

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** Lake MI 3
**Date/Time:** 8/29/13 1311
**Crew:** MLV + DJ

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 9.01 | 22.72 | |
| 1.0 | 8.96 | 22.03 | X |
| 2.0 | 8.81 | 21.37 | |
| 3.0 | 8.75 | 21.23 | |
| 4.0 | 8.86 | 21.17 | |
| 5.0 | 8.73 | 21.14 | |
| 6.0 | 8.75 | 21.12 | |
| 7.0 | 8.53 | 21.08 | |
| 8.0 | 8.70 | 21.00 | |
| 9.0 | 8.73 | 20.94 | |
| 10.0 | 8.66 | 20.76 | X |
| 11.0 | 8.89 | 20.40 | |
| 11.1 | 9.21 | 20.39 | |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
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| DUP 1.0 | 8.77 | 22.40 | |
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**Total Depth:** 11.1 M

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** Lake MI 4
**Date/Time:** 8/29/13 1219
**Crew:** MLV + DJ

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 8.95 | 21.87 | |
| 1.0 | 8.84 | 21.76 | X |
| 2.0 | 8.66 | 21.35 | |
| 3.0 | 8.79 | 21.25 | |
| 4.0 | 8.81 | 21.22 | |
| 5.0 | 8.65 | 21.21 | |
| 6.0 | 8.68 | 21.20 | |
| 7.0 | 8.66 | 21.19 | |
| 8.0 | 8.76 | 21.18 | |
| 9.0 | 8.70 | 21.16 | |
| 10.0 | 8.65 | 21.13 | |
| 11.0 | 8.90 | 20.65 | |
| 12.0 | 9.23 | 18.85 | |
| 13.0 | 9.70 | 17.78 | |
| 14.0 | 10.24 | 16.25 | |
| 15.0 | 10.98 | 14.91 | |
| 16.0 | 10.96 | 13.99 | |
| 17.0 | 11.12 | 13.71 | X |
| 18.0 | 10.90 | 13.54 | |
| 18.5 | 10.87 | 13.53 | |
| | | | |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| DUP 1.0 | 8.72 | 21.84 | |

**Total Depth:** 18.5m

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** Lake M15
**Date/Time:** 8/29/13 1130
**Crew:** DJ & MLV

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? | Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|---|---|---|---|
| Surface | 8.96 | 22.16 | | | | | |
| 1.0 | 8.75 | 21.40 | X | | | | |
| 2.0 | 8.89 | 21.25 | | | | | |
| 3.0 | 8.66 | 21.22 | | | | | |
| 4.0 | 8.56 | 21.20 | | | | | |
| 5.0 | 8.61 | 21.18 | | | | | |
| 6.0 | 8.56 | 21.17 | | | | | |
| 7.0 | 8.57 | 21.15 | | | | | |
| 8.0 | 8.64 | 21.14 | | | | | |
| 9.0 | 8.74 | 21.07 | | | | | |
| 10.0 | 8.78 | 20.75 | | | | | |
| 11.0 | 8.51 | 20.34 | X | | | | |
| 11.6 | 8.31 | 20.26 | | | | | |
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| | | | | DUP 1.0 | 8.65 | 21.87 | |
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**Total Depth:** 11.6 m

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** Lake MI 6
**Date/Time:** 8/29/13 1158
**Crew:** MLV & DJ

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 8.92 | 22.14 | |
| 1.0 | 8.64 | 22.21 | X |
| 2.0 | 8.84 | 21.31 | |
| 3.0 | 8.83 | 21.25 | |
| 4.0 | 8.73 | 21.23 | |
| 5.0 | 8.67 | 21.21 | |
| 6.0 | 8.72 | 21.14 | X |
| 6.6 | 9.01 | 21.05 | |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
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| DUP 1.0 | 8.59 | 21.85 | |
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**Total Depth:** 6.6m

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT
2244-00

**Station:** R1

**Date/Time:** 9/11/2013 1502

**Crew:** J.STRICKO, D.JOHNS

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 9.27 | 17.11 | |
| 1.0 | 9.24 | 17.07 | x |
| 2.0 | 9.06 | 17.06 | |
| 3.0 | 8.98 | 16.82 | |
| 4.0 | 9.26 | 16.40 | |
| 5.0 | 9.18 | 16.32 | |
| 6.0 | 9.29 | 16.26 | |
| 7.0 | 9.30 | 16.19 | |
| 8.0 | 9.16 | 16.09 | |
| 9.0 | 9.24 | 16.08 | |
| 10.0 | 9.21 | 16.02 | x |
| 11.0 | 9.29 | 15.87 | |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
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| DUP SURF | 9.07 | 17.11 | |
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**Total Depth:** 11.1 METERS

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** R2

**Date/Time:** 9/11/2013 15:50

**Crew:** J. STRICKO, D. JOHNS

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 9.04 | 17.38 | |
| 1.0 | 8.97 | 17.37 | x |
| 2.0 | 8.89 | 17.35 | |
| 3.0 | 8.96 | 17.26 | |
| 4.0 | ~~8.65~~* | 17.21 | |
| 5.0 | 8.99 | 16.97 | |
| 6.0 | 8.97 | 16.58 | |
| 7.0 | 9.02 | 16.45 | |
| 8.0 | 9.38 | 16.17 | |
| 9.0 | 9.46 | 16.03 | x |
| 10.0 | 9.82 | 15.98 | |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
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| DUP SURF | 8.99 | 17.40 | |
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**Total Depth:** 10.4 METERS

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

* D.O. = 8.93

LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT
2244-00

**Station:** R3

**Date/Time:** 9/11/2013 16:45

**Crew:** J. STRICKO

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 9.32 | 17.07 | |
| 1.0 | 9.15 | 17.05 | |
| 2.0 | 9.10 | 17.05 | |
| 3.0 | 9.04 | 17.05 | |
| 4.0 | 9.04 | 17.04 | |
| 5.0 | 8.97 | 17.04 | |
| 6.0 | 8.93 | 17.04 | |
| 7.0 | 8.90 | 17.04 | |
| 8.0 | 8.90 | 17.03 | |
| 9.0 | 9.02 | 16.85 | |
| 10.0 | 8.97 | 16.65 | |
| 11.0 | 9.00 | 16.50 | |
| 12.0 | 9.04 | 16.34 | |
| 13.0 | 9.02 | 16.23 | |
| 14.0 | 9.17 | 16.15 | |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
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| DUP SURF | 9.00 | 17.09 | |
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**Total Depth:** 14.8

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** LM1

**Date/Time:** 9/11/2013 09:50

**Crew:** J. STRICKO, D. JOHNS

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 8.93 | 18.57 | |
| 1.0 | 8.89 | 18.57 | X |
| 2.0 | 8.71 | 18.57 | |
| 3.0 | 8.84 | 18.30 | |
| 4.0 | 9.03 | 18.11 | |
| 5.0 | 9.04 | 18.00 | |
| 6.0 | 9.02 | 17.97 | |
| 7.0 | 9.03 | 17.86 | |
| 8.0 | 9.01 | 17.83 | |
| 9.0 | 8.98 | 17.82 | |
| 10.0 | 9.03 | 17.81 | |
| 11.0 | 9.02 | 17.82 | |
| 12.0 | 9.01 | 17.82 | |
| 13.0 | 9.03 | 17.82 | |
| 14.0 | 9.03 | 17.81 | X |
| 15.0 | 9.07 | 17.81 | |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
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| DUP SURF | 8.84 | 18.55 | |
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**Total Depth:** 15.7 METERS

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** LM2
**Date/Time:** 9/11/2013 10:30
**Crew:** J, STRICKD , D, JOHNS

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 8.91 | 18.20 | |
| 1.0 | 8.89 | 18.23 | X |
| 2.0 | 8.83 | 18.21 | |
| 3.0 | 8.87 | 18.18 | |
| 4.0 | 8.79 | 18.10 | |
| 5.0 | 8.73 | 18.04 | |
| 6.0 | 8.88 | 18.00 | X |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
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| DUP SURF | 8.90 | 18.29 | |
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**Total Depth:** 6.6 METERS

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** LM3
**Date/Time:** 9/11/2013 10:50
**Crew:** J. STRICKO, D. JOHNS

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 8.87 | 18.29 | |
| 1.0 | 8.91 | 18.29 | X |
| 2.0 | 8.90 | 18.29 | |
| 3.0 | 8.88 | 18.30 | |
| 4.0 | 8.87 | 18.27 | |
| 5.0 | 8.87 | 18.26 | |
| 6.0 | 8.85 | 18.24 | |
| 7.0 | 8.88 | 18.23 | |
| 8.0 | 8.86 | 18.19 | |
| 9.0 | 8.83 | 18.16 | |
| 10.0 | 8.83 | 18.08 | |
| 11.0 | 8.85 | 18.03 | X |
| 12.0 | 8.86 | 18.03 | |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
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| DUP SURF | 8.86 | 18.32 | |
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**Total Depth:** ~~11.3 METERS~~ 12.1 METERS

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**

**2244-00**

**Station:** LM4

**Date/Time:** 9/11/2013 12:00

**Crew:** J. Stricko, D. Johns

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? | Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|---|---|---|---|
| Surface | 9.02 | 18.59 | | | | | |
| 1.0 | 9.02 | 18.59 | X | | | | |
| 2.0 | 8.98 | 18.53 | | | | | |
| 3.0 | 8.95 | 18.48 | | | | | |
| 4.0 | 8.95 | 18.42 | | | | | |
| 5.0 | 9.01 | 18.21 | | | | | |
| 6.0 | 9.02 | 18.12 | | | | | |
| 7.0 | 9.03 | 18.06 | | | | | |
| 8.0 | 9.02 | 18.03 | | | | | |
| 9.0 | 9.04 | 18.02 | | | | | |
| 10.0 | 9.07 | 18.00 | | | | | |
| 11.0 | 9.10 | 17.93 | | | | | |
| 12.0 | 9.04 | 17.93 | | | | | |
| 13.0 | 9.04 | 17.91 | | | | | |
| 14.0 | 9.05 | 17.90 | | | | | |
| 15.0 | 9.09 | 17.79 | | | | | |
| 16.0 | 9.10 | 17.44 | | | | | |
| 17.0 | 9.14 | 17.29 | | | | | |
| 18.0 | 9.11 | 17.19 | | | | | |
| 19.0 | 9.07 | 17.14 | | DUP SURF | 8.88 | 18.79 | |
| ~~20.0~~ [illegible] | | | | | | | |

**Total Depth:** 19.5 METERS

**DO and Temp** measurements are taken every 1 meter

**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** LM5
**Date/Time:** 9/11/2013 12:25
**Crew:** J. Stricko, D. Johns

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 8.88 | 18.76 | |
| 1.0 | 8.87 | 18.75 | X |
| 2.0 | 8.86 | 18.61 | |
| 3.0 | 8.85 | 18.50 | |
| 4.0 | 8.86 | 18.39 | |
| 5.0 | 8.82 | 18.12 | |
| 6.0 | 8.87 | 17.97 | |
| 7.0 | 8.86 | 17.82 | |
| 8.0 | 8.94 | 17.72 | |
| 9.0 | 9.01 | 17.56 | |
| 10.0 | 9.06 | 17.45 | X |
| 11.0 | 9.05 | 17.42 | |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
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| DUP SURF | 8.82 | 18.79 | |
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**Total Depth:** 11.7 METERS

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT
2244-00

**Station:** LM6
**Date/Time:** 9/11/2013 12:45
**Crew:** J. STRICKO, D. JOHNS

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 8.88 | 18.59 | |
| 1.0 | 8.89 | 18.45 | X |
| 2.0 | 8.90 | 18.29 | |
| 3.0 | 8.82 | 18.08 | |
| 4.0 | 8.89 | 18.07 | |
| 5.0 | 8.99 | 17.78 | X |
| 6.0 | 9.03 | 17.58 | |
| ~~7.0~~ | | | |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
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| DUP SURF | 8.84 | 18.57 | |
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**Total Depth:** 6.5 meters

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** R1
**Date/Time:** 9/25/2013 1545
**Crew:** J. Streicko, D. Johns

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| **Surface** | 9.44 | 15.33 | |
| 1.0 | 9.29 | 15.34 | x |
| 2.0 | 9.23 | 15.20 | |
| 3.0 | 9.20 | 14.82 | |
| 4.0 | 9.32 | 14.77 | |
| 5.0 | 9.20 | 14.75 | |
| 6.0 | 9.19 | 14.72 | |
| 7.0 | 9.24 | 14.70 | |
| 8.0 | 9.17 | 14.68 | |
| 9.0 | 9.13 | 14.68 | |
| 10.0 | 9.15 | 14.68 | |
| 11.0 | 9.16 | 14.67 | |
| 12.0 | 9.09 | 14.67 | |
| 13.0 | 9.13 | 14.67 | |
| 14.0 | 9.16 | 14.67 | |
| 15.0 | 9.13 | 14.67 | |
| 16.0 | 9.10 | 14.68 | x |
| 17.0 | 9.18 | 14.67 | |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
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| **DUP** surf | 9.20 | 15.29 | |
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**Total Depth:** 17.4 meters

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT
2244-00

**Station:** R2

**Date/Time:** 9/25/2013 16:05

**Crew:** J. STRICCO, D. JOHNS

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 9.24 | 15.17 | |
| 1.0 | 9.28 | 15.16 | |
| 2.0 | 9.18 | 15.10 | |
| 3.0 | 9.22 | 15.09 | |
| 4.0 | 9.23 | 14.92 | |
| 5.0 | 9.22 | 14.72 | |
| 6.0 | 9.20 | 14.71 | |
| 7.0 | 9.17 | 14.69 | |
| 8.0 | 9.24 | 14.68 | |
| 9.0 | 9.11 | 14.67 | |
| 10.0 | 9.11 | 14.67 | |
| 11.0 | 9.05 | 14.66 | |
| 12.0 | 9.17 | 14.66 | |
| 13.0 | 9.16 | 14.66 | |
| 14.0 | 9.15 | 14.66 | |
| 15.0 | 9.10 | 14.66 | |
| 16.0 | 9.18 | 14.66 | |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
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| DUP Surf | 9.19 | 15.18 | |
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**Total Depth:** 16.8 meters

**DO and Temp** measurements are taken every 1 meter

**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** R3

**Date/Time:** 9/25/2013 16:30

**Crew:** J. STRICKO, D. JOHNS

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 9.20 | 15.10 | |
| 1.0 | 9.24 | 15.09 | |
| 2.0 | 9.18 | 15.09 | |
| 3.0 | 9.05 | 15.05 | |
| 4.0 | 9.21 | 14.76 | |
| 5.0 | 9.18 | 14.73 | |
| 6.0 | 9.12 | 14.74 | |
| 7.0 | 9.05 | 14.72 | |
| 8.0 | 9.10 | 14.72 | |
| 9.0 | 9.09 | 14.71 | |
| 10.0 | 9.08 | 14.70 | |
| 11.0 | 9.07 | 14.68 | |
| 12.0 | 9.09 | 14.68 | |
| 13.0 | 9.11 | 14.68 | |
| 14.0 | 9.12 | 14.68 | |
| 15.0 | 9.07 | 14.68 | |
| 16.0 | 9.09 | 14.67 | |
| 17.0 | 9.07 | 14.67 | |
| 18.0 | 9.04 | 14.67 | |
| 19.0 | 9.09 | 14.65 | |
| 20.0 | 9.12 | 14.65 | |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| 21.0 | 9.04 | 14.65 | |
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| DUP SURF | 9.05 | 15.12 | |
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**Total Depth:** 21.3 meters

DO and Temp measurements are taken every 1 meter
turbidity samples are taken 1 meter below surface and 1 meter above bottom

LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT
2244-00

**Station:** LM1

**Date/Time:** 9/25/2013 13:35

**Crew:** J. Stricco, D. Johns

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 9.20 | 16.12 | |
| 1.0 | 9.27 | 16.15 | X |
| 2.0 | 9.15 | 15.93 | |
| 3.0 | 9.24 | 15.56 | |
| 4.0 | 9.17 | 15.20 | |
| 5.0 | 9.26 | 15.00 | |
| 6.0 | 9.28 | 14.73 | |
| 7.0 | 9.41 | 14.69 | |
| 8.0 | 9.27 | 14.69 | |
| 9.0 | 9.32 | 14.69 | |
| 10.0 | 9.30 | 14.62 | |
| 11.0 | 9.34 | 14.36 | |
| 12.0 | 9.34 | 13.87 | X |
| 13.0 | 10.01 | 12.65 | |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
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| DUP surf | 9.09 | 16.12 | |
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**Total Depth:** 13.5 meters

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** LM2
**Date/Time:** 9/25/2013 13:14
**Crew:** J. STRICKO, D. JOHNS

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 9.48 | 14.83 | |
| 1.0 | 9.55 | 14.68 | |
| 2.0 | 9.44 | 14.40 | |
| 3.0 | 9.49 | 13.95 | |
| 4.0 | 9.52 | 13.85 | |
| 5.0 | 9.64 | 13.64 | X |
| 6.0 | 9.79 | 13.65 | |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
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| DUP SURF | 9.34 | 14.97 | |
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**Total Depth:** 6.1 meters

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** LM3
**Date/Time:** 9/25/2013
**Crew:** J. STRICKO, D. JOHNS

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| **Surface** | 9.40 | 15.94 | |
| 1.0 | 9.34 | 15.86 | X |
| 2.0 | 9.40 | 15.17 | |
| 3.0 | 9.46 | 14.84 | |
| 4.0 | 9.46 | 14.60 | |
| 5.0 | 9.50 | 14.41 | |
| 6.0 | 9.48 | 14.37 | |
| 7.0 | 9.46 | 14.24 | |
| 8.0 | 9.47 | 14.07 | |
| 9.0 | 9.49 | 13.76 | |
| 10.0 | 9.69 | 13.50 | X |
| 11.0 | 10.03 | 12.89 | |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
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| **DUP**SURF | 9.15 | 15.74 | |
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**Total Depth:** 11.0 meters

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT
2244-00

**Station:** LM4
**Date/Time:** 9/25/2013 12:17
**Crew:** J. Stricco, D. Johns

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 9.42 | 17.09 | |
| 1.0 | 9.25 | 16.65 | X |
| 2.0 | 9.19 | 16.53 | |
| 3.0 | 9.07 | 16.48 | |
| 4.0 | 9.12 | 16.44 | |
| 5.0 | 9.12 | 16.40 | |
| 6.0 | 9.02 | 16.38 | |
| 7.0 | 9.04 | 16.35 | |
| 8.0 | 8.99 | 16.32 | |
| 9.0 | 9.00 | 16.29 | |
| 10.0 | 8.92 | 16.26 | |
| 11.0 | 9.00 | 15.94 | |
| 12.0 | 9.17 | 15.15 | |
| 13.0 | 9.23 | 14.89 | |
| 14.0 | 9.33 | 14.45 | |
| 15.0 | 9.53 | 13.96 | |
| 16.0 | 9.78 | 11.71 | |
| 17.0 | 10.26 | 9.74 | |
| 18.0 | 10.25 | 9.47 | X |
| 19.0 | 10.28 | 9.34 | |
| | | | |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
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| DUPsurf | 9.00 | 16.96 | |
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**Total Depth:** 19.3 METERS DEEP

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** LMS
**Date/Time:** 9/25/2013 11:06
**Crew:** J. STRICKO, D. JOHNS

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? | Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|---|---|---|---|
| **Surface** | 9.24 | 15.75 | | | | | |
| 1.0 | 9.24 | 15.76 | X | | | | |
| 2.0 | 9.12 | 15.63 | | | | | |
| 3.0 | 9.05 | 15.62 | | | | | |
| 4.0 | 9.07 | 15.54 | | | | | |
| 5.0 | 8.87 | 15.55 | | | | | |
| 6.0 | 8.89 | 15.50 | | | | | |
| 7.0 | 9.13 | 15.43 | | | | | |
| 8.0 | 9.11 | 15.35 | | | | | |
| 9.0 | 9.10 | 15.34 | | | | | |
| 10.0 | 9.28 | 15.33 | | | | | |
| 11.0 | 9.77 | 13.83 | | | | | |
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| | | | | **DUP** SURF | 9.08 | 15.89 | |
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**Total Depth:** 11.5 METERS

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** LM6
**Date/Time:** 9/25/2013 11:59
**Crew:** J. Strickd, D. Johns

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 9.28 | 15.52 | |
| 1.0 | 9.18 | 15.51 | X |
| 2.0 | 9.23 | 15.47 | |
| 3.0 | 9.27 | 15.33 | |
| 4.0 | 9.28 | 15.19 | |
| 5.0 | 9.21 | 15.03 | |
| 6.0 | 9.39 | 15.02 | |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
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| DUP SURF | 9.02 | 16.23 | |
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**Total Depth:** 6.1 meters

**DO and Temp** measurements are taken every 1 meter
**turbidity samples** are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** R1
**Date/Time:** 10/11/13 3:11 PM
**Crew:** Snider / Saxton

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 9.19 | 16.64 | |
| 1.0 | 9.02 | 16.59 | X |
| 2.0 | 8.94 | 16.55 | |
| 3.0 | 8.83 | 16.53 | |
| 4.0 | 8.81 | 16.51 | |
| 5.0 | 8.82 | 16.48 | |
| 6.0 | 8.71 | 16.42 | |
| 7.0 | 8.75 | 16.40 | |
| 8.0 | 8.74 | 16.38 | |
| 9.0 | 8.69 | 16.37 | |
| 10.0 | 8.68 | 16.36 | |
| 11.0 | 8.65 | 16.35 | |
| 12.0 | 8.58 | 16.35 | |
| 13.0 | 8.57 | 16.35 | |
| 14.0 | 8.61 | 16.35 | |
| 15.0 | 8.56 | 16.35 | |
| 16.0 | 8.55 | 16.34 | |
| 17.0 | 8.51 | 16.35 | |
| 18.0 | 8.59 | 16.34 | |
| 19.0 | 8.63 | 16.35 | X |
| | | | |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
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| DUP | 8.69 | 16.61 | |
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**Total Depth:** 19.8 m

DO and Temp measurements are taken every 1 meter
turbidity samples are taken 1 meter below surface and 1 meter above bottom

LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT
2244-00

Station: R2
Date/Time: 10/11/13 3:32 PM
Crew: Stricko / Saxton

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 8.83 | 16.68 | |
| 1.0 | 8.79 | 16.59 | X |
| 2.0 | 8.71 | 16.50 | |
| 3.0 | 8.65 | 16.47 | |
| 4.0 | 8.62 | 16.44 | |
| 5.0 | 8.64 | 16.44 | |
| 6.0 | 8.66 | 16.43 | |
| 7.0 | 8.66 | 16.42 | |
| 8.0 | 8.64 | 16.41 | |
| 9.0 | 8.61 | 16.38 | |
| 10.0 | 8.61 | 16.38 | |
| 11.0 | 8.56 | 16.38 | |
| 12.0 | 8.53 | 16.37 | |
| 13.0 | 8.53 | 16.36 | |
| 14.0 | 8.53 | 16.36 | |
| 15.0 | 8.56 | 16.36 | |
| 16.0 | 8.55 | 16.36 | |
| 17.0 | 8.51 | 16.35 | |
| 18.0 | 8.51 | 16.35 | X |
| | | | |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
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| DUP | 8.74 | 16.68 | |
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Total Depth: 18.0

DO and Temp measurements are taken every 1 meter
turbidity samples are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

Station: R3
Date/Time: 10/11/13 3:51 pm
Crew: Stricko / Saxton

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 8.67 | 16.72 | |
| 1.0 | 8.72 | 16.70 | X |
| 2.0 | 8.69 | 16.63 | |
| 3.0 | 8.66 | 16.53 | |
| 4.0 | 8.65 | 16.49 | |
| 5.0 | 8.61 | 16.48 | |
| 6.0 | 8.61 | 16.45 | |
| 7.0 | 8.60 | 16.43 | |
| 8.0 | 8.64 | 16.42 | |
| 9.0 | 8.57 | 16.42 | |
| 10.0 | 8.57 | 16.42 | |
| 11.0 | 8.60 | 16.41 | |
| 12.0 | 8.55 | 16.41 | |
| 13.0 | 8.50 | 16.41 | |
| 14.0 | 8.57 | 16.41 | |
| 15.0 | 8.59 | 16.41 | |
| 16.0 | 8.58 | 16.41 | |
| 17.0 | 8.53 | 16.41 | |
| 18.0 | 8.55 | 16.41 | |
| 19.0 | 8.53 | 16.41 | |
| 20.0 | 8.51 | 16.41 | |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| 21.0 | 8.52 | 16.41 | |
| 22.0 | 8.50 | 16.41 | |
| 23.0 | 8.49 | 16.41 | X |
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| DUP | 8.68 | 16.76 | |
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Total Depth: 23.2 m

DO and Temp measurements are taken every 1 meter
turbidity samples are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** LM1
**Date/Time:** 10/11/13 12:55pm
**Crew:** Stricko / Saxton

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 9.15 | 16.67 | |
| 1.0 | 9.10 | 16.65 | X |
| 2.0 | 9.09 | 16.64 | |
| 3.0 | 9.05 | 16.63 | |
| 4.0 | 8.97 | 16.62 | |
| 5.0 | 9.01 | 16.60 | |
| 6.0 | 8.99 | 16.59 | |
| 7.0 | 8.98 | 16.56 | |
| 8.0 | 8.98 | 16.56 | |
| 9.0 | 8.98 | 16.56 | |
| 10.0 | 9.01 | 16.56 | |
| 11.0 | 9.00 | 16.55 | |
| 12.0 | 8.99 | 16.55 | |
| 13.0 | 8.99 | 16.54 | |
| 14.0 | 8.99 | 16.52 | X |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
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| DUP | 9.07 | 16.66 | |
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**Total Depth:** 14.2 m

DO and Temp measurements are taken every 1 meter
turbidity samples are taken 1 meter below surface and 1 meter above bottom

# LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT
## 2244-00

Station: LM2
Date/Time: 10/11/13 12:39 PM
Crew: Stricko / Saxton

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 9.21 | 16.32 | |
| 1.0 | 9.09 | 16.32 | X |
| 2.0 | 9.03 | 16.33 | |
| 3.0 | 9.02 | 16.32 | |
| 4.0 | 8.98 | 16.27 | |
| 5.0 | 9.00 | 16.26 | X |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
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| DUP | 9.10 | 16.34 | |
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Total Depth: 5.3 m

DO and Temp measurements are taken every 1 meter
turbidity samples are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

Station: LM3
Date/Time: 10/11/13 12:21 pm
Crew: Stricko / Saxton

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 9.32 | 16.44 | |
| 1.0 | 9.19 | 16.45 | X |
| 2.0 | 9.12 | 16.43 | |
| 3.0 | 8.99 | 16.43 | |
| 4.0 | 9.01 | 16.40 | |
| 5.0 | 9.02 | 16.39 | |
| 6.0 | 8.95 | 16.37 | |
| 7.0 | 8.98 | 16.37 | |
| 8.0 | 8.96 | 16.34 | |
| 9.0 | 8.93 | 16.33 | |
| 10.0 | 8.88 | 16.32 | |
| 11.0 | 8.92 | 16.32 | X |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
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| DUP | 8.98 | 16.45 | |
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Total Depth: 11.2 m

DO and Temp measurements are taken every 1 meter
turbidity samples are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

Station: LM4
Date/Time: 10/11/13 11:46AM
Crew: Stricko / saxton

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 9.27 | 16.68 | |
| 1.0 | 9.26 | 16.68 | X |
| 2.0 | 9.13 | 16.68 | |
| 3.0 | 9.11 | 16.68 | |
| 4.0 | 9.02 | 16.68 | |
| 5.0 | 9.03 | 16.68 | |
| 6.0 | 8.98 | 16.67 | |
| 7.0 | 8.98 | 16.67 | |
| 8.0 | 9.01 | 16.66 | |
| 9.0 | 8.97 | 16.66 | |
| 10.0 | 8.93 | 16.66 | |
| 11.0 | 8.91 | 16.66 | |
| 12.0 | 8.95 | 16.65 | |
| 13.0 | 8.92 | 16.65 | |
| 14.0 | 8.94 | 16.65 | |
| 15.0 | 8.94 | 16.64 | |
| 16.0 | 8.93 | 16.64 | |
| 17.0 | 8.91 | 16.63 | |
| 18.0 | 8.88 | 16.62 | |
| 19.0 | 8.79 | 16.62 | X |
| | | | |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
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| DUP | 9.17 | 16.68 | |
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Total Depth: 19.1 m

DO and Temp measurements are taken every 1 meter
turbidity samples are taken 1 meter below surface and 1 meter above bottom

**LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT**
**2244-00**

**Station:** LM5
**Date/Time:** 10/11/13 11:25 AM
**Crew:** Stricko / Saxton

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 9.11 | 16.35 | |
| 1.0 | 8.95 | 16.36 | X |
| 2.0 | 8.92 | 16.36 | |
| 3.0 | 8.90 | 16.36 | |
| 4.0 | 8.90 | 16.34 | |
| 5.0 | 8.88 | 16.32 | |
| 6.0 | 8.88 | 16.31 | |
| 7.0 | 8.82 | 16.31 | |
| 8.0 | 8.86 | 16.30 | |
| 9.0 | 8.85 | 16.31 | |
| 10.0 | 8.83 | 16.30 | |
| 11.0 | 8.82 | 16.30 | X |
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| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
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| DUP | 8.89 | 16.37 | |
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**Total Depth:** 11.5m

DO and Temp measurements are taken every 1 meter
turbidity samples are taken 1 meter below surface and 1 meter above bottom

LUDINGTON PUMPED STORAGE HYDROELECTRIC PROJECT
2244-00

Station: LM6
Date/Time: 10/11/13 11:05 AM
Crew: Stricko / Saxton

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| Surface | 9.25 | 16.41 | |
| 1.0 | 9.03 | 16.41 | X |
| 2.0 | 9.02 | 16.41 | |
| 3.0 | 8.99 | 16.42 | |
| 4.0 | 8.98 | 16.41 | |
| 5.0 | 8.94 | 16.41 | |
| 6.0 | 8.93 | 16.41 | X |

| Depth (m) XX.X | $O_2$ (mg/L) XX.X | Temp (°C) XX.X | Turbidity Sample Taken? |
|---|---|---|---|
| DUP | 8.91 | 16.41 | |

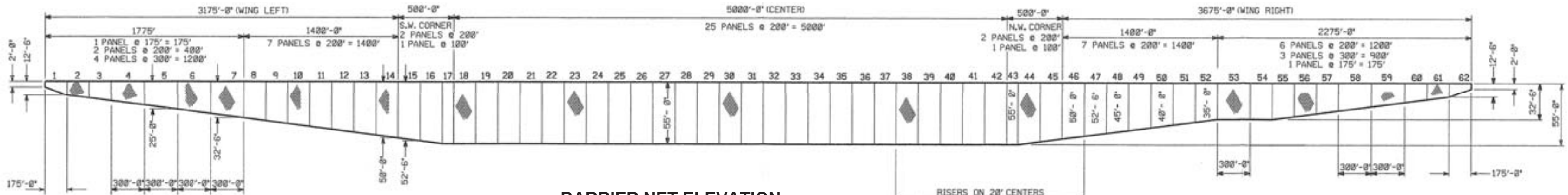
Total Depth: 6.4 m

DO and Temp measurements are taken every 1 meter
turbidity samples are taken 1 meter below surface and 1 meter above bottom

**Enclosure 3**

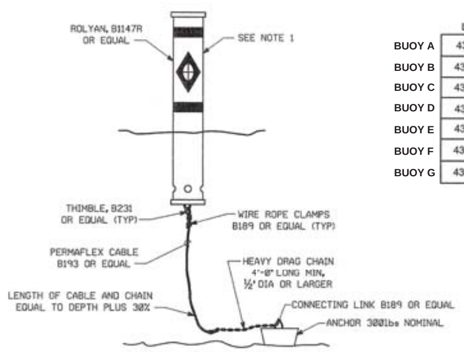
Exhibit F – Revised

Contains CEII
Sheets 1-6 Filed separately as a Non-Public Document
Sheet 7 Public Document




## BARRIER NET ELEVATION

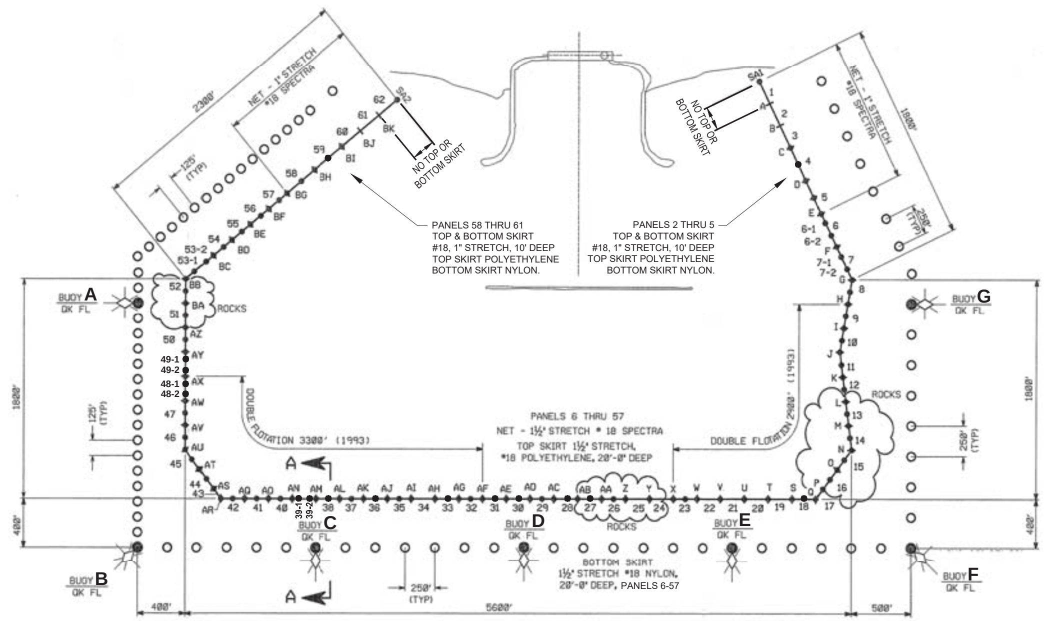
SCALE: NONE

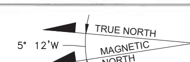



## DETAIL 1
## REGULATORY BUOY

SCALE: NONE

| | LATITUDE | LONGITUDE |
|---|---|---|
| BUOY A | 43°54' 13.22898" | -86°27' 13.71978" |
| BUOY B | 43°54' 11.74842" | -86°27' 42.27648" |
| BUOY C | 43°53' 55.97964" | -86°27' 40.4046" |
| BUOY D | 43°53' 37.1709" | -86°27' 38.5197" |
| BUOY E | 43°53' 18.4095" | -86°27' 36.40884" |
| BUOY F | 43°53' 07.73682" | -86°27' 35.17668" |
| BUOY G | 43°53' 09.47802" | -86°27' 06.64974" |




2016 MAGNETIC DECLINATION IN PROJECT AREA 5° 12'W

## LOCATION PLAN

SCALE: 1" = 400'

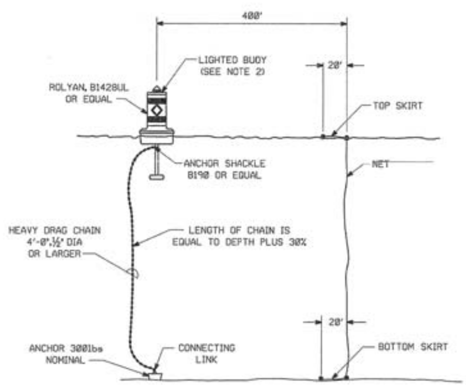
GRAPHICAL SCALES:
1" = 400'


## LEGEND:

- REGULATORY BUOY (SEE NOTE 1)
- LIGHTED BUOY (SEE NOTE 2)
- PERMANENT ANCHOR

1, 2, 3, etc. DESIGNATES PANEL NUMBERS

A, B, C, etc. DESIGNATES PANEL JOINTS




## SECTION A-A
## LIGHTED BUOY

SCALE: NONE

## NOTES:

1. REGULATORY BUOYS (WHITE AND ORANGE) SHALL CONTAIN SIGNS READING: "DANGER - SHALLOW NET" AND "KEEP OUT - SHALLOW NET" ON ALTERNATE SIDES.
2. LIGHTED BUOYS (WHITE WITH A WHITE LIGHT AND ORANGE LETTERING) SHALL BE LOCATED ON EACH CORNER WITH THREE (3) ADDITIONAL LIGHTED BUOYS ALONG THE NORTH-SOUTH LINE AND ONE (1) EACH ALONG EAST-WEST LINE.

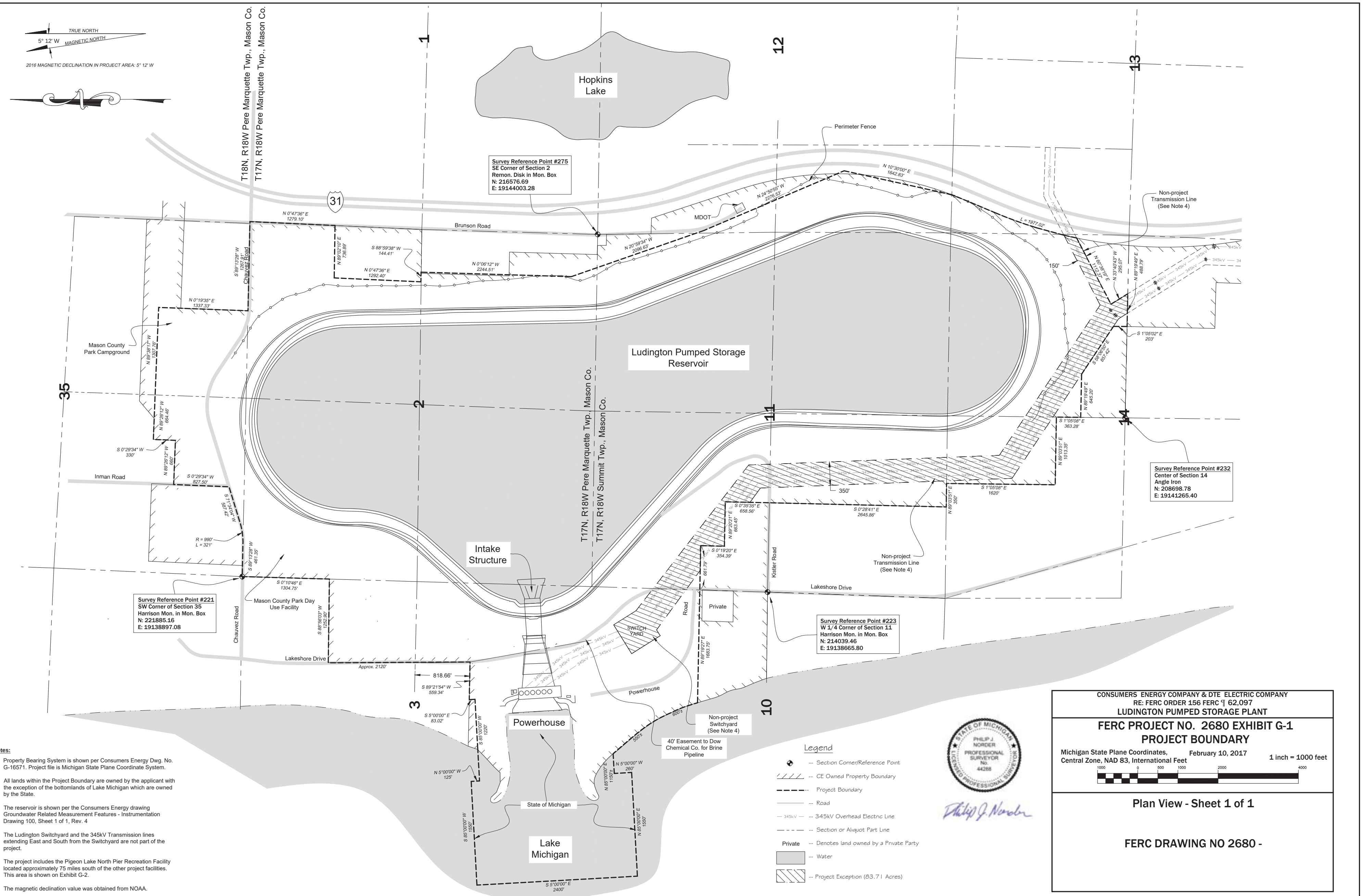
REVISION: A - 08/31/17
ISSUED FOR RECORD
(FERC FINAL LICENSE APPLICATION)

EXHIBIT-F7

CONSUMERS ENERGY COMPANY &
THE DTE ELECTRIC COMPANY
LUDINGTON, MICHIGAN
LUDINGTON PUMPED STORAGE PROJECT
BARRIER NET
PLAN AND DETAILS
FERC PROJECT NO. 2680

**Enclosure 4**

Exhibit G Revised




**Notes:**

1. Property Bearing System is shown per Consumers Energy Dwg. No. G-16571. Project file is Michigan State Plane Coordinate System.
2. All lands within the Project Boundary are owned by the applicant with the exception of the bottomlands of Lake Michigan which are owned by the State.
3. The reservoir is shown per the Consumers Energy drawing Groundwater Related Measurement Features - Instrumentation Drawing 100, Sheet 1 of 1, Rev. 4
4. The Ludington Switchyard and the 345kV Transmission lines extending East and South from the Switchyard are not part of the project.
5. The project includes the Pigeon Lake North Pier Recreation Facility located approximately 75 miles south of the other project facilities. This area is shown on Exhibit G-2.
6. The magnetic declination value was obtained from NOAA.

Legend

- -- Section Corner/Reference Point
- -- CE Owned Property Boundary
- -- Project Boundary
- -- Road
- -- 345kV Overhead Electric Line
- -- Section or Aliquot Part Line
- Private -- Denotes land owned by a Private Party
- -- Water
- -- Project Exception (83.71 Acres)

STATE OF MICHIGAN
PHILIP J. NORDER
PROFESSIONAL SURVEYOR
No. 44288
LICENSED PROFESSIONAL SURVEYOR

Philip J. Norder

CONSUMERS ENERGY COMPANY & DTE ELECTRIC COMPANY
RE: FERC ORDER 156 FERC ¶ 62,097
LUDINGTON PUMPED STORAGE PLANT

**FERC PROJECT NO. 2680 EXHIBIT G-1**
**PROJECT BOUNDARY**

Michigan State Plane Coordinates, Central Zone, NAD 83, International Feet

February 10, 2017

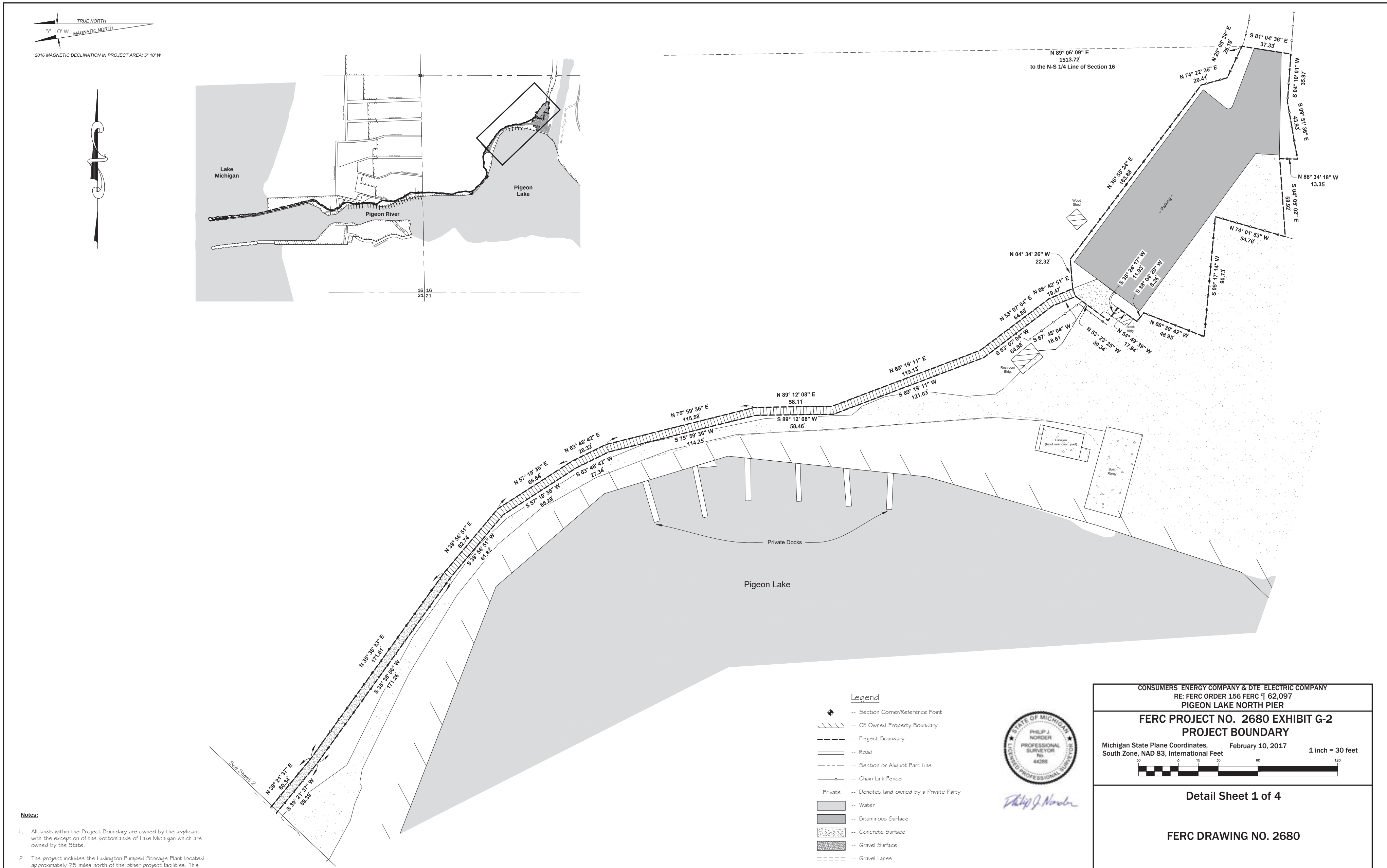
1 inch = 1000 feet

1000 0 500 1000 2000 4000

**Plan View - Sheet 1 of 1**

**FERC DRAWING NO 2680 -**

k:\gensrv\cadd\projects\21162 lps exhibit g dwgs\dwg\21162base.dwg 8/15/2017 9:38 AM




**Notes:**

1. All lands within the Project Boundary are owned by the applicant with the exception of the bottomlands of Lake Michigan which are owned by the State.
2. The project includes the Ludington Pumped Storage Plant located approximately 75 miles north of the other project facilities. This area is shown on Exhibit G-1.
3. The magnetic declination value was obtained from NOAA.

Legend

- -- Section Corner/Reference Point
- -- CE Owned Property Boundary
- -- Project Boundary
- -- Road
- -- Section or Aliquot Part Line
- -- Chain Link Fence
- Private -- Denotes land owned by a Private Party
- -- Water
- -- Bituminous Surface
- -- Concrete Surface
- -- Gravel Surface
- -- Gravel Lanes
- -- Wood Walkway

STATE OF MICHIGAN
PHILIP J. NORDER
PROFESSIONAL SURVEYOR
No. 44288
LICENSED PROFESSIONAL SURVEYOR

Philip J. Norder

CONSUMERS ENERGY COMPANY & DTE ELECTRIC COMPANY
RE: FERC ORDER 156 FERC ¶ 62,097
PIGEON LAKE NORTH PIER

# FERC PROJECT NO. 2680 EXHIBIT G-2
# PROJECT BOUNDARY

Michigan State Plane Coordinates, South Zone, NAD 83, International Feet

February 10, 2017

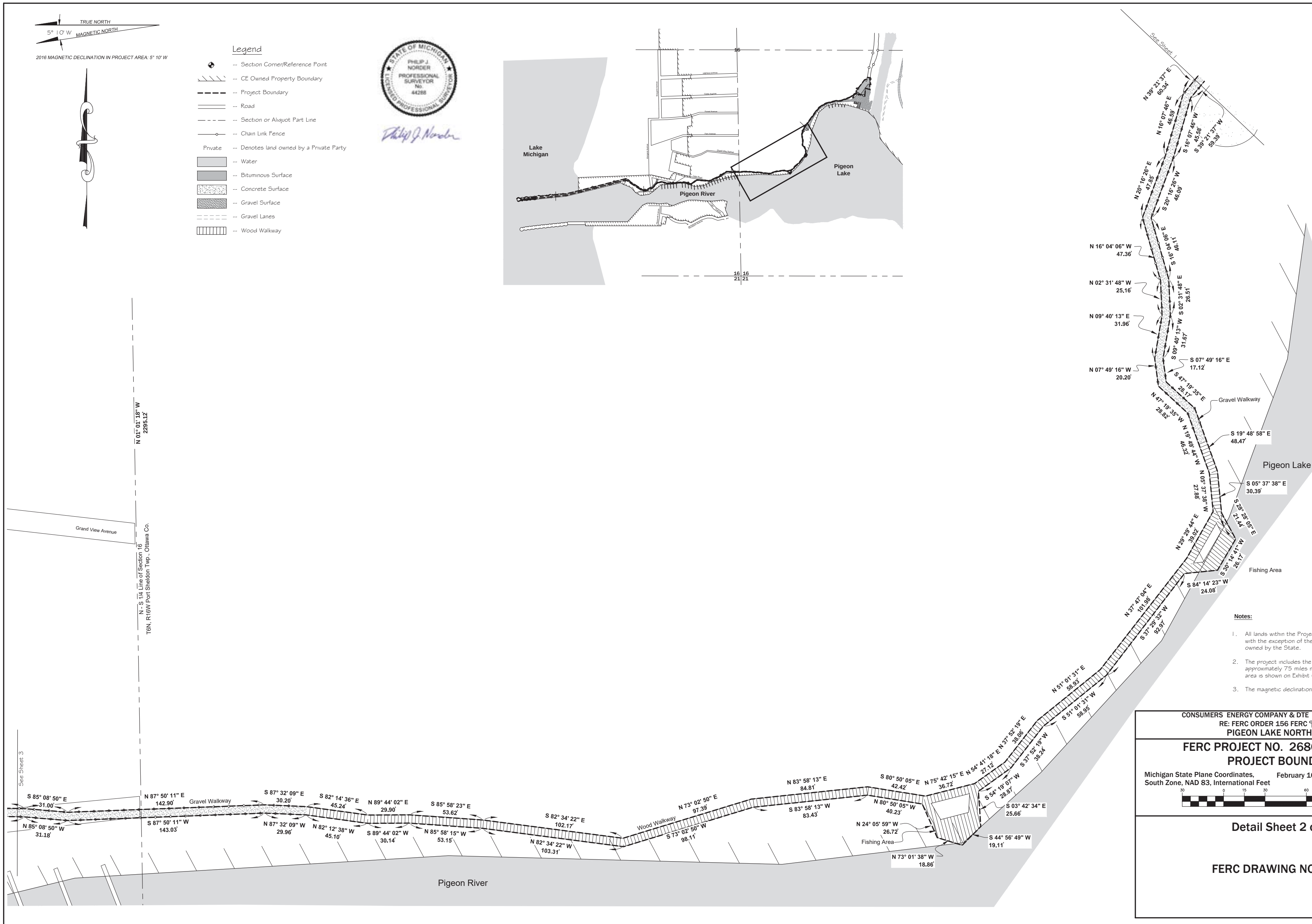
1 inch = 30 feet

30 0 15 30 60 120

## Detail Sheet 1 of 4

## FERC DRAWING NO. 2680

k:\gensrv\cadd\projects\22903 pigeon lake north pier exhibit g\dwg\22903base.dwg 8/7/2017 9:38 AM




**Notes:**

1. All lands within the Project Boundary are owned by the applicant with the exception of the bottomlands of Lake Michigan which are owned by the State.
2. The project includes the Ludington Pumped Storage Plant located approximately 75 miles north of the other project facilities. This area is shown on Exhibit G-1.
3. The magnetic declination value was obtained from NOAA.

CONSUMERS ENERGY COMPANY & DTE ELECTRIC COMPANY
RE: FERC ORDER 156 FERC ¶ 62,097
PIGEON LAKE NORTH PIER

FERC PROJECT NO. 2680 EXHIBIT G-2
PROJECT BOUNDARY

Michigan State Plane Coordinates, South Zone, NAD 83, International Feet

February 10, 2017

1 inch = 30 feet

30 0 15 30 60 120

Detail Sheet 2 of 4

FERC DRAWING NO. 2680

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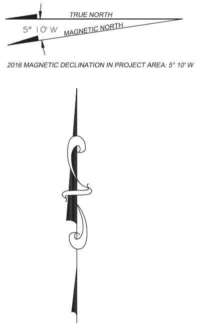
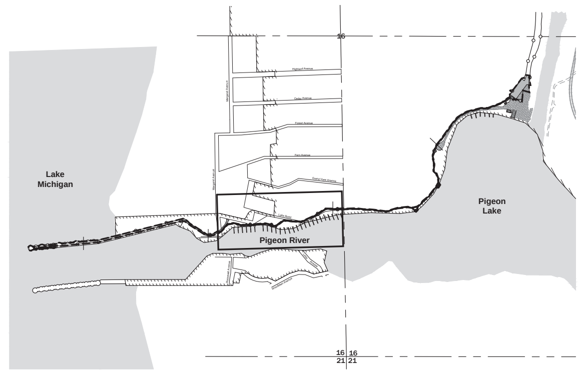
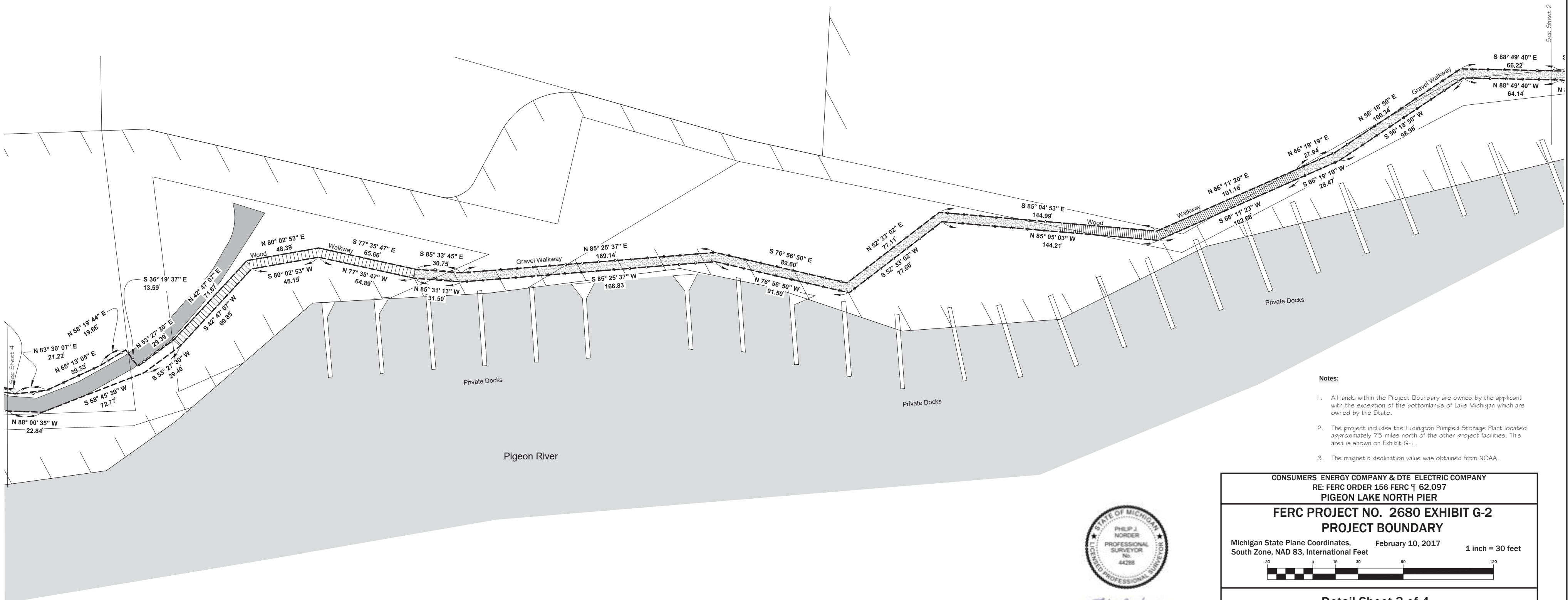



## Legend

- -- Section Corner/Reference Point
- -- CE Owned Property Boundary
- -- Project Boundary
- -- Road
- -- Section or Aliquot Part Line
- -- Chain Link Fence
- Private -- Denotes land owned by a Private Party
- -- Water
- -- Bituminous Surface
- -- Concrete Surface
- -- Gravel Surface
- -- Gravel Lanes
- -- Wood Walkway

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STATE OF MICHIGAN
PHILIP J.
NORDER
PROFESSIONAL
SURVEYOR
No.
44288
LICENSED PROFESSIONAL SURVEYOR

Philip J. Norder

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RE: FERC ORDER 156 FERC ¶ 62,097
PIGEON LAKE NORTH PIER

# FERC PROJECT NO. 2680 EXHIBIT G-2
# PROJECT BOUNDARY

Michigan State Plane Coordinates,
South Zone, NAD 83, International Feet

February 10, 2017

1 inch = 30 feet

30 0 15 30 60 120

## Detail Sheet 3 of 4

## FERC DRAWING NO. 2680

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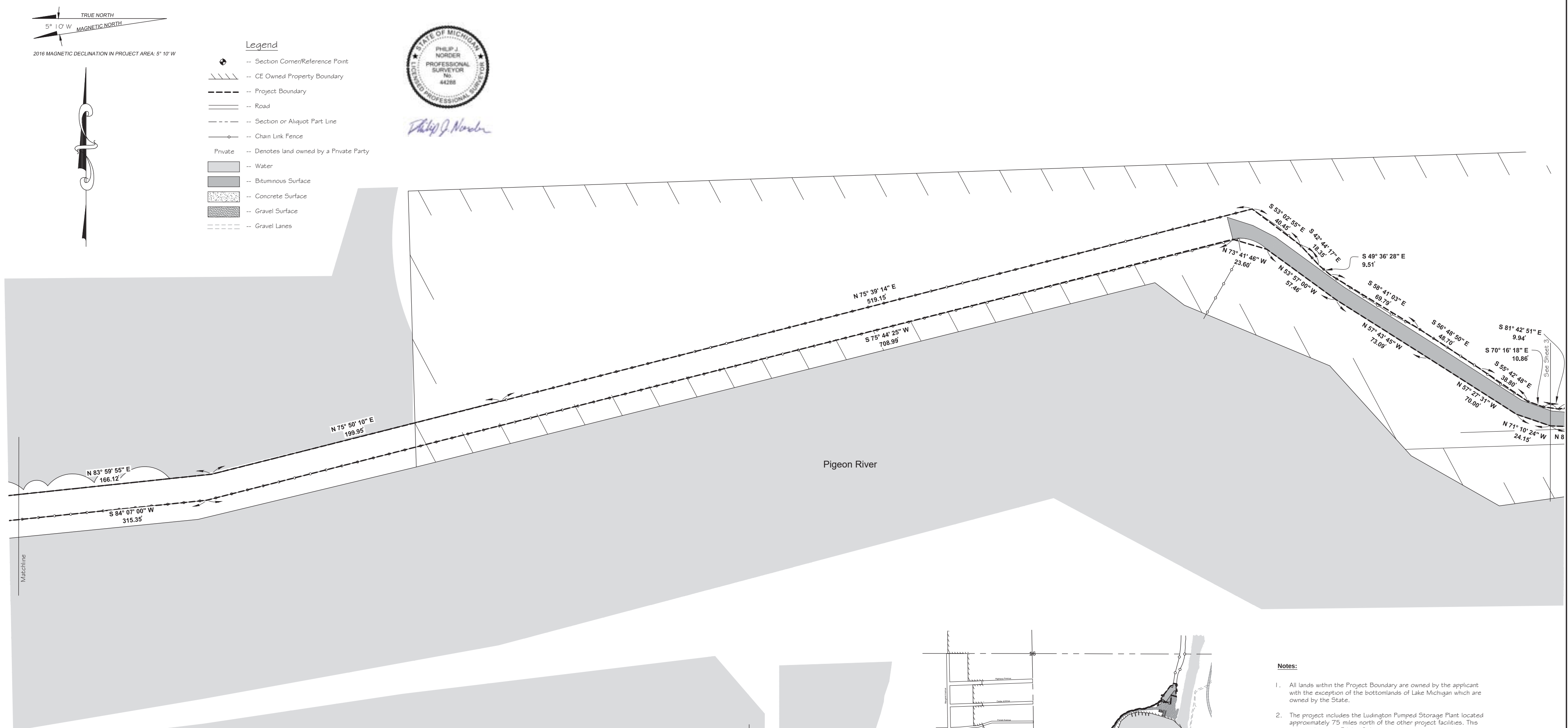


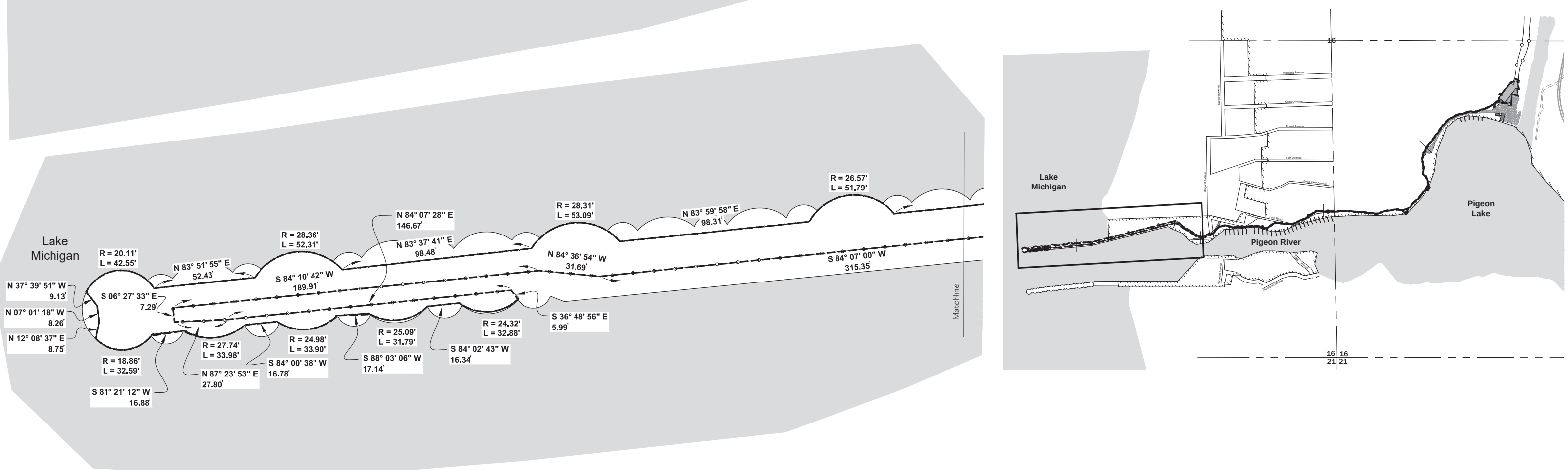


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**CONSUMERS ENERGY COMPANY & DTE ELECTRIC COMPANY**
**RE: FERC ORDER 156 FERC ¶ 62,097**
**PIGEON LAKE NORTH PIER**

## FERC PROJECT NO. 2680 EXHIBIT G-2
## PROJECT BOUNDARY

Michigan State Plane Coordinates, South Zone, NAD 83, International Feet

February 10, 2017

1 inch = 30 feet

30 0 15 30 60 120

**Detail Sheet 4 of 4**

**FERC DRAWING NO. 2680**

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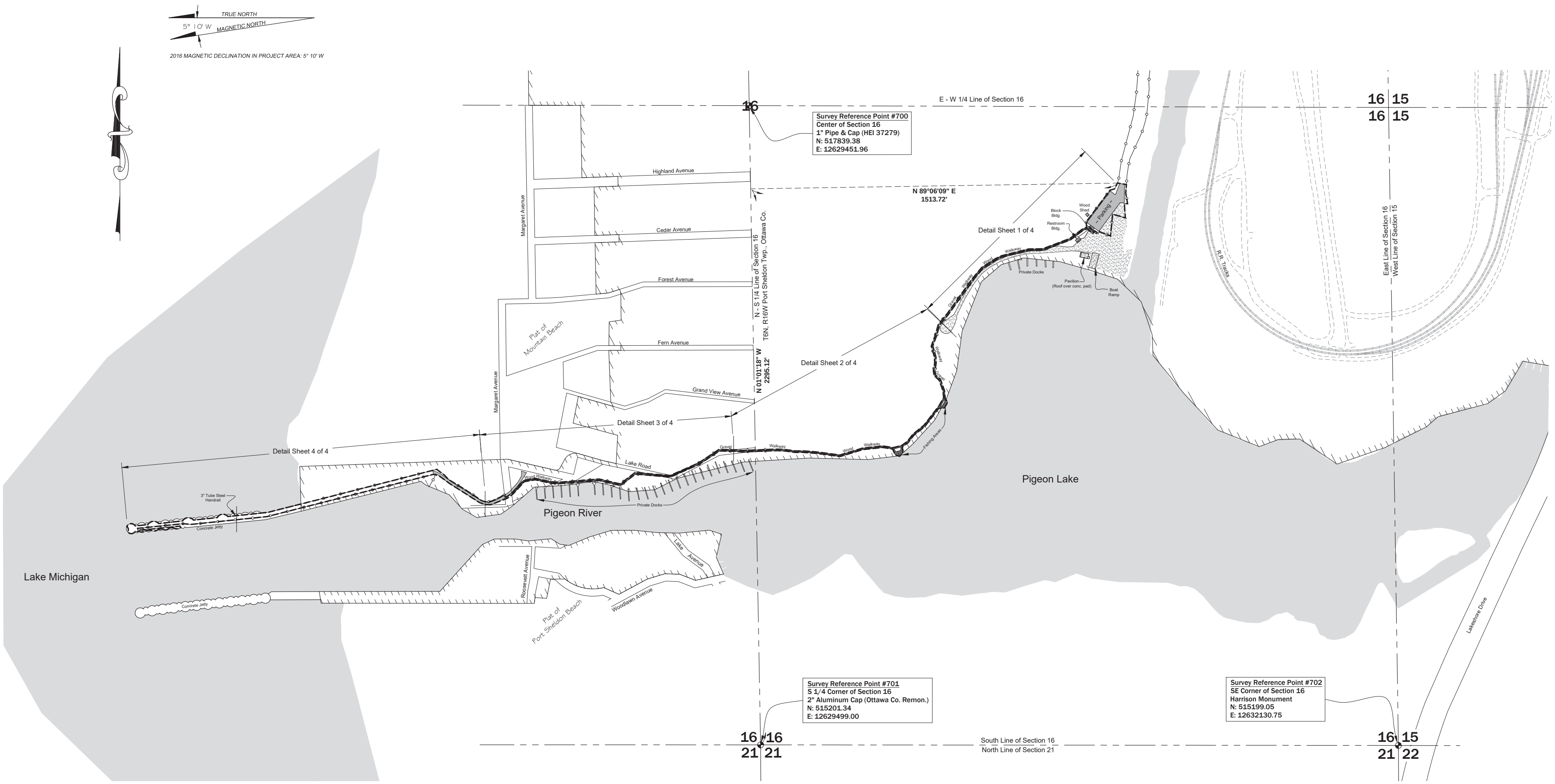


## Legend

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STATE OF MICHIGAN
PHILIP J. NORDER
PROFESSIONAL SURVEYOR
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**CONSUMERS ENERGY COMPANY & DTE ELECTRIC COMPANY**
**RE: FERC ORDER 156 FERC ¶ 62,097**
**PIGEON LAKE NORTH PIER**

## FERC PROJECT NO. 2680 EXHIBIT G-2
## PROJECT BOUNDARY

Michigan State Plane Coordinates, South Zone, NAD 83, International Feet

February 10, 2017

1 inch = 200 feet

200 0 100 200 400 800

## Plan View - Sheet 1 of 1

## FERC DRAWING NO. 2680 -

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