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Memorandum

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Date: October 24, 2013

Project: LOSL5

To: George Controneo, USACE
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CC: Greg Coniglio, Ecology & Environment

SUBJECT: **Documentation of the Lake Ontario – St. Lawrence River "Integrated Ecological Response Model" (IERM) Source Code (DRAFT)**

Introduction

In response to concerns related to potential environmental impacts of the current water level/flow regulation plan (1958DD), the International Joint Commission (IJC) of the U. S. and Canada established the Lake Ontario-St. Lawrence (LOSL) Study Board to evaluate emerging issues possibly associated with water level/flow changes and to determine what would be required to establish new water-level regulation criteria. As part of this effort, LimnoTech developed the "Integrated Ecological Response Model" (IERM) to serve as a tool for quantifying ecological responses to potential water level/flow regimes based on proposed LOSL regulation plans and a range of climactic conditions. The original IERM development and application effort was conducted during the period 2002-2005, and results from the model were delivered and used by the LOSL Study Board to support an evaluation of environmental impacts related to regulation and net basin supply factors. At that time, the IERM software (i.e., installation files) and theory and user documentation were provided as final project deliverables to the U. S. Army Corps of Engineers (USACE) Institute for Water Resources (IWR). Since 2005, USACE and Environment Canada (EC) have continued to work with the IERM model to evaluate the potential impacts and benefits of candidate water level regulation plans for the LOSL system. This model application and evaluation work has been performed largely independent of LimnoTech, although LimnoTech has provided support on an as-needed basis since 2010, including the incorporation of updates to several IERM algorithms (for the northern pike and muskrat sub-models) during 2010-11.

LimnoTech is currently conducting a scope of work to migrate the LOSL IERM from the original Visual Basic 6 platform to Visual Basic within the .NET Framework. This migration effort will help ensure the long-term usability and maintainability of the IERM. USACE and EC have also identified the need for documentation of the model source code to support long-term maintenance and enhancement of the IERM by the agencies. This memorandum provides a detailed description of the source code and the supporting Microsoft Access databases, including:

- General overview of IERM framework configuration, including software and hardware requirements;
- Purpose, structure, and content of the key supporting databases (and associated tables);
- General IERM simulation protocols;

- Purpose and design of the ecological simulation modules and routines;
- Purpose and design of major graphical user interface (GUI) components; and
- Compilation and distribution of the IERM.NET application.

The following sections address each of the major items listed above.

Overview of IERM Source Code Configuration & Requirements

The IERM framework consists of a .NET software program written in Visual Basic (VB.NET), accompanying program files, and a suite of supporting files, including:

- Microsoft Access databases (*.mdb);
- Documentation files (*.pdf); and
- Executable and input files for the Upper St. Lawrence River northern pike model.

The IERM.NET program includes modules, classes, and forms that support the simulation of hydraulic and ecological sub-models for the LOSL system and the visualization of performance indicator (PI) results from model simulations. Utilities for importing LOSL regulation plan data and exporting PI results are also available in the program. Figure 1 provides a schematic that illustrates the communication between the IERM.NET program executable (IERM.exe), the IERM main database ("IERM_v5.mdb"), and the other supporting databases. All databases are currently in Access 97-2003 format (*.mdb), but they could be upgraded to Access 2007-10 (and later) format (*.accdb) using the Microsoft Access "save as" options and minor adjustments to the IERM source code.

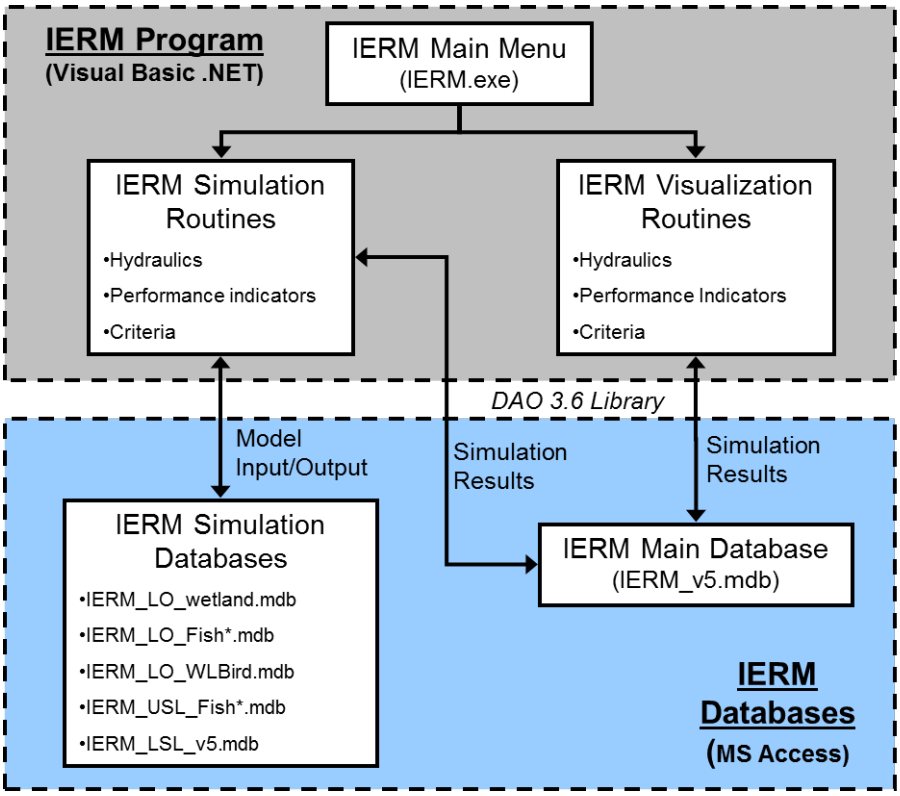


Figure 1. IERM Framework Overview

General Configuration

Execution of the IERM.NET software requires that the following executable and supporting files be placed or installed in a common folder:

- **"IERM.exe" file** – program executable file;
- **"IERM.exe.manifest" and "IERM.exe.config" files** – manifest and configuration files;
- **"dao360.dll"** – Microsoft "Data Access Objects" dynamic link library (version 3.6); and
- **"bin" subfolder** – folder containing the supporting dynamic link library (DLL) files and ActiveX object files (*.ocx) that are required to execute the IERM.

Three additional subfolders must be present and populated with the necessary files in the folder that the "IERM.exe" file is executed from:

- **"databases" subfolder**, which contains 8 Microsoft Access databases that are required to execute and visualize IERM simulations;
- **"documentation" subfolder**, which contains PDF versions of the fact sheets for the 32 key ecological PIs; and
- **"NPike_Model" subfolder**, which contains a standalone executable ("ThousandIslndsPikeModel.exe") and approximately 100 supporting input files for simulating the Upper St. Lawrence northern pike PI developed by John Farrell's team.

Software Requirements

The .NET version of the IERM software has been migrated, tested, and edited using Microsoft Visual Studio 2010 Professional (VS 2010). Other software besides VS 2010 that is required for development is the Microsoft .NET Framework 4.0 and ProEssentials Professional (version 7), which requires that a developer license be obtained from Gigasoft, Inc. (http://www.gigasoft.com). Both VS 2010 and ProEssentials can be installed and used for IERM code development, testing, and deployment tasks on computers running Microsoft Windows 7 or 8. It should also be possible to install both software packages and conduct development activities on Windows XP or Vista, although development on these Windows platforms has not been directly tested by LimnoTech staff.

In general, the software files required for an end user to install and run the .NET version of the IERM are all included in the IERM installation program, which can be generated using the "IERM Setup" program included in the Visual Studio 2010 solution (see section titled "Compilation and Distribution of the IERM.NET Application"). However, the end user must separately install Microsoft Office (including Excel and Access) in order for an end user to 1) import input data from an Excel spreadsheet; 2) export PI results to an Excel spreadsheet; and/or 3) open, view, and edit data tables in the supporting Microsoft Access databases.

Hardware Requirements

The available memory and CPU processing speed on any machine running Windows 7 or 8 should generally be sufficient to develop, test, and run the IERM software. The availability of multiple processing cores/threads will generally not reduce runtime because the source code is not

currently parallelized in any way. Therefore, available CPU processing speed (i.e., in GHz) will dictate the total runtime required to complete a model simulation. LimnoTech has conducted a number of test simulations with the IERM.NET software, and the overall runtime including all ecological sub-models has been found to be approximately one hour on a typical Windows 7 machine.

IERM Database Structure & Content

As discussed above, the IERM main program folder must include a "databases" subfolder that contains a suite of 8 (eight) Microsoft Access databases that support the simulation and visualization of the ecological PIs. Table 1 provides a listing of the databases and a description of their role within the IERM framework.

Table 1. Overview of IERM Databases

Access Database File	Description
IERM_v5.mdb	Main IERM database containing general PI information and simulation results, hydrologic/hydraulic inputs and simulation results, and other supporting data. The content in this database is frequently queried and updated during the course of an IERM simulation and/or visualization session.
IERM_LO_wetland.mdb	Provides inputs specific to the Lake Ontario wetland vegetation sub-model developed by Wilcox et al. In addition to providing inputs to the model, the database stores detailed results (vegetation type by elevation zone) from the wetland vegetation sub-model simulations ("Sim_Results" table).
IERM_LO_Fish.mdb	Provides inputs to support the simulation of the fish sub-model developed by the Minns/Doka research group for Lake Ontario locations.
IERM_LO_Fish_Output.mdb	Stores temporary simulation results for Lake Ontario fish PIs calculated by the fish model developed by the Minns/Doka research group.
IERM_LO_WLBird.mdb	Provides inputs to the wetland bird simulation for Lake Ontario (multiple PIs for multiple bird species).
IERM_USL_Fish.mdb	Provides inputs to support the simulation of the fish sub-model developed by the Minns/Doka research group for Upper St. Lawrence River locations.
IERM_USL_Fish_Output.mdb	Stores temporary simulation results for Upper St. Lawrence River fish PIs calculated by the fish model developed by the Minns/Doka research group.
IERM_LSL_v5.mdb	Provides inputs for the regression-based simulation of Lower St. Lawrence River ecological PIs based on work by Jean Morin and his team at EC.

Descriptions of the key tables in the "IERM_v5.mdb" database are provided in Table 2. The majority of the tables in the database can be broadly grouped as follows:

- The **"Reg_*"** tables contain information related to regulation plans and associated releases at the Moses Saunders Dam, climate (i.e., net basin supply (NBS)) scenarios, and location-specific inputs/outputs for the hydrologic/hydraulic ("H&H") simulation.
- The **"PI_*"** tables contain information related to ecological performance indicators, including inputs, annual results, and aggregate results for the 101-year simulation period.
- The **"Criteria_*"** tables contain information related to hydraulic criteria developed by the LOSL Environmental Technical Working Group (ETWG) based on the PI simulation results. (Note that these tables are not documented in Table 2; see Appendix B.)

Figure 2 provides a schematic showing the relationships between key tables in the "IERM_v5.mdb" database. Additional documentation of database tables and fields for the "IERM_v5.mdb" database and the other IERM databases described in Table 1 are provided in Appendix B.

Upgrading Access Database File Type

As noted previously, the current suite of IERM database are provided in Microsoft Access 97-2003 format (*.mdb), in order to maintain consistency with the original IERM and existing versions of the databases on USACE and EC computers. Beginning with Microsoft Access 2007 and later versions, the *.accdb format is used as the default database format. If desired by USACE or EC, the IERM databases can be readily upgraded to the *.accdb format by following the steps outlined below:

1. Open each of the IERM databases (8 databases total):
    a. Select the "File" tab on the Microsoft Access ribbon;
    b. Select the "Save and Publish" option on the left menu;
    c. Select "Save Database As" and then the *.accdb option; and
    d. Click the "Save As" button to save the database based on the Access 2007-10 (and later) format (using the same base filename – e.g., "IERM_v5.accdb", and saving the file in the existing "databases" folder).
2. In the IERM Visual Studio project, conduct a global search of the source code for all instances of ".mdb" and replace with ".accdb" (approximately 10-15 occurrences total) and recompile/redistribute the code.

Table 2. Key Tables in Main IERM Database ("IERM_v5.mdb")

Table Name	Table Purpose / Description
PI_Matrix	Provides a complete listing of all PIs represented in the IERM, information on which group and location each PI belongs to, the aggregation approach, and general documentation. The "Key_PI" field is used to indicate which of the 619 total ecological PIs are the 'key' PIs (32 total).
PI_Groups	Provides a listing of the 6 ecological groups/components represented by the suite of individual PIs.
PI_Locations	Provides a listing of the locations within the LOSL system for which one or more PIs are computed for.
PI_Results	Contains the scenario-specific, year-specific PI results for all IERM simulations that have been run (i.e., 101 results for each PI and regulation plan scenario combination).
PI_Aggregates	Contains the scenario-specific aggregate PI results for all IERM simulations that have been run (i.e., one result for reach PI and regulation plan scenario combination).
PI_Weights	Provides a listing of weighting factors for unique PI group and region combinations (used for computing a weighted average for key PI results).
Reg_Plans	Contains a listing of the regulation plan scenarios for which inputs (and results) are available in the "IERM_v5" database. Note that each entry in this table represents a unique combination of regulation plan and climate/NBS condition.
Reg_Releases	Contains the quarter-monthly releases (for Moses Saunders Dam) associated with each regulation plan scenario represented in the "Reg_Plans" table.
Reg_ClimateScen	Contains a listing of climate/NBS scenarios available to associate with regulation plan scenarios in the IERM. Each record in the "Reg_Plans" table is associated with one (and only one) of these climate/NBS scenarios.
Reg_HHFactors	Contains a listing of H&H input time series types (flow, tidal, ice) that are required for simulating H&H conditions in the IERM for a particular scenario.
Reg_HHInputs	Provides input time series for each climate/NBS scenario for the H&H factors listed in the "Reg_HHFactors" table.
Temperature	Contains time series of air temperature and water temperature (for Alexandria Bay) required for simulating the Upper St. Lawrence River northern pike PI.
Reg_Locations	Provides a listing of 20 'locations' that have associated water level or flow time series in the "Reg_Hydraulics" table, based on the results of an IERM H&H scenario simulation.
Reg_Regions	Provides a listing of the three main LOSL regions.
Reg_Hydraulics	Provides output water level / flow time series for the individual locations in the "Reg_Locations" table based on IERM simulations of H&H conditions for specific scenarios in the "Reg_Plans" table.

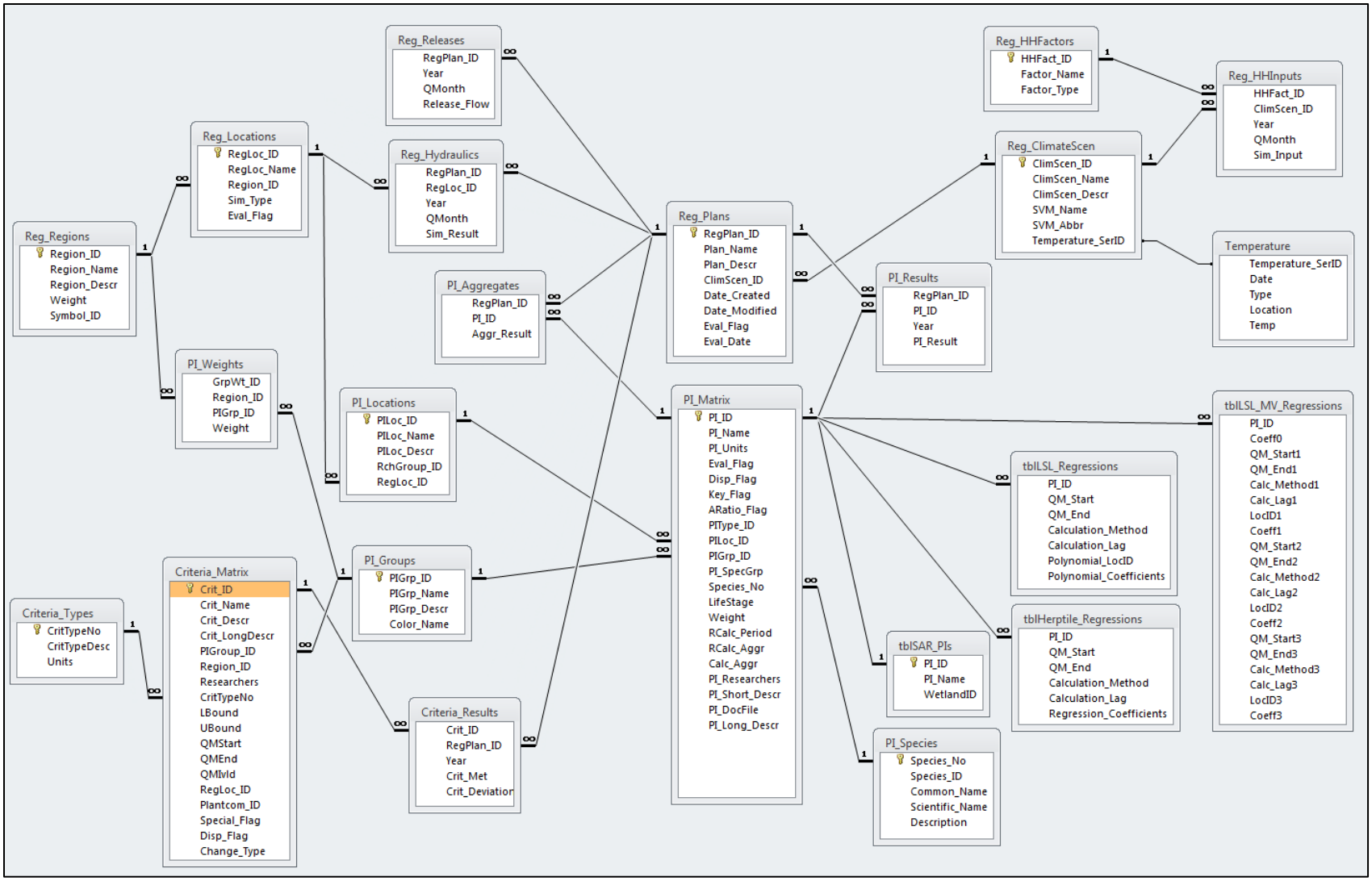


Figure 2. Schematic of Data Table Relationships in the IERM Main Database ("IERM_v5.mdb")

IERM Source Code Organization

The IERM source code consists of a total of 143 files representing Visual Basic .NET modules, classes, interfaces, forms, and supporting files. The source code files are organized into a total of 8 subfolders in the "source" subfolder within the main IERM VS 2010 solution folder:

- **"Modules_Main"** – contains 13 modules that control the IERM's hydrologic/hydraulic and ecological sub-model simulations, which are described in later sections of this memorandum;
- **"Classes"** – contains 7 .NET custom classes that support the simulation of the hydrologic/hydraulic and ecological sub-models;
- **"Forms"** – contains 22 forms (66 files total) that represent the graphical user interface components of the IERM;
- **"Modules_Fish"** – contains 7 modules that support the fish habitat and population sub-models for Lake Ontario and the Upper St. Lawrence River;
- **"Classes_Fish"** – contains 22 .NET classes that support the fish habitat and population sub-models for Lake Ontario and the Upper St. Lawrence River;
- **"Interfaces_Fish"** – contains 4 .NET interfaces that support the fish habitat and population sub-models for Lake Ontario and the Upper St. Lawrence River;
- **"Modules_LSL"** – contains 6 modules that support the Lower St. Lawrence River regression-based PI calculations; and
- **"Modules_Util"** – contains 6 modules that provide utility subroutines and functions to support the hydraulic and ecological simulations.

Appendix A provides a complete listing of the IERM source code files and their purpose.

General Simulation Approach & Protocols

The IERM framework provides the capability for simulating: 1) water level and flow conditions throughout the LOSL system; and 2) ecological sub-models and associated PIs for locations in Lake Ontario, the Upper St. Lawrence River (USLR), and the Lower St. Lawrence (LSLR) River. Model simulations can be set up by the user and then executed by clicking on the "Run IERM" button located near the top of the Main Menu (Figure 3). (Note that the Main Menu form is based on the "frmIERM_MainMenu" class in the source code.)

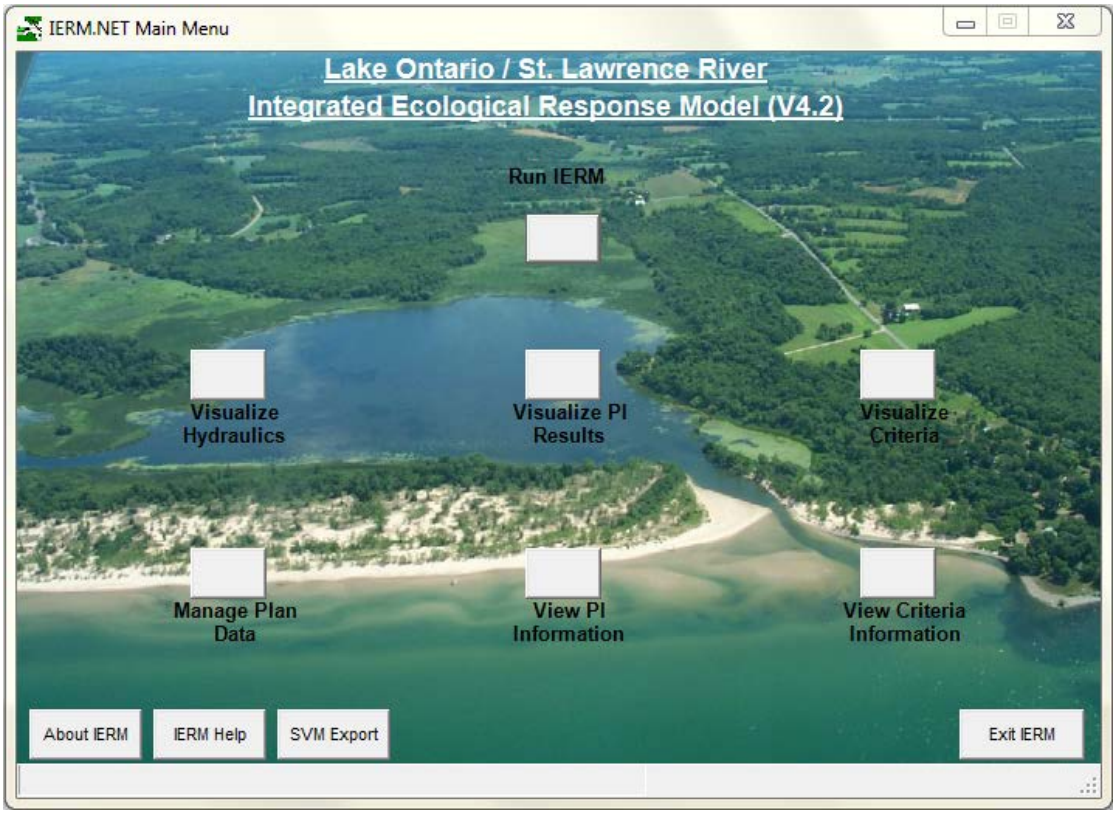


Figure 3. IERM Main Menu

Clicking the "Run IERM" button loads the "IERM Simulation Builder" form, which is based on the "frmIERM_RunModel" form class in the source code ("frmIERM_RunModel.vb"). The scenario builder form is designed to allow the user to run one or more regulation plan scenarios by selecting plan name(s) on the "Simulation Builder" form and then clicking the "Run IERM" button (Figure 4). This form can also be used to import plan scenarios from a LOSL Shared Vision Model (SVM) file. In the original IERM, the user could select the "Import Plan from the SVM" option, which was used to import a single plan scenario and run a simulation for that scenario when the user clicked the "Run IERM" button. In order to provide better flexibility for importing multiple plans prior to starting a simulation, the form has been modified to include an "Import Plan" button. Pressing this button will allow the user to import a single plan, but it will not immediately run the plan. This allows the user to import as many plans as desired prior to running one or more simulations, rather than running one imported regulation plan scenario at a time.

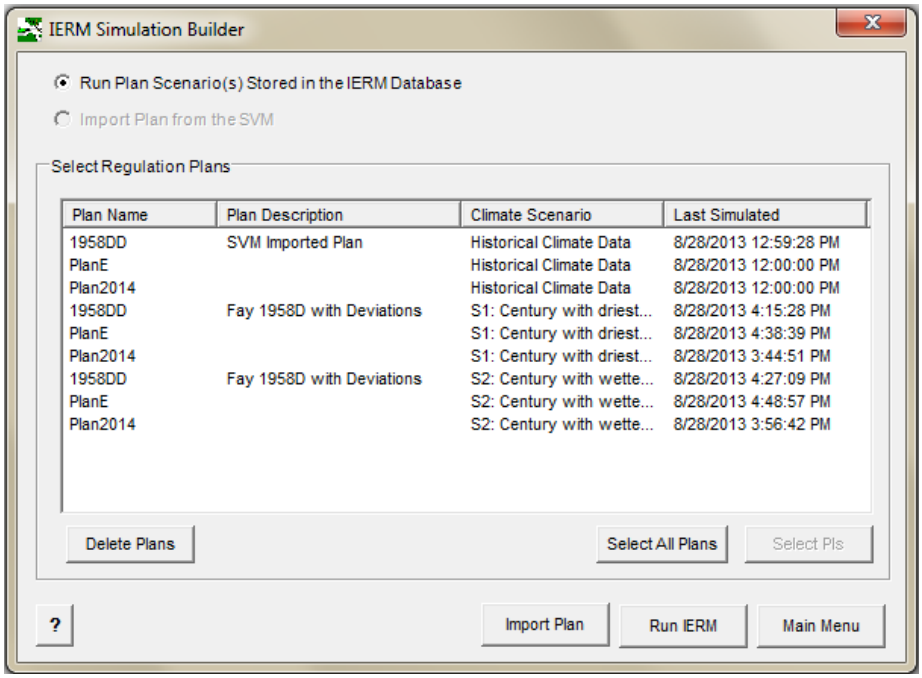


Figure 4. "IERM Simulation Builder" Form

With respect to importing plan data, the IERM requires that a properly configured "IERM Import" sheet be made available by the user through one of the following two approaches:

1. A previously opened Excel workbook is available that has either the "Board Room" or "SVM Post Processor" as part of its file name and contains an "IERM Import" sheet; or
2. The user opens an Excel workbook that contains an "IERM Import" sheet and has either "Board Room" or "SVM Post Processor" as part of its filename. (Note that the code has been updated to allow the user to select a file based on any of the more recent (2007 and later) Excel file formats (*.xlsb, *.xlsm, *.xlsx).)

The import utility expects quarter-monthly releases to be available in range "D9:D4856" (in units of 10 m^3/s), and it reads the plan scenario name from cell "AB25" in the "IERM Import" worksheet (Figure 5). In addition the import utility requires that the Excel workbook name end with the two-digit (or in the case of historic, one-digit) identifier for the climate/NBS scenario that the plan releases are specified for in the "IERM Import" sheet. For example, a file named "SVM Board Room H.xlsb" meets the necessary requirements for the file naming convention, while a file named "SVM File.xlsb" would not.

Prior to importing the time series of releases for a new plan, the IERM verifies that the newly imported plan is associated with a climate/NBS scenario that is already available in the "Reg_ClimateScen" table. Following this verification step, the import tool creates a new entry (or overwrites an existing entry) in the "Reg_Plans" table for the plan being imported and then adds the release time series data to the "Reg_Releases" table (refer to the "SVM_Import" subroutine in the "frmIERM_RunModel" form class).

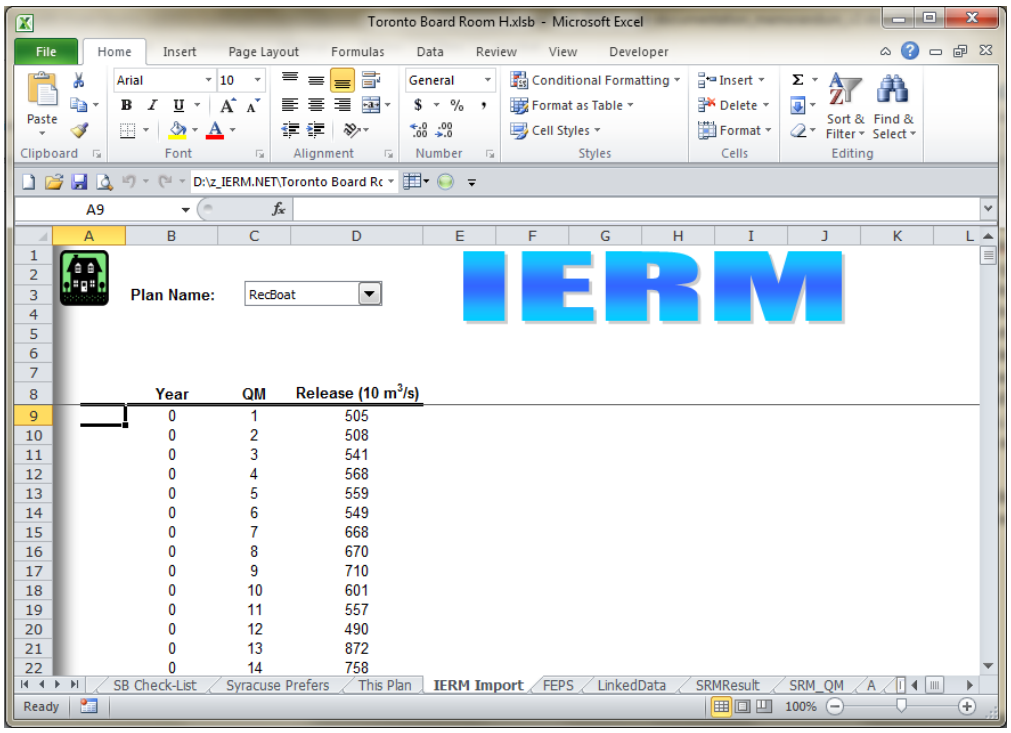


Figure 5. Example "IERM Import" Worksheet Configuration for Importing a Release Time Series

Following user selection of the regulation plan scenario(s) to run on the "IERM Simulation Builder" ("frmIERM_RunModel") form, the "RunIERM" subroutine is called to execute the following simulation sequence:

1. The "Reg_Plans" table in the "IERM_v5.mdb" database is queried for a list of the regulation plan scenarios to be run;
2. The hydrologic and hydraulic simulation is run based on the plan release time series (via the "Reg_Releases" table), and the "Reg_Hydraulics" table is populated with the results of the simulation (via the "RunRegHydraulicsSim" subroutine);
3. The Lake Ontario wetland simulation is run (via the "RunWetlandSim" subroutine);
4. The Minns/Doka fish sub-model simulations for Lake Ontario and Upper St. Lawrence PIs are run (via the "RunFishSim" subroutine);
5. The Upper St. Lawrence River northern pike sub-model (Farrell et al.) is run using the standalone "ThousandIslndsPikeModel.exe" executable available in the "NPike_Model" subfolder (via the "RunUSLNPike" subroutine);
6. The wetland bird simulation is run to generate results for Lake Ontario and Upper St. Lawrence River PIs (via the "RunWLBirdSim" subroutine);
7. The herptile simulation is run (via the "RunHerptileSim" subroutine);
8. The species-at-risk PI results are calculated (via the "RunSARSim" subroutine);
9. The muskrat simulation for the Upper St. Lawrence River is run (via the "RunMuskrats" subroutine);

10. The suite of regression calculations for the Lower St. Lawrence River PIs are conducted (via the "RunLSL_PIs" and "RunLSL_RegressionSim" subroutines);
11. The annual (101-year) results for each PI computed for the current regulation plan scenario are aggregated to a single PI result based on information contained in "Calc_Aggr" field in the "PI_Matrix" table (via the "IERM_AggregatePIs" subroutine in the "Utils_IERM" module); and
12. Hydraulic criteria are calculated for the scenario (via the "IERMCriteria" subroutine in the "SimCriteria" module).

Following the completion of a simulation (or batching of multiple simulations), the IERM will return the Main Menu, where the user can select from visualization options and/or set up additional simulations.

The following sections provide a more detailed description of the protocols for the IERM H&H simulation and the ecological sub-model simulations. It is important to note that the below sections are focused primarily on source code considerations. The IERM peer review report (LimnoTech 2005) and accompanying PI fact sheets should be consulted regarding the scientific aspects and supporting details and literature for the various ecological sub-models and PIs represented in the IERM. The fact sheets for the key PIs are also included as Appendix C to this memorandum. The IERM peer review report also includes references for detailed technical reports developed by each of the ETWG researchers involved with the IJC LOSL water levels study.

Hydrology & Hydraulic Simulation

As discussed above and shown in Table 2, the "Reg_*" tables in the "IERM_v5.mdb" database contain all input/output information for H&H aspects of all regulation plan scenarios. As noted in the "General Protocols" section above, regulation plan scenarios and their associated time series of releases can be imported into the "Reg_Plans" table and the "Reg_Releases" table, respectively, using the IERM import utility. During the import process, the IERM verifies that the climate/NBS scenario associated with the new plan (e.g., "H" / "Historical") is present in the "Reg_ClimateScen" table. The IERM main database currently only contains information in the "Reg_ClimateScen" and "Reg_HHInputs" table for the climate/NBS scenarios listed in Table 3.

Table 3. Climate / Net Basin Supply Scenarios Available in the IERM

Climate/NBS Scenario ID	Climate/NBS Scenario Description
H	Historical Climate Data
S1	Stochastic century with driest segment
S2	Stochastic century with wettest segment
S3	Stochastic century similar to historical
S4	Stochastic Century with longest drought
C1	Climate change scenario (warm, dry)
C2	Climate change scenario (not as warm, dry)
C3	Climate change scenario (warm, wet)
C4	Climate change scenario (not as warm, wet)

The "IERM Plan Utility" form ("frmIERM_PlanUtility" class) was originally designed to allow users to delete/import information from/to the climate-related tables (e.g., "Reg_HHInputs" table); however, this form has never been fully tested in the original or .NET versions of the IERM. In case there is a desire by USACE or EC to further develop this utility in the future, it has been retained in the .NET version of IERM. Currently, this form can be accessed by clicking on the "Manage Plan Data" button on the Main Menu. In lieu of a fully-functioning utility, the scenario entries in the "Reg_ClimateScen" table and the associated H&H input time series (i.e., for flow, ice, water level) in the "Reg_HHInputs" table can be manually edited by IERM developers who are comfortable working directly with the database tables in Microsoft Access.

As discussed previously, the IERM is designed to simulate H&H conditions based on a quarter-monthly time series of releases for a given regulation plan scenario ("Reg_Releases" table) and the ice, flow, and tidal time series contained in the "Reg_HHInputs" table. The H&H simulation is carried out in the "RunRegHydraulicsSim" table in the "SimRegHydraulics" module. As the H&H simulation progresses, quarter-monthly time series of either water level or flow are written to the "Reg_Hydraulics" table for each of the 20 locations listed in the "Reg_Locations" table. As the IERM runs each of the ecological sub-models, the "Reg_Hydraulics" table will be queried for the relevant water level and/or flow time series to support each sub-model. For example, the Lake Ontario wetland vegetation model queries Lake Ontario water level results from the "Reg_Hydraulics" table to serve as the basis for the required flooding/dewatering calculations.

The H&H algorithms contained in the "RunRegHydraulicsSim" routine are based on the hydrologic/hydraulic algorithms and coefficients that were provided by David Fay, Yin Fan, and others at EC when the IERM was originally developed during the 2002-05 time period. At that time, the H&H algorithms in the IERM were tested extensively, and the results were verified against time series results for water level and flow generated by EC staff. However, because these algorithms and/or some of the H&H time series in the "Reg_HHInputs" table are now likely to be outdated, this information should be revisited and updated to reflect current H&H information for the LOSL system.

As an alternative to simulating H&H conditions within the IERM for each plan, a user could pre-populate the (20) water level and flow time series in the "Reg_Hydraulics" table prior to running a given plan. When an IERM simulation begins, the "RunIERM" subroutine will check to see if the 20 required time series already exist in the "Reg_Hydraulics" table. If a complete set of quarter-monthly values is available for each of the 20 required locations, then the IERM will bypass the H&H simulation and simply query results from the "Reg_Hydraulics" table as needed to support the individual ecological sub-models. This approach would require the additional effort of populating the "Reg_Hydraulics" table for each regulation plan scenario. However, if this approach was used consistently, it would not be necessary to refine/maintain the algorithms and coefficients in the "RunRegHydraulicsSim" subroutine or the 25 forcing function time series contained for each climate/NBS scenario in the "Reg_HHInputs" table.

Ecological Simulation Components

The IERM ecological simulation follows a progression consistent with the simulation sequence outlined above. Because the Lake Ontario wetland vegetation sub-model provides results that are used by several of the other sub-models, it is the first ecological sub-model to be evaluated during a simulation. The entire ecological simulation sequence is outlined in Table 4 below. There are a total of 619 individual PIs calculated by the suite of ecological sub-models, with 32 of those PIs being designated as "key" PIs. Column 4 in Table 4 provides the range of PI identifiers associated

with each sub-model (see the "PI_ID" field in the "PI_Matrix" table). Column 5 in the table provides the overall number of PIs and the number of key PIs associated with each sub-model.

Table 4. IERM Ecological Sub-Model Simulation Sequence

Sequence No.	Description (Researchers)	Main Subroutines (module file)	PI Numeric Identifier Range[1]	Total PIs [Key PIs]
1	Wetland vegetation for Lake Ontario (Wilcox et al.)	RunWetlandSim ("SimWetland.vb")	11001 - 11005	5 [1]
2	Fish habitat/population for Lake Ontario and the USLR (Minns, Doka, et al.)	RunFishSim ("SimFish.vb")	LO: 12001 -12402 USL: 22001 - 22402	308 [10]
3	Northern pike population for USLR, Thousand Islands area (Farrell et al.)	RunUSLNPike ("SimUSL_NPike.vb")	22501 - 22502	2 [1]
4	Wetland birds for Lake Ontario and the USLR (Ingram et al.)	RunWLBirdSim ("SimWBirds.vb"	LO: 13001 - 13999, USL: 23007 - 23107	29 [2]
5	Herptiles (amphibians, reptiles) for Lake Ontario and the USLR (Gibbs et al.)	RunHerpileSim ("SimHerptile.vb")	14001 - 14006	5 [0]
6	Species-at-risk habitat supply for Lake Ontario and the USLR.	RunSARSim ("SimSAR.vb")	LO: 13106-13209, USL: 16101-16402	32 [4]
7	Muskrat population for the USLR.	RunMuskrats ("SimMuskrats")	25001	1 [1]
8	Lower St. Lawrence River (all sub-models, based on regressions)	RunLSL_PIs, RunLSL_RegressionSim ("SimLSL_PIs.vb", "SimLSL_Regressions.vb")	31001 - 38005 (23	237 [13]

[1] This range refers to the range of "PI_ID" integer values in the "PI_Matrix" table of the main IERM database ("IERM_v5.mdb").

Each of the individual sub-models listed in Table 4 is further described in the following sub-sections. When a given ecological sub-model is executed, the IERM queries the necessary H&H time series from the "Reg_Hydraulics" table, and any other supporting information from the collection of supporting IERM database is also queried via the code. A particular sub-model may create various temporary results at finer temporal (e.g., daily) or spatial (e.g., reach-level) scales

that those used to report final PI results. For example, the Lake Ontario wetland vegetation model initially computes vegetation type at 1-cm elevation increments for four different coastal wetland types (barrier beach, drowned river mouth, open embayment, protected embayment), and then aggregates those results for PI reporting purposes. Ultimately, each sub-model generates results for one or more PIs at an *annual scale*, and then those results are saved to the "PI_Results" table in the IERM main database.

Following the completion of all ecological sub-model simulations, IERM computes aggregate values for the entire set of ecological PIs for the plan under evaluation via the "IERM_AggregatePIs" subroutine (see the "Utils_IERM" module). The aggregation routine uses a text 'code' provided in the "Calc_Aggr" field of the "PI_Matrix" table to determine the aggregation approach to use. The following aggregation options are currently used for one or more of the ecological PIs (via the "Calc_Aggr" field):

- **"AVG"** – instructs the IERM to calculate the mean results based on the 101 annual PI results;
- **"SUM"** – instructs the IERM to calculate the sum of the 101 annual PI results; and
- **"Q1-58DD"** – instructs IERM to calculate the fraction of years where the PI result is greater than the 25th percentile result from the 1958DD simulation conducted for the same climate/NBS scenario (via the "Quartile1_Agg" function).

Proper calculation of aggregate results for PIs based on the "Q1-1958DD" approach requires that a 1958DD simulation for the current climate/NBS scenario be run prior to any other regulation plans for that NBS scenario. Furthermore, the regulation plan name for each 1958DD simulation must be set to exactly "1958DD" in the "Plan_Name" field of the "Reg_Plans" table in the "IERM_v5.mdb" database in order to allow the "IERM_AggregatePIs" routine to properly identify it and use the associated PI results.

The IERM includes several linkages between the Lake Ontario wetland vegetation model and other ecological sub-models developed for Lake Ontario and the Upper St. Lawrence River. Sub-models that utilize results from the wetland sub-model as part of their input data set include:

- Wetland birds (Lake Ontario / USLR);
- Herptiles (Lake Ontario);
- Muskrats (USLR); and
- Species-at-risk (Lake Ontario / USLR).

These linkages are further discussed within the below sub-sections that address each individual ecological sub-model.

Wetland Vegetation (Lake Ontario)

The ecological response of each wetland type is calculated within the "SimWetland" module, which in turn uses the "LO_Wetland" class. The results from these calculations, as well as the inputs required to support the calculations, are stored in the "IERM_LO_Wetland.mdb" database (hereafter referred to as the "wetlands database"). The inputs are read from the wetland database into variables and arrays by the "SimWetland" module, and then those inputs are passed to the "LO_Wetland" class where the vegetation responses are computed.

Wetland Database Design & Inputs

The wetlands database was designed to provide the necessary inputs to support the annual simulation of wetland vegetation conditions, including:

- Wetland geomorphic type information ("Wetlands" table);
- Plant community types ("Plant_Communities" table);
- Wetland elevation "zones", based on 1-cm elevation increments ("Elevation_Zones" table); and
- Additional inputs to define the linkages between the wetland vegetation outputs and the fish, wetland bird, herptile, species-at-risk, and muskrat sub-models (see tables "Structural_Types", "WLBird_Habitats", and "Muskrat_PIs").

A schematic illustrating the key tables in the wetland database and the inter-table relationships is shown in Figure 6.

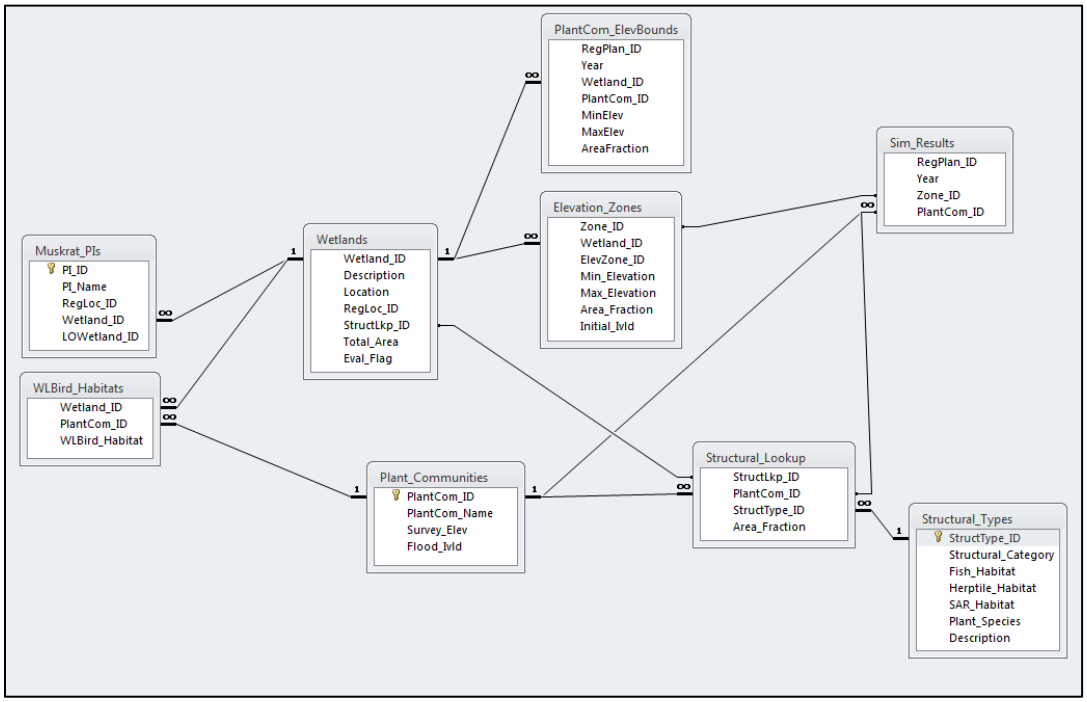


Figure 6. Schematic of Data Table Relationships in the IERM Wetland Database ("IERM_LO_wetland.mdb")

The Lake Ontario wetland vegetation model represents four geomorphic wetland types for the (distinctly represented) Lake Ontario and Upper St. Lawrence River systems via the "Wetlands" table:

- Drowned river mouth;
- Barrier beach;
- Protected embayment; and
- Open embayment.

In addition to providing a listing of these wetland types for Lake Ontario and the USLR, the "Wetlands" table includes a custom entry to represent drowned river mouth wetland conditions

used for the USLR muskrat PI calculations ("Muskrat Wetlands", "Wetland_ID" = 5). Each wetland location has an associated surface area (i.e., across Lake Ontario or the USLR region) and associated hydrologic location, which is also defined in the "Wetlands" table. (The "RegLoc_ID" entries in this table refer to entries in the "Reg_Locations" table in the IERM main database.) Seven plant communities are defined in the "Plant_Communities" model (A – G), and each of the plant communities has an associated flood interval class (see the "Flood_Ivld" field). A set of elevation 'zones' and an initial flood condition for each of the zones are stored in the "Elevation_Zones" table. The information is read from these input tables by the "RunWetlandSim" subroutine in the "SimWetland" module.

Wetland Simulation

After the wetland inputs are read from the database in the "RunWetlandSim" subroutine, the code begins by initializing the flood intervals via the "LO_Wetland.InitializeFloodIntervals" subroutine. This code loops over each bathymetric zone and assigns a flooding and dewatering value based on the initial conditions read from the "Elevation_Zones" table ("Initial_Ivld" field). Next, the initial plant communities in each bathymetric zone are assigned via the "LO_Wetland.InitialPlantCommunity" subroutine by comparing the flooding value to the flood interval class of the 7 plant communities ("A"-"G").

After these initialization steps, the Lake Ontario / USLR water levels previously calculated and stored in the "Reg_Hydraulics" table are read and transferred to the "LO_Wetland.UpdatePlantCommunity" subroutine to drive the wetland response calculations. The code in the "LO_Wetland.UpdatePlantCommunity" routine determines the number of years elapsed since the last flooding event or the last dewatering event for each elevation zone, and then assigns the appropriate plan community to that zone based on the flooding/dewatering intervals specified in the "Flood_Ivld" field in the "Plant_Communities" table in the wetland database.

After the first iteration, the 101-year simulation is repeated for a second cycle in order to ensure that the assumed *initial* flooding/dewatering conditions at the beginning of the simulation do not influence the wetland model PI results. Therefore, the wetland model is effectively run for 202 years, and the water level conditions experienced during the latter half of the first 101-year sequence of the 2-century cycle influences the results in the early years of the second cycle. Only the results from the second iteration (cycle) are written to the "PlantCom_ElevBounds" table in the "IERM_LO_Wetland.mdb" database.

The results written to the "PlantCom_ElevBounds" table represent the elevation range and the fraction of the total wetland area for which each of the seven plant community types was assigned for a particular wetland during a specific calendar year. The "RunWetlandSim" routine then queries the information from this table and the "Total_Area" field in the "Wetlands" table in order to compute the overall (i.e., lake-wide or river-wide) area of a particular vegetative community that corresponds to a specific vegetation PI in the "PI_Matrix" table in the IERM main database. For example, the Lake Ontario meadow marsh PI is calculated for a given regulation plan scenario and simulation year (e.g., "1913") using the following steps:

1. Sum up the total area fraction for plant community types "A", "B", and "C" for each geomorphic wetland type (via the "PlantCom_ElevBounds" table);
2. Compute the total meadow marsh (A-B-C) surface area by wetland geomorphic type by multiplying the results from step #1 by the total area specified in the "Total_Area" field ("Wetlands" table);

3. Calculate the total meadow marsh surface area across all four geomorphic types by summing the areas calculated in step #2 above; and
4. Write the calculated annual meadow marsh surface areas to the "PI_Results" table in the main IERM database (the meadow marsh supply-based has "PI_ID" = 11003).

Because the detailed results in the "PlantCom_ElevBounds" table provide the elevation range associated with each plant community type, the results in this table can be used to diagnose the wetland model's behavior and for comparison against independent (e.g., spreadsheet or FORTRAN) wetland vegetation calculations.

Wetland Vegetation PI Summary

The wetland vegetation model generates results for a total of 5 PIs, with the "supply-based" meadow marsh surface area PI ("PI_ID" = 11003) representing the sole key PI for this sub-model. Threshold values of NBS are used to determine which years the meadow marsh PI results should be reported for, based on the understanding that the PI results are only relevant during and immediately following periods of low NBS. The supply-based PI is reported beginning in years where the mean NBS for January-June falls below the "lower" threshold of 6,792 (in units of 10 m^3/s). Reporting of the PI then occurs for each year thereafter until the mean NBS for January-June increases above the "upper" threshold of 7,916. These thresholds are represented as "hardcoded" values for the "NBS_Lbound" and "NBS"Ubound" variables in the "RunWetlandSim" subroutine.

Fish Habitat Supply & Population Indices (Lake Ontario / USLR)

The fish sub-model developed by the Minns/Doka research group for Lake Ontario and the USLR computes results a large suite of habitat supply and population PIs. The simulation of fish habitat sub-models for Lake Ontario is divided into two general categories: species-specific PIs and fish guild PIs. The suite of species-specific and guild-specific PIs includes habitat supply indicators (expressed as area/time in units of "hectare-days") and population indicators (expressed as an index, #/ha, or kg/ha). The four primary fish species simulated by the model are northern pike, smallmouth bass, largemouth bass, and yellow perch. In addition, habitat supply is simulated by this sub-model for two fish species-at-risk: bridle shiner and pugnose shiner. Population PIs are calculated only for the specific fish species listed above and not for the guilds.

The subroutines that control the fish habitat/population simulation are contained in the "SimFish" module and are described below.

- **"RunFishSim"** is the master control routine for the fish subroutine that calls the "RunFishSpeciesSim" and "RunFishGuildSim" subroutines to calculate the species and guild PI sets for Lake Ontario and the USLR.
- **"RunFishSpeciesSim"** controls the simulation and calculation of habitat supply and population PIs for specific fish species (e.g., northern pike). Five subroutines are called to carry out the species-specific PI calculations:
    - "FishHabitatSim" – simulates habitat supply for a specific fish species and location in Lake Ontario or the USLR;
    - "PikePopulationSim" – simulates population response for northern pike;
    - "SmBassPopulationSim" – simulates population response for smallmouth bass;

  - "LmBassPopulationSim" – simulates population response for largemouth bass; and
  - "YPerchPopulationSim" – simulates population response for yellow perch.

- **"RunFishGuildSim"** controls the habitat supply simulation and PI calculations for various fish guilds (i.e., classes of fish that have similar water temperature and vegetation preferences) by calling the "FishHabitat" subroutine (available in the "FH_RunModel" module).

The above routines query the fish habitat supply and population PIs (via the "PI_Matrix" and "PI_Species" tables in "IERM_v5.mdb"), and then the habitat response for each species/guild are simulated for specific regions within Lake Ontario and the USLR. The detailed, location-specific results generated by the fish habitat simulation are stored in the "IERM_HabitatSupply" and "IERM_HabitatSupply_Annual" tables contained in the "IERM_LO_Fish_Output.mdb" and "IERM_USL_Fish_Output.mdb" databases. The raw results contained in these tables are further processed by the "RunFishSpeciesSim" and "RunFishGuildSim" routines, and annual habitat supply PI results are then written to the "PI_Results" table in the IERM main database.

As noted above, fish population performance indicators are computed for four common nearshore species (yellow perch, northern pike, small mouth bass, and largemouth bass), as well as for two species-at-risk (bridle shiner, pugnose shiner). Each of these species have separate growth models and subroutines that are called individually within the code; however, each population simulations is dependent on the output from the habitat supply simulation stored in the "IERM_HabitatSupply*" tables in the "IERM_LO_Fish_Output.mdb" (for Lake Ontario) and the "IERM_USL_Fish_Output.mdb" (for the USLR) databases. The detailed, region-specific results of the fish species population simulations are written to the "IERM_Population" tables in each of these databases. Analogous to the approach for the habitat supply PIs, the results in the "IERM_Population" tables are used to compute the final annual population PI results, which are then written to the "PI_Results" table in the IERM main database.

The above discussion is focused on the key subroutines that control the fish habitat supply and population simulations and the interactions with the "IERM_*_Fish_Output.mdb" databases. However, it is important to note that a large and complex body of source code serves as the foundation for the fish habitat and population simulations. The collection of modules, classes, and interfaces contained in the "Modules_Fish", "Classes_Fish" and "Interfaces_Fish" subfolders (with filenames beginning with "FH_", "FHC_", and "IC", respectively) represent this portion of the IERM source code. This code was developed by JEMSys Software Systems Inc. on behalf of the Minns/Doka research group at EC. The fish sub-model code was migrated to the .NET framework in its entirety, and successfully benchmarked against the original IERM software. However, complete documentation of this portion of the source code is beyond the scope of this memorandum and would require significant input from the original developer.

Fish Habitat/Population PI Summary

The Lake Ontario and USLR fish sub-model generates results for a total of 308 PIs, with 10 of those PIs designated as "key" PIs (Table 5).

Table 5. Key PIs for the Lake Ontario / USLR Fish Sub-Model

PI Numeric Identifier ("PI_ID")	LOSL Region	Key PI Description
12006	Lake Ontario	"Low vegetation preference, 18°C" fish guild spawning habitat supply in Lake Ontario
12007	Lake Ontario	"High vegetation preference, 24°C" fish guild spawning habitat supply in Lake Ontario
12008	Lake Ontario	"Low vegetation preference, 24°C" fish guild spawning habitat supply in Lake Ontario
12401	Lake Ontario	Northern pike young-of-year recruitment in Lake Ontario
12402	Lake Ontario	Largemouth bass young-of-year recruitment in Lake Ontario
22006	USLR	"Low vegetation preference, 18°C" fish guild spawning habitat supply in the USLR
22007	USLR	"High vegetation preference, 24°C" fish guild spawning habitat supply in the USLR
22008	USLR	"Low vegetation preference, 24°C" fish guild spawning habitat supply in the USLR
22401	USLR	Northern pike young-of-year recruitment in the USLR
22402	USLR	Largemouth bass young-of-year recruitment in the USLR

Northern Pike Population (USLR – Thousand Islands Area)

The Upper St. Lawrence River Northern Pike model is run via an external, standalone executable program ("ThousandIslndsPikeModel.exe"), which is contained and run within the "NPike_Model" subfolder. The "RunUSLNPike" subroutine in the IERM controls the pre-processing, execution, and post-processing of the northern pike population simulation. The northern pike sub-model relies on water levels, climate scenario dependent air temperatures, and climate scenario dependent water temperatures, all of which are stored in the IERM main database. Prior to running the standalone executable, the "RunUSLNPike" routine creates the following input files for the model based on information contained in the "Reg_Hydraulics" and "Temperature" tables in the IERM main database:

- "AlexBayIGLD.prn" – contains estimated daily water level in Alexandria Bay based on quarter-monthly water levels calculated by the IERM (or manually imported to the "Reg_Hydraulics" table) for the Thousand Islands area;
- "AlexBayWTemp.prn" – contains estimated daily water temperature in Alexandria Bay; and
- "AirT_WtTown.prn" – contains estimated daily air temperature for Watertown, NY.

When the "ThousandIslndsPikeModel.exe" program is executed by the "RunUSLNPike" subroutine, the program reads each of the three above files, in addition to reading input data from approximately 90 other input files contained in the "NPike_Model" subfolder. After the external

program has run to completion, the "SimUSL_NPike" routine reads the northern pike PI results from the "ThousIslsNPike.out" output file that was generated. The PI results are then written to the "PI_Results" table in the IERM main database.

Northern Pike Population PI Summary

The northern pike sub-model for the Thousand Islands region generates results for a total of 2 PIs, with both of those PIs designated as "key" PIs (Table 6).

Table 6. Key PIs for the USLR Northern Pike Sub-Model

PI Numeric Identifier ("PI_ID")	LOSL Region	Key PI Description
22501	USLR (Thousand Islands region)	Northern pike annual young-of-year net productivity in the Thousand Islands region
22502	USLR (Thousand Islands region)	Northern pike annual egg productivity in the Thousand Islands region

Wetland Bird Capacity and Reproduction (Lake Ontario / USLR)

The wetland bird performance indicators rely on the output from the Lake Ontario wetland plant community simulation, which is stored in the "IERM_LO_Wetland.mdb database". The results of the wetland vegetation simulation, which was discussed in detail above, are linked to appropriate bird habitat types via the table "WLBird_Habitats" in the IERM wetland database and the wetland classes in the "tblWLBird_Species" table in the "IERM_LO_WLBird.mdb" database.

The simulation for the wetland bird PIs is controlled by the "RunWLBirdSim" subroutine in the "SimWBirds" module. This subroutine utilizes the "WBird_Density" and "WBird_Nesting" classes. The wetland bird densities are calculated first in the code, based on the wetland plant communities, water level conditions, and regression coefficients stored in the "tblWLBird_Density" table. The wetland bird nesting calculations are also based on the wetland and hydraulic calculations; however, the response is based on the potential for stranding and flooding of an elevation zone. Regression coefficients for these calculations are contained in the "tblWLBird_Nest_Properties" table in the "IERM_LO_WLBird.mdb" database. The nesting success PIs are based on a 2-year rolling average of the success rate.

Wetland Bird PI Summary

The wetland bird sub-model for the Lake Ontario and Upper St. Lawrence River regions generates results for a total of 40 PIs, with 4 of those PIs designated as "key" PIs (Table 7). Note that neither the PI totals nor Table 7 include the six wetland bird PIs that are simulated as part of the "species-at-risk" sub-model simulation (see the "Species-at-Risk (Lake Ontario)" section below).

Table 7. Key PIs for the Lake Ontario / USLR Wetland Bird Sub-Model

PI Numeric Identifier ("PI_ID")	LOSL Region	Key PI Description
13006	Lake Ontario	Least Bittern - reproductive index (Lake Ontario)
13007	Lake Ontario	Virginia Rail - reproductive index (Lake Ontario)
13009	Lake Ontario	Black Tern - reproductive index (Lake Ontario)
23007	USLR	Virginia Rail - reproductive index (Lake St. Lawrence)

Herptile Habitat Supply (Lake Ontario)

Herptile performance indicators are calculated within the "RunHerptileSim" subroutine in the "SimHerptile" module. These PIs are all calculated via polynomial regressions based on the hydraulic calculations previously stored in "Reg_Hydraulics" table in the IERM main database. Polynomial regression coefficients, as well as time period constraints, are defined in the "tblHerptile_Regressions" table of the IERM main database.

Herptile PI Summary

The herptile sub-model for the Lake Ontario and Upper St. Lawrence River regions generates results for a total of 8 PIs (including three species-at-risk), and none of the PIs is designated as a "key" PI.

Species-at-Risk (Lake Ontario)

The "RunSARSim" subroutine contained in the "SimSAR" module is responsible for calculation of eight additional species-at-risk (SAR) PIs for that are not directly computed by the other vegetation, fish, wetland bird, and herptile sub-models for Lake Ontario and the Upper St. Lawrence River. The eight species-at-risk simulated by this subroutine are listed in the "tblSAR_PIs" table in the IERM main database. There are two categories of SAR PIs simulated by this routine: 1) spiny softshell turtle ("PI_ID" = 16402), and 2) other vegetation, fish, wetland bird, and herptile SARs ("PI_ID" = 16101, 16301-16306). The spiny softshell turtle response is calculated using the same approach as for the Lake Ontario herptile PIs (i.e., using a polynomial regression based on hydraulic conditions). The remaining SAR PIs are calculated based on the previously simulated wetland community response. The table "Structural_Types_SAR" in the "IERM_LO_Wetland.mdb" database contains the lookup table defining the ideal plant community structure for each wetland SAR. The areas of each of these communities are summed as defined in the table to represent the SAR PI result.

Species-at-Risk PI Summary

The species-at-risk sub-model for the Lake Ontario and Upper St. Lawrence River regions generates results for a total of 8 PIs (including three species-at-risk), with 2 of the SAR wetland bird PIs designated as "key" PIs (Table 8).

Table 8. Key PIs for the Lake Ontario / USLR Species-at-Risk Sub-Model

PI Numeric Identifier ("PI_ID")	LOSL Region	Key PI Description
16301	Lake Ontario	Yellow Rail - preferred breeding habitat coverage (Lake Ontario)
16302	Lake Ontario	King Rail - preferred breeding habitat coverage (Lake Ontario)

Muskrat Population (Upper St. Lawrence River)

The Upper St. Lawrence River muskrat population model is simulated by the "RunMuskrats" subroutine contained in the "SimMuskrats" module. The muskrat sub-model is based on a regression that utilizes estimates of fall and winter water depth in the cattail-dominated wetland zone and air temperature as inputs. Air temperature information for the Thousand Islands area is read from the "Temperature" table in the IERM main database. Fall and winter water depths are calculated based on:

1. Thousands Islands (RegLoc_ID = 201) water levels, which are queried by the "RunMuskrats" routine from the "Reg_Hydraulics" table; and

2. The elevation range of the cattail-dominated zone in Upper St. Lawrence River wetlands, which is queried from the "Elevation_Zones" table in the "IERM_LO_Wetland.mdb" database for the "Muskrats Wetlands" wetland type ("Wetland_ID" = 5 in the "Wetlands" table).

Following the compilation of the water depth and air temperature inputs, the "RunMuskrats" subroutine computes 1) the probability of muskrat occupancy in cattail wetlands, and 2) muskrat house density. The PI is calculated as the muskrat house density for each year, and the results of the calculation are written to the "PI_Results" table in the IERM main database.

Muskrat PI Summary

The muskrat sub-model for the Upper St. Lawrence River region generates results for one PI, which is designated as a "key" PI (Table 9).

Table 9. Key PIs for the Upper St. Lawrence River Muskrat Sub-Model

PI Numeric Identifier ("PI_ID")	LOSL Region	Key PI Description
25001	USLR	Muskrat - house density in drowned river mouth wetlands (Thousand Islands area)

Lower St. Lawrence River (all PIs)

The collection of vegetation, fish, wetland bird, muskrat, and other PIs for the Lower St. Lawrence River was developed as a set of simplified calculations intended to represent the more detailed and nuanced results generated by a suite of complex, multi-dimensional hydrodynamic and ecological response models developed by Jean Morin and his team at Environment Canada. The results of those multi-dimensional model simulations were used to develop a set of regressions that correlate ecological PIs response to a particular hydraulic parameter (e.g., water level or flow), and the "IERM_LSL_v5.mdb" database was populated with this information to support the calculation of the PIs within the IERM framework.

The "RunLSL_PIs" and "RunLSL_RegressionSim" subroutines contained in the "SimLSL_PIs" and "SimLSL_Regressions" modules, respectively, control the simulation of the LSLR regression models and the generation of final PI results. These subroutines rely on the subroutines and functions contained in the six "SMC_*" source files, which are organized in the "Modules_LSL" subfolder. Specific questions regarding the development and implementation of the regression-based PIs for the Lower St. Lawrence River should be directed to the original developers (Jean Morin et al.).

Lower St. Lawrence PI Summary

The Lower St. Lawrence River regression models generate results for a total of 237 PIs, with 13 of those PIs designated as "key" PIs (Table 10).

Table 10. Key PIs for the Lower St. Lawrence River

PI Numeric Identifier ("PI_ID")	Key PI Description
32004	Golden Shiner - suitable feeding habitat surface area (Lake St. Louis to Trois-Rivières)
32109	Wetlands fish - abundance index (Lower St. Lawrence)
33004	Migratory wildfowl - floodplain habitat surface area (Lake St. Louis to to Trois-Rivières)
33054	Least Bittern - reproductive index (Lake St. Louis to Trois-Rivières)
33059	Virginia Rail - reproductive index (Lake St. Louis to Trois-Rivières)
33085	Migratory wildfowl - productivity (Lake St. Louis to to Trois-Rivières)
33119	Black Tern - reproductive index (Lake St. Louis to Trois-Rivières)
33134	Northern Pike - suitable reproductive habitat surface area (Lake St. Louis to Trois-Rivières)
36013	Frog sp. - reproductive habitat surface area (Lake St. Louis to Trois-Rivières)
36043	Eastern Sand Darter - reproductive habitat surface area (Lake St. Louis to Trois-Rivières)
36048	Spiny Softshell Turtle - reproductive habitat surface area (Lake St. Louis to Trois-Rivières)
36053	Bridle Shiner - reproductive habitat surface area (Lake St. Louis to Trois-Rivières)
38001	Muskrat - surviving houses (Lake St. Louis to Trois-Rivières)

Graphical User Interface Components

In addition to the subroutines and functions required to support the ecological sub-model simulations, the IERM provides a suite of graphical user interface (GUI) components (i.e., forms) that allow users of the IERM to: 1) manage and execute regulation plan scenarios, 2) visualize the results of regulation plan scenarios, and 3) view documentation for ecological PIs and hydraulic criteria. The following sub-sections provide an overview of key source code considerations related to the GUI components, including specific steps to modify the code to eliminate the influence of the ProEssentials graphics software. Table A-2 in Appendix A provides a complete listing of IERM forms and a description of their purpose within the IERM framework.

IERM Main Menu Options

The IERM Main Menu (Figure 1) provides a suite of options for setting up and running new IERM simulations and visualizing the results of completed IERM simulations. Table 11 provides a listing of the key options available on the Main Menu ("frmIERM_MainMenu" form) along with corresponding form that is invoked when a user selects that option on the Main Menu.

Table 11. IERM Main Menu Options and Associated Forms

Main Menu Option	IERM Form Name	Description
"Run IERM"	frmIERM_RunModel	Loads a form that allows the user to import/select regulation plan scenarios to run ecological simulations for
"Manage Plan Data" [1]	frmIERM_PlanUtility	Loads a form that allows the user to manage input data for climate/NBS scenarios and regulation plan scenarios
"View PI Information"	frmIERM_PIBrowser	Loads a form that provides documentation for ecological PIs
"View Criteria Information"	frmIERM_CritBrowser	Loads a form that provides documentation for hydraulic criteria
"Visualize Hydraulics"	frmIERM_TSeries_HH	Loads a time series comparison of hydrologic/hydraulic results for previously simulated scenarios
"Visualize PI Results"	frmIERM_Target	Loads the PI target visualization, which provides access to additional PI visualization options
"Visualize Criteria"	frmIERM_CriteriaEval	Loads a form for visualizing hydrologic criteria
"SVM Export"	frm_SVMExport	Loads a form that allows the user to export IERM PI results to a SVM Excel worksheet
"About IERM"	frmIERM_About	Provides general information concerning the IERM
"IERM Help"	n/a	Loads the "IERM_UserManual.pdf" documentation file

Managing and Running IERM Simulations

As described previously, IERM regulation plan scenarios can be imported and executed via the "frmIERM_RunModel" form, which is accessed by selecting the "Run IERM" option on the IERM Main Menu. See the earlier section entitled "General Simulation Approach & Protocols" for a discussion of source code considerations related to importing plan releases and running IERM simulations. Also, as noted earlier in this memorandum, the "frmIERM_PlanUtility" form was originally intended to provide a tool to revise input data for the H&H simulation ("Reg_Releases" and "Reg_HHInputs" tables); however, this form has never been fully implemented and tested and should not be used without being thoroughly tested by USACE and/or EC staff.

Visualization Forms

As indicated in Table 11, three visualization options are available on the IERM Main Menu:

- Visualize hydraulics ("frmIERM_TSeries_HH" form);
- Visualize PI results ("frmIERM_Target" form); and
- Visualize criteria ("frmIERM_CriteriaEval" form).

These and all other visualization tools available in the IERM were developed based on the ProEssentials (version 7, profession) software, which is developed and distributed by Gigasoft, Inc (http://www.gigasoft.com). The hydraulics and criteria visualization forms ("frmIERM_TSeries_HH", "frmIERM_CriteriaEval") are "terminal" forms, meaning that they do not provide access to additional options for visualizing results. The PI target form ("frmIERM_Target"), on the other hand, provides access to several other (PI) visualization options. Specifically, the user can double-click on a particular PI shown on the target diagram to access a visualization of annual time series results for that PI ("frmIERM_TSeries_PI" and "frmIERM_TSeries_MultiPIs" forms). Additional visualization elements that are accessible from the PI target diagram display include:

- Bar chart showing ranked plan results ("frmIERM_RankPlans" form), which is accessible via the "Compare Plans" button;
- Bar chart showing weight factors applied to individual PIs ("frmIERM_Weights" form), which is accessible via the "Set Weights" button; and
- Pie charts summarizing the weight factors defined for individual PIs ("frmIERM_WeightSummary" form), which is accessible via the "View Summary" button on the "frmIERM_Weights" form.

Configuring the IERM without ProEssentials

As noted in the above discussion regarding visualization forms, the ProEssentials software serves as the basis for the graphics that are generated by the IERM, including the PI "target" display and H&H and PI time series visualizations. ProEssentials requires a relatively expensive developer license (see: http://www.gigasoft.com), and USACE indicated that it may take several months or longer to obtain the licenses necessary to use the software within the IERM development environment. Therefore, it will likely be desirable for USACE and EC to have access to a reconfigured version of the IERM in that does not rely on the ProEssentials software or the associated developer licenses. Reconfiguring the IERM in this way can and has been accomplished with relatively little effort by following the steps outlined below:

1. In the source code for the "frmIERM_MainMenu" form, set the "Enabled" property to FALSE for the following button controls (3 total):
    a. "cmbVizResults_HH"
    b. "cmbVizResults_PI"
    c. "cmbVizResults_Crit"

2. In the Visual Studio "Solution Explorer" window, right-click on the following form class objects and select the "Exclude from project" option (11 forms total):
    a. frmIERM_CriteriaEval
    b. frmIERM_Target
    c. frmIERM_TSeries_HH
    d. frmIERM_TSeries_PI
    e. frmIERM_TSeries_MultiPIs
    f. frmIERM_PIView
    g. frmIERM_RankPlans
    h. frmIERM_Weights
    i. frmIERM_WeightSummary
    j. frmIERM_WtAvg_Tree
    k. frmIERM_Aggregate

3. In the Main Menu ("frmIERM_MainMenu") code, comment out the following button click event subroutines (3 total):
    a. "cmbVizResults_HH_Click"
    b. "cmbVizResults_Crit_Click"
    c. "cmbVizResults_PI_Click"

4. In the "frmIERM_PIExport" form source code, comment out the "If-Then" conditional in the "frmIERM_PIExport_Load" event subroutine.

5. In the "frmIERM_PIBrownser" form source code, comment out the following line:

    ```
    si = frmIERM_Target.Pepso1.CursorSubset
    ```

6. In the "frmIERM_PIToggle" form source code, comment out the "If-Then" conditional in the "frmIERM_PIToggle_Load" event subroutine.

These steps were followed by LimnoTech to develop a "lite" IERM project, which is included alongside the master (full version) "IERM" project. The "lite" version includes the modifications outlined above, and the VS 2010 project does not include any references to ProEssentials graphical components. The "IERM Lite" version largely uses the same set of source code files as the "full" IERM version (excluding the forms listed in step 2 above). However, it uses modified versions of four forms:

- "frmIERM_MainMenu_lite";
- "frmIERM_PIBrowser_lite";
- "frmIERM_PIExport_lite"; and
- "frmIERM_PIToggle_lite".

The "full" version of IERM uses the original versions of these forms and excludes the "_lite" versions.

Exporting Results to Shared Vision Model

The "SVM Export" button opens the "Export IERM Results to SVM" form ("frmIERM_SVMExport"), which allows the user to export IERM key PI results to a regulation plan scenario worksheet contained in a Share Vision Model workbook (Figure 7). The following steps are followed by the "frmExport_Click" event subroutine in the "frmIERM_SVMExport" form class to initiate and complete the export process:

1. Once the user clicks on the "Export Results" button, the IERM scans the local machine for any Microsoft Excel workbooks that are open. If a workbook containing either "SVM Post Processor" or "Board Room" in its filename is found, then the IERM assumes that the user wants to export the key PI results to that specific workbook.

2. If no open workbook is found that meets the above naming criteria, then the IERM will prompt the user to select a workbook to export the PI results to. The user-selected workbook must adhere to the same naming convention described above (i.e., the file name must include either "SVM Post Processor" or "Board Room"). Note that the IERM code has been revised in the .NET version so that a workbook based on any of the potential Excel file formats (*.xls, *.xlsb, *.xlsx, *.xlsm) may be selected.

3. Once the target workbook has been identified, the IERM will try to determine the applicable climate/NBS scenario based on the end of the workbook's filename. For example, a SVM workbook ending with "H.xls*" is expected to represent historical NBS conditions, whereas a workbook containing stochastic #1 results must end in "S1.xls*"

4. The IERM identifies the specific worksheet that will be targeted for the export based on the regulation plan scenario name. For example, when exporting a regulation plan scenario called "Natural A" in the IERM, the IERM will export the results to the worksheet with that exact name, if it exists. If a worksheet with the exact scenario name does not exist, the IERM will add a worksheet based on that name to the workbook and write PI results to that worksheet.

5. Once it has identified (or created it, if necessary) the target worksheet, the IERM will write the aggregate and annual results for the 32 key PIs to the "CM1:DT111" range in the sheet. Hydraulic criteria results from the scenario simulation will also be written to the worksheet in the "DY1:EA39" range.

The current IERM SVM export approach was developed based on the original design and organization of the SVM's regulation plan scenario workbooks and worksheets circa 2005. Because the design of the SVM workbook has evolved since that time (Bill Werick, personal correspondence), it may be desirable to modify the format that the key PI results are written to. This can be accomplished by modifying the code in the "frmExport_Click" event subroutine contained within the "frmIERM_SVMExport" form class.

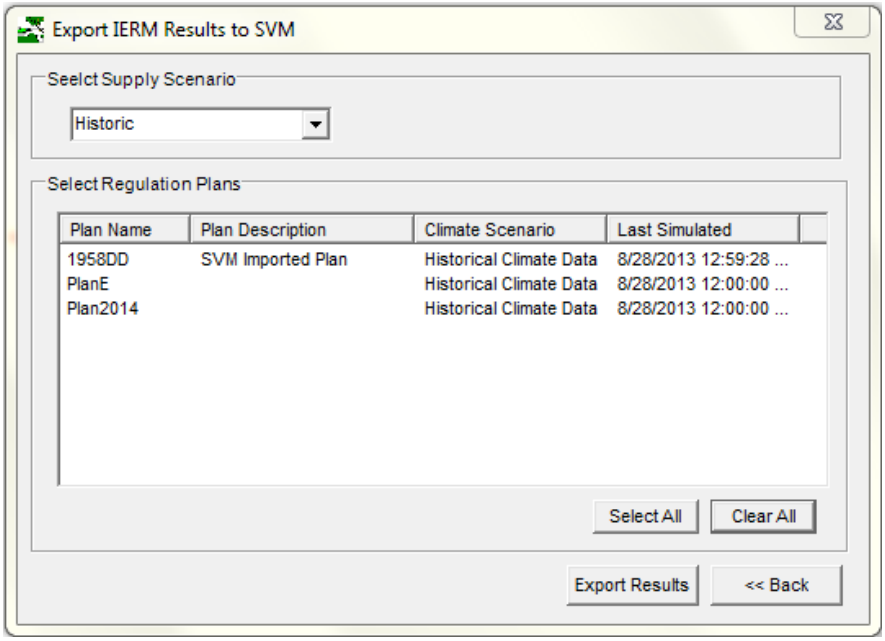


Figure 7. SVM Export Form

Documentation Forms

The "frmIERM_PIBrowser" (Figure 8) and the "frmIERM_CritBrowser" provide the user with tools to browse the documentation available in the IERM database for PIs and hydraulic criteria, respectively. The "View Docs" button on the PI browser form will open the associated PI fact sheet from the "documentation" subfolder (if available).

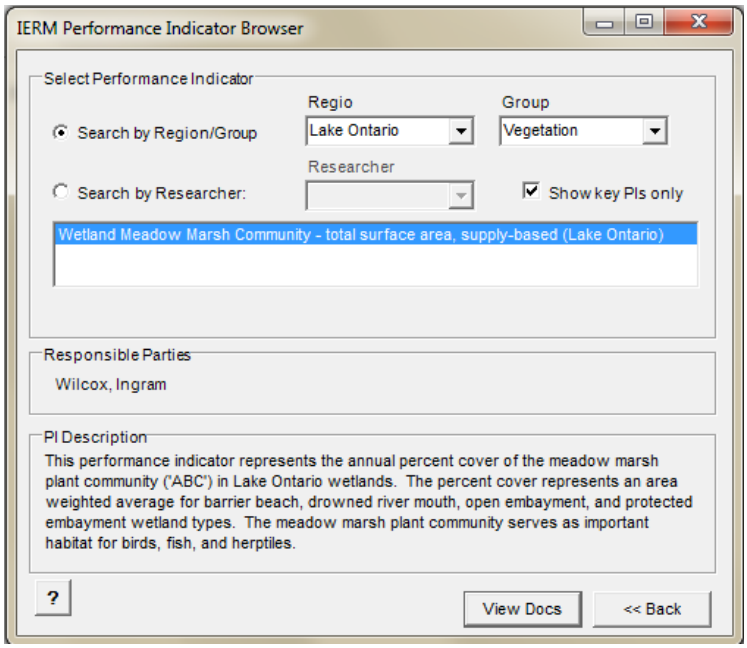


Figure 8. PI Documentation Browser Form

Miscellaneous Forms

In addition to the interactive user forms discussed above, the IERM includes "utility" forms that provide a means for updating the user, including:

- "frmIERM_Progress" – reports progress to the user as the IERM H&H and ecological simulations proceed; and
- "frmIERM_ErrorLog" – following an IERM run, this form provides the user with a summary of errors encountered during the simulation.

IERM.NET Compilation and Deployment

The IERM.NET application is organized into two primary VS 2010 solutions and projects representing the "full" version of IERM and the "lite" version of IERM (excluding ProEssentials), respectively. The IERM VS 2010 solutions/projects are organized within a single common folder (Figure 9). The "full" IERM solution and project files are "IERM.sln" and "IERM.vbproj", and the IERM "lite" version solution and project files are "IERM_lite.sln" and "IERM_lite.vbproj". Either of the solution files (*.sln) can be opened in VS 2010 in order to access the desired IERM project and associated source code files.

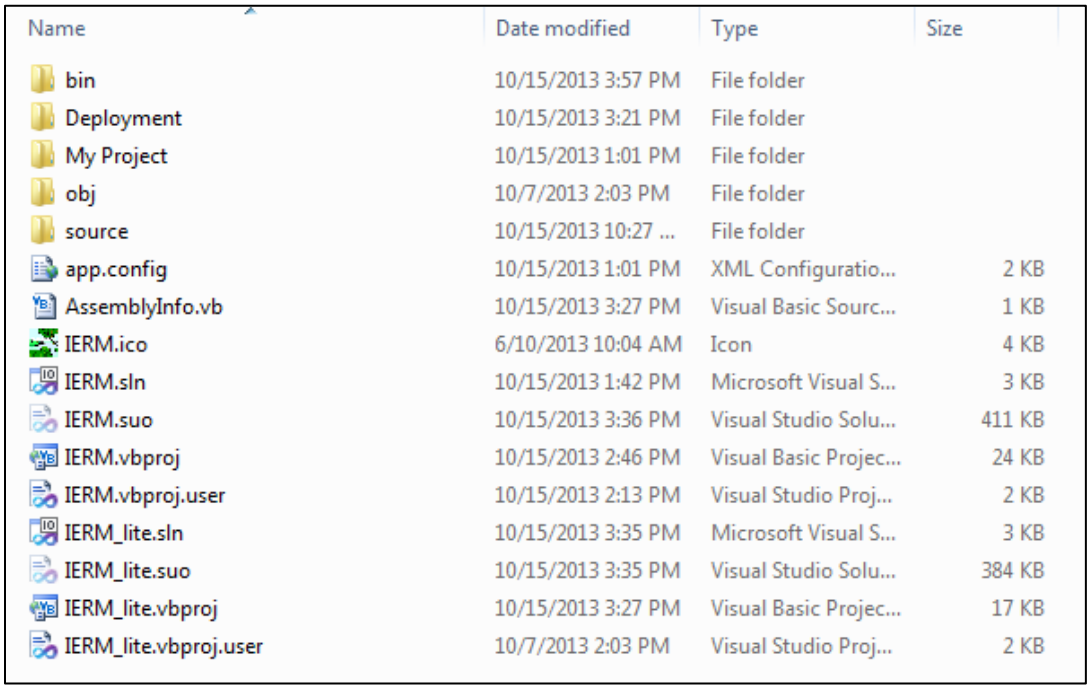


Figure 9. IERM.NET VS 2010 Solution/Project Main Folder Organization

The subfolders included in the main IERM folder (i.e., alongside the solution and project files) are as follows:

- **"source"** – folder includes all of the IERM source code, with files organized into the 8 subfolders described in previous sections ("Classes", "Classes_Fish", "Forms", "Interfaces_Fish", "Modules"Fish", "Modules_LSL", "Modules_Main", and "Modules_Util");

- **"My Project"** – includes general files that support the IERM projects (no interaction with these files is needed);
- **"obj"** – folder contains intermediate output/executable files generated during the compilation process;
- **"bin"** – folder contains the final output/executable files generated during the compilation process (see the "x86" subfolder); and
- **"Deployment"** – contains three IERM "setup" projects and supporting files to facilitate deployment of the IERM software (both "full" and "lite" versions). Additional discussion of the contents of this folder is provided below.

Compiling with VS 2010

The IERM.NET software can be compiled by opening the solution corresponding to the desired version ("IERM.sln" for full version, or "IERM_lite.sln" for the "lite version). The VS 2010 "solution explorer" can be used to view the contents of the applicable IERM project and supporting files (Figure 10). Two deployment projects are also included in each of the solutions and will be further discussed in the "Deployment via VS 2010" section below.

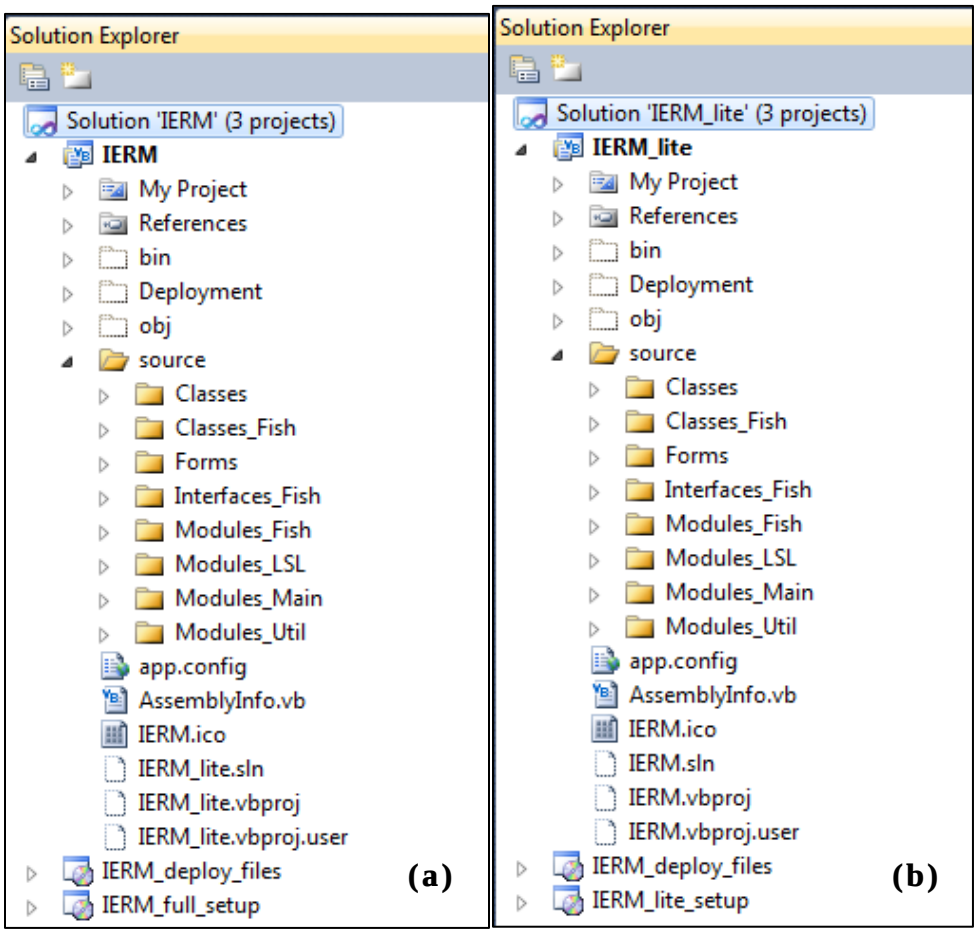


Figure 10. IERM "Full" (a) and IERM "Lite" (b) Solution File Sets

As discussed earlier in this memorandum, the same basic set of source code files are used in the two versions of IERM; however, a number of the Windows Forms used in the "full" version are either excluded from the "lite" version, or modified versions of the forms are used. The forms that are included or excluded in each IERM solution can be viewed by expanding the "Forms" subfolder within the "source" folder. It is important to note that USACE or EC developers who do not have ProEssentials 7 installed on their development machine should not attempt to open or compile the IERM "full" solution. Those developers should only work with the "lite" version of the IERM.

Once an IERM solution has been opened in VS 2010, the associated main IERM project can be compiled by following the steps outlined below:

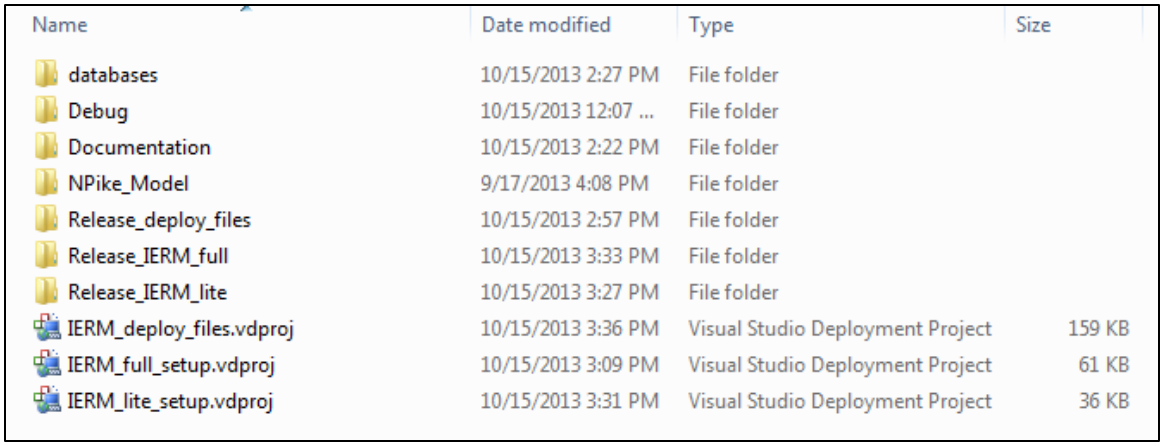
1. Select the main project entry in the "Solution Explorer" (i.e., the second line shown in the window);
2. Set the 'active' configuration as desired by clicking on the "Build" menu, then "Configuration Manager...", selecting either "Debug" or "Release", and then clicking the "Close" button.
3. Click "Build *" on the "Build" menu, where * represents the IERM project name.

The IERM projects are currently targeting an "x86" (32-bit) environment, which means that the software files they produce can be installed on either 32-bit Windows machines or 64-bit Windows 7 or 8 machines (which provide 32-bit compatibility by installing programs in the "C:\Program Files (x86)" folder). The results of the compilation process will be written to either the ".\bin\x86\Debug" or ".\bin\x86\Release" subfolder, depending on the configuration that was selected in step #2 above. Typically, the files written to the "bin" folder will not be directly used or manipulated by the programmer as part of the deployment process; however, the compilation output in the ".\bin\x86\Debug" folder is used by VS 2010 whenever a debug session is conducted with the code.

Note that the IERM projects require that the Microsoft .NET Framework 4.0 (full version) be installed on the development machine and that the .NET Framework 4.0 ("client profile" or "extended" version) be installed on targeted (i.e., end user) machines.

Deployment via VS 2010

As noted above, both the IERM "full" and "lite" solutions include two projects in addition to the main IERM project ("IERM" or "IERM_lite"). These projects are designed to produce a Microsoft software installation file (*.msi) that can be used to install components of the IERM on an end user's machine. All of the deployment projects are contained in the "Deployment" subfolder shown in Figure 9. Figure 11 shows the file and folder configuration within the "Deployment" subfolder.



Name	Date modified	Type	Size
databases	10/15/2013 2:27 PM	File folder	
Debug	10/15/2013 12:07 ...	File folder	
Documentation	10/15/2013 2:22 PM	File folder	
NPike_Model	9/17/2013 4:08 PM	File folder	
Release_deploy_files	10/15/2013 2:57 PM	File folder	
Release_IERM_full	10/15/2013 3:33 PM	File folder	
Release_IERM_lite	10/15/2013 3:27 PM	File folder	
IERM_deploy_files.vdproj	10/15/2013 3:36 PM	Visual Studio Deployment Project	159 KB
IERM_full_setup.vdproj	10/15/2013 3:09 PM	Visual Studio Deployment Project	61 KB
IERM_lite_setup.vdproj	10/15/2013 3:31 PM	Visual Studio Deployment Project	36 KB

Figure 11. IERM "Deployment" Subfolder Contents

The VS 2010 deployment projects are as follows:

- **"IERM_full_setup.vbproj"** – the deployment project for the "full" version of IERM, including installation of the required ProEssentials components (note that this project is only included in the "IERM.sln" solution);
- **"IERM_lite_setup.vbproj"** – the deployment project for the "lite" version of IERM, excluding all ProEssentials components (note that this project is only included in the "IERM_lite.sln" solution); and
- **"IERM_deploy_files.vdproj"** – a deployment project that installs all of the supporting files for the IERM application, including the complete contents of the "databases", "documentation", and "NPike_Model" subfolders, based on the versions of those folders/files included in the "Deployment" sub-folder. Note that this project is included in both of the IERM solutions.

The deployment project settings can be reviewed and modified as needed within the VS 2010 solutions; however, there generally will not be a need for USACE or EC to modify these projects unless changes are made to the folder/file structure and/or the software components required by the IERM. The deployment projects can be compiled using the same "Build" option described above for the main IERM projects (but with the deployment project(s) selected). Building a deployment project will produce a MSI file within a "Release_*" subfolder in the "Deployment" folder, where * represents the base name of the project that is being built. The resulting MSI files can be transferred to a network location and/or a target machine and then double-clicked to install the software and/or supporting files. Generally, either the "IERM_full_setup.msi" or the "IERM_lite_setup.msi" installation file should be run before installing the supporting file system (via the "IERM_deploy_files.msi" file).

References

LimnoTech. 2005. "Development of an Integrated Ecological Response Model (IERM) for Lake Ontario – St. Lawrence River Study." Technical report prepared for the U.S. Army Corps of Engineers – Institute for Water Resources and the International Joint Commission in fulfillment of a subcontract with CDM, Carbondale, IL, April 28, 2005. 56 pp.

Appendix A. IERM Source Code Listing

Table A-1. General IERM Source Code File Listing

Subfolder	Source Code File	Source Type	Description
Modules_Main	SimCriteria.vb	Module	Routine for calculating hydraulic criteria for IERM simulation
Modules_Main	SimFish.vb	Module	Routine for controlling LO/USLR fish sub-model (see Table X)
Modules_Main	SimGlobals.vb	Module	Contains IERM global variables and pointers
Modules_Main	SimHerptile.vb	Module	Routine(s) for simulating LO/USLR herptile PI responses
Modules_Main	SimLSL_PIs.vb	Module	Routine for controlling simulation of LSLR PIs
Modules_Main	SimLSL_Regressions.vb	Module	Routine for controlling simulation of LSLR PIs
Modules_Main	SimMain.vb	Module	Master subroutine controlling the overall IERM ecological simulation
Modules_Main	SimMuskrats.vb	Module	Routine for simulating USLR muskrat density
Modules_Main	SimRegHydraulics.vb	Module	Routine for simulating LOSL hydraulic response
Modules_Main	SimSAR.vb	Module	Routine for simulating LO/USLR species-at-risk PI response
Modules_Main	SimUSL_NPike.vb	Module	Routine for controlling USLR northern pike simulation
Modules_Main	SimWBirds.vb	Module	Routine for controlling LO/USLR wetland bird simulation
Modules_Main	SimWetland.vb	Module	Routine for controlling LO wetland vegetations simulation
Classes	Herptile_Regressions.vb	Class	Class for implementing regression sub-models for LO/USLR herptile PIs
Classes	LO_Wetland.vb	Class	Class for implementing LO wetland vegetation sub-model
Classes	LSL_Regression.vb	Class	Class for implementing LSLR PI regression sub-models
Classes	RegHydraulics.vb	Class	Class for calculating LO/USLR/LSLR hydraulic results
Classes	SARCalc.vb	Class	Class for calculating species-at-risk PIs
Classes	WBird_Density.vb	Class	Class for calculating LO/USLR wetland bird densities
Classes	WBird_Nesting.vb	Class	Class for calculating LO/USLR wetland bird nesting success
Modules_LSL	SMC_Lineaires.vb	Module	Class supporting the LSLR PI calculations
Modules_LSL	SMC_Matrices.vb	Module	Class supporting the LSLR PI calculations
Modules_LSL	SMC_Sauvagines.vb	Module	Class supporting the LSLR waterfowl PI calculations
Modules_LSL	SMC_Stat_Anterieur.vb	Module	Class supporting the LSLR PI calculations
Modules_LSL	SMC_Weibull.vb	Module	Class supporting the LSLR PI calculations
Modules_LSL	SMC_Wetland.vb	Module	Class supporting the LSLR wetland PI calculations

Subfolder	Source Code File	Source Type	Description
Modules_Util	ShellProg.vb	Module	Utility routine used to shell the northern pike standalone program
Modules_Util	Utils_database.vb	Module	Utility routines related to interaction with the supporting Microsoft Access databases
Modules_Util	Utils_Excel.vb	Module	Utility routines related to manipulating Excel workbooks, worksheets, and ranges
Modules_Util	Utils_general.vb	Module	General utility routines
Modules_Util	Utils_IERM.vb	Module	Utility routines specific to IERM tasks
Modules_Util	Utils_PEgraphics.vb	Module	Utility routines related to generating and manipulating ProEssentials graphics

Table A-2. IERM Graphical User Interface Form Source File Listing

Source Code File	IERM "full"	IERM "Lite"	Description
frmIERM_About.vb	X	X	Form for showing IERM version and other general information
frmIERM_Aggregate.vb	X	X	Form for modifying PI-specific aggregation approach and reaggregating annual results
frmIERM_CritBrowser.vb	X	X	Form for browsing H&H criteria documentation
frmIERM_CriteriaEval.vb	X	X	Form for visualizing H&H criteria simulation results
frmIERM_ErrorLog.vb	X	X	Form for displaying error log results following an IERM simulation
frmIERM_MainMenu.vb	X		Form for IERM Main Menu
frmIERM_MainMenu_lite.vb		X	Form for IERM Main Menu ("Lite" version)
frmIERM_PIBrowser.vb	X		Form for browsing/displaying PI documentation
frmIERM_PIBrowser_lite.vb		X	Form for browsing/displaying PI documentation ("Lite" version)
frmIERM_PIExport.vb	X		Form for exporting PI simulation results (aggregate scores and ratios)
frmIERM_PIExport_lite.vb		X	Form for exporting PI simulation results (aggregate scores and ratios) ("Lite" version)
frmIERM_PIToggle.vb	X		Form for selecting individual PIs to simulate or visualize with target diagram
frmIERM_PIToggle_lite.vb	X	X	Form for selecting individual PIs to simulate or visualize with target diagram ("Lite" version)
frmIERM_PIView.vb	X		Form summarizing PI aggregate results and ratios; accessed by double-clicking on a PI point on the "target" diagram
frmIERM_PlanUtility.vb	X	X	Form intended to provide capabilities for importing new/modified input time series for regulation plan releases and time series associated with climate/NBS scenarios
frmIERM_ProgressBar.vb	X	X	Form providing updates on progress during IERM simulations
frmIERM_RankPlans.vb	X		Form providing a bar chart that displays relative plan rankings
frmIERM_RunModel.vb	X	X	Form used to import regulation plan releases and initiate IERM simulation(s)
frmIERM_SVMExport.vb	X	X	Form used to export key PI results to a Shared Vision Model regulation plan worksheet
frmIERM_Target.vb	X		Form that provides the PI "target" diagram and provides the user with access to additional visualization capabilities
frmIERM_TSeries_HH.vb	X		Form that provides comparison of water level and flow time series for various LOSL system locations for two selected IERM scenarios

Source Code File	IERM "full"	IERM "Lite"	Description
frmIERM_TSeries_MultiPIs.vb	X		Form that allows user to plot time series for multiple PIs that are grouped together based on the "PI_SpecGrp" field in the "PI_Matrix" table; accessed via the PI time series form ("frmIERM_TSeries_PI")
frmIERM_TSeries_PI.vb	X		Form that allows the user to plot time series results for two selected regulation plan scenarios for a specific PI; accessed via the "frmIERM_PIView" form.
frmIERM_Weights.vb	X		Form providing a bar chart that can be used to visualize PI weighting factors
frmIERM_WeightSummary.vb	X		Form providing pie charts that summarize PI weighting factors by PI group / region
frmIERM_WtAvg_Tree.vb	X		Form providing a "tree" that can be expanded to show weighting factors for individual PIs, PI groups, and PI regions

Table A-3. LO/USLR Fish Sub-Model Source Code File Listing

Subfolder	Source Code File	Source Type	Description
Interfaces_Fish	ICSpeciesModel.vb	Interface	Encapsulates info and services for the habitat model of one species, used to define interface only
Interfaces_Fish	ICTemperatures.vb	Interface	Encapsulates all reference temperature and season data and operations related to the preparation and availability thereof.
Interfaces_Fish	ICVegetation.vb	Interface	Encapsulates all operations related to the preparation and availability of vegetation estimates.
Interfaces_Fish	ICWaterLevels2.vb	Interface	Encapsulates all elevations scenario data and operations related to the preparation and availability thereof.
Modules_Fish	FH_Globals.vb	Module	Defines table and field names, system parameters, has various system-level utility routines
Modules_Fish	FH_Import.vb	Module	Defines import table and field names, defines other names related to data import, has all data import routines.
Modules_Fish	FH_RunModel.vb	Module	Contains all top-level code responsible for actually running the study habitat model and generating output
Modules_Fish	FH_SpeciesModels.vb	Module	Contains the only code that (in theory anyway) needs to be changed to add a new species species population suitability model to the system
Modules_Fish	FH_Utilities.vb	Module	Common utility routines for the LO/USLR fish sub-model
Modules_Fish	FH_Version.vb	Module	Module for dealing with version and time-stamping information
Modules_Fish	VarPtrSupport.vb	Module	VARPTR implementation in VB.NET
Classes_Fish	FHC_BrShinerModel.vb	Class	An implementation of the CSpeciesModel class specific to bridle shiner
Classes_Fish	FHC_Events.vb	Class	Class for fish sub-model events
Classes_Fish	FHC_GuildModel.vb	Class	Class for implementing the fish guild simulation
Classes_Fish	FHC_HypsoWLevels.vb	Class	Encapsulates all hypsographic data, customised for IJC water levels study and deals only with elevations as input. Purpose in this context is to convert an elevation profile to a depth profile given a surface elevation.
Classes_Fish	FHC_JSObject.vb	Class	Sets up from a JavaScript object literal, providing an object with the same properties
Classes_Fish	FHC_LmBassModel.vb	Class	An implementation of the CSpeciesModel class specific to largemouth bass

Subfolder	Source Code File	Source Type	Description
Classes_Fish	FHC_NPikeModel.vb	Class	n implementation of the CSpeciesModel class specific to northern pike
Classes_Fish	FHC_PnShinerModel.vb	Class	An implementation of the CSpeciesModel class specific to pugnose shiner
Classes_Fish	FHC_Reach.vb	Class	Encapsulates all reach attributes and operations related to the preparation thereof
Classes_Fish	FHC_Reaches.vb	Class	Crude collection class created to implement a super-reach solution. This class will encapsulate all activities related to the Reaches table, and will be responsible for instantiating and returning CReach objects.
Classes_Fish	FHC_SmBassModel.vb	Class	An implementation of the CSpeciesModel class specific to largemouth bass
Classes_Fish	FHC_SpeciesSuitability.vb	Class	Provides services for generating species suitabilities for species population models
Classes_Fish	FHC_SPLT2TVGuildModel.vb	Class	An implementation of the CSpeciesModel class and CGuildModel class specific to the SPLT2TV guild model(4 thermal groups, 2 veg groups, 3 life stages, species spawning in <2 metres of water)
Classes_Fish	FHC_Substrate.vb	Class	Encapsulates all operations related to the preparation and availability of substrate estimates
Classes_Fish	FHC_Temperatures_LO.vb	Class	Encapsulates all reference temperature and season data and operations related to the preparation and availability thereof. This is an implementation of CTemperatures specific to Lake Ontario
Classes_Fish	FHC_Temperatures_USL.vb	Class	Encapsulates all reference temperature and season data and operations related to the preparation and availability thereof. This is an implementation of CTemperatures specific to the Upper River
Classes_Fish	FHC_Vegetation_LO.vb	Class	Encapsulates all operations related to the preparation and availability of vegetation estimates. This is an implementation of CVegetation specific to Lake Ontario.
Classes_Fish	FHC_Vegetation_USL.vb	Class	Encapsulates all operations related to the preparation and availability of vegetation estimates. This is an implementation of CVegetation specific to the Upper River.
Classes_Fish	FHC_VelocityWLevels.vb	Class	A class analogous to and based on CHypsoWLevels, the purpose of which is to deal with and generate products related to fetch velocity profiles

Subfolder	Source Code File	Source Type	Description
Classes_Fish	FHC_WaterLevels2_LO.vb	Class	Encapsulates all elevations scenario data and operations related to the preparation and availability thereof.
Classes_Fish	FHC_WaterLevels2_USL.vb	Class	Encapsulates all elevations scenario data and operations related to the preparation and availability thereof.
Classes_Fish	FHC_YPerchModel.vb	Class	An implementation of the CSpeciesModel class specific to yellow perch

Appendix B. IERM Database Table & Field Dictionary Reference

Table B-1. "IERM_v5" Database Table Listing

Table Name	Table Description
Criteria_Matrix	H&H criteria listing and supporting information
Criteria_Results	H&H criteria annual results generated by IERM simulation
Criteria_Types	H&H criteria types
ErrorLog	Error log generated by IERM simulation
PI_Aggregates	Ecological PI aggregate results
PI_Groups	Ecological PI groups
PI_Locations	Ecological PI locations
PI_Matrix	PI listing and supporting information
PI_QM_Result	PI results at quarter month scale
PI_Researchers	ETWG researcher listing
PI_Results	PI annual results reported by IERM simulation
PI_Species	Species associated with individual ecological PIs
PI_Type	Ecological PI type listing
PI_Weights	PI weights by PI group & region
Reg_ClimateScen	Climate/NBS scenario listing (manually populated)
Reg_HHFactors	H&H time series associated with each climate/NBS scenario
Reg_HHInputs	H&H time series inputs associated with H&H factors listed in "Reg_HHFactors" table
Reg_Hydraulics	Quarter-monthly water level and flow results associated with individual regulation plan scenarios
Reg_Locations	Regulation LOSL location listing
Reg_Plans	Regulation plan listing
Reg_Regions	LOSL region listing
Reg_Releases	Release quarter-monthly time series associated with regulation plan scenarios
tblHerptile_Regressions	Herptile PI regression parameters
tblLSL_MV_Regressions	Lower St. Lawrence PI multi-variate regression parameters
tblLSL_Regressions	Lower St. Lawrence PI regression parameters
tblSAR_PIs	Species-at-risk PI listing for SAR sub-model
Temperature	Air and water temperature time series used to support fish sub-models
tlkpCalc_Type	Calculation/aggreation types listing
tlkpPE_Colors	Color listing for ProEssentials graphics
tlkpPE_LineTypes	ProEssentials graphic line types
tlkpPE_Symbols	ProEssentials graphic symbols

Table B-2. "IERM_v5" Database Field Listing

Table Name	Field Name	Field Description
Criteria_Matrix	Crit_ID	Criterion unique numeric ID
Criteria_Matrix	Crit_Name	Criterion short name
Criteria_Matrix	Crit_Descr	Criterion description (short)
Criteria_Matrix	Crit_LongDescr	Criterion description (long)
Criteria_Matrix	PIGroup_ID	PI group unique numeric ID
Criteria_Matrix	Region_ID	LOSL region unique numeric ID
Criteria_Matrix	Researchers	Researcher name(s)
Criteria_Matrix	CritTypeNo	Criterion type unique numeric ID
Criteria_Matrix	LBound	Lower bound of water level or depth for criterion evaluation
Criteria_Matrix	UBound	Upper bound of water level or depth for criterion evaluation
Criteria_Matrix	QMStart	Quarter month starting point for criterion evaluation
Criteria_Matrix	QMEnd	Quarter month ending point for criterion evaluation
Criteria_Matrix	QMIvld	Quarter month interval
Criteria_Matrix	RegLoc_ID	LOSL location unique numeric ID
Criteria_Matrix	Plantcom_ID	Comma-delimited list of wetland vegetation plant community classes (e.g., "A") relevant for the criterion
Criteria_Matrix	Special_Flag	Flag indicating this criterion is a special case handled in the IERM code
Criteria_Matrix	Disp_Flag	Flag indicating whether to display the criterion information in IERM forms
Criteria_Matrix	Change_Type	1 = Increase, 0 = Both, 2 = Decrease
Criteria_Results	Crit_ID	Criterion unique numeric ID
Criteria_Results	RegPlan_ID	Regulation plan unique numeric ID
Criteria_Results	Year	Year associated with result
Criteria_Results	Crit_Met	Flag indicating whether criterion was met (Yes = Met, NO = Violated)
Criteria_Results	Crit_Deviation	Value of deviation from the criteron
Criteria_Types	CritTypeNo	Criterion type unique numeric ID
Criteria_Types	CritTypeDesc	Criterion type description
Criteria_Types	Units	Criterion units
ErrorLog	Date	Date/time that IERM simulation error was logged
ErrorLog	Error_Descr	Description of error logged
ErrorLog	Module	IERM module where the error occurred
ErrorLog	Line	Source code line number where error occurred within the parent module
PI_Aggregates	RegPlan_ID	Regulation plan unique numeric ID
PI_Aggregates	PI_ID	PI unique numeric ID
PI_Aggregates	Aggr_Result	PI aggregate result (one value per "RegPlan_ID" and "PI_ID")
PI_Groups	PIGrp_ID	PI group unique numeric ID
PI_Groups	PIGrp_Name	PI category name
PI_Groups	PIGrp_Descr	Full description of PI category

Table Name	Field Name	Field Description
PI_Groups	Color_Name	Name of color to use in PI "target" plots (refer to "tlkpPE_Colors" table)
PI_Locations	PILoc_ID	PI location unique numeric ID
PI_Locations	PILoc_Name	PI location name
PI_Locations	PILoc_Descr	Full description of PI location
PI_Locations	RchGroup_ID	Reach group ID (relevant only for Lake Ontario fish)
PI_Locations	RegLoc_ID	Regulation location unique numeric ID (join to "Reg_Locations" table)
PI_Matrix	PI_ID	PI unique numeric ID
PI_Matrix	PI_Name	PI short name identifier
PI_Matrix	PI_Units	Units associated with PI result
PI_Matrix	Eval_Flag	Flag indicating whether or not PI should be evaluated
PI_Matrix	Disp_Flag	Flag indicating whether or not PI should be displayed in output visualization
PI_Matrix	Key_Flag	Flag indicating whether or not PI is considered a "Key PI"
PI_Matrix	ARatio_Flag	Flag indicating whether ratio should be computed as mean of annual ratios instead of aggregated result
PI_Matrix	PIType_ID	PI type (habitat, population, etc.)
PI_Matrix	PILoc_ID	Unique PI location ID
PI_Matrix	PIGrp_ID	Unique PI category ID
PI_Matrix	PI_SpecGrp	ID for group of PI species to be plotted together
PI_Matrix	Species_No	Unique species ID
PI_Matrix	LifeStage	Life stage of species for PI (applicable only to fish habitat/population PIs?)
PI_Matrix	Weight	Weighting factor
PI_Matrix	RCalc_Period	Number of years for a rolling calculation (only populated when rolling calcs are required)
PI_Matrix	RCalc_Aggr	Aggregation function to apply for the rolling calculation
PI_Matrix	Calc_Aggr	Aggregation function to apply for the final PI calculation representing 101-year simulation period (should always be populated)
PI_Matrix	PI_Researchers	Name of researche(s) responsible for PI
PI_Matrix	PI_Short_Descr	Brief description of PI
PI_Matrix	PI_DocFile	Documentation file for PI found in "documentation" subfolder - can be any Windows file (e.g., PDF, DOC, TXT)
PI_Matrix	PI_Long_Descr	Full description of PI
PI_QM_Result	RegPlan_ID	Regulation plan scenario unique numeric ID
PI_QM_Result	PI_ID	PI unique numeric ID
PI_QM_Result	Year	H&H year associated with result
PI_QM_Result	Qmonth	Quarter month associated with result
PI_QM_Result	PI_Result	PI result
PI_Researchers	Researcher_ID	Name of ETWG researchers
PI_Researchers	LastName	n/a
PI_Researchers	FirstName	n/a
PI_Researchers	Affiliation	n/a

Table Name	Field Name	Field Description
PI_Researchers	Email_Address	n/a
PI_Researchers	Street_Address	n/a
PI_Researchers	City	n/a
PI_Researchers	Postal_Code	n/a
PI_Researchers	Country	n/a
PI_Researchers	Phone	n/a
PI_Researchers	Fax	n/a
PI_Results	RegPlan_ID	Regulation plan scenario unique ID
PI_Results	PI_ID	PI unique ID
PI_Results	Year	Year associated with result
PI_Results	PI_Result	PI result
PI_Species	Species_No	Flora/fauna species unique numeric ID
PI_Species	Species_ID	Short name or abbreviation for species
PI_Species	Common_Name	Full common name for species
PI_Species	Scientific_Name	Scientific name of species
PI_Species	Description	Species description
PI_Type	PIType_ID	PI type unique numeric ID
PI_Type	PIType_Name	PI type name
PI_Type	PIType_Descr	PI type description
PI_Weights	GrpWt_ID	Unique numeric ID for weight entry
PI_Weights	Region_ID	LOSL region unique numeric ID
PI_Weights	PIGrp_ID	PI group unique numeric ID
PI_Weights	Weight	PI group/location weight factor
Reg_ClimateScen	ClimScen_ID	Climate/NBS scenario unique numeric ID
Reg_ClimateScen	ClimScen_Name	Climate/NBS scenario name
Reg_ClimateScen	ClimScen_Descr	Climate/NBS scenario description
Reg_ClimateScen	SVM_Name	Scenario ID used in Shared Vision Model
Reg_ClimateScen	SVM_Abbr	Scenario abbreviation used in Shared Vision Model
Reg_ClimateScen	Temperature_SerID	Temperature (air and water) time series ID for the climate scenario
Reg_HHFactors	HHFact_ID	H&H time series type unique numeric ID
Reg_HHFactors	Factor_Name	H&H time series type name
Reg_HHFactors	Factor_Type	H&H time series type ("Flow", "Tidal", or "Ice")
Reg_HHInputs	HHFact_ID	H&H time series type unique numeric ID
Reg_HHInputs	ClimScen_ID	Climate/NBS scenario unique numeric ID
Reg_HHInputs	Year	Simulation year
Reg_HHInputs	QMonth	Simulation quarter month
Reg_HHInputs	Sim_Input	Time series value
Reg_Hydraulics	RegPlan_ID	Regulation plan unique numeric ID (join to "Reg_Plans")
Reg_Hydraulics	RegLoc_ID	Regulation location unique numeric ID (join to "Reg_Locations" table)
Reg_Hydraulics	Year	Simulation year (1900-2000, or 0-100)
Reg_Hydraulics	QMonth	Simulation quarter month (1-48)
Reg_Hydraulics	Sim_Result	Simulated discharge or water level
Reg_Locations	RegLoc_ID	Regulation location unique numeric ID

Table Name	Field Name	Field Description
Reg_Locations	RegLoc_Name	Regulation location name
Reg_Locations	Region_ID	LOSL study region unique numeric ID (join to "Reg_Regions" table)
Reg_Locations	Sim_Type	Simulated time series type (either "Discharge" or "Water Level")
Reg_Locations	Eval_Flag	Flag indicating whether location will be simulation in IERM H&H simulation
Reg_Plans	RegPlan_ID	Regulation plan scenario unique numeric ID
Reg_Plans	Plan_Name	Common short name for regulation plan
Reg_Plans	Plan_Descr	Full description of regulation plan
Reg_Plans	ClimScen_ID	Climate/NBS scenario unique numeric ID (join to "Reg_ClimateScen" table)
Reg_Plans	Date_Created	Date/time plan was created in database
Reg_Plans	Date_Modified	Date/time plan was last modified
Reg_Plans	Eval_Flag	Temporary flag indicating if plan will be simulated by IERM
Reg_Plans	Eval_Date	Date/time plan was last evaluated in IERM
Reg_Regions	Region_ID	LOSL study region unique numeric ID
Reg_Regions	Region_Name	Study region name
Reg_Regions	Region_Descr	Full description of study region
Reg_Regions	Weight	Weight factor for LOSL region
Reg_Regions	Symbol_ID	ProEssentials point symbol ID (see "tlkpPE_Symbols" table)
Reg_Releases	RegPlan_ID	Regulation plan scenario unique numeric ID
Reg_Releases	Year	Simulation year
Reg_Releases	QMonth	Simulation quarter month
Reg_Releases	Release_Flow	Moses Saunders dam release flow (cms)
tblHerptile_Regressions	PI_ID	PI unique numeric ID associated with herptile PI
tblHerptile_Regressions	QM_Start	Quarter month at start of regression period
tblHerptile_Regressions	QM_End	Quarter month at end of regression period
tblHerptile_Regressions	Calculation_Method	Method for calculation of hydraulic dependent variable
tblHerptile_Regressions	Calculation_Lag	Lag period for calculation in years
tblHerptile_Regressions	Regression_Coefficients	Regression coefficients, starting with zero order. Each coefficient needs a place holder in this order: H2ODEP, FLE, BLE, UPL, SUBFL, SHRSCR
tblLSL_MV_Regressions	PI_ID	PI unique numeric ID
tblLSL_MV_Regressions	Coeff0	Zero order coefficient
tblLSL_MV_Regressions	QM_Start1	Quarter month at start of regression period for 1st variable
tblLSL_MV_Regressions	QM_End1	Quarter month at end of regression period for 1st variable
tblLSL_MV_Regressions	Calc_Method1	Method for calculation of 1st variable
tblLSL_MV_Regressions	Calc_Lag1	Lag period for calculation in years for 1st variable
tblLSL_MV_Regressions	LocID1	Independent variable for 1st order (unique RegLoc_ID for variable)

Table Name	Field Name	Field Description
tblLSL_MV_Regressions	Coeff1	Coefficient for 1st variable
tblLSL_MV_Regressions	QM_Start2	Quarter month at start of regression period for 2nd variable
tblLSL_MV_Regressions	QM_End2	Quarter month at end of regression period for 2nd variable
tblLSL_MV_Regressions	Calc_Method2	Method for calculation of 2nd variable
tblLSL_MV_Regressions	Calc_Lag2	Lag period for calculation in years for 2nd variable
tblLSL_MV_Regressions	LocID2	Independent variable for 2nd order (unique RegLoc_ID for variable)
tblLSL_MV_Regressions	Coeff2	Coefficients for 2nd variable
tblLSL_MV_Regressions	QM_Start3	Quarter month at start of regression period for 3rd variable
tblLSL_MV_Regressions	QM_End3	Quarter month at end of regression period for 3rd variable
tblLSL_MV_Regressions	Calc_Method3	Method for calculation of 3rd variable
tblLSL_MV_Regressions	Calc_Lag3	Lag period for calculation in years for 3rd variable
tblLSL_MV_Regressions	LocID3	Independent variable for 3rd order (unique RegLoc_ID for variable)
tblLSL_MV_Regressions	Coeff3	Coefficients for 3rd variable
tblLSL_Regressions	PI_ID	PI unique numeric ID
tblLSL_Regressions	QM_Start	Quarter month at start of regression period
tblLSL_Regressions	QM_End	Quarter month at end of regression period
tblLSL_Regressions	Calculation_Method	Method for calculation of hydraulic dependant variable
tblLSL_Regressions	Calculation_Lag	Lag period for calculation in years
tblLSL_Regressions	Polynomial_LocID	Independent variable for polynomial regressions (unique RegLoc_ID for variable)
tblLSL_Regressions	Polynomial_Coefficients	Polynomial regression coefficeints, starting with zero order. Each order needs a place holder (i.e. '0')
tblSAR_PIs	PI_ID	PI unique numeric ID
tblSAR_PIs	PI_Name	PI name/description
tblSAR_PIs	WetlandID	Semi-colon delimited string of wetlands that are incorporated into SAR PI calculation
Temperature	Temperature_SerID	Temperature data time series unique numeric ID
Temperature	Date	Date
Temperature	Type	Type of temperature data (e.g., air or water)
Temperature	Location	Text identifier for location
Temperature	Temp	Air/water temperature (degrees Celsius)
tlkpCalc_Type	CalcType_No	Calculation type unique numeric ID
tlkpCalc_Type	CalcType_ID	Calculation type text ID
tlkpCalc_Type	Calc_Descr	Calculation type description
tlkpPE_Colors	Color_ID	Color unique numeric ID
tlkpPE_Colors	Color_Name	Color name
tlkpPE_Colors	Color_Category	Color category
tlkpPE_Colors	Red_Index	RGB "R" index value
tlkpPE_Colors	Green_Index	RGB "G" index value

Table Name	Field Name	Field Description
tlkpPE_Colors	Blue_Index	RGB "B" index value
tlkpPE_Colors	Hex	Hexadecimal code for color
tlkpPE_LineTypes	LineType_ID	ProEssentials line type unique numeric ID
tlkpPE_LineTypes	PE_Const	ProEssentials constant name
tlkpPE_LineTypes	LineType_Descr	ProEssentials line type description
tlkpPE_Symbols	Symbol_ID	ProEssentials symbol unique numeric ID
tlkpPE_Symbols	PE_Const	ProEssentials constant name
tlkpPE_Symbols	Symbol_Descr	ProEssentials symbol description

Table B-3. "IERM_LO_Wetland" Database Table Listing

Table Name	Table Description
Elevation_Zones	Wetland elevation zone listing for Lake Ontario (1-cm increments between 73.00 and 75.75 m)
Muskrat_PIs	Upper St. Lawrence River muskrat PI listing
Plant_Communities	Lake Ontario wetland plan community categories
PlantCom_ElevBounds	Plant community assignments to elevation ranges based on IERM wetland vegetation simulation
Sim_Results	Plant community assignments to specific (1-cm) elevation zones based on IERM wetland vegetation simulation
Structural_Lookup	Fraction of plant structural types associated with each plan community category
Structural_Types	Plant structural type listing
Structural_Types_SAR	Plant structural types with habitat type assignments for specific species-at-risk PIs
Target_Distribution	Not used by IERM
Wetland_PI	Wetland vegetation PI listing
Wetlands	Wetland geomorphic type listing by region (Lake Ontario / Upper St. Lawrence River)
WLBird_Habitats	Wetland bird habitat types cross-referenced to wetland plant community types

Table B-4. "IERM_LO_Wetland" Database Field Listing

Table Name	Field Name	Field Description
Elevation_Zones	Zone_ID	Wetland-specific elevation zone unique numeric ID
Elevation_Zones	Wetland_ID	Wetland unique numeric ID
Elevation_Zones	ElevZone_ID	General elevation zone unique numeric ID
Elevation_Zones	Min_Elevation	Lower elevation bound associated with elevation zone
Elevation_Zones	Max_Elevation	Upper elevation bound associated with elevation zone
Elevation_Zones	Area_Fraction	Fraction of total wetland area associated with elevation zone
Elevation_Zones	Initial_Ivld	Initial flooding (+) / dewatering (-) interval assigned to zone
Muskrat_PIs	PI_ID	Muskrat PI unique numeric ID (refer to main "PI_Matrix" table in "IERM_v5.mdb")
Muskrat_PIs	PI_Name	Muskrat PI short name
Muskrat_PIs	RegLoc_ID	Regulation location unique numeric ID (refer to "Reg_Locations" table in "IERM_v5.mdb")
Muskrat_PIs	Wetland_ID	Wetland ID that PI is assigned to (joins to "Wetlands" table)
Muskrat_PIs	LOWetland_ID	Wetland ID for corresponding Lake Ontario wetland type (*not used*))
Plant_Communities	PlantCom_ID	Plant community unique numeric ID
Plant_Communities	PlantCom_Name	Plant class ID based on flooding/dewatering sequence (A-G)
Plant_Communities	Survey_Elev	Elevation that Wilcox et al. surveyed as basis for plant community
Plant_Communities	Flood_Ivld	Elapsed years since last flood (negative values indicate area has not been dewatered for X years)
PlantCom_ElevBounds	RegPlan_ID	Regulation plan unique numeric ID (refer to "Reg_Plans" table in "IERM_v5.mdb")
PlantCom_ElevBounds	Year	Simulation year
PlantCom_ElevBounds	Wetland_ID	Wetland unique numeric ID (joins to "Wetlands" table)
PlantCom_ElevBounds	PlantCom_ID	Plant community unique numeric ID (joins to "Plant_Communities" table)
PlantCom_ElevBounds	MinElev	Lower bound elevation for plant community
PlantCom_ElevBounds	MaxElev	Upper bound elevation for plant community
PlantCom_ElevBounds	AreaFraction	Fraction of wetland area associated with plant community
Sim_Results	RegPlan_ID	Regulation plan unique numeric ID
Sim_Results	Year	Year for simulation results
Sim_Results	Zone_ID	Elevation zone unique numeric ID (by wetland and elevation)
Sim_Results	PlantCom_ID	Plant community unique numeric ID
Structural_Lookup	StructLkp_ID	Numeric ID for unique plant community and structural type combination
Structural_Lookup	PlantCom_ID	Plant community unique numeric ID
Structural_Lookup	StructType_ID	Structural type unique numeric ID

Table Name	Field Name	Field Description
Structural_Lookup	Area_Fraction	Fraction of total wetland area
Structural_Types	StructType_ID	Structural type unique numeric ID
Structural_Types	Structural_Category	Structural category description
Structural_Types	Fish_Habitat	Fish habitat description
Structural_Types	Herptile_Habitat	Herptile habitat description
Structural_Types	SAR_Habitat	Species-at-risk habitat description
Structural_Types	Plant_Species	Plant species associated with structural type
Structural_Types	Description	General description
Structural_Types_SAR	StructType_ID	Structural type unique numeric ID
Structural_Types_SAR	Structural_Category	Structural category description
Structural_Types_SAR	BLTE_Habitat	Black tern habitat type
Structural_Types_SAR	LEBI_Habitat	Least bittern habitat type
Structural_Types_SAR	PBGR_Habitat	Pied-billed grebe habitat type
Structural_Types_SAR	CONO_Habitat	Yellow rail habitat type
Structural_Types_SAR	RAEL_Habitat	King rail habitat type
Structural_Types_SAR	EMBL_Habitat	Blanding's turtle habitat type
Target_Distribution	Wetland_ID	Wetland unique numeric ID
Target_Distribution	PlantCom_ID	Plant community unique numeric ID
Target_Distribution	Target_PC	Target value
Wetland_PI	PI_ID	Wetland PI unique numeric ID
Wetland_PI	PI_Name	Short Name of wetland PI
Wetland_PI	PI_Type	Wetland PI type
Wetland_PI	Wetland_ID	Wetland unique numeric ID
Wetland_PI	Plant_Comm	Plant communities included in calculation
Wetlands	Wetland_ID	Wetland unique numeric ID
Wetlands	Description	Wetland description
Wetlands	Location	Wetland location description
Wetlands	RegLoc_ID	Regulation location unique numeric ID (refer to "Reg_Locations" table in "IERM_v5.mdb")
Wetlands	StructLkp_ID	Wetland type unique ID
Wetlands	Total_Area	Total areal extent of wetland (hectares)
Wetlands	Eval_Flag	Flag for evaluating this wetland within the IERM
WLBird_Habitats	Wetland_ID	Wetland unique numeric ID
WLBird_Habitats	PlantCom_ID	Plant community unique numeric ID
WLBird_Habitats	WLBird_Habitat	Wetland bird habitat type description

Table B-5. "IERM_*_Fish" Database Table Listing

Table Name	Table Description
Encoded Reference Temperatures	Temperature daily time series by reference set and year, along with daily season identifiers
Guilds: Descriptions	By guild model and guild, stores guild descriptions for documentation purposes only.
Guilds: Models	By guild model, stores model description for documentation purposes only.
Guilds: Suitabilities	By guild model, stores a guild suitabilty array and related index arrays
IERM_PI_Doc_Matrix	Documentation matrix for IERM region-specific fish PIs
IERM_PI_Doc_Output	Documentation of output for IERM region-specific fish PIs
IERM_PI_Matrix	Matrix of IERM region-specific fish PIs
IERM_PI_Templates	Template information for region-specific fish PIs
Reach Group Lists	By reach group, stores lists of the reach IDs included in the reach group
Reach Groups	By reach group, stores reach group IDs and descriptions of the groups. Reach groups are the basic means for selecting reaches for analysis.
Reaches	By reach, stores all properties ofall reaches in the system. The reach is the basic geographic unitin the system
Reference Temperature Sets	IDs and descriptions of temperature model reference temperature sets
RegPlans: Checksums	Stores 32-bit CRC checksums of regulation plan sim results by reg plan
RegPlans: Levels Data Arrays	Used to store memory images of water levels data arrays by reg plan
Study Parameters	Provides a way of externalising certain system parameters such as class widths etc.. INCORRECTLY CHANGING THIS TABLE WILL CRASH THE SYSTEM!
Substrate: Composition	By substrate index and depth range, stores percent composition of substrate broken down into 8 classes: Bedrock, Boulder, Rubble, Cobble, Gravel, Sand, Silt, Clay
Suitability Rules: LifeStages	Stores the complete list of life-stage IDs and descriptions for all species (and guild) life-stages recognised by the system
Suitability Rules: Rules	By species and life-stage, stores species habitat suitability rules. Used for northern pike only.
Suitability Rules: Species	Stores the complete list of species IDs and names for those species recognised by the system
Version	Region-specific fish input database version log
Wetlands	By wetland reach ID, stores addtional wetland properties
Wetlands Veg: Checksums	Stores 32-bit CRC checksums of wetlands veg sim results by reg plan
Wetlands Veg: Cover Data Arrays	Used to store memory images of wetlands cover data arrays by reg plan and year
Wetlands Veg: EV Data Arrays	Used to store memory images of wetlands EV data arrays by reg plan
Wetlands Veg: EV Maps	Used to map output from the wetlands vegetation model (percent cover by structural type) to percent cover by emergent category

Table B-6. "IERM_*_Fish" Database Field Listing

Table Name	Field Name	Field Description
Encoded Reference Temperatures	ReferenceSetID	Unique identifier of one of many possible reference temperature time series
Encoded Reference Temperatures	ClimScen_ID	Unique identifier of one of many possible climate change scenarios. These should be consistent with the corresponding values in the IERM.
Encoded Reference Temperatures	Year	Year corresponding to a temperatures list
Encoded Reference Temperatures	TemperatureList	Lists by day of temperatures in deg C
Guilds: Descriptions	ModelID	Guild model ID
Guilds: Descriptions	Guild ID	Unique ID for a guild
Guilds: Descriptions	Description	Guild description
Guilds: Models	ModelID	Guild model ID
Guilds: Models	Description	Guild model description
Guilds: Suitabilities	ModelID	Guild model ID (only one as of 24/8/04, temperature and veg gulds for species spawning in <2m)
Guilds: Suitabilities	DMSuitsMasterLookup	Tab/CRLF-delimited 2D master index array for dealing w/ DMSuits data (copied from Excel), 1 row per subindex (1-80), one column per depth range, contents are row numbers in DMSuits data
Guilds: Suitabilities	DMSuitsData	Tab/CRLF-delimited 2D suitabilities array from Defensible Methods analysis (copied from Excel)
Guilds: Suitabilities	DMSuitsGuildIndex	Tab/CRLF-delimited 2D index array (copied from Excel), one row per guild, one column per life stage, contents are column numbers in DMSuits data
IERM_PI_Doc_Matrix	PI_ID	Unique identifier for a performance indicator
IERM_PI_Doc_Matrix	TemplateID	ID of boiler-plate template to use for this PI
IERM_PI_Doc_Matrix	Region	Name of region for which a results set was created: "Lake Ontario"|"Upper St. Lawrence River"
IERM_PI_Doc_Matrix	RchGroupID	ID of reach group for which a results set was created
IERM_PI_Doc_Matrix	ReachGroup	Name of reach group for purposes of PI documentation
IERM_PI_Doc_Matrix	SpeciesGuild	ID ofspecies (or guild) for which a results set was created
IERM_PI_Doc_Matrix	LifeStage	ID of lifestage for which a results set was created
IERM_PI_Doc_Matrix	Metric	Text of metric name, e.g., "WSA"
IERM_PI_Doc_Matrix	Units	Abbreviated text of metric units, e.g., "ha-days"
IERM_PI_Doc_Matrix	LongUnits	Full text of metric units, e.g., "hectare-days"
IERM_PI_Doc_Matrix	TempNotes	Text of any notes specific to the "Temporal Validity" documentation of this PI
IERM_PI_Doc_Matrix	SpatNotes	Text of any notes specific to the "Spatial Validity" documentation of this PI
IERM_PI_Doc_Matrix	Map	ID of map to accompany "Spatial Validity" documentation
IERM_PI_Doc_Matrix	HydrologyNotes	Text of any notes specific to the "Hydrology Link" documentation of this PI

Table Name	Field Name	Field Description
IERM_PI_Doc_Matrix	HabitatVariables	Comma-delimited list of variable names for use in the "Independent Variables" documentation of this PI
IERM_PI_Doc_Matrix	CalNotes	Text of any notes specific to the "Calibration Data" documentation of this PI
IERM_PI_Doc_Matrix	ValNotes	Text of any notes specific to the "Validation Data" documentation of this PI
IERM_PI_Doc_Matrix	WebSite	URL of web site reference for more detailed documentation
IERM_PI_Doc_Matrix	OtherResearchers	Comma-delimited list of other researcher's last names: ", Landry, Schiavone"
IERM_PI_Doc_Matrix	TempDisclaimer	n/a
IERM_PI_Doc_Output	PI_ID	Unique identifier for a performance indicator
IERM_PI_Doc_Output	Region	Template text for "Region" section of PI document
IERM_PI_Doc_Output	SubGroup	Template text for "Subgroup" section of PI document
IERM_PI_Doc_Output	Researchers	Template text for "Researchers" section of PI document
IERM_PI_Doc_Output	LongDescription	Template text for "PI Long Description" section of PI document
IERM_PI_Doc_Output	Temporal	Template text for "Temporal Validity" section of PI document
IERM_PI_Doc_Output	Spatial	Template text for "Spatial Validity" section of PI document
IERM_PI_Doc_Output	Hydrology	Template text for"Hydrology Link" section of PI document
IERM_PI_Doc_Output	Variables	Template text for "Independent Variables" section of PI document
IERM_PI_Doc_Output	Calibration	Template text for "Calibration Data" section of PI document
IERM_PI_Doc_Output	Validation	Template text for "Validation Data" section of PI document
IERM_PI_Doc_Output	Equation	Template text for "Equation" section of PI document
IERM_PI_Matrix	PI_ID	Unique performance indicator (PI) ID
IERM_PI_Matrix	PI_Name	PI name
IERM_PI_Matrix	PI_Units	Units associated with PI result
IERM_PI_Matrix	LifeStage	Life stage of species for PI (applicable only to fish habitat/population PIs?)
IERM_PI_Matrix	PI_Researchers	Name of researche(s) responsible for PI
IERM_PI_Matrix	PI_Short_Descr	Brief description of PI
IERM_PI_Templates	TemplateID	Unique identifier for one of many possible PI boiler-plate templates
IERM_PI_Templates	Template	RTF text of a boiler-plate template, place-holders embedded
IERM_PI_Templates	Region	Template text for "Region" section of PI document
IERM_PI_Templates	SubGroup	Template text for "Subgroup" section of PI document
IERM_PI_Templates	Researchers	Template text for "Researchers" section of PI document
IERM_PI_Templates	LongDescription	Template text for "PI Long Description" section of PI document
IERM_PI_Templates	Temporal	Template text for "Temporal Validity" section of PI document

Table Name	Field Name	Field Description
IERM_PI_Templates	Spatial	Template text for "Spatial Validity" section of PI document
IERM_PI_Templates	Hydrology	Template text for"Hydrology Link" section of PI document
IERM_PI_Templates	Variables	Template text for "Independent Variables" section of PI document
IERM_PI_Templates	Calibration	Template text for "Calibration Data" section of PI document
IERM_PI_Templates	Validation	Template text for "Validation Data" section of PI document
IERM_PI_Templates	Equation	Template text for "Equation" section of PI document
Reach Group Lists	GroupID	Text ID uniquely identifying a group of reach IDs
Reach Group Lists	ReachID	A reach ID, one of this group's set of IDs
Reach Groups	GroupID	Text ID uniquely identifying a group of reach IDs
Reach Groups	Description	Description or rationale for this grouping of reaches
Reach Groups	MapPath	Path (relative to this MDB) for Word doc containing a map image
Reaches	ReachID	Unique reach identifier, i.e., shoreline segment identifier
Reaches	BoundXMin	Minimum easting (metres) of all of the cells associated with this reach
Reaches	BoundYMin	Minimum northing
Reaches	BoundXMax	Maximum easting
Reaches	BoundYMax	Minimum northing
Reaches	ElevationMin	Minimum study elevation (metres above IGLD85) of all of the cell elevations associated with this reach
Reaches	ElevationMax	Maximum study elevation
Reaches	SubIndex	Substrate subindex, associating this reach with a unique combination of shoretype and substrate
Reaches	Average Fetch	Average effective fetch (metres)
Reaches	Distance To Fetch Point	Shortest distance from the reach to the point used to define fetch (metres)
Reaches	SectionID	Section ID: "LO"
Reaches	IsWetland	Whether this is a special "ReachID" referring to a wetland
Reaches	IsStudyArea	Whether this reach has one or more cells considered to be in the study area
Reaches	Reach Length	Length of reach in metres
Reaches	Cell Count	Total number of cells associated with this reach
Reaches	Elevation Profile	CR-delimited array of cell counts by elevation class, classes is ascending elevation order from "Elevation Minimum" to "Elevation Maximum" incrementing at "Elevation Reclass Interval" (c.f. [Study Parameters] table)
Reaches	TempDevMin	Minimum temperature deviation observed on import of the temperature offset classes
Reaches	TempDevMax	Maximum temperature deviation observed on import of the temperature offset classes

Table Name	Field Name	Field Description
Reaches	Temperature Offset	Class of mid-point value used to offset reference temperature for purpose of estimating reach temperature before applying temperature-at-depth model. Classes: 0=no deviation, 1=-1.043 to -0.5, 2=-1.0 to -0.5, 3=-0.5 to 0, 4=0 to 0.5, 5=0.5 to .7489.
Reaches	Temperature Notes	Rationale for various decisions about temperature-related items
Reaches	Study Zone	Value used for now to distinguish between two areas: Study Zone=1 implies main lake plus Lower Bay of Quinte, 99 implies Upper and Middle Bays of Quinte
Reaches	Original Elevation Profile	CR-delimited array of cell counts by elevation class, classes as described above, prior to any adjustments
Reaches	Distance To Shore	Distance (metres) to nearest shoreline; for wetlands; zero otherwise
Reaches	RegionID	Region_ID as corresponds to the hydrological simulations
Reaches	ReferenceTemperatureSet	ID of encoded reference temperature set to be used for this reach
Reaches	Temperature Offset_Old	(Original Versions) Value used to offset reference temperature for purpose of estimating "Lake" temperature prior to applying temperature-at-depth model.
Reference Temperature Sets	ReferenceSetID	Unique identifier for a encoded 101-year reference daily temperature set
Reference Temperature Sets	Description	Intended use of temperature set
RegPlans: Checksums	RegPlan_ID	Unique regulation plan ID
RegPlans: Checksums	RegPlanCRC	CRC generated by fish habitat code as a check on whether regulation plan sim results have changed since last time look-up table generated
RegPlans: Levels Data Arrays	RegPlan_ID	Unique regulation plan ID
RegPlans: Levels Data Arrays	Year	Regulation plan year
RegPlans: Levels Data Arrays	ArrayData	Memory image of water levels data array for all years for this reg plan
Study Parameters	Parameter Name	Name of system parameter
Study Parameters	Parameter Value	Value currently associated with this name
Study Parameters	Parameter Units	Units of parameter value
Study Parameters	Description	n/a
Substrate: Composition	DataSource	Source of percent composition data; either "Rukavina" or "Quinte"
Substrate: Composition	SubIndex	Substrate subindex, a unique combination of ST and NS; used for selecting a row in a suitability matrix or substrate composition matrix
Substrate: Composition	DepthMin	Lower bound of depth interval (m) for which this composition applies
Substrate: Composition	DepthMax	Upper bound of depth interval (m) for which this composition applies
Substrate: Composition	Bedrock	Percent composition

Table Name	Field Name	Field Description
Substrate: Composition	Boulder	Percent composition
Substrate: Composition	Rubble	Percent composition
Substrate: Composition	Cobble	Percent composition
Substrate: Composition	Gravel	Percent composition
Substrate: Composition	Sand	Percent composition
Substrate: Composition	Silt	Percent composition
Substrate: Composition	Clay	Percent composition
Suitability Rules: LifeStages	LifeStage	Unique identifier for a fish species' life stage
Suitability Rules: LifeStages	Ordinal	Number providing the order in which life stages will be displayed etc.
Suitability Rules: LifeStages	Description	Life stage description (from C. Chu's framework document for Northern pike)
Suitability Rules: Rules	SpeciesID	ID of species to which rule applies
Suitability Rules: Rules	LifeStage	Life stage to which rule applies
Suitability Rules: Rules	Rule	Encode rule object literal
Suitability Rules: Species	SpeciesID	ID of species to which rule applies
Suitability Rules: Species	Name	Full name of species for display purposes
Version	ID	Arbitrary system-generated ID to ensure the last record is the most recently added
Version	Version	Version number, starting with 4.3.0 31/10/01
Version	Date	Date and time of last system changes
Version	Comment	n/a
Wetlands	WetlandID	Unique wetland identifier, as per polygons from the Wetlands Group
Wetlands	ReachID	Unique reach identifier, i.e., shoreline segment identifier; majority of wetland cells overlap this reach
Wetlands	Site Class	Primary hydrogeomorphic classification: BB = barrier beach wetland, DRM = drowned river mouth, OB = open embayment, PB = protected embayment
Wetlands	Site Class2	Secondary hydrogeomorphic classification, where multiple hydrogeomorphic types drive the wetland system.
Wetlands	Area	Polygon area (ha), based on vector calculations, so may differ from the sum of associated cell areas
Wetlands	Name	Wetland name
Wetlands Veg: Checksums	RegPlan_ID	Unique regulation plan ID
Wetlands Veg: Checksums	WetlandsVegCRC	CRC generated by fish habitat code as a check on whether wetlands veg sim results have changed since last time look-up table generated
Wetlands Veg: Cover Data Arrays	RegPlan_ID	Unique regulation plan ID
Wetlands Veg: Cover Data Arrays	Year	Regulation plan year
Wetlands Veg: Cover Data Arrays	ArrayData	Memory image of wetlands percent cover values by cover type, depth, and wetland type
Wetlands Veg: EV Data Arrays	RegPlan_ID	Unique regulation plan ID

Table Name	Field Name	Field Description
Wetlands Veg: EV Data Arrays	ArrayData	Memory image of EV data array for all wetland types and years for this reg plan
Wetlands Veg: EV Maps	StructType_ID	Plant community structural type ID
Wetlands Veg: EV Maps	EV_Weight	Weight (0 to 1) to be applied for this species to obtain emergent percent cover
Wetlands Veg: EV Maps	EVNU_Weight	Weight (0 to 1) to be applied for this species to obtain emergent (not useful) percent cover

Table B-7. "IERM_*_Fish_Output" Database Table Listing

Table Name	Table Description
IERM_AgeStructure	Age structure information for northern pike, smallmouth bass, largemouth bass, and yellow perch population models
IERM_HabitatSupply	Fish sub-model daily results for habitat supply
IERM_HabitatSupply_Annual	Fish sub-model annual results for habitat supply
IERM_HabitatSupply_TimeStamps	Time and version log for fish sub-model habitat simulation
IERM_Population	Fish sub-model population results for IERM Lake Ontario fish PIs

Table B-8. "IERM_*_Fish_Output" Database Field Listing

Table Name	Field Name	Field Description
IERM_AgeStructure	ID	Unique numeric identifier
IERM_AgeStructure	SpeciesID	Fish species ID
IERM_AgeStructure	RchGroupID	Reach group ID
IERM_AgeStructure	Age	This is the population data table, Age, Males and Females must contain input data the other columns are calculated by the model
IERM_AgeStructure	Males_IC	Male population in age class (count)
IERM_AgeStructure	Females_IC	Female population in age class (count)
IERM_AgeStructure	MLength_IC	Average length of male fish in age class (mm)
IERM_AgeStructure	FLength_IC	Average length of female fish in age class (mm)
IERM_AgeStructure	Males	Male population in age class (count)
IERM_AgeStructure	Females	Female population in age class (count)
IERM_AgeStructure	MLength	Average length of male fish in age class (mm)
IERM_AgeStructure	FLength	Average length of female fish in age class (mm)
IERM_HabitatSupply	RegPlan_ID	ID of reg plan for which this results set was created
IERM_HabitatSupply	SpeciesID	ID ofspecies for which this results set was created
IERM_HabitatSupply	RchGroupID	ID of reach group for which this results set was created
IERM_HabitatSupply	Date	Date
IERM_HabitatSupply	Year	This is essentially the habitat input table
IERM_HabitatSupply	Julian_Day	Day of the year
IERM_HabitatSupply	Temperature	Mean temperature in 0 to 5 metre zone, degrees C
IERM_HabitatSupply	STF	Suitability factor (sum of WSAs over life stage divided by total area)
IERM_HabitatSupply	Spawn_WSA	Spawning area (m2)
IERM_HabitatSupply	Fry_WSA	Area suitable for fry (swim-up) (m2)
IERM_HabitatSupply	YOY_WSA	Area suitable for YOY (m2)
IERM_HabitatSupply	Juvenile_WSA	Area suitable for the juveniles (m2)

Table Name	Field Name	Field Description
IERM_HabitatSupply	Adult_WSA	Area suitable for the adults (m2)
IERM_HabitatSupply	Total_Area	Total lake/study area (m2)
IERM_HabitatSupply	Water_Level	Interpolated water level (meters IGLD85)
IERM_HabitatSupply	WL_Change	if water levels increase this value is set to 1 if it decreases this value decreases ie a 1% decrease in water level = WLchange = 0.99
IERM_HabitatSupply_Annual	RegPlan_ID	ID of reg plan for which this results set was created
IERM_HabitatSupply_Annual	SpeciesID	ID ofspecies for which this results set was created
IERM_HabitatSupply_Annual	RchGroupID	ID of reach group for which this results set was created
IERM_HabitatSupply_Annual	Year	Year
IERM_HabitatSupply_Annual	Spawn_WSA_Days	Spawning WSA-days, summed over reaches (m2-days)
IERM_HabitatSupply_Annual	YOY_WSA_Days	YOY WSA-days, summed over reaches (m2-days)
IERM_HabitatSupply_Annual	Adult_WSA_Days	Adult WSA-days, summed over reaches (m2-days)
IERM_HabitatSupply_Annual	Spawn_WSA	Spawning area, averaged in spawning window 1 (end-start+1), summed over reaches (m2)
IERM_HabitatSupply_Annual	YOY_WSA	Area suitable for YOY, averaged in YOY window 1 (end-start+1), summed over reaches (m2)
IERM_HabitatSupply_Annual	Adult_WSA	Area suitable for the adults, averaged in adult window 1 (end-start+1), summed over reaches (m2)
IERM_HabitatSupply_Annual	Spawn_WSA2	Spawning area, averaged in spawning window 2 (end-start+1 minus days where T not suitable), summed over reaches (m2)
IERM_HabitatSupply_Annual	YOY_WSA2	Area suitable for YOY, averaged in YOY window 2 (end-start+1 minus days where T not suitable), summed over reaches (m2)
IERM_HabitatSupply_Annual	Adult_WSA2	Area suitable for the adults, averaged in adult window 2 (end-start+1 minus days where T not suitable), summed over reaches (m2)
IERM_HabitatSupply_TimeStamps	RegPlan_ID	ID of reg plan for which this results set was created
IERM_HabitatSupply_TimeStamps	SpeciesID	ID of species for which this results set was created
IERM_HabitatSupply_TimeStamps	RchGroupID	ID of reach group for which this results set was created
IERM_HabitatSupply_TimeStamps	TimeStampStart	Date/time creation of results set began
IERM_HabitatSupply_TimeStamps	TimeStampEnd	Date/time writing of results set ended
IERM_HabitatSupply_TimeStamps	RchCount	Number of reaches in the reach list
IERM_HabitatSupply_TimeStamps	RchGroupCRC	Checksum of reach IDs on reach list
IERM_HabitatSupply_TimeStamps	RchCountActual	Number of reaches actually included in this results set (some may be excluded at run-time)
IERM_HabitatSupply_TimeStamps	RchGroupCRCActual	Checksum of reach list for the reach group on which these results are actually based
IERM_HabitatSupply_TimeStamps	Database_Version	Version ID of source database used to generate this set
IERM_HabitatSupply_TimeStamps	Software_Version	Version ID of software used to generate this set
IERM_HabitatSupply_TimeStamps	IsSuperReach	True: Results reflect "super-reach" aggregation; False: (Normal) Results obtained by processing all individual reaches
IERM_HabitatSupply_TimeStamps	StudyParameters	CR-delimited array of values read from [Study Parameters] table of main MDB

Table Name	Field Name	Field Description
IERM_Population	RegPlan_ID	Regulation plan unique numeric ID
IERM_Population	SpeciesID	Species text identifier
IERM_Population	RchGroupID	Reach group identifier
IERM_Population	Year	Year
IERM_Population	Fish_Total	Total # of fish
IERM_Population	YOY_Total	Total # of young-of-year fish
IERM_Population	YOY_Density	Young-of-year density
IERM_Population	Hatchling_Density	Hatchling density
IERM_Population	JuvAdult_Density	Juvenile-adult density
IERM_Population	Mature_Density	Mature fish density
IERM_Population	Biomass_Density	Fish biomass density
IERM_Population	P/B	Production-to-biomass ratio
IERM_Population	Weight/fish	Weight per individual fish
IERM_Population	Mature_Biomass	Mature fish biomass

Table B-9. "IERM_WL_Bird" Database Table Listing

Table Name	Table Description
tblWLBird_Density	Wetland bird density function parameters
tblWLBird_Hydr_Impacts	Wetland bird hydrologic impact parameters
tblWLBird_Nest_Properties	Wetland bird nest flooding/stranding function parameters
tblWLBird_PI	Wetland bird IERM PI listing
tblWLBird_Species	Wetland bird species listing
Water_Depth	Diagnostic table for reporting water depth within wetland bird habitats (*not currently used by IERM*)

Table B-10. "IERM_WL_Bird" Database Field Listing

Table Name	Field Name	Field Description
tblWLBird_Density	Species_No	Wetland bird species unique numeric ID
tblWLBird_Density	Species_ID	Wetland bird species code
tblWLBird_Density	StartQM	Start quarter month for evaluation
tblWLBird_Density	EndQM	End quarter month for evaluation
tblWLBird_Density	Variable	Hydrologic variable for density function
tblWLBird_Density	Coefficients	Coefficients for density function
tblWLBird_Density	LBound	Lower bound for hydrologic variable
tblWLBird_Density	UBound	Upper bound for hydrologic variable
tblWLBird_Density	Density_LBound	Minimum value for wetland bird density
tblWLBird_Density	Hydr_Bounds	Hydrologic bounds
tblWLBird_Density	Hydr_Impact	Hydrologic impact parameters
tblWLBird_Hydr_Impacts	WLevel_Change	Water Level change scenarion (increasing or decreasing)
tblWLBird_Hydr_Impacts	Habitat	Plant Community
tblWLBird_Hydr_Impacts	Depth	Description of Water Depth
tblWLBird_Hydr_Impacts	Hydr_Scenario	Description of Hydrologic Impact Scenario
tblWLBird_Hydr_Impacts	Scenario_ID	Unique Hydrologic Scenario ID
tblWLBird_Hydr_Impacts	Impact_Index	Comma delimited string of hydrologic impact indices (1=null, 2=low, 3=moderate,4=high,5=exceptional)
tblWLBird_Nest_Properties	Species_No	Wetland bird species unique numeric ID
tblWLBird_Nest_Properties	Species_ID	Wetland bird species code
tblWLBird_Nest_Properties	Nesting_Period	Quarter Months
tblWLBird_Nest_Properties	Nesting_Rate	Species Specific Baseline Nesting Rate
tblWLBird_Nest_Properties	Renesting_Rate	Species Specific renesting Rate
tblWLBird_Nest_Properties	Stranding_Failure	Probability of Nest Failure Due to Stranding
tblWLBird_Nest_Properties	Initial_QM	Beginning Quarter month for Initial Nesting Attempt
tblWLBird_Nest_Properties	Renest_QM	Beginning Quarter month for Renesting Attempt
tblWLBird_Nest_Properties	Flooding_Coefficients	Comma delimtted list of flooding regression coefficients. Sorted by increasing order (i.e., zero order, one order, etc)
tblWLBird_Nest_Properties	Flood_Log_Flag	Flag to designate flooding regression equation as logrithmic. (Yes = logrithmic, NO = polynomial)
tblWLBird_Nest_Properties	Flood_Floor	lower bound of validity for flood regression

Table Name	Field Name	Field Description
tblWLBird_Nest_Properties	Flood_Ceiling	upper bound of validity for flood regression
tblWLBird_Nest_Properties	Stranding_Coefficients	Comma delimtted list of stranding regression coefficients. Sorted by increasing order (i.e., zero order, one order, etc)
tblWLBird_Nest_Properties	Strand_Log_Flag	Flag to designate stranding regression equation as logrithmic. (Yes = logrithmic, NO = polynomial)
tblWLBird_Nest_Properties	Strand_Floor	lower bound of validity for flood regression
tblWLBird_Nest_Properties	Strand_Ceiling	upper bound of validity for flood regression
tblWLBird_PI	PI_ID	Wetland bird PI unique numeric ID
tblWLBird_PI	PI_Type	PI calculation type (either Nesting Success or Density)
tblWLBird_PI	Species_No	Wetland bird species unique numeric ID
tblWLBird_PI	RegLoc_ID	Location where species are present
tblWLBird_PI	Wetland_ID	Semi-colon delmited string of wetland IDs where PI species is present
tblWLBird_Species	Species_No	Wetland bird species unique numeric ID
tblWLBird_Species	Species_ID	Wetland bird species code
tblWLBird_Species	Species_Descr	Wetland bird species description
tblWLBird_Species	Habitat	Plant Community the species exists in
tblWLBird_Species	Scientific_Name	Latin Name (genus/species)
tblWLBird_Species	M2_LBound	25th percentile reproductive index for each species for 1958DD (historical supply)
tblWLBird_Species	M3_RPeriod	Rolling period for evaluating species sustainability index
tblWLBird_Species	M3_LBound	Lower bound on nest success (success/capacity) for evaluating species sustainability index
Water_Depth	RegPlan_ID	Regulation plan unique numeric ID
Water_Depth	Wetland_ID	Wetland unique numeric ID
Water_Depth	Year	Year
Water_Depth	WLBird_SpeciesID	Wetland bird species ID
Water_Depth	Min_Elev	Minimum elevation
Water_Depth	Max_Elev	Maximum elevation
Water_Depth	Water_Depth	Water depth

Table B-11. "IERM_LSL_v5" Database Table Listing

Table Name	Table Description
Division_Fleuve	Hydrologic divisions of the Lower St. Lawrence River
INTERPOLATION_MATRICE_PI	Interpolation matrix
MATRICE_ESPMEN_DEC	PI parameters related to water level increase conditions
MATRICE_ESPMEN_INC	PI parameters related to water level decrease conditions
MATRICE_GRENOUILLE	Parameters for LSLR frog PIs
MATRICE_HUTTE_RAT	Input parameters for LSLR muskrat PI
MATRICE_OISEAUX	Input parameters for wildfowl PIs
MATRICE_OISEAUX_SUPPORT	Additional input parameters for wildfowl PIs
MATRICE_REPR_FISH	Input parameters for fish reproductive PIs
MOY_ANT_WETLAND	Average LSLR wetland area results
OUAOUARON_WEIBULL	Input parameters for bullfrog PIs
PI_Results	PI annual results table (mirrors "PI_Results" table in main IERM database)
QM_REPR_FISH	Quarter month ranges for fish reproduction PIs
RegGrenouille	Regression parameters for frog PIs
Sauvagine_Nb_nids	Input parameters for wildfowl PIs
Scenario_Stl	Seasonal flow scenarios at Sorel
STAT_ANT_WETLAND	Wetland surface area statistics
WETLAND	Wetland vegetation PI listing

Table B-12. "IERM_LSL_v5" Database Field Listing

Table Name	Field Name	Field Description
Division_Fleuve	RegLoc_ID	Identifiant du parametre hydrologique
Division_Fleuve	DIVISION_ID	Numero de la section du fleuve
Division_Fleuve	NOM_DIVISION	Nom de la section du fleuve
INTERPOLATION_MATRICE_PI	PI_ID	Numero identifiant l'indicateur de performence
INTERPOLATION_MATRICE_PI	SURFACE_ID_BI	Surface: Borne inferieur de debit
INTERPOLATION_MATRICE_PI	SURFACE_ID_BS	Surface: Bornesuperieure de debit
MATRICE_ESPMEN_DEC	PI_ID	Numero de l'indicateur de performance
MATRICE_ESPMEN_DEC	H_SOREL	NIVEAU D'EAUX a Sorel des scenarios
MATRICE_ESPMEN_DEC	PILocID	Numero de la section du fleuve
MATRICE_ESPMEN_DEC	DECREASE	Valeur de la diminution du niveau de l'eau
MATRICE_ESPMEN_DEC	SURFACE_PI	Valeur de la surface de l'indicateur
MATRICE_ESPMEN_DEC	QM_START_SCN	Contient le debut du calcul de l'Indicateur
MATRICE_ESPMEN_DEC	QM_END_SCN	Contient la fin du calcul de l'indicateur
MATRICE_ESPMEN_DEC	QM_START_DIFF	n/a
MATRICE_ESPMEN_DEC	QM_END_DIFF	n/a
MATRICE_ESPMEN_INC	PI_ID	Numero de l'indicateur de performance
MATRICE_ESPMEN_INC	H_SOREL	NIVEAU D'EAUX a Sorel des scenarios
MATRICE_ESPMEN_INC	PILocID	Numero de la section du fleuve
MATRICE_ESPMEN_INC	INCREASE	Valeur de la diminution du niveau de l'eau
MATRICE_ESPMEN_INC	SURFACE_PI	Valeur de la surface de l'indicateur
MATRICE_ESPMEN_INC	QM_START_SCN	Contient le debut du calcul de la moy annuelle
MATRICE_ESPMEN_INC	QM_END_SCN	Contient la fin du calcul de la moy annuelle
MATRICE_ESPMEN_INC	QM_START_DIFF	Contient le début du calcul du dec ou inc
MATRICE_ESPMEN_INC	QM_END_DIFF	Contient la fin du calcul du dec ou inc
MATRICE_GRENOUILLE	PI_ID	Numero de l'indicateur de performance
MATRICE_GRENOUILLE	PILoc_ID	Numero de la section du fleuve
MATRICE_GRENOUILLE	H_SOREL	NIVEAU a Sorel des scenarios
MATRICE_GRENOUILLE	MH	Milieu_humdie typique
MATRICE_GRENOUILLE	DECREASE	Valeur de la diminution du niveau de l'eau
MATRICE_GRENOUILLE	SURFACE_PI	Valeur de la surface de l'indicateur
MATRICE_GRENOUILLE	QM_START	Contient le début du quart de mois de calcul
MATRICE_GRENOUILLE	QM_END	Contient le début du quart de mois de calcul
MATRICE_HUTTE_RAT	PI_ID	Contient le numéro de l'indicateur de la performance
MATRICE_HUTTE_RAT	PILoc_ID	Contient le numéro du secteur fluvial
MATRICE_HUTTE_RAT	MH	Contient le numéno MH
MATRICE_HUTTE_RAT	H_SOREL	Contient les valeurs de niveau d'eau pour chacun des scénarios
MATRICE_HUTTE_RAT	Nb_hutte	Contient le nombre de huttes calculées
MATRICE_HUTTE_RAT	QM_START	Contient le numéro du quart de mois de départ (novembre)
MATRICE_HUTTE_RAT	QM_END	Contient le numéro du quart de mois d'arrêt (novembre)
MATRICE_OISEAUX	PI_ID	Contient le numéro de l'indicateur de performance
MATRICE_OISEAUX	PILocID	Contient le secteur fluvial
MATRICE_OISEAUX	MH	Contient la milieu humide

Table Name	Field Name	Field Description
MATRICE_OISEAUX	H_SOREL	Contient la valeur du niveau à Sorel pour les scenarios
MATRICE_OISEAUX	INCREASE	Contient l'increase
MATRICE_OISEAUX	DECREASE	Contient le decrease
MATRICE_OISEAUX	NB_OISEAU	Contient la valeur de l'indicateur
MATRICE_OISEAUX	QM_START	Contient le début du calcul
MATRICE_OISEAUX	QM_END	Contient la fin du calcul
MATRICE_OISEAUX_SUPPORT	PI_ID	Contient le numéro de l'indicateur de performance
MATRICE_OISEAUX_SUPPORT	H_SOREL	Contient la valeur du niveau à Sorel pour les scenarios
MATRICE_OISEAUX_SUPPORT	INCREASE	Contient l'increase
MATRICE_OISEAUX_SUPPORT	DECREASE	Contient le decrease
MATRICE_OISEAUX_SUPPORT	PILocID	Contient le secteur fluvial
MATRICE_OISEAUX_SUPPORT	MH	Contient la milieu humide
MATRICE_OISEAUX_SUPPORT	CAPACITE_SUPPORT	Contient la valeur de l'indicateur
MATRICE_OISEAUX_SUPPORT	QM_START	Contient le début du calcul
MATRICE_OISEAUX_SUPPORT	QM_END	Contient la fin du calcul
MATRICE_REPR_FISH	PI_ID	n/a
MATRICE_REPR_FISH	PILocID	n/a
MATRICE_REPR_FISH	MH	n/a
MATRICE_REPR_FISH	H_SOREL	n/a
MATRICE_REPR_FISH	DECREASE	n/a
MATRICE_REPR_FISH	SURFACE	n/a
MOY_ANT_WETLAND	Annee	n/a
MOY_ANT_WETLAND	PlanID	n/a
MOY_ANT_WETLAND	RegLoc	n/a
MOY_ANT_WETLAND	NbAnneeAnterieure	n/a
MOY_ANT_WETLAND	Moy	n/a
OUAOUARON_WEIBULL	PI_ID	Contient le numéro de l'indicateur de performance
OUAOUARON_WEIBULL	MH	Contient le milieu humide
OUAOUARON_WEIBULL	PILoc_ID	Contient le secteur fluvial
OUAOUARON_WEIBULL	RegLocID	Contient l'identifiant du paramètre hydrolique
OUAOUARON_WEIBULL	ALPHA	Contient le terme alpha de l'équation de Weibull
OUAOUARON_WEIBULL	MU	Contient le terme mu de l'équation de Weibull
OUAOUARON_WEIBULL	GAMMA	Contient le terme Gamma de l'équation de Weibull
OUAOUARON_WEIBULL	FACTMULTI	Contient le terme multiplicatif de l'équation de Weibull
PI_Results	RegPlan_ID	n/a
PI_Results	PI_ID	n/a
PI_Results	Year	n/a
PI_Results	PI_Result	n/a
QM_REPR_FISH	PI_ID	n/a
QM_REPR_FISH	YEAR	n/a
QM_REPR_FISH	QM_START_MOY	n/a
QM_REPR_FISH	QM_END_MOY	n/a
QM_REPR_FISH	QM_START_DIFF	n/a
QM_REPR_FISH	QM_END_DIFF	n/a
RegGrenouille	PI_ID	Contient le numero de l'indicateur de performance

Table Name	Field Name	Field Description
RegGrenouille	MH	Contient le milieu humide
RegGrenouille	QM_Start	Debut de la periode de calcul
RegGrenouille	QM_End	Fin de la periode de calcul
RegGrenouille	Calulation method	n/a
RegGrenouille	Calculation_Lag	n/a
RegGrenouille	Polynomial_LocId	n/a
RegGrenouille	Polynomial_Coefficients	n/a
Sauvagine_Nb_nids	Qmonth	Contient les quart de temps de 1 à 48
Sauvagine_Nb_nids	RegLoc_ID	Identifiant du paramètre hydrologique
Sauvagine_Nb_nids	Sim_Result	Contient la valeur du niveau à Sorel
Sauvagine_Nb_nids	Increase	Contient la valeur de remontée de niveau par rapport qu Qmonth précédent
Sauvagine_Nb_nids	Succes	Contient le succes reproducteur
Sauvagine_Nb_nids	Nb_nids	Contient le nombre de nid théorique durant le Qmonth
Sauvagine_Nb_nids	Perte_nids	Contient le nombre de nids actif durant le Qmonth
Scenario_Stl	RegLoc_ID	Identifiant du paramtere hydrologique
Scenario_Stl	Q_Sorel	Valeur du debir a Sorel
Scenario_Stl	Numero_scenario	Identifiant du scenario
Scenario_Stl	Saison_scenario	saison hydrologique
STAT_ANT_WETLAND	Annee	n/a
STAT_ANT_WETLAND	PlanID	n/a
STAT_ANT_WETLAND	RegLoc	n/a
STAT_ANT_WETLAND	NbYrAnt	Nombre d'annee anterieure utilisé pour faire les calculs
STAT_ANT_WETLAND	QMoy	Debit moyen a Sorel sur NbYrAnt
STAT_ANT_WETLAND	Etype	Ecart Type sur NbYrAnt
STAT_ANT_WETLAND	Mediane	Mediane sur NbYrAnt
STAT_ANT_WETLAND	NbCycle	Moyenne du nombre de Cycle Annuel sur NbYrAnt
WETLAND	PI_ID	Numéro de l'idicateur
WETLAND	Desc	Nom Commun de l'indicateur
WETLAND	PILocID	Contient le numero du secteur fluvial
WETLAND	ANNEE_ANT	Contient le nombre d'annee anterieur du calcul du débit

Appendix C. Fact Sheets for Key Ecological Performance Indicators

Table C-1 provides a cross-reference between the key PI fact sheet PDF files and the "PI_Matrix" table in the IERM main database. Both the table and the PI fact sheets are included as Appendix C to the memorandum.

Table C-1. Key PI Fact Sheet Summary

PI Numeric Identifier ("PI_ID")	PI Description	PI Fact Sheet Filename
11003	Wetland meadow marsh total area, supply-based (Lake Ontario)	E1_LO_Veg_MeadowMarsh.pdf
12006	"Low vegetation preference, 18°C" fish guild spawning habitat supply in Lake Ontario	E2_LO_Fish_LVeg-18C_guild.pdf
12007	"High vegetation preference, 24°C" fish guild spawning habitat supply in Lake Ontario	E3_LO_Fish_HVeg-24C_guild.pdf
12008	"Low vegetation preference, 24°C" fish guild spawning habitat supply in Lake Ontario	E4_LO_Fish_LVeg-24C_guild.pdf
12401	Northern pike young-of-year recruitment in Lake Ontario	E5_LO_Fish_NPike.pdf
12402	Largemouth bass young-of-year recruitment in Lake Ontario	E6_LO_Fish_LmBass.pdf
22006	"Low vegetation preference, 18°C" fish guild spawning habitat supply in the USLR	E12_USL_Fish_LVeg-18C_guild.pdf
22007	"High vegetation preference, 24°C" fish guild spawning habitat supply in the USLR	E13_USL_Fish_HVeg-24C_guild.pdf
22008	"Low vegetation preference, 24°C" fish guild spawning habitat supply in the USLR	E14_USL_Fish_LVeg-24C_guild.pdf
22401	Northern pike young-of-year recruitment in the USLR	E15_USL_Fish_NPike-Minns.pdf
22402	Largemouth bass young-of-year recruitment in the USLR	E16_USL_Fish_LmBass.pdf
22501	Northern pike annual young-of-year net productivity in the Thousand Islands region	E17_USL_Fish_NPike-Farrell.pdf

PI Numeric Identifier ("PI_ID")	PI Description	PI Fact Sheet Filename
22502	Northern pike annual egg productivity in the Thousand Islands region	E17_USL_Fish_NPike-Farrell.pdf
13006	Least Bittern - reproductive index (Lake Ontario)	E8-E29_LO-LSL_SAR_LeastBittern.pdf
13007	Virginia Rail - reproductive index (Lake Ontario)	E7-E18-E24_LO-USL-LSL_Bird_VirginiaRail.pdf
13009	Black Tern - reproductive index (Lake Ontario)	E9-E26_LO-LSL_SAR_BlackTern.pdf
23007	Virginia Rail - reproductive index (Lake St. Lawrence)	E7-E18-E24_LO-USL-LSL_Bird_VirginiaRail.pdf
16301	Yellow Rail - preferred breeding habitat coverage (Lake Ontario)	E10_LO_SAR_YellowRail.pdf
16302	King Rail - preferred breeding habitat coverage (Lake Ontario)	E11_LO_SAR_KingRail.pdf
25001	Muskrat - house density in drowned river mouth wetlands (Thousand Islands area)	E19_USL_Mammal_Muskrat.pdf
32004	Golden Shiner - suitable feeding habitat surface area (Lake St. Louis to Trois-Rivières)	E20_LSL_Fish_GoldenShiner.pdf
32109	Wetlands fish - abundance index (Lower St. Lawrence)	E21_LSL_Fish_WetlandIndex.pdf
33134	Northern Pike - suitable reproductive habitat surface area (Lake St. Louis to Trois-Rivières)	E22_LSL_Fish_NorthernPike.pdf
33004	Migratory wildfowl - floodplain habitat surface area (Lake St. Louis to to Trois-Rivières)	E23_LSL_Bird_Waterfowl_migration.pdf
33059	Virginia Rail - reproductive index (Lake St. Louis to Trois-Rivières)	E7-E18-E24_LO-USL-LSL_Bird_VirginiaRail.pdf
33085	Migratory wildfowl - productivity (Lake St. Louis to to Trois-Rivières)	E25_LSL_Bird_Waterfowl_productivity.pdf
33119	Black Tern - reproductive index (Lake St. Louis to Trois-Rivières)	E9-E26_LO-LSL_SAR_BlackTern.pdf
36013	Frog sp. - reproductive habitat surface area (Lake St. Louis to Trois-Rivières)	E27_LSL_Herp_FrogSpecies.pdf
38001	Muskrat - surviving houses (Lake St. Louis to Trois-Rivières)	E28_LSL_Mammal_Muskrat.pdf

PI Numeric Identifier ("PI_ID")	PI Description	PI Fact Sheet Filename
33054	Least Bittern - reproductive index (Lake St. Louis to Trois-Rivières)	E8-E29_LO-LSL_SAR_LeastBittern.pdf
36043	Eastern Sand Darter - reproductive habitat surface area (Lake St. Louis to Trois-Rivières)	E30_LSL_SAR_EasternSandDarter.pdf
36048	Spiny Softshell Turtle - reproductive habitat surface area (Lake St. Louis to Trois-Rivières)	E31_LSL_SAR_SpinySoftshell-MapTurtle.pdf