DRESDEN ISLAND HYDROELECTRIC PROJECT
FERC NO. 12626

CONSERVATION PLAN

PREPARED FOR:

NORTHERN ILLINOIS HYDROPOWER, LLC
JOLIET, ILLINOIS

PREPARED BY:

Kleinschmidt

www.KleinschmidtUSA.com

DECEMBER 2013

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

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CONSERVATION PLAN

1.0 PROPOSED ACTION

1.1 PROJECT LOCATION

The Proposed Project is located on the Illinois River immediately downstream of the confluence of the Des Plaines and Kankakee Rivers and 271.5 miles above its confluence with the Mississippi River, and approximately 15 miles southwest of Joliet, Illinois. The Illinois River lies within the upper Mississippi River Basin and is part of the Illinois Waterway (Figure 1). The proposed Project is located at an existing United States Army Corps of Engineers (USACE) facility. While the USACE owns the civil structures associated with the Lock and Dam, these structures are generally sited on and adjacent to lands of the State of Illinois. The total area of land within the project boundary is approximately 3.7 acres. Of that, approximately 0.73 acre is property of the United States, 2.6 acres are lands of the State of Illinois, and .37 acre is in private ownership. The USACE Lock and Dam Facilities are located at 7521 Lock Road, Morris, Illinois.

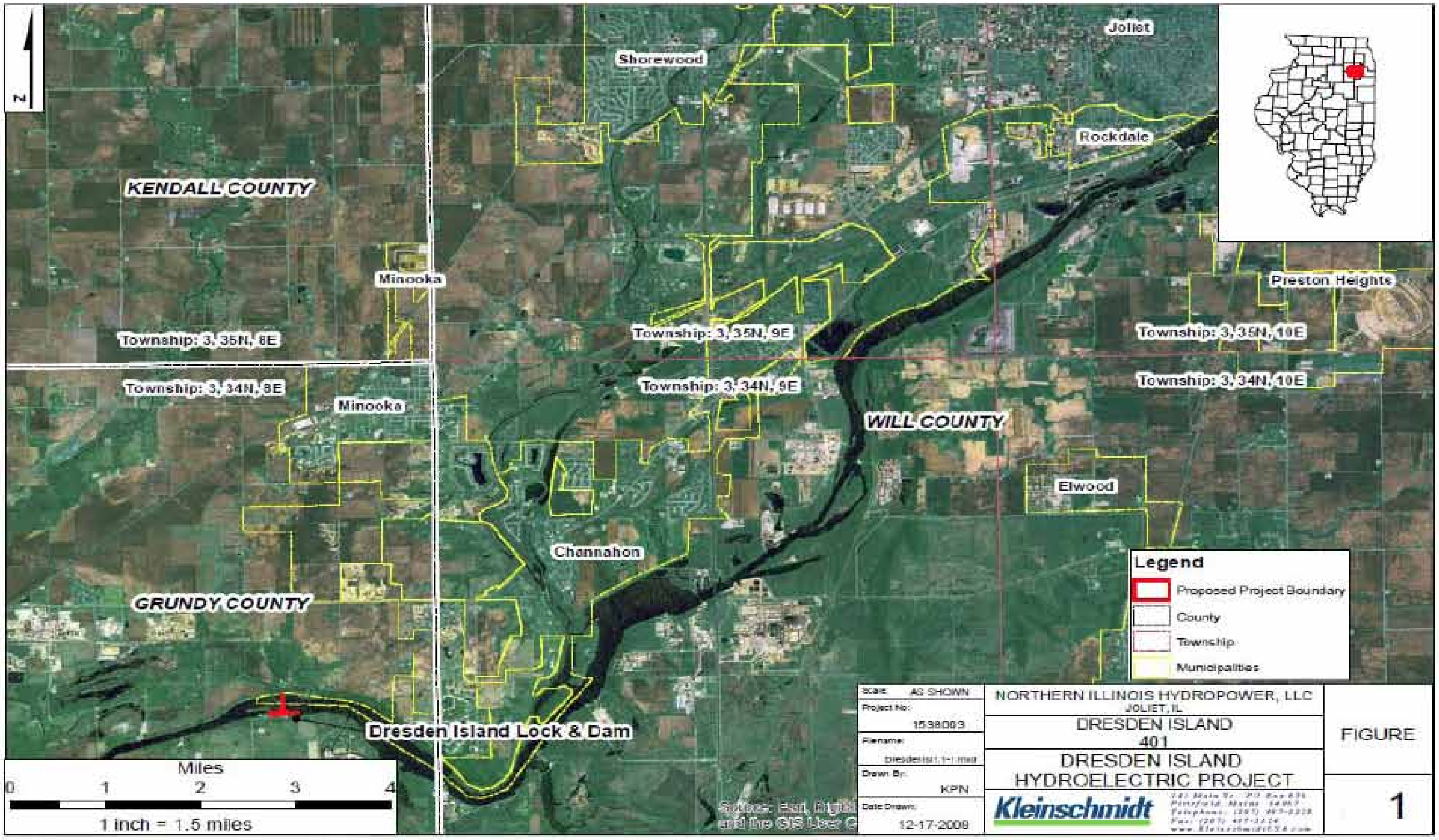

FIGURE 1. PROJECT LOCATION MAP

1.2 AFFECTED SPECIES

Currently three Illinois threatened/endangered fish species have been reported within the vicinity of the project; the river redhorse (*Moxostoma carinatum*), greater redhorse (*Moxostoma valenciennesi*), and pallid shiner (*Hybopsis amnis*). These species are all protected under the Illinois Endangered Species Protection Act (Act) [520 ILCS 10, *et seq.*]. The river redhorse and greater redhorse are both in the Catostomidae (sucker) family while the pallid shiner is in the Cyprinidae (minnow) family.

1.2.1 RIVER REDHORSE

The river redhorse population ranges from the upper St. Lawrence River, south to Florida and west to the drainages of the Mississippi River (Scott and Crossman, 1998). The river redhorse was found within the Dresden pool in 1985 and more recently in 2006 in the tailwater of Dresden Island (IDNR, 2008; Midwest Biodiversity Institute, 2008). This species is common in the Kankakee River but is uncommon in the rest of Illinois (Smith, 2002). The river redhorse prefers large rivers and the lower portions of their main tributaries. It uses habitats with slack water or swift moving water with clean gravel and rubble. This species is not typically found in deep water with fine benthic substrates. The river redhorse primarily feeds on mollusks. The decline of this species has been attributed to increased turbidity and other forms of pollution which likely affected their food source first. River redhorse typically migrate upstream to spawn in water 2-4 feet deep, in moderate current, and over gravel or rubble substrate. Spawning typically occurs during the last few weeks of May or early June when water temperatures are approximately 20-23^{o}C (Becker, 1983).

The habitat behind Dresden Island Lock and Dam generally contains slow moving water with fine benthic substrate such as silt or sand. This habitat would not likely provide ideal habitat for the river redhorse. The specimen found in Dresden Pool was likely washed downstream during high flows but would not regularly be found in Dresden Pool. However, downstream of the Dresden Island Dam the benthic substrate contains some areas of gravel or rubble that would likely provide spawning habitat for redhorse species. The redhorse may use this habitat for spawning in the late spring or early summer. Known mussel beds downstream of the dam would also likely provide foraging habitat for the redhorse.

1.2.2 GREATER REDHORSE

The greater redhorse population is known to occur in the Upper Mississippi and Great Lakes-St. Lawrence watersheds (Scott and Crossman, 1998). The greater redhorse has been reported as extirpated in the state of Illinois (Smith, 2002). However, the Illinois Department of Natural Resources has indicated that specimens were collected at the mouth of the Kankakee River and downstream of the Dresden Island Dam. The most recent record of greater redhorse in the vicinity of the proposed Project was caught at the mouth of the Kankakee River in 1985 (IDNR, 2008). Very little is known about the biology of the greater redhorse, but this species likely shares similar life histories to other redhorse species (Scott and Crossman, 1998; Smith, 2002). This species likely prefers habitats with clean gravel or rubble benthic substrate. Spawning likely occurs from late spring to early summer in habitat that contains moderate current and gravel or rubble substrate.

The habitat behind Dresden Island Lock and Dam generally contains slow moving water with fine benthic substrate such as silt or sand. This habitat would not likely provide ideal habitat for the greater redhorse. However, downstream of the Dresden Island Dam the benthic substrate contains some areas of gravel or rubble that would likely provide spawning habitat for the greater redhorse. This species may use this habitat for spawning in the late spring or early summer. Known mussel beds downstream of the dam would also likely provide foraging habitat for the greater redhorse.

1.2.3 PALLID SHINER

The pallid shiner population ranges from the Mississippi Valley from the St. Croix River in Minnesota and Wisconsin, south to Louisiana and west to Texas. An isolated population is known to occur in the Kankakee River in northern Illinois (Kwak, 1991). The preferred habitat of the pallid shiner may include aquatic vegetation but it is not necessary. The preferred benthic substrate may vary from fine sediments to gravel and rock. This species prefers slower moving water and has been shown to be tolerant of a wide range of turbidity; however, turbidity is cited as a contributing factor in the decline of the species (Kwak, 1991). The species is generally found in larger waters that are warmer than smaller streams (Becker, 1983).

The habitat of the Kankakee River in the area of known pallid shiner populations was described as "…shallow with little or no current in moderately clear waters that are warm, average pH, and well oxygenated during summer day light hours" (Kwak, 1991). Both adult and juvenile pallid shiners were found in water less than 1 meter depth and less than 1 cm/s velocity. Little is known about the spawning or food habits of this species but it is thought that the species spawns after March in the Kankakee River and likely uses the floodplain for spawning habitat (Becker, 1983; Kwak, 1991). Although the Pallid shiner occurs in the Kankakee River this species is unlikely to occur in habitat adjacent to the Project. A specimen found in Dresden Pool in 1985 was likely washed downstream during high flows but would not regularly be found in Dresden Pool (IDNR, 2008).

1.3 PROPOSED ACTION

Northern Illinois Hydropower, LLC ("Applicant") has filed with the Federal Energy Regulatory Commission (FERC) a License Application for the proposed Dresden Island Hydroelectric Project (FERC Project No. 12626 (Project or Dresden Island)). The Applicant proposes to construct a new powerhouse at the existing USACE Dresden Island Lock and Dam and operate the Project pursuant to the information provided in the Application for Section 401 Water Quality Certification (IEPA Log No. c-0408-08).

In preparation of the site for the construction of temporary cofferdams and rock excavation on the downstream side of the existing dam, the Applicant proposes to mechanically dredge the work area to remove existing sediment and overburden. The limits of the dredging cover an area approximately 1.49 acres upstream of the existing dam and 0.37 acres downstream of the existing dam. The Applicant plans to construct temporary downstream cofferdams consisting of sheet pile cofferdam cells and a section of earthen cofferdam to dewater the worksite for dredging, excavation and construction.

The Applicant proposes to install a reinforced concrete forebay and power station with foundation dimensions of approximately 93 feet wide by 221 feet in length immediately downstream of the existing USACE head gate sections 2 through 15. The depth of riverbed excavation for the powerhouse foundation will average 4 feet in depth.

An excavated tailrace channel is planned downstream of the power station. This excavation will result in removal of approximately 2,500 cubic yards of rock from the riverbed. To protect relatively soft rock in the tailrace area, the Applicant proposes to construct a reinforced concrete apron downstream of the power station structure extending to the upper elevation of the soft rock layer.

The proposed Project switchyard is located adjacent to the Project and above the water line. Existing USACE structure will support the transmission line for 851 feet then the applicant will bury the transmission line in a conduit trench at the riverbed for approximately 603 feet. After the submerged transmission line daylights to the south of the USACE lock, the applicant will install wooden poles to support an overhead transmission line for approximately 3,082 feet in length to a nearby substation.

Operation of the powerhouse would be in compliance with the USACE's reservoir regulation and navigation guidelines. The existing Dresden Island Lock and Dam navigational pool is maintained at a water surface elevation held constant at 504.5.0 ft NGVD. Water is released at the same rate as it enters the facility. The Applicant proposes to operate the proposed powerhouse on a strict run-of-river mode where outflow will not exceed inflow. The Applicant and the Illinois Environmental Protection Agency (IEPA) and IDNR have agreed that a 1,000 cfs minimum bypass flow at the Dresden Island dam will maintain dissolved oxygen and support habitat for aquatic life. The applicant will meet this requirement by operating only when flow measured by the USACE for operations at Dresden Island (or some other means as agreed upon by the USACE, and the state agencies) exceeds 1,000 cfs plus the minimum necessary flow of approximately 400 cfs to run a turbine-generator unit. The operational capacity of the proposed powerhouse would be approximately 8,000 cfs. The Applicant will control the project with an automated system that will automatically start up, run, and shut down the turbines. The automated control package will have overload, fault, and runaway speed protection. The system will allow the USACE to modify hydroelectric operations instantaneously in response to emergencies related to the Lock operation or flood control.

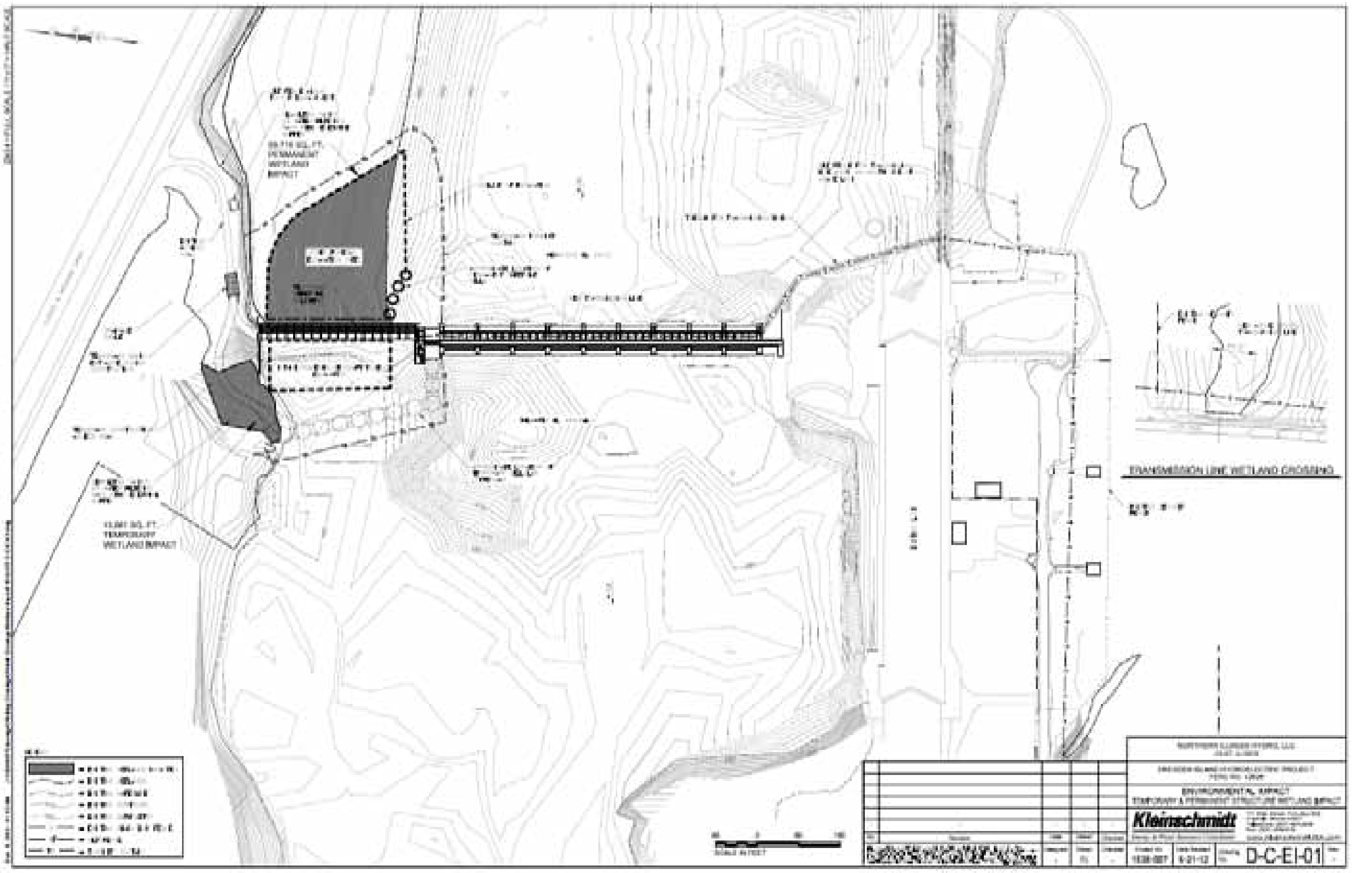

FIGURE 2. PROJECT AREA MAP

1.4 ENVIRONMENTAL EFFECTS

Temporary effects of construction activities include increased turbidity and habitat alteration. Potential long-term effects related to the operation of the proposed project are related to potential increases in impingement/entrainment of fish species from project structures, potential changes in water quality such as dissolved oxygen (DO) below the dam, and the potential for limited habitat alteration.

1.4.1 IMPINGEMENT AND ENTRAINMENT

The Illinois Department of Natural Resources (IDNR), in correspondence dated August 12 and December 5, 2008 noted that hydropower operations may affect fisheries resources depending on turbine design, screening, and other project details. The IDNR cited entrainment and impingement of fish as potential effects of hydropower operations. At the request of the IDNR, the Applicant provided estimated velocities for the proposed designs at the Projects. The U.S. Fish and Wildlife Service (USFWS) in an August 6, 2008 meeting also requested the Applicant to perform entrainment studies.

The Applicant conducted a desktop analysis of entrainment at the proposed Project. The Applicant provided a supplement to the original entrainment analysis on January 14, 2011 based upon revisions to the original proposed powerhouse design. The analyses indicated that Cyprinidae and Catostomidae each represent about 11% of the total fish entrained by the project. Of the 11% that are entrained, only approximately 15% to 25% of the Catostomidae and Cyprinidae result in mortality, respectively. The river redhorse, greater redhorse, and pallid shiner likely represent a minor portion of the population of Catostomidae and Cyprinidae upstream of the Project. In addition, these species are highly fecund, reproduce at a high rate and are subject annually to large natural mortality. When potential Project mortality is considered as part of the population within the river, the percentage of fish potentially entrained combined with the low entrainment mortality results in a minor or fractional potential loss compared with a natural mortality of many of the species present that well exceeds 50% (Kleinschmidt, 2009).

1.4.2 WATER QUALITY

As a result of consultation with the IDNR, IEPA, and USFWS the Applicant conducted DO and temperature monitoring upstream and downstream of the Dresden Island dam. The results of that study were provided as part of the FERC license application as well as provided to IDNR. Data from 2009 showed that during late July, DO can fall below 5.0 mg/L in the Dresden Island pool. Minimum instantaneous standards, 7-day average daily minimum standards, and 30-day average daily mean standards were always met despite several low readings in July. The summer of 2009 was generally a low DO period throughout the region due to unusually high temperatures and low river flows; as such, the 2009 data likely represents one of the worst cases for DO concentrations at the Project. Currently, water not used for USACE operations is spilled through the tainter gates at the dam. Historically, this aeration at the Dresden Island dam provided a means to reduce the high Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) of the Illinois River. With the consistent and on-going improvement to the upstream water quality, the difference between upstream and downstream dissolved oxygen has diminished; however, the spill still provides a level of aeration that may be important to the downstream system. The 1000 cfs pass-by flow will continue to provide aeration of water downstream.

1.4.3 Sediment and Turbidity

The proposed construction would temporarily affect portions of in-stream habitat. The Applicant anticipates dredging sediment and other materials directly upstream and downstream of the proposed powerhouse as part of the proposed construction activities. Concerns regarding sediment quality were discussed with IDNR, IEPA, USFWS, FERC, and the USACE. As part of additional information requested by the IEPA in support of the Applicant 401 Application, the Applicant is providing a detailed plan for the removal of sediment and rock material for the construction of the Project. This additional information includes detailed plans for minimizing release of silt and contaminants as sediments are removed as well as describing the best practices to be employed to contain any incidental release.

1.4.4 Habitat

The proposed Project may also have temporary effects on fish due to displacement from habitats at dredging locations and the powerhouse construction site. This may also result in a re-distribution of abundance and diversity of fish using the habitat for foraging.

The development of the Dresden Island Lock & Dam Hydroelectric Facility will result in changes to the flow releases and USACE operating policy, which could have the potential to adversely affect downstream fish habitat. To understand better the potential effects of the proposed Project, the Applicant contracted for a third-party review of the potential effects of the proposed operations on the fish resource below the dam. NIH hired the Midwest Biodiversity Institute (MBI) a firm highly recommended by IEPA, as they had conducted earlier work for the state on the Des Plaines and Illinois Rivers, to evaluate potential changes in habitat during proposed operations. Appendix A presents MBI's analysis in a document entitled '*An Analysis of Predicted Changes in Fish Habitat Downstream of the Dresden Island Dam from a Proposed Hydroelectric Facility*'. The MBI study identified the critical species in the river, in addition to their habitat criteria for depth and velocity. Kleinschmidt quantified these parameters using a 2-dimensional hydrodynamic model for both the existing and proposed conditions, allowing an assessment of total habitat area, to look at the changes in habitat from the construction of the

Dresden Island project, and the reallocation of river flows from the tainter gates to the powerhouse (Appendix B).

Three different flow rates were assessed, and include:

- A River flow of 1600 cfs, which would include minimum single unit powerhouse generation, with 1000 cfs minimum flow from the tainter gates,
- A River flow of 9000 cfs, which is full Dresden Island powerhouse (8000 cfs), and 1000 cfs minimum spill, and
- A River flow of 15000 cfs, which is Dresden Island powerhouse and remainder spilled equally among the tainter gates.

These analyses demonstrate and support the earlier conclusions that construction and operation of the proposed Project likely will have minimal overall effects, both positive and negative, on aquatic habitat, though the locations of existing habitat conditions may be altered (Table 1-3). NIH emphasizes that there are literally hundreds of combinations of USACE gate operations both with and without the proposed Project and that the modeling only serves to illustrate a reasonable scenario based upon current operations. NIH further emphasizes that it is committed to working with the IDNR, IEPA and the USACE to design and construct habitat modifications using clean rock materials removed during construction of the powerhouse.

TABLE 1. SUMMARY OF HABITAT AREAS BY SPECIES (1600 CFS)

1600 CFS

	EXISTING CONDITIONS (M^2)	PROPOSED CONDITIONS (M^2)	AREA CHANGE (M^2)	PERCENT CHANGE (%)
Greater Redhorse	97,957	99,312	1,355	1.38%
Pallid Shiner	13,414	14,035	621	4.63%
River Redhorse	4,204	4,610	406	9.66%
	115,575	**117,957**	**2,382**	**2.06%**

TABLE 2. SUMMARY OF HABITAT AREAS BY SPECIES (9000 CFS)

9000 CFS

	EXISTING CONDITIONS (M^2)	PROPOSED CONDITIONS (M^2)	AREA CHANGE (M^2)	PERCENT CHANGE (%)
Greater Redhorse	21,548	21,558	10	0.05%
Pallid Shiner	3,247	2,278	-969	-29.84%
River Redhorse	5,730	5,523	-207	-3.61%
	30,525	**29,359**	**-1166**	**-3.82%**

TABLE 3. SUMMARY OF HABITAT AREAS BY SPECIES (15000 CFS)

15000 CFS

	EXISTING CONDITIONS (M^2)	PROPOSED CONDITIONS (M^2)	AREA CHANGE (M^2)	PERCENT CHANGE (%)
Greater Redhorse	8,750	8,255	-495	-5.66%
Pallid Shiner	1,286	1,222	-64	-4.98%
River Redhorse	361	354	-7	-1.94%
	10,397	**9,831**	**-566**	**-5.44%**

In addition to temporary effects, the excavation of the intake/forebay area would permanently affect 1.37 acres of emergent wetland that likely provides rearing habitat for juvenile fish, including suckers and minnows. A portion of this wetland habitat will be replaced by a forebay that provides deep, open water habitat that would likely not attract juvenile fish. Similarly, downstream tailrace excavation would temporarily affect 0.32 acres of emergent wetland and permanently affect 1.37 acres of emergent wetland.

2.0 PROPOSED MINIMIZATION AND MITIGATION MEASURES

The Applicant is taking a number of steps to ensure that any incidental take of protected fish is avoided or minimized. Effects on the species identified by the IDNR are primarily related to impingement and entrainment at project structures and temporary displacement during construction. The Project also has the potential to affect DO levels below the dam. Additionally, construction of the project may result in temporary increases in turbidity. Measures to avoid or minimize effects are described below.

2.1 MINIMIZATION MEASURES

2.1.1 ENTRAINMENT AND IMPINGEMENT

To minimize the effects of project entrainment, the Applicant has designed the trash rack at the intake with 2-inch spacing and has designed the project to meet the IDNR's request for intake velocities of 1.5 ft/sec to minimize potential impacts to the greater redhorse, river redhorse, and pallid shiner. IDNR confirmed the acceptance of those parameters in a November 29, 2010 letter to the FERC.

2.1.2 DISSOLVED OXYGEN

The Applicant and the Illinois Environmental Protection Agency (IEPA) have agreed that a 1,000 cfs minimum bypass flow at the Dresden Island dam for maintaining dissolved oxygen and supporting habitat for aquatic life provides sufficient mitigation under Illinois' anti-degradation regulations. At Dresden Island, the applicant will meet this requirement by operating only when flow measured by the USACE for operations at Dresden Island (or some other means as agreed upon by the USACE, and the state agencies) exceeds 1,000 cfs plus the minimum necessary to run a turbine-generator unit.

2.1.3 INCREASED TURBIDITY DURING CONSTRUCTION

The use of BMPs during construction and proposed mitigation measures related to water quality will serve to ensure that temporary effects to habitat during excavation and dredging are minimized. Use of BMPs will be according to IEPA's 401 Water Quality Certification and the requirements of the USACE. BMPs employed will be reviewed with IDNR and all other jurisdictional federal and state agencies prior to construction.

2.1.4 TEMPORARY DISPLACEMENT

The Applicant proposes to avoid in-water work during the spawning season of the redhorse to not disturb the potential spawning below the Dresden Island Dam. The Applicant will not conduct in-stream construction at the site during the last 3 weeks of May or the first week of June. This means that any cofferdam construction or associated dredging or other disturbances of the river bed – including installation of sediment barriers or other containment systems – will occur prior to the last 3 weeks in May or after the first week in June in each year of construction. Additional measures will include removal of fish trapped within cofferdams during construction. These fish will be netted and safely/humanely returned to the river. Construction activities will be documented using photographs and a formal construction report will be made available to the IDNR.

2.2 MANAGEMENT PLAN

The Applicant has proposed to complete in-water construction outside the spawning season of the greater redhorse and river redhorse. This action would allow the greater redhorse and river redhorse to complete a critical stage in their life history. All other construction would be preformed based on BMPs established with the IEPA and USACE to minimize sedimentation, turbidity, and other water pollutions. Fish will be humanely returned to the river if construction activities isolate fish within cofferdams.

2.3 MITIGATION MEASURES

The effects of the project on freshwater mussels may indirectly affect redhorse foraging opportunities. The Applicant has committed to resurvey the mussel beds prior to construction and after project completion to develop a plan to mitigate any potential effects on the mussels.

In addition, the Applicant will be required by the USACE and the IEPA during the 401/404 permitting process to mitigate the emergent wetland upstream of the Dresden Dam that will be affected by the construction of the Project intake/forebay. This mitigation project would replace the functions and values that would be lost by the construction of the Project.

The Applicant and the IEPA have agreed that a 1,000 cfs minimum bypass flow at the Dresden Island dam for maintaining dissolved oxygen and supporting habitat for aquatic life provides sufficient mitigation under Illinois' anti-degradation regulations. At Dresden Island, the applicant will meet this requirement by operating only when flow measured by the USACE for operations at Dresden Island (or some other means as agreed upon by the USACE, and the state agencies) exceeds 1,000 cfs plus the minimum necessary to run a turbine-generator unit.

2.4 MONITORING MEASURES

The Applicant will be required by the terms of the State 401 Water Quality Certification to monitor turbidity upstream and downstream during construction. The current parameters are unknown, but compliance will include ceasing operations and altering construction methods if disturbance results in turbidity or other water quality parameters exceed limits. If turbidity or other water quality parameters exceed standards during construction, the Applicant will be required to cease operations and develop alternative plans and BMPs in consultation with IEPA and IDNR.

The Applicant has proposed to re-survey the mussel beds downstream of the Project just prior to construction and then post construction to monitor the mussel beds and determine if mussels are being affected. If the mussels are being affected by project operations then the Applicant would propose appropriate mitigation.

The Applicant proposes to establish a real-time DO monitoring system both in the forebay of the Dresden Island dam and downstream of the dam. The Applicant proposes to conduct monitoring studies for 3 years.

2.5 ADAPTIVE MANAGEMENT PLAN

In the event that mussels are affected by construction operation, the Applicant would most likely propose to move the mussel population to more suitable habitat. As an important forage base for the greater and river redhorse, the mussel population should be moved to a location that would still be accessible to the redhorse population.

The Applicant's proposal to establish a real-time DO monitoring system both in the forebay of the Dresden Island dam and downstream of the dam is a water quality adaptive management plan. This real-time monitoring would allow the Project to measure and adjust flows in a way that maintains Illinois water quality standards. Flows spilled through the existing spillway gates would gain dissolved oxygen because of increased turbulence. By shifting flows to the existing spillway gates the Applicant could manipulate the DO concentrations. The Applicant proposes to conduct monitoring studies for 3 years following construction.

If turbidity or other water quality parameters exceed standards during construction, the Applicant will be required to cease operations and develop alternative plans and BMPs in consultation with IEPA and IDNR.

2.6 FINANCIAL ASSURANCE

Northern Illinois Hydro has proposed these measures as part of the overall construction and design of the project. The proposed design features and best management practices are integral to the federal license from FERC; a Memorandum of Agreement with the USACE; and other Illinois permits such as the 401 Water Quality Certification and a lease from IDNR for the use of State lands and waters at the site. FERC and the USACE will not approve commencement of construction for the Project until proof of financial responsibility is verified. If approved, the project would be constructed and operated as specified by the agencies and agreed to by Northern Illinois Hydro, LLC.

3.0 NO ACTION ALTERNATIVE

The no Action alternative would leave the Dresden Island Lock and Dam as is and would not result in the construction and operation of the hydropower facility. Under this alternative, the existing conditions would not change and mortality of the protected fisheries resources in the vicinity would continue as before (*i.e.*, natural mortality). This alternative is not preferred as it would not result in the development of a sustainable source of clean energy on an existing dam and provide the socioeconomic benefits to the state of Illinois or other benefits as described in the license application.

4.0 POPULATION RESILIENCE

Overall the Dresden Pool is mostly comprised of common species including gizzard shad (*Dorosoma cepedianum*), common carp (*Cyprinus carpio*), and bluntnose minnow (*Pimephales notatus*). Based on prior data (CE, 1996), these species accounted for 49% of larval species. Juvenile species within the upper Dresden pool were from the sunfish family (*Lepomis spp*.). In addition to these species many other fish species occur within the Illinois River including smallmouth buffalo (*Ictiobus bubalus*), freshwater drum (*Aplodinotus grunniens*) and catfish (CE, 1996). The river redhorse, greater redhorse, and pallid shiner likely represent a minor component of the fish population in the Illinois River.

The Kankakee River is likely the source of the population of the protected species that have been found in Dresden Pool. Therefore, the core habitat and spawning sites likely occur in the Kankakee River and the Project would not affect the Kankakee River. Therefore, these species would continue to reproduce in the Kankakee River. Fish that leave the Kankakee River system are likely not significant to the maintenance of the core population but may provide the basis for an expanded population.

Downstream of the dam the river may have a population of redhorse, including greater and/or river redhorse. These species may find foraging and spawning habitat below Dresden Island Dam. In-water construction has been scheduled to avoid the spawning season of the greater and river redhorse. These species may be temporarily displaced from foraging sites during in-water construction during other seasons. The Applicant and the IEPA have agreed that a 1,000 cfs minimum bypass flow at the Dresden Island dam for maintaining dissolved oxygen and supporting habitat for aquatic life provides sufficient mitigation under Illinois' anti-degradation regulations. At Dresden Island, the applicant will meet this requirement by operating only when flow measured by the USACE for operations at Dresden Island (or some other means as agreed upon by the USACE, and the state agencies) exceeds 1,000 cfs plus the minimum necessary to run a turbine-generator unit. Therefore, upon completion of construction, the tailrace would again provide potential foraging and spawning opportunities below the Dresden Dam.

The natural mortality of Cyprinidae and Catostomidae is often greater than 50% of the population (Kleinschmidt, 2009). The additional mortality from entrainment on project structures is a small fraction of the population. Therefore, the project as proposed will not significantly reduce the survival of these species.

5.0 IMPLEMENTATION AGREEMENT

Northern Illinois Hydro has identified the additional measures to be undertaken for the protection of or minimization of effects to threatened and endangered species in Illinois in the Conservation Plan above and agrees to take financial responsibility for implementing those measures. Northern Illinois Hydro or the Agents (as directed by NIH) of the Applicant will be responsible for completing the required measures as agreed upon by the IDNR and the Applicant.

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APPENDIX A

AN ANALYSIS OF PREDICTED CHANGES IN FISH HABITAT DOWNSTREAM OF THE DRESDEN ISLAND DAM FROM A PROPOSED HYDROELECTRIC FACILITY

An Analysis of Predicted Changes in Fish Habitat Downstream of the Dresden Island Dam from a Proposed hydroelectric Facility

Midwest Biodiversity Institute

Peter A. Precario, Executive Director
David J. Horn, Board President

An Analysis of Predicted Changes in Fish Habitat Downstream of the Dresden Island Dam from a Proposed Hydroelectric Facility

MBI Technical Report MBI/2012-5-8

May 7, 2012

A Third Party Assessment for Consideration by:

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Illinois DNR
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Table of Contents

List of Tables

List of Figures

Introduction

This report is an addendum to a prior analysis (Yoder and Rankin 2011) about the predicted effects of proposed hydroelectric facilities at the Brandon Road and Dresden Island dams on the Lower DesPlaines-Upper Illinois River system. The focus of this report is a more quantitative assessment of the effects of modeled habitat changes from the predicted operations of the Dresden Island facility. Yoder and Rankin (2011) relied on maps of modeled flow and depth distribution changes to reach their conclusions about the maintenance of flow dependent habitats below the proposed facilities. This report attempts to consider more specific concerns about potential adverse effects on specific fish species that have been articulated by Illinois DNR related to the length and depth of the excavated tailraces downstream of each facility that could act to bypass the "fast, shallow" habitat areas not located directly below the existing head and tainter gates, particularly at the Dresden Island Lock and Dam. This report attempts a more quantitative examination of the predicted changes specifically focused on spawning and adult habitat preferences of fish species of interest in the Dresden Island Dam tailwaters.

Concerns over the potential adverse effects of the proposed hydroelectric facilities are focused on the loss of habitat for key fluvial specialist and dependent fish species and mineral substrate (i.e., lithophilic) spawners (Table 1) that now inhabitat these areas and are thought to be dependent on the existing distribution of habitat features in the tailwater area. The installation of the proposed hydroelectric facility will change the distribution of flows in the tailwater areas of these dams (Kleinschmidt 2010) and our intent is to render an opinion about whether these changes will likely be detrimental, neutral, or beneficial to fluvial specialist and dependent fish species.

A particular concern that has been expressed about the installation of the predicted hydropower facilities at the Dresden Island Lock and Dam and the Brandon Road Lock and Dam is the potential loss of habitats for fluvial specialist and fluvial dependent species in the Lower Des Plaines/Upper Illinois River system. Several of these species were reduced in range and abundance from the Lower DesPlaines and Upper Illinois River system by historical wastewater and urban pollution from Chicago. As the pollutional impacts have been reduced by Clean Water Act (CWA) initiated remediation efforts over the past 30 years there has been a demonstrated and incremental recovery of these fluvial specialist and dependent fish species. Many of these species are equally sensitive to water quality and pollutional impacts in addition to flow and habitat alterations. Illinois DNR in a letter to the Federal Energy Regulatory Commission (Illinois DNR 2011) summarized their concern that the proposed hydroelectric facilities would reduce wetted habitat (i.e., riffles and runs) and the aeration provided in the tailraces of these facilities. Yoder and Rankin (2011) examined analyses about the fluvial geomorphology and changes that might occur after installation of the hydroelectric facilities and concluded that their operation would not have significant impacts on the fish assemblages. However, the analyses were not convincing enough to the Illinois agencies therefore we have undertaken additional and more detailed analyses to evaluate that original conclusion.

Methodology

Additional modeling runs of depth and current velocity distributions under critical flow conditions were conducted by Kleinschmidt. These were then used to assess the concerns of Illinois DNR in relation to loss of critical habitats related to the predicted operation of the hydropower facilities. Yoder and Rankin (2011) initially relied on two-dimensional modeling results (maps) of velocities, depths, and shear stress (Kleinschmidt 2011) to conclude that the operation of the proposed hydroelectric facilities would result in a distribution of flows that result in more consistently occurring high flow areas that are required by key fluvial fish species (e.g., redhorse) compared to existing conditions. Further, our broad experience with Midwestern rivers is that habitats with deep and fast flows (e.g., representing chutes, raceways, or deep runs) are critical habitats for the most intolerant of these species.

To build on the two-dimensional analyses we previously reported about predicted changes in water velocity and depth from the operation of the hydroelectric facilities we conducted additional quantitative analyses to directly calculate changes in the frequency of habitat types important to the selected species of concern. Our approach in this report is to compare the predicted changes in the distribution of flow, depth, and habitat features in the Dresden Island dam tailwater area under two critical flows (1395 cfs and at Q7,10 flows, 2100 cfs) when the tainter and head gates are bypassed (no spillage) and all flows are directed through the powerhouse and for the existing conditions at these same flows. The modeling results were provided by Kleinschmidt as a grid of flow and depth variables with data on flow (meters/sec), depth (meters) and calculated variables such as a Froude[1] number (Kleinschmidt 2011). The data presents information from approximately 4.5 m square grids generated using the CCHE2D model (Kleinschmidt 2011). Kleinschmidt also associated generalized substrate materials for each grid from a field survey (Jon Quebbeman, personal communication).

Table 1. Fish species of concern related to the installation of hydropower facilities at the Brandon Road and Dresden Island dams including coarse substrate spawning substrate preference and fluvial species characteristics.

Fish Species	Lithophil Spawner	Fluvial Character
Hornyhead Chub	X	FS
Central Stoneroller	X	FS
Striped Shiner	X	FS
Redfin Shiner	-	FS
Northern Hog Sucker,	X	FS
River Redhorse	X	FS
Shorthead Redhorse	X	FS
Black Redhorse	X	FS
Golden Redhorse	X	FD
Silver Redhorse	X	FD
Rock Bass	-	FD
Smallmouth Bass	-	FD
Sauger	-	FD
Blackside Darter	X	FD
Slenderhead Darter	X	FS
Logperch	X	FD

FS – Fluvial specialist; **FD** – Fluvial dependent

We used the depth and current definitions of aquatic habitat features as described by Aadland (1993) as slow riffles, fast riffles, raceways, medium pools and deep pools to illustrate important general "mesohabitat" features for aquatic life. We then compared changes in these ecologically-based mesohabitat types and compared the frequency of habitat types between existing conditions and post-

[1] A Froude number is used to determine the resistance of a partially submerged object moving through water, and permits the comparison of objects of different sizes.

powerhouse construction and operation at the same two critical flows (1396 cfs and 2100 cfs). Results are reported in tabular form as frequencies and percent of grids in preferred habitat types (depth, current, substrate, depth x current, and depth x current x substrate). Habitat types were then mapped based on current x depth co-occurrence frequencies to illustrate the location of habitat type changes (blue shaded columns on tables).

For a subset of key fluvial species that have been observed in the Dresden Island dam tailwater we obtained literature values of preferred spawning habitat characteristics for current velocities, spawning depths, and spawning substrates for each species (Table 2). We also obtained adult habitat preference for these species to illustrate differences between adult and spawning habitats (Table 3). We focused on spawning habitat characteristics because they tend be more narrow and limiting than preferences during most other life stages. Given variables of depth, velocity, and substrate, we calculated pre- and post-operational frequency distributions of the spawning habitat types individually (depth, velocity, and substrate material) and in combination (co-occurring depth and velocity ranges and co-occurring depth, velocity, and substrate ranges). Again, as with mesohabitat types, we illustrated the predicted shifts in

Table 2. Spawning habitat preferences in terms of current velocity (m/s), depth (m) and substrate from the literature or on aquatic fishery web sites.

Species	Spawning Habitat Preferences
River redhorse	Migrate to smaller streams, spawning at top and bottom ends of shallow riffles.[a] River redhorse spawn at water depths of 0.2 to 1.2 m at relatively swift surface water velocities (0.6 to 1.0 m/s);[c] cobble-gravel.
Golden redhorse	Shallow shoals 0.12-0.24 m; velocity 0.19-0.45 m/s, mostly fine gravel (sand-small cobble); shoals were adjacent to pools;[d] cobble-gravel.
Black redhorse	Riffles 0.12-0.37 m; velocities 0.17-1.29 m/s; small cobble (fine gravel to large cobble).[d]
Greater redhorse	Riffles, runs with depths 0.1-1.0m; velocity 0.038-1.169 m/s; gravel and cobble substrates.[e]
Shorthead redhorse	Spawning fish collected mid-channel at 1.5-2.5 m in depth at 0.5 -1.1 m/s (could include “staging” fish);[f] cobble-gravel; but Aadland et al. (1991) 0.45-1.25 m depth; velocity < 0.3.[c]
Smallmouth bass	Nest 0.55-0.85 m; < 0.04 m/s; gravel-cobble.[c,g]
Hornyhead chub	Nests 0.15-0.91 m[h]; 0.18-0.36 m/s (average; upper range)[I]; gravel.
Northern Hog Sucker	Depths: 0.3-1.6 m; Velocity 0.3-0.8 m/s; Gravel/cobble[j]
Sauger	Depths 0.60-5.5 m; Velocity 0.33-0.98 cm/s; Boulder-Sand[k]

[a] http://www.dnr.state.oh.us/Default.aspx?tabid=21974
[b] http://dnr.wi.gov/org/land/er/biodiversity/index.asp?mode=info&Grp=13&SpecCode=AFCJC10040
[c] Aadland et al. 1991
[d] Kwak and Skelly 1992
[e] Tomsic et al. 2007
[f] Hendry and Chang 2001
[g] Edwards et al. 1983
[h] Becker 1983
[I] Vives 1990
[J] http://mdc4.mdc.mo.gov/applications/mofwis/Mofwis_Detail.aspx?id=0100183
[K] Barton 2011

Table 3. Adult habitat preferences in terms of current velocity (m/s), depth (m) and substrate from the literature or on aquatic fishery web sites. Used either narrative descriptions of habitat preferences or where quantitative used the 25th and 75th percentiles of preference curves for current and depth and most frequently used substrates.

Species	Adult Habitat Preferences
Pallid shiner	Range: Depths 0.4-1.5: Current < 5 cm/s; Preferred: Depth 0.5-0.74; Current < 1 cm/s.[a]
Smallmouth bass	Preferred: Depths 0.5-1.8 m; 0.03-0.75 m/s; boulder-silt.[b]
Logperch	Preferred: Depths 0.1-1.3 m; 0.0-1.38 m/s; boulder-gravel.[b]
Shorthead redhorse	Preferred: Depths 0.55-1.3 m; 0.0-1.40 m/s; cobble-gravel.[b]
Northern hog sucker	Preferred: Depths 0.25-1.25 m; 0.15-1.24 m/s; cobble-gravel.[b]
Slenderhead darter	Preferred: Depths 0.05-1.25 m; 0.05-0.85 m/s; boulder-cobble.[b]

[a] Kwak 1991
[b] Aadland et al. 1991

the location of spawning habitat using the depth x current habitat categories. Substrates were generated from a substrate grid based on field observations under existing conditions (Kleinschmidt 2010). Because substrate distributions will likely change over time in response to current and depth we felt a focus on the predicted current x depth changes was the most appropriate combination under which to examine potential habitat shifts.

Background – Importance of Fluvial Habitat Features

General associations between the hydraulic features of rivers and their biological assemblages have been documented in a number of studies (e.g., Hynes 1970; Gorman and Karr 1981). The quantification of these hydraulic features have often been relatively simple (e.g., presence of deep runs or riffles, measures of current velocity and depth, etc.,) and have been associated with the presence and abundance of aquatic species. More detailed habitat suitability indices (HSI) have been developed for key aquatic species to understand the influence of flow reductions on the preferred habitat of these species (Milhous et al. 1989; Lamouroux and Jowett 2005). Many stream and river based multimetric indices (e.g., IBIs) have used numbers or populations of *fluvial dependent* or *fluvial specialist* species as key metrics or have sensitive or intolerant species list that are largely comprised of these species (e.g., Ohio EPA 1989; Smogor 2000). A *fluvial specialist* is almost always found only in free-flowing reaches of streams and rivers, or is described as requiring flowing water habitats throughout most stages of its life. *Fluvial dependent* species are found in a variety of habitats, but require flowing water at some point in their life history (e.g., spawning). *Macrohabitat generalists* are found in rivers, but they do not require flowing water habitats and can also be commonly found in lakes, ponds, and other lentic habitats. They frequently respond positively to modifications of riverine habitat and flows.

Quantification of Fluvial Features

As mentioned above, populations of fluvial fish species have been generally been associated with reach-level features such as riffles and runs, but the specific quantification of these habitat types or insights into the mechanism for biological associations with these habitat types is often lacking. Recently Lamouroux et al. (1999) related specific hydraulic metrics (e.g., Froude number) with traits and populations of fish assemblages across Europe and North America. Over the past decade more research has emerged in a discipline termed "ecohydrology" which is "the study of the functional interrelations between hydrology and biota at the catchment scale" (Zalewski 2000). Their argument for investigation in this area is that we do not yet understand well enough the relationships between the hydraulic features of rivers and streams and the biota that depend on these features for their various life stages. They suggest that more complex hydraulic variables, such as a Froude number, may provide better insights into these requirements for various aquatic species. The Froude number is a hydraulic variable that describes surface flow types (Kemp et al. 2000). It is calculated as:

$$Fr = v/\sqrt{g * D}$$

where v is water velocity (m/s), g is acceleration due to gravity (m/s^2), and D is hydraulic depth (m). It essentially characterizes the interaction between flow depth and velocity (Seip 2004) and is described as better reflecting hydraulic habitat features than measures of current or depth alone. Kern et al. (2000) suggest that the Froude number may be used as a tool for stream and river management and restoration. Here we conceptually link the Froude number to a broader scale habitat measure, the Hydro-QHEI (Rankin et al. 2011) that combines information on depth and current related habitat characteristics of rivers and streams. We have used it as another variable to compare the effects of the predicted DI hydroelectric project to existing conditions in the Dresden Island tailwater.

The Importance of Fast, Deep Habitat Types

The Qualitative Habitat Evaluation Index (QHEI; Ohio EPA 1989; Ohio EPA 2006) is used widely throughout the Midwest U.S. for the assessment of habitat quality and heterogeneity and it has been shown to be strongly correlated to fish assemblage condition as measured by the IBI and to key components of the fish assemblage (Rankin 1995). Rankin et al. (2011) used components of the QHEI that are directly reflective of depth and current as the "Hydro-QHEI" to estimate how changes to increasing (or decreasing) base flow affected fish assemblages in streams and rivers. Because the Hydro-QHEI is a compilation of the QHEI metrics that measure depth and current velocity we suggest it is a qualitative analog to the Froude number which captures the interactive importance of depth and current velocity.

Results

When we categorized habitat types (shallow riffle, fast riffle, raceway, etc.,) using the standardized depth and current velocity of ranges of Aadland et al (1991) we observed only slight changes in the frequency of these habitat types between existing conditions and predicted conditions under the two different low flow regimes (1396 cfs and 2100 cfs; Table 4-5). There were slight increases in the frequency of fast flow habitat types when river flow is passed through the powerhouse, showing that there is no significant loss of habitat features from installation of the predicted hydropower facility (Tables 4-5).

We also mapped the mesohabitats at the lowest flow (1396 cfs) which were overlain on an existing aerial photo of the Dresden Island tailwater to ascertain the location of predicted changes in the distribution of these habitats (Figure 1-3). As with the frequency of habitat there were only minor shifts in the distribution of key habitat types between the existing and predicted conditions, which resulted in the incremental addition of fast flow habitats (e.g., raceways, fast riffles) in the immediate vicinity of the powerhouse discharge (Figures 1 and 2). The U.S. Army Corps has filled the areas immediately below the dam with concrete to protect the integrity of the dam structured from scouring high flows (Kleinschmidt 2010). Riffle and raceway habitats are located at short distances downstream of the dam under both existing and predicted conditions.

Table 4. Changes in the distribution of biological habitat types as described by Aadland (1993) at a flow rate of 1396 cfs; all flows are through the powerhouse (no spillage). Shade column (depth x velocity) represents data depicted on maps.

		Velocities		**Depths**		**Depth x Vel.**		**Substrates**		**Depth x Velocity x Substrate**	
Species	**Condition**	Freq Cells	Pct	Freq Cells	Pct	Freq Cells	Pct	Freq Cells	Pct	Freq Cells	Pct
Slow Riffles (Z: 0.1-0.6 m; V: 0.3-0.59 m/s)	Existing	1789	9.76	2850	15.55	357	1.95	17383	94.86	357	1.95
	Predicted	1746	9.54	2867	15.67	402	2.2	17351	94.85	402	2.2
Fast Riffles (Z: 0.1-0.6 m; V: > 0.6 m/s)	Existing	700	3.82	2850	15.55	436	2.38	17383	94.86	436	2.38
	Predicted	804	4.4	2867	15.67	381	2.08	17351	94.85	381	2.08
Raceways (Z: 0.6-1.49 m; V: 0.3-2.0 m/s)	Existing	2502	13.65	6289	34.32	1526	8.33	18325	100	1526	8.33
	Predicted	2567	14.03	6268	34.26	1612	8.81	18293	100	1612	8.81
Med. Pools (Z: 0.6-1.49 m; V: M 0.3 m/s)	Existing	15824	86.35	6289	34.32	4764	26.00	17383	94.86	4716	25.74
	Predicted	15726	85.97	6268	34.26	4656	25.45	17351	94.85	4608	25.19
Deep Pools (Z: > 1.5 m; V: < 0.3 m/s)	Existing	15824	86.35	8731	47.65	8578	46.81	18325	100	8578	46.81
	Predicted	15726	85.97	8721	47.67	8587	46.94	18293	100	8587	46.94
Deep Pools, No Silt (Z: > 1.5 m; V: < 0.3 m/s)	Existing	15824	86.35	8731	47.65	8578	46.81	17383	94.86	7701	42.02
	Predicted	15726	85.97	8721	47.67	8587	46.94	17351	94.85	7710	42.15

Several researchers have examined combining fish species into habitat “guilds” based on shared preference for specific habitat types (Aadland 1993; Vadas and Orth 2000; Dilts et al. 2003) and have found that species with in common environmental traits generally use habitat types in a similar manner

Table 5. Changes in the distribution of biological habitat types as described by Aadland (1993) at a flow rate of 2100 cfs; all flows are through the powerhouse (no spillage). Shade column (depth x velocity) represents data depicted on maps.

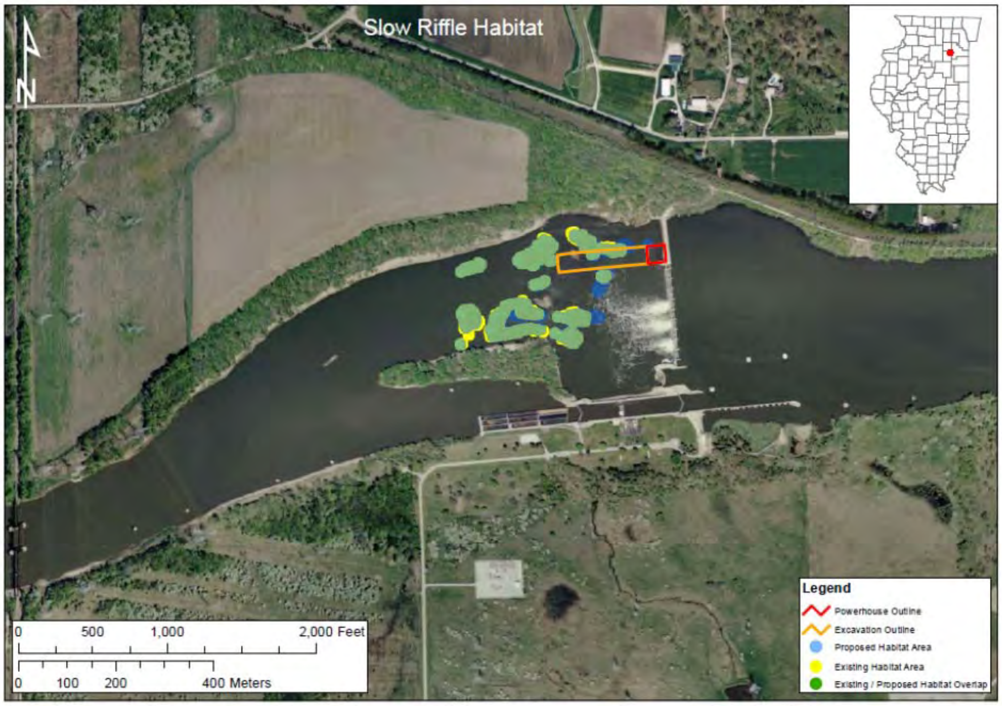
Species	Condition	Velocities		Depths		Depth x Vel.		Substrates		Depth x Velocity x Substrate	
		Freq Cells	Pct	Freq Cells	Pct	Freq Cells	Pct	Freq Cells	Pct	Freq Cells	Pct
Slow Riffles (Z: 0.1-0.6 m; V: 0.3-0.59 m/s)	Existing	3565	19.32	2640	14.31	441	2.39	17506	94.89	441	2.39
	Predicted	3468	18.77	2671	14.46	466	2.52	17530	94.9	466	2.52
Fast Riffles (Z: 0.1-0.6 m; V: > 0.6 m/s)	Existing	1159	6.28	2640	14.31	552	2.99	17506	94.89	552	2.99
	Predicted	1354	7.33	2671	14.46	575	3.11	17530	94.9	575	3.11
Raceways (Z: 0.6-1.49 m; V: 0.3-2.0 m/s)	Existing	4760	25.8	6552	35.52	3002	16.27	18448	100	3002	16.27
	Predicted	4859	26.3	6553	35.48	3142	17.01	18472	100	3142	17.01
Med. Pools (Z: 0.6-1.49 m; V: M 0.3 m/s)	Existing	13688	74.2	6552	35.52	3550	19.24	17506	94.89	3502	18.98
	Predicted	13610	73.68	6553	35.48	3411	18.47	17530	94.9	3363	18.21
Deep Pools (Z: > 1.5 m; V: < 0.3 m/s)	Existing	13688	74.2	8837	47.9	8110	43.96	18448	100	8110	43.96
	Predicted	13610	73.68	8806	47.67	8185	44.31	18472	100	8185	44.31
Deep Pools, No Silt (Z: > 1.5 m; V: < 0.3 m/s)	Existing	13688	74.2	8837	47.9	8110	43.96	17506	94.89	7233	39.21
	Predicted	13610	73.68	8806	47.67	8185	44.31	17530	94.9	7308	39.56

(e.g., fluvial species all use fast, deep riffles and raceways). Given that deep-slow habitats (pools) and shallow habitats (littoral areas) are ubiquitous in the upper Illinois and Lower DesPlaines Rivers, habitats of primary importance are the habitat types previously defined as slow riffles, fast riffles, and raceways. Based on these analyses, so long as substrate conditions match the expected substrate types for the interaction of depths and velocity (e.g., Froude number), concentrating flows through the powerhouse should not detrimentally affect the net quantity of these habitats and, at the upper end of velocity distributions, could even enhance these habitats and make them more available during the lowest flow periods when they can be the most limited.

Predicted Changes in Flow and Depth Distributions

If we compare the change in the overall frequency distributions of depths and current velocities on the frequency plots (Figure 4), independent of species habitat preferences, a slight increase in highest current velocities is predicted at both 1396 cfs (top) and 2100 cfs (bottom). A focus on the deepest (>2 m) and fastest (>0.5 cm/sec) habitat at these flows in Figure 5 illustrates a slight increase in these flows under the passage of flow through the powerhouse with no spillage over the tainter or head gates compared to existing conditions.

Figure 6 (top) illustrates the difference in the frequency of grids by Froude number between existing and predicted conditions in the Dresden Island dam tailwater and demonstrates a slight increase in the highest Froude numbers. A column plot (Figure 6, bottom) of the Froude number by substrate type in the Dresden Island dam tailwater under existing critical low flow conditions (2100 cfs) illustrates that it is generally associated with larger substrate materials (e.g., cobble and boulder). Others have also found that the Froude number can be associated with other important habitat biotypes (Kern et al.



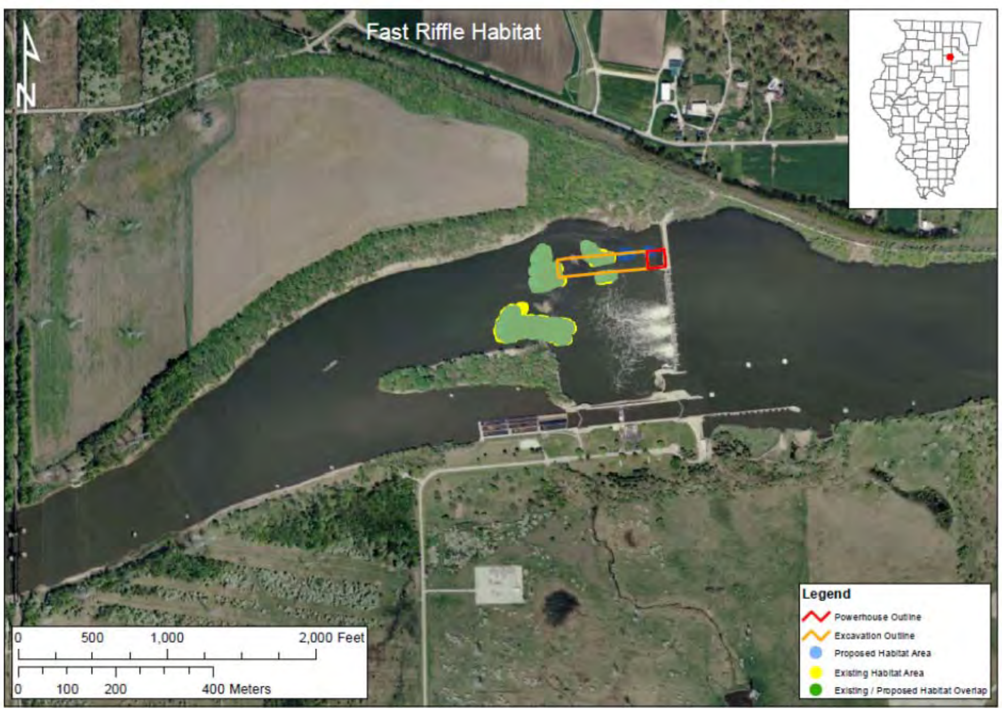


Figure 1. Maps illustrating aquatic mesohabitats (slow riffle, top; fast riffle, bottom) in the Dresden Island tailwater at a flow of 1396 cfs. Blue dots represent predicted areas of new habitat, yellow dots existing areas of habitat, and green dots areas of overlap between existing and predicted conditions. The location of the proposed powerhouse and discharge are also shown.

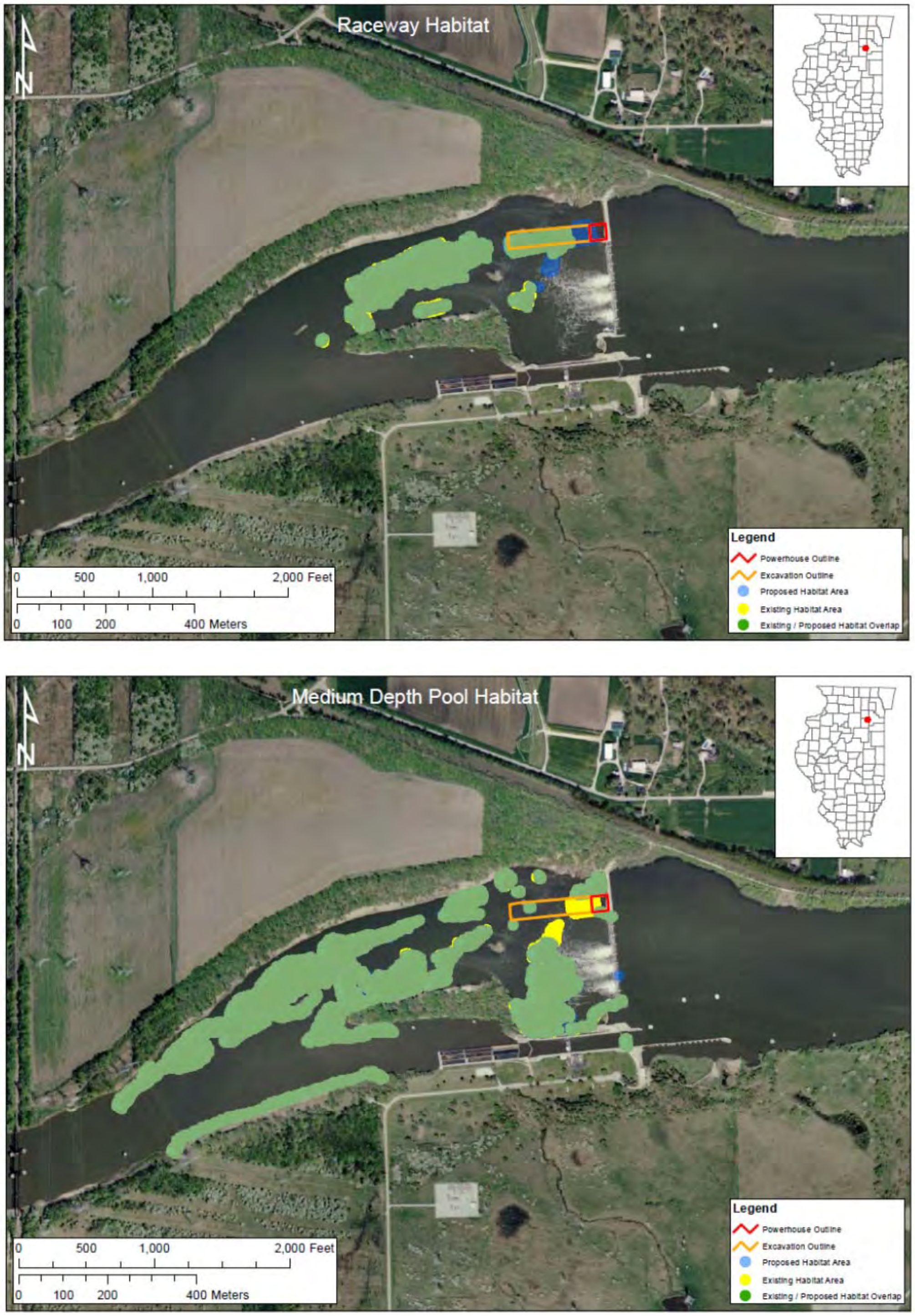


Figure 2. Maps illustrating aquatic mesohabitats (raceway, top; medium pool, bottom) in the Dresden Island tailwater at a flow of 1396 cfs. Blue dots represent predicted areas of new habitat, yellow dots existing areas of habitat, and green dots areas of overlap between existing and predicted conditions. The location of the proposed powerhouse and discharge are also shown.

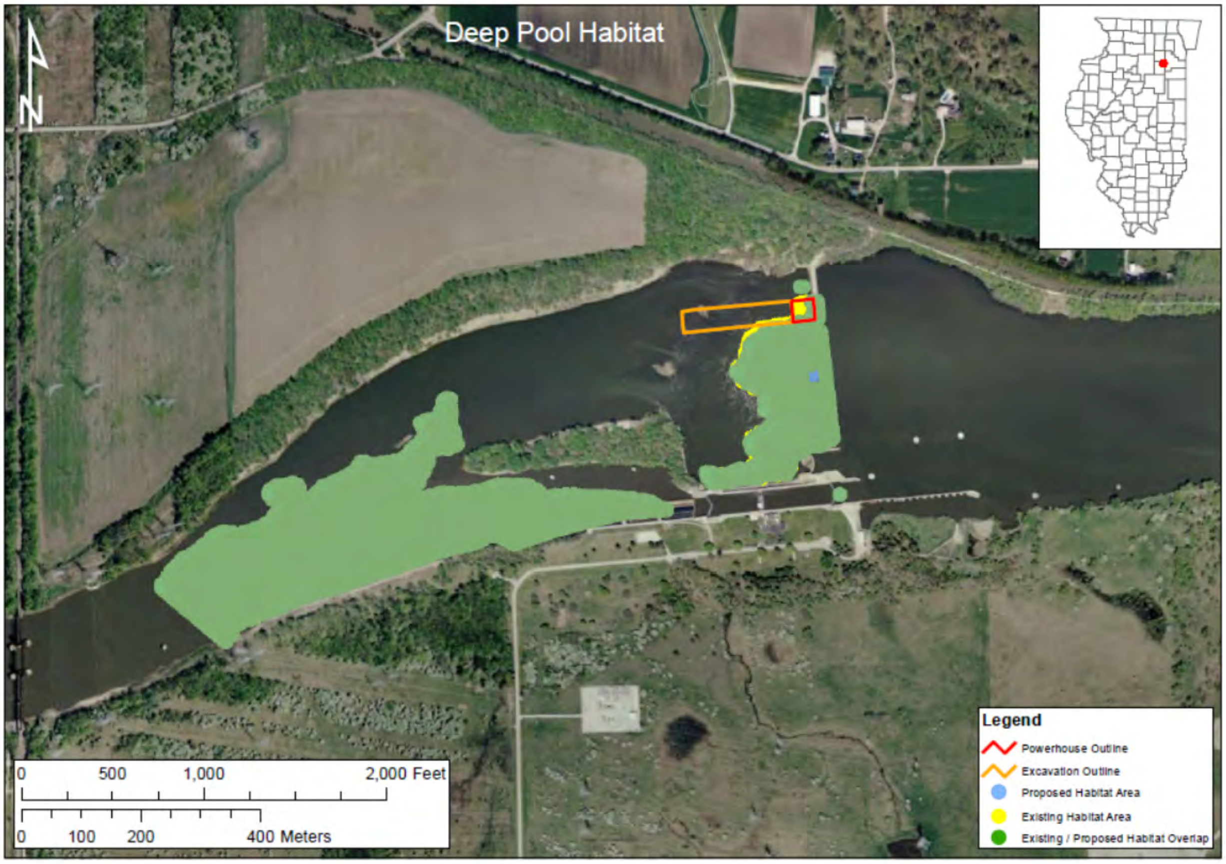
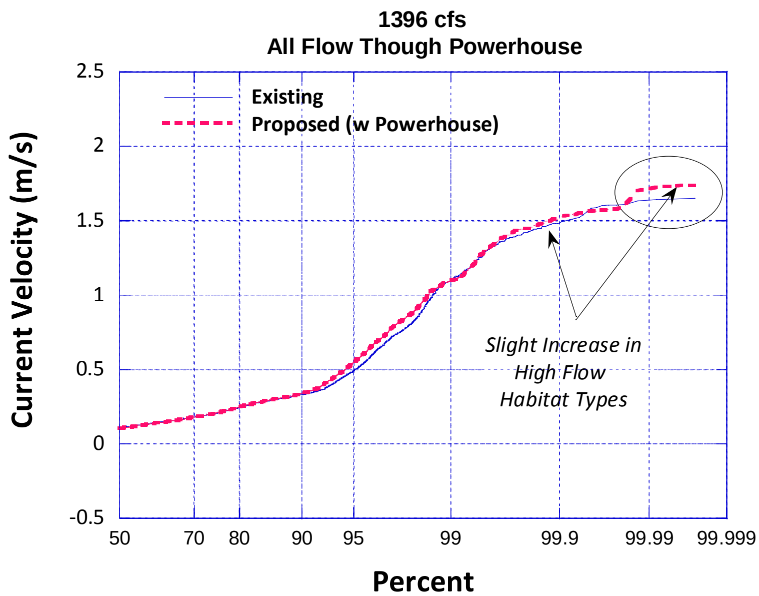


Figure 3. Map illustrating aquatic mesohabitats (deep pools) in the Dresden Island tailwater at a flow of 1396 cfs. Blue dots represent predicted areas of new habitat, yellow dots existing areas of habitat, and green dots areas of overlap between existing and predicted conditions. The location of the proposed powerhouse and discharge are also shown.

2000; Lamouroux and Jowett 2005; Persinger et al. 2010). Although the increase in the Froude number is relatively slight, it suggests that the concentration of flows through the powerhouse could create small pockets of a habitat type that is presently very limited in the upper Illinois and lower DesPlaines River system under the prevailing impounded conditions.

Predicted Effects on Spawning Habitat

The frequency of specific spawning habitat attributes (current velocity, depth) for nine fish species were examined in the Dresden Island dam tailwater under existing conditions and predicted conditions (where most of the flow moves through powerhouse and no spillage occurs) and are presented in Tables 6 (1396 cfs) and 7 (2100 cfs). At these two critical river flows the preferred habitats of more species either increased or did not change under the predicted operational scenarios compared to those that decreased (yellow shaded cells; Tables 6 and 7), although the predicted changes in either direction were typically very small. The light blue shaded columns represent habitat frequencies and percentages of habitats where preferred current and velocity conditions co-occur; this is represents the same data used in the map depicted changes in distribution of preferred spawning areas. The “optimum” spawning



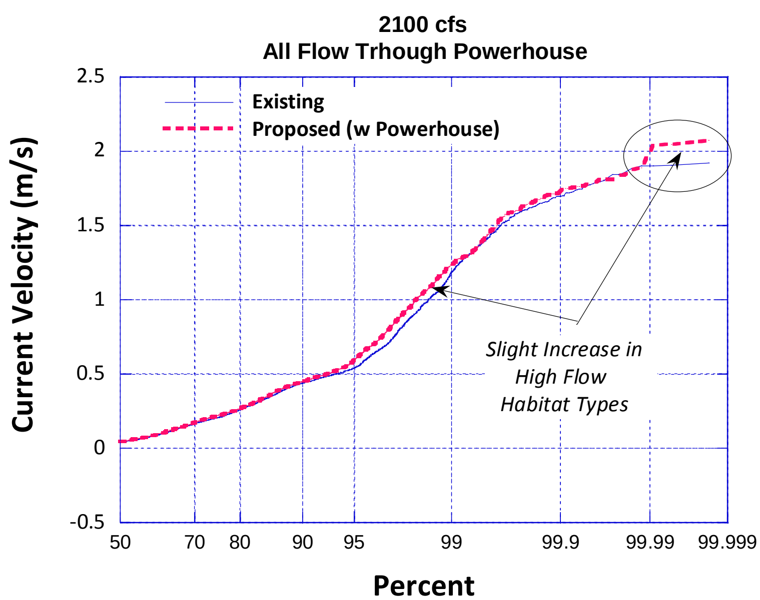


Figure 4. Frequency plots of current velocity habitats for the Dresden Island dam tailwater area under existing conditions (solid blue line) and predicted conditions with all flow through the powerhouse at river flows of 1396 cfs (top) and 2100 cfs (bottom).

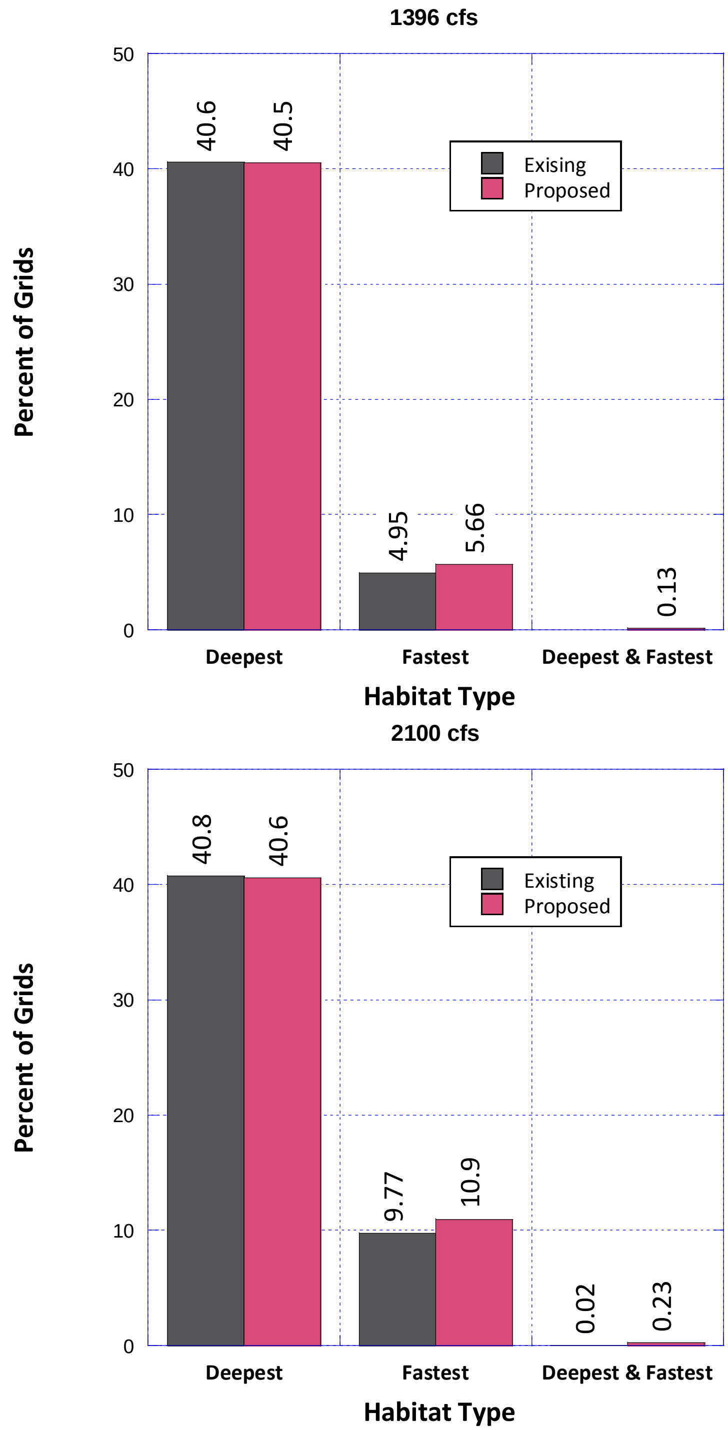
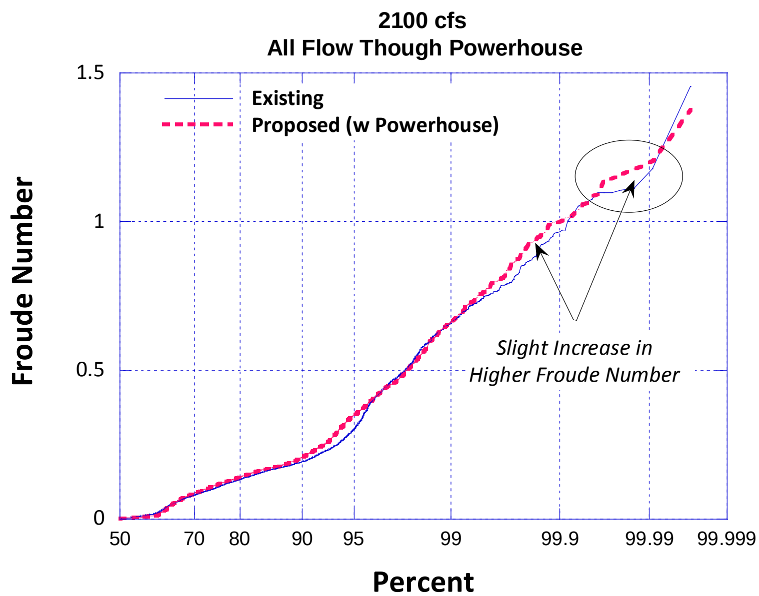


Figure 5. Column plots of deepest (>2 m), fastest (>0.5 m/sec) and the co-occurrence of deepest and fastest (>2 m and > 0.5 m/sec) habitats for the Dresden Island dam tailwater area under existing conditions (gray bar) and predicted conditions (red bars) with all flow through the powerhouse at river flows of 1396 cfs (top) and 2100 cfs (bottom).



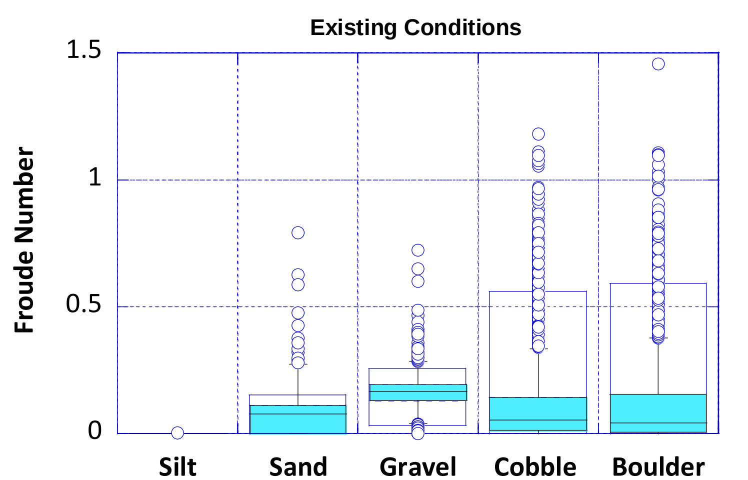


Figure 6. Frequency plot of habitat grids by Froude number for the Dresden Island dam tailwater area under existing conditions (solid blue line) and predicted conditions (red dashed line) at 2100 cfs (top) and a column plot (bottom) illustrating the association between Froude number and substrate type under existing conditions (2100 cfs).

Table 6. Changes in the distribution of species-specific preferred habitat areas at a flow rate of 1396 cfs; all flows are through the powerhouse (no spillage). Shade column (depth x velocity) represents data depicted on maps.

Species	Condition	**Preferred Spawning Velocities**		**Preferred Spawning Depths**		**Preferred Spawning Depth x Vel.**		**Preferred Spawning Substrates**		**Optimum Spawning Habitat**	
		Freq Cells	Pct	Freq Cells	Pct	Freq Cells	Pct	Freq Cells	Pct	Freq Cells	Pct
Shorthead Redhorse	Existing	2321	12.67	6780	37.00	1725	9.41	4886	26.66	1400	7.64
	Predicted	2390	13.07	6758	36.94	1791	9.79	4881	26.68	1454	7.95
River Redhorse	Existing	444	2.42	7892	43.07	404	2.2	4886	26.66	235	1.28
	Predicted	529	2.89	7889	43.13	469	2.56	4881	26.68	294	1.61
Golden Redhorse	Existing	4140	22.59	502	2.74	52	0.28	2267	12.37	2	0.01
	Predicted	3924	21.45	518	2.83	57	0.31	2267	12.39	2	0.01
Black Redhorse	Existing	5901	32.2	1131	6.17	395	2.16	4886	26.66	267	1.46
	Predicted	5795	31.68	1141	6.24	397	2.17	4881	26.68	277	1.51
Greater Redhorse	Existing	13045	71.19	7296	39.81	5748	31.37	4886	26.66	3147	17.17
	Predicted	12840	70.19	7305	39.93	5797	31.69	4881	26.68	3202	17.5
Smallmouth Bass	Existing	8726	47.62	5753	31.39	422	2.3	4886	26.66	658	3.59
	Predicted	8915	48.73	5754	31.45	446	2.44	4881	26.68	621	3.39
Hornyhead Chub	Existing	4130	22.54	6503	35.49	1745	9.52	2267	12.37	951	5.19
	Predicted	3888	21.25	6506	35.57	1707	9.33	2267	12.39	946	5.17
Northern Hog Sucker	Existing	2117	11.55	8545	46.63	1802	9.83	4886	26.66	1528	8.34
	Predicted	2085	11.4	8543	46.7	1794	9.81	4881	26.68	1535	8.39
Sauger	Existing	1580	8.62	14957	81.62	1016	5.54	17383	94.86	1016	5.54
	Predicted	1668	9.12	14928	81.6	1086	5.94	17351	94.85	1086	5.94

habitat column reflects when all three preferences (current, depth, and substrate) co-occur. Recall that the substrate data is a generalized coverage under existing conditions and we simply assumed for the purposes of this analysis that it would be the same under predicted conditions. Under actual conditions substrates are likely to shift in response to any changes in hydraulic conditions. At both these river flows (1396 and 2100 cfs) under both the existing and predicted scenarios the Dresden Island tailwater areas will provide important spawning habitat for the fluvial fish species that have recently increased in abundance with the lessening of pollution effects from upriver sources.

The following figure (Figures 7-10) illustrate locations of preferred spawning habitats of eight key fluvial fish species in the Dresden Island dam tailwaters comparing existing to predicted conditions at 1396 cfs

Table 7. Changes in the distribution of species-specific preferred habitat areas at a flow rate of 2100 cfs; all flows are through the powerhouse (no spillage). Shade column (depth x velocity) represents data depicted on maps.

Species	Condition	Preferred Spawning Velocities		Preferred Spawning Depths		Preferred Spawning Depth x Vel.		Preferred Spawning Substrates		Optimum Spawning Habitat	
		Freq Cells	Pct	Freq Cells	Pct	Freq Cells	Pct	Freq Cells	Pct	Freq Cells	Pct
Shorthead Redhorse	Existing	4440	24.07	6932	37.58	3073	16.66	4925	26.70	227 8	12.35
	Predicted	4466	24.18	6925	37.49	3129	16.94	4937	26.73	233 1	12.62
River Redhorse	Existing	737	4.00	7952	43.10	685	3.71	4925	26.70	525	2.85
	Predicted	837	4.53	7959	43.09	737	3.99	4937	26.73	591	3.20
Golden Redhorse	Existing	4884	26.47	445	2.41	53	0.29	2275	12.33	9	0.05
	Predicted	5067	27.43	459	2.48	58	0.31	2278	12.33	8	0.04
Black Redhorse	Existing	7935	43.01	1031	5.59	406	2.20	4925	26.70	252	1.37
	Predicted	8154	44.14	1082	5.86	447	2.42	4937	26.73	278	1.50
Greater Redhorse	Existing	13572	73.57	7165	38.84	5836	31.63	4925	26.70	320 0	17.35
	Predicted	13817	74.80	7334	39.70	6064	32.83	4937	26.73	330 0	17.86
Smallmouth Bass	Existing	4595	24.91	3404	18.45	328	1.78	4925	26.70	137	0.74
	Predicted	4321	23.39	3420	18.51	267	1.45	4937	26.73	124	0.67
Hornyhead Chub	Existing	3907	21.18	6126	33.21	1516	8.22	2275	12.33	208	1.13
	Predicted	4074	22.06	6202	33.58	1515	8.20	2278	12.33	208	1.13
Northern Hog Sucker	Existing	4069	22.06	8665	46.97	3263	17.69	4925	26.70	233 7	12.67
	Predicted	4047	21.91	8694	47.07	3339	18.08	4937	26.73	240 4	13.01
Sauger	Existing	3853	20.89	15309	82.98	3136	17.00	17506	94.89	313 6	17.00
	Predicted	3884	21.03	15285	82.75	3057	16.55	17530	94.90	305 7	16.55

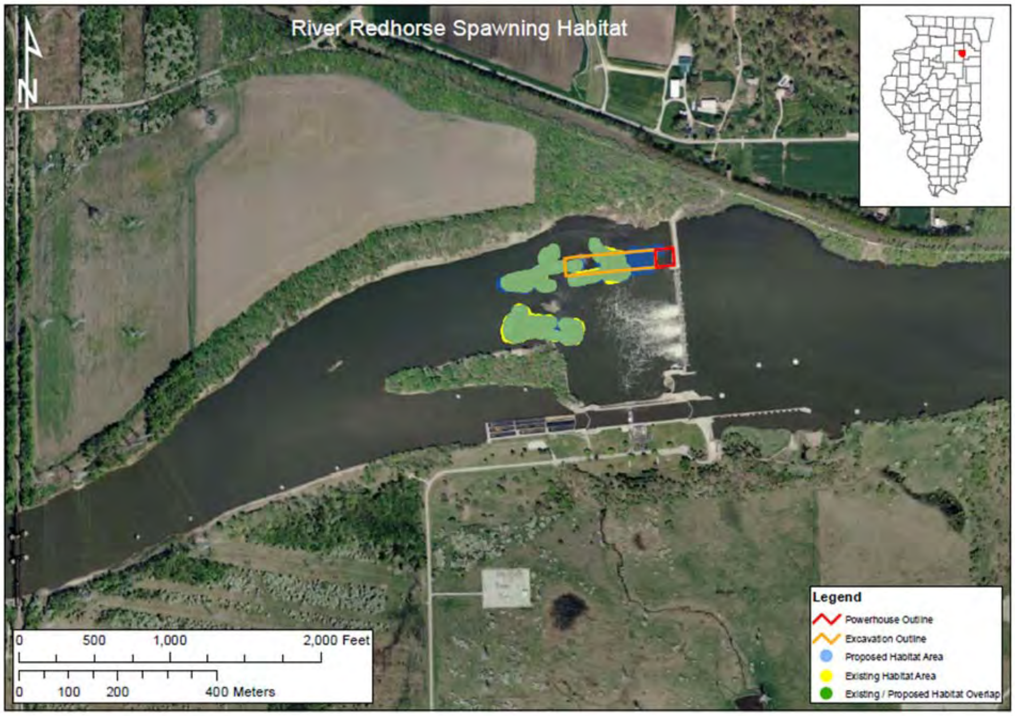
which was considered to be limiting in terms of the effect on the flow habitat types in the tailwaters. An important conclusion on the basis of these comparisons is the rather slight differences in the distribution of habitats as well as their frequencies (Tables 6 and 7) between the existing and predicted conditions for all of these species. The relative size of the acceptable spawning habitat areas for each species is related to the restricted nature of their spawning preferences. River redhorse (Figure 7, top) has a narrow range of acceptable habitat areas in the Dresden Island tailwater because of their narrow range of depth preferences for spawning compared to shorthead redhorse (Figure 7, bottom). A similar pattern exists when comparing greater redhorse (Figure 8, top) to sauger (Figure 8, bottom). Smallmouth bass (a macrohabitat generalist) can use areas of slower relative velocity for spawning and a wide range of depths (Figure 9, top), whereas golden redhorse prefer shallow flowing areas (Figure 9, bottom). Northern hog sucker has a relatively wide range of spawning habitat types as do hornyhead chub, however both of these species can also spawn in smaller streams and rivers. In addition, substrate conditions are critical to the choice of spawning areas. Hornyhead chub, for example, build long nests of small pebbles which may be limiting in the preferred areas of the tailwater, especially close to the dam where the artificial armoring of the substrates makes such spawning areas limited for one or more of these species. These conditions would be limiting under both existing and predicted conditions (see concerns with substrate conditions discussed later).

Predicted Effects on Adult Habitat

Although we focused on spawning habitat preference because such preferences are narrower and thus potentially more limiting, we also examined adult habitat preferences of six fish species. Tables 8 and 9 provide a frequency analysis of the areas below the Dresden Island dam that provide suitable adult habitat for these species at flows of 1396 cfs and 2100 cfs, respectively. We mapped the spatial distribution of these habitats using the depth x current velocity co-occurrences for several of these species (Figures 11-13). One species of particular interest is the pallid shiner *(Hybopsis amnis)* that has been identified throughout its range as a declining species (Smith 1979, Clemmer et al. 1980) and is listed as endangered in Illinois. Kwak 1991 developed habitat suitability curves for adults and juveniles based on data collected from the Kankakee River. In general they have been described as inhabiting the quiet to sluggish flows of large lowland rivers and adjacent sloughs. Kwak (1991) found that adult and juvenile habitat preferences were similar with velocities less than about 5 cm/sec and depths between 0.5-1.0 m.

There was little difference in preferred habitats between existing and predicted conditions for the pallid shiner (Table 8-9) at either flow (1396 or 2100 cfs). Tailwater areas are not the preferred habitat of this species. The map of the distribution of preferred habitat reveals only a few scattered suitable areas near the shoreline (Figure 11, top). Thus, pallid shiner would not be limited by any changes in habitat below under existing or predicted conditions. Their low abundance in the Illinois River system may be more related to the loss of adjacent sloughs and backwaters resulting from historical alterations (Kwak 1991). The one location where MBI collected this species in 2006 was at a site with the appropriate habitat (Moose Island Slough).

The optimal spawning habitat percentages as measured by current depth x depth co-occurrences were mostly in the single digits as percent of the available tailwater wetted habitats below the Dresden Island dam (see Table 6 and 7). With the exception of the pallid shiner, the percent of available adult habitat for the species we examined were all greater than 20% of the tailwater area. For example, spawning habitat for northern hog sucker, smallmouth bass, and shorthead redhorse were less common than adult habitat in the tailwater areas (compare Figures 7, 9, and 10 to Figure 11-13). Thus, the spawning habitat areas are more limiting than the adult habitat areas for the fluvial fish species that we examined. The predicted operation of the Dresden Island hydropower facility does not appear likely to have a significant adverse impact on the availability of either spawning or adult habitats based on the modeling



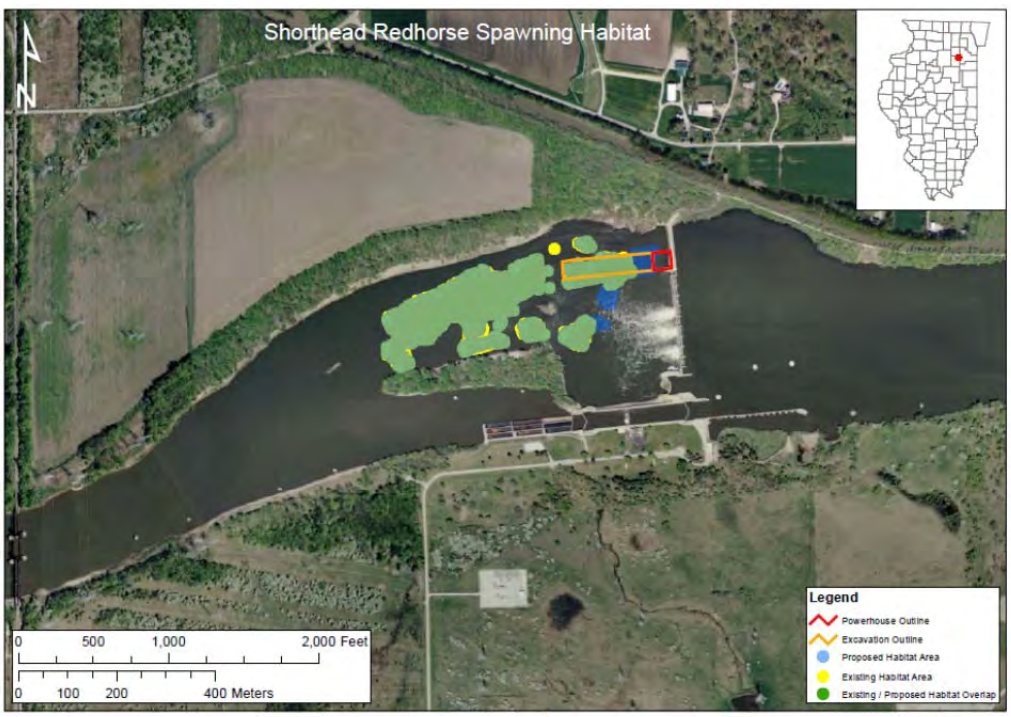


Figure 7. Maps illustrating preferred spawning habitat based on the co-occurrence of depth and velocity preferences of river redhorse (top) and shorthead redhorse (bottom) in the Dresden Island dam tailwater at a flow of 1396 cfs. Blue dots represent predicted areas of new habitat, yellow dots existing areas of habitat, and green dots areas of overlap between existing and predicted conditions. The location of the proposed powerhouse and discharge are also shown.

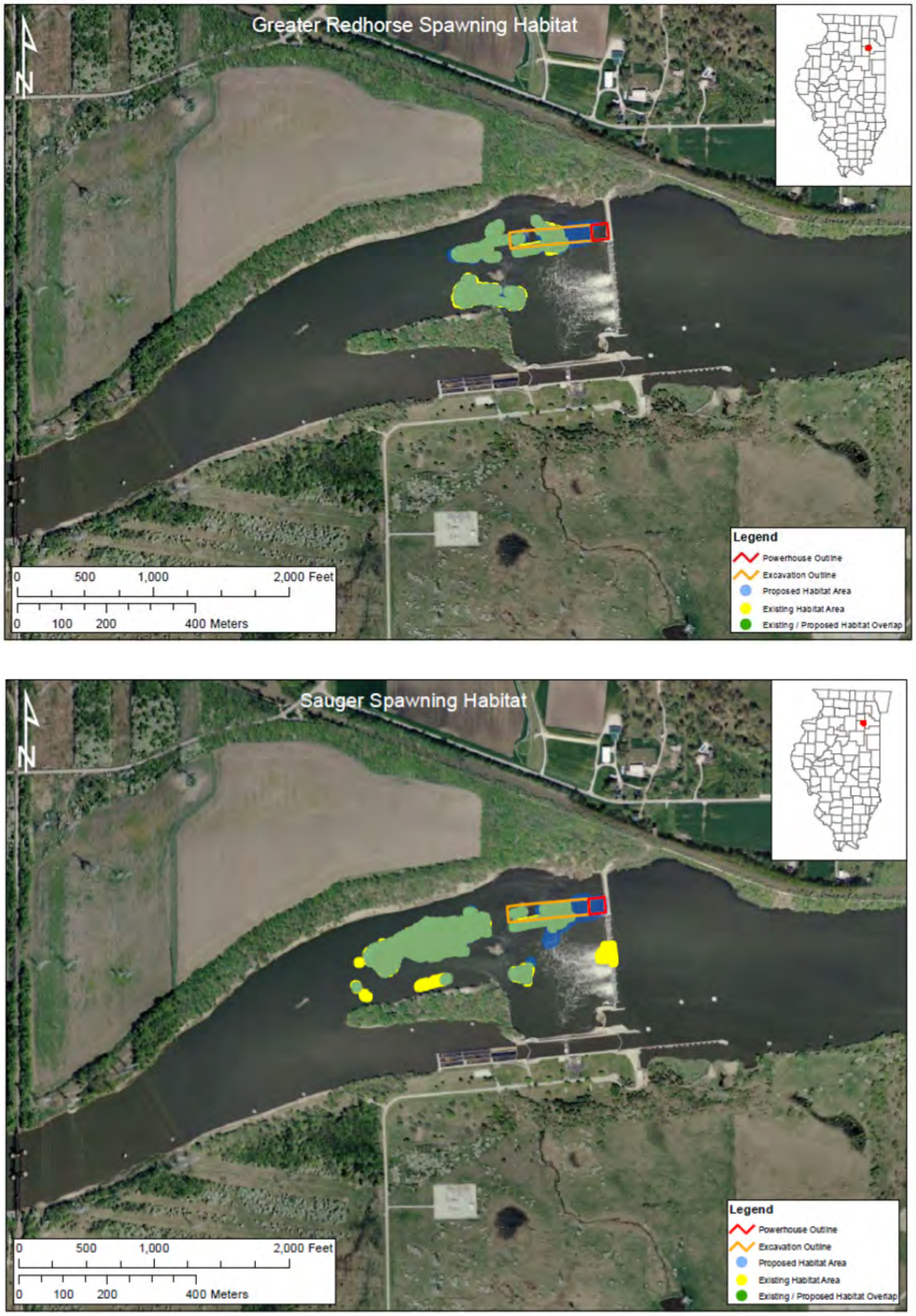


Figure 8. Maps illustrating preferred spawning habitat based on the co-occurrence of depth and velocity preferences of greater redhorse (top) and sauger (bottom) in the Dresden Island dam tailwater at a flow of 1396 cfs. Blue dots represent predicted areas of new habitat, yellow dots existing areas of habitat, and green dots areas of overlap between existing and predicted conditions. The location of the proposed powerhouse and discharge are also shown.

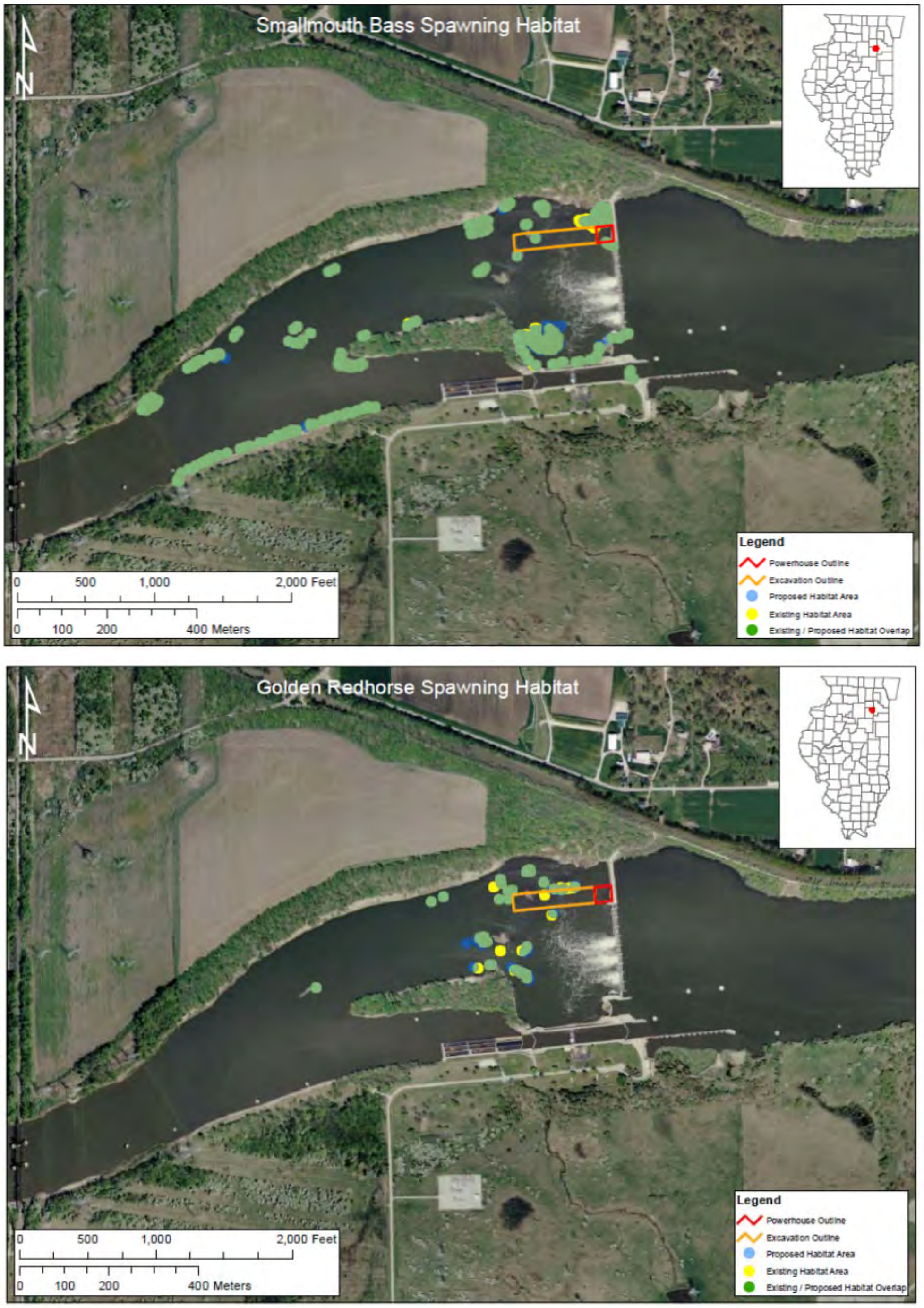
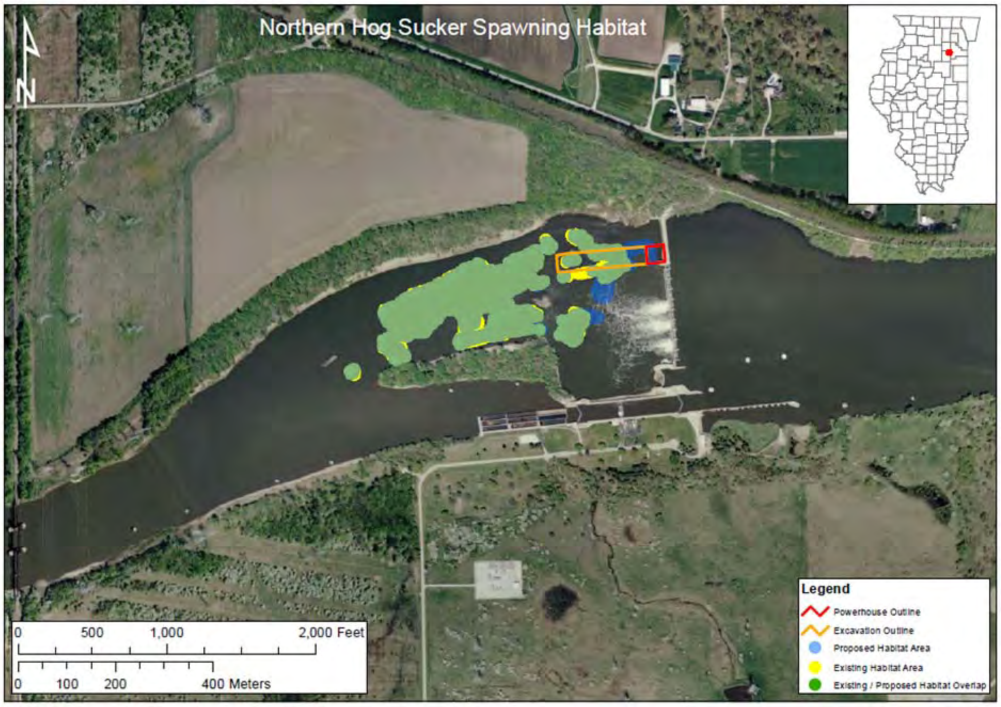


Figure 9. Maps illustrating preferred spawning habitat based on the co-occurrence of depth and velocity preferences of smallmouth bass (top) and golden redhorse (bottom) in the Dresden Island dam tailwater at a flow of 1396 cfs. Blue dots represent predicted areas of new habitat, yellow dots existing areas of habitat, and green dots areas of overlap between existing and predicted conditions. The location of the proposed powerhouse and discharge are also shown.



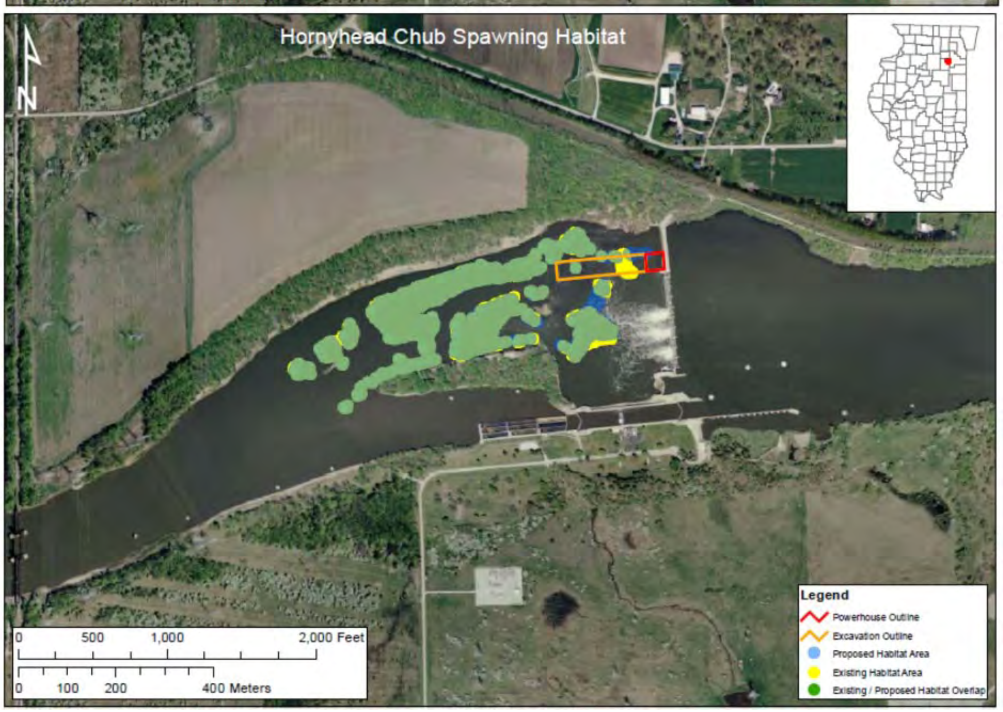


Figure 10. Maps illustrating preferred spawning habitat based on the co-occurrence of depth and velocity preferences of northern hog sucker (top) and hornyhead chub (bottom) in the Dresden Island dam tailwater at a flow of 1396 cfs. Blue dots represent predicted areas of new habitat, yellow dots existing areas of habitat, and green dots areas of overlap between existing and predicted conditions. The location of the proposed powerhouse and discharge are also shown.

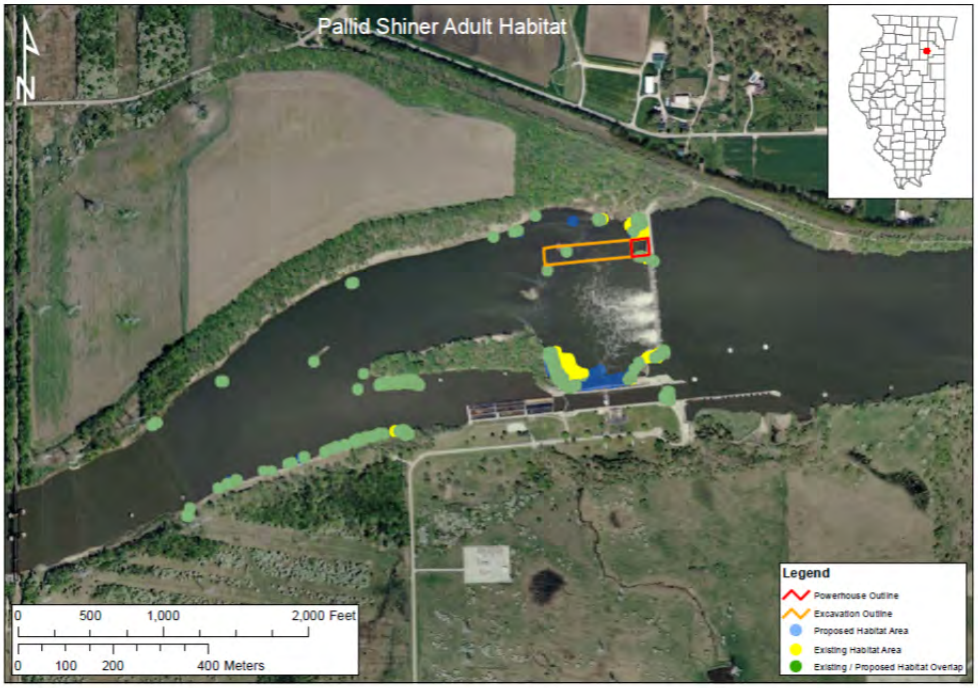
Table 8. Changes in the distribution of species-specific adult preferred habitat areas at a flow rate of 1396 cfs; all flows are through the powerhouse (no spillage). Shade column (depth x velocity) represents data depicted on maps.

Species	Condition	Preferred Adult Velocities		Preferred Adult Depths		Preferred Adult Depth x Vel.		Preferred Adult Substrates		Optimum Adult Habitat	
		Freq Cells	Pct	Freq Cells	Pct	Freq Cells	Pct	Freq Cells	Pct	Freq Cells	Pct
Pallid Shiner	Existing	1762	9.62	7753	42.31	306	1.67	18325	100	306	1.67
	Predicted	1713	9.36	7730	42.26	240	1.31	18293	100	240	1.31
Smallmouth Bass	Existing	13339	72.79	7885	43.03	6465	35.28	18325	100	6465	35.28
	Predicted	13101	71.62	7866	43.00	6295	34.41	18293	100	6295	34.41
Logperch	Existing	18267	99.68	8630	47.09	8572	46.78	6916	37.74	4925	26.88
	Predicted	18225	99.63	8627	47.16	8559	46.79	6884	37.63	4912	26.85
Northern Hog Sucker	Existing	6855	37.41	7854	42.86	4317	23.56	4886	26.66	2811	15.34
	Predicted	6686	36.55	7836	42.84	4359	23.83	4881	26.68	2871	15.69
Slenderhead Darter	Existing	12296	67.1	8702	47.49	6361	34.71	4649	25.37	1670	9.11
	Predicted	11953	65.34	8700	47.56	6343	34.67	4617	25.24	1657	9.06
Shorthead Redhorse	Existing	18277	99.74	6155	33.59	6155	33.59	4886	26.66	3076	16.79
	Predicted	18233	99.67	6115	33.43	6104	33.37	4881	26.68	3038	16.61

Table 9. Changes in the distribution of species-specific adult preferred habitat areas at a flow rate of 2100 cfs; all flows are through the powerhouse (no spillage). Shade column (depth x velocity) represents data depicted on maps.

Species	Condition	Preferred Adult Velocities		Preferred Adult Depths		Preferred Adult Depth x Vel.		Preferred Adult Substrates		Optimum Adult Habitat	
		Freq Cells	Pct	Freq Cells	Pct	Freq Cells	Pct	Freq Cells	Pct	Freq Cells	Pct
Pallid Shiner	Existing	1523	8.26	7883	42.73	223	1.21	18448	100	223	1.21
	Predicted	1412	7.64	7893	42.73	200	1.08	18472	100	200	1.08
Smallmouth Bass	Existing	13339	72.79	7885	43.03	6465	35.28	18325	100	6465	35.28
	Predicted	13101	71.62	7866	43.00	6295	34.41	18293	100	6295	34.41
Logperch	Existing	18267	99.68	8630	47.09	8572	46.78	6916	37.74	4925	26.88
	Predicted	18225	99.63	8627	47.16	8559	46.79	6884	37.63	4912	26.85
Northern Hog Sucker	Existing	6855	37.41	7854	42.86	4317	23.56	4886	26.66	2811	15.34
	Predicted	6686	36.55	7836	42.84	4359	23.83	4881	26.68	2871	15.69
Slenderhead Darter	Existing	12296	67.1	8702	47.49	6361	34.71	4649	25.37	1670	9.11
	Predicted	11953	65.34	8700	47.56	6343	34.67	4617	25.24	1657	9.06
Shorthead Redhorse	Existing	18277	99.74	6155	33.59	6155	33.59	4886	26.66	3076	16.79
	Predicted	18233	99.67	6115	33.43	6104	33.37	4881	26.68	3038	16.61

data we utilized. For other species of concern such as pallid shiner, other habitat types appear to be limiting.



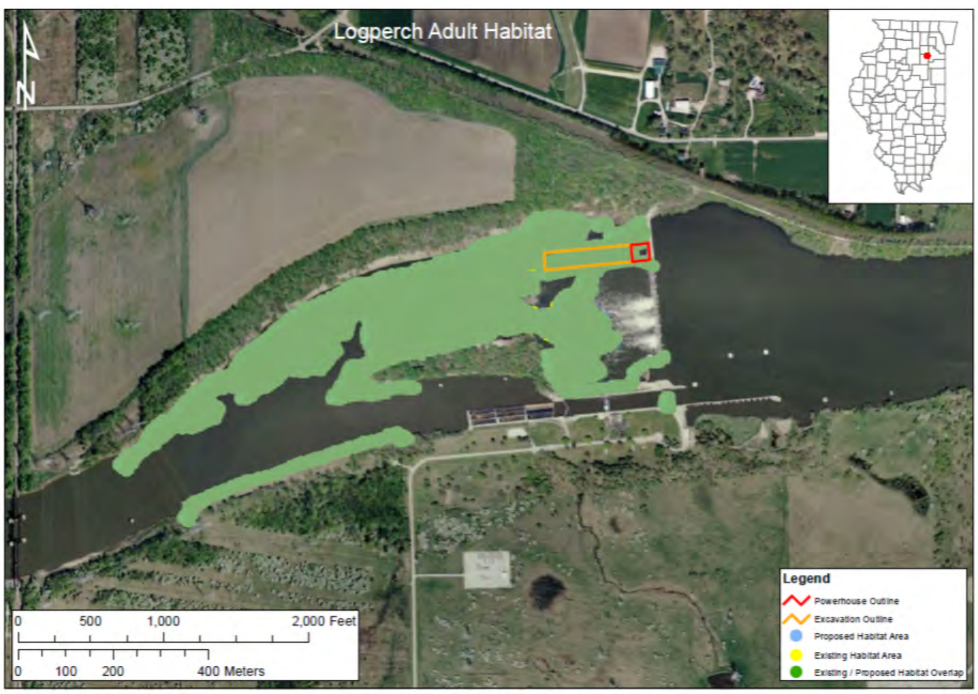


Figure 11. Maps illustrating preferred adult habitat based on the co-occurrence of depth and velocity preferences of pallid shiner (top) and logperch darter (bottom) in the Dresden Island dam tailwater at a flow of 1396 cfs. Blue dots represent predicted areas of new habitat, yellow dots existing areas of habitat, and green dots areas of overlap between existing and predicted conditions. The location of the proposed powerhouse and discharge are also shown.

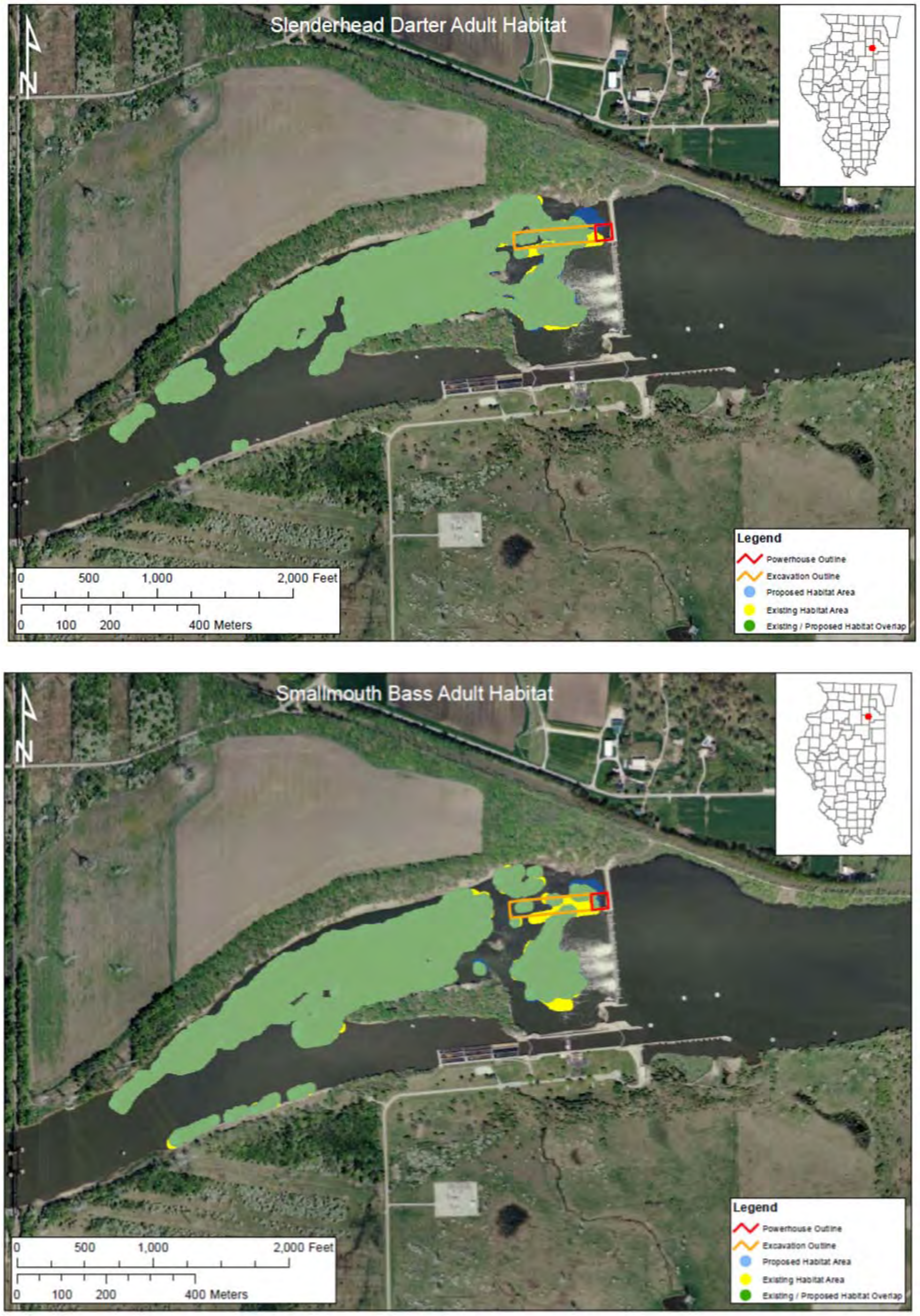


Figure 12. Map illustrating preferred adult habitat based on the co-occurrence of depth and velocity preferences of smallmouth bass (top) and slenderhead darter (bottom) in the Dresden Island dam tailwater at a flow of 1396 cfs. Blue dots represent predicted areas of new habitat, yellow dots existing areas of habitat, and green dots areas of overlap between existing and predicted conditions. The location of the proposed powerhouse and discharge are also shown.

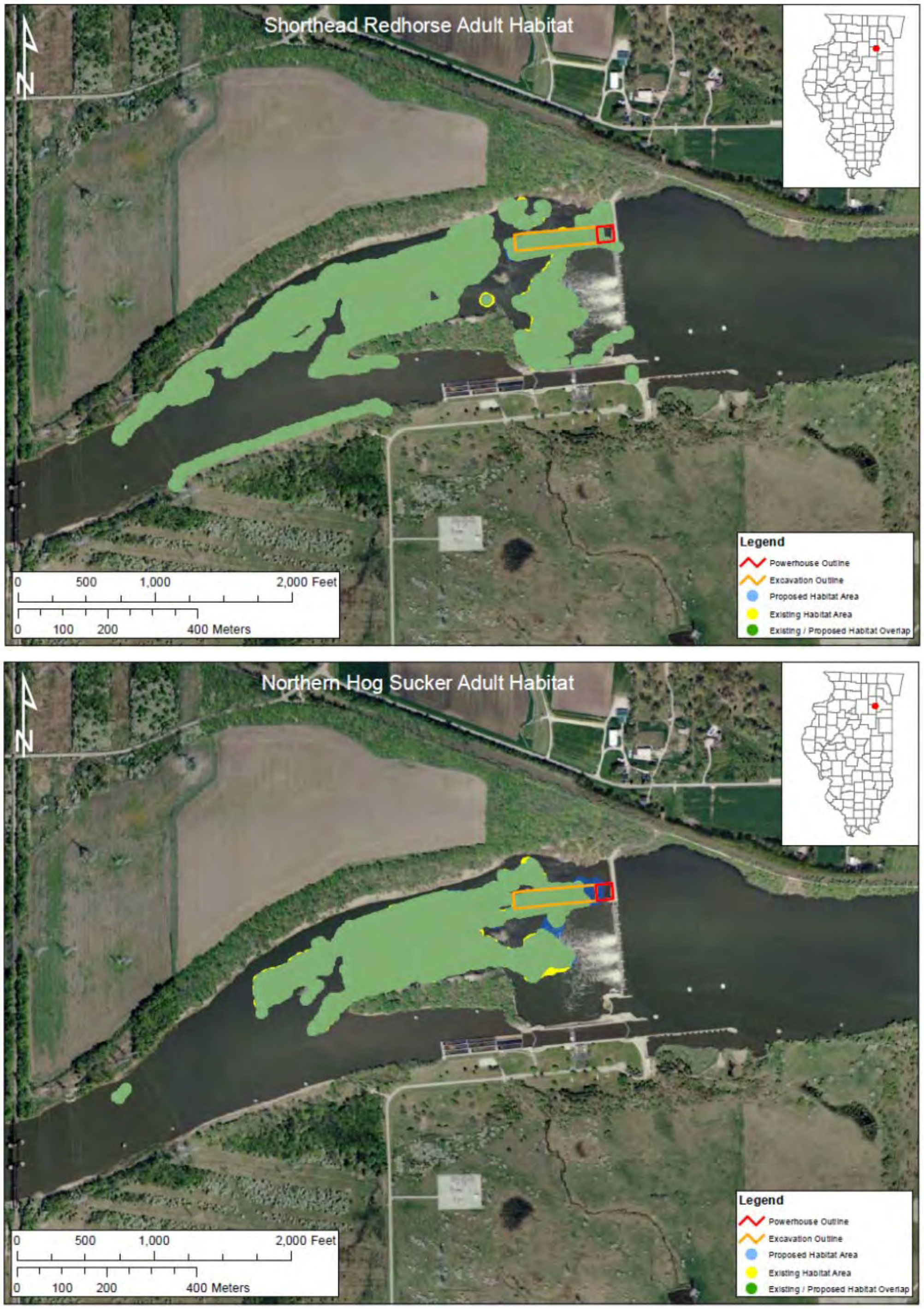


Figure 13. Map illustrating preferred adult habitat based on the co-occurrence of depth and velocity preferences of shorthead redhorse (top) and northern hog sucker (bottom) in the Dresden Island dam tailwater at a flow of 1396 cfs. Blue dots represent predicted areas of new habitat, yellow dots existing areas of habitat, and green dots areas of overlap between existing and predicted conditions. The location of the proposed powerhouse and discharge are also shown.

Discussion

Our analyses suggest that little difference exists in terms of important habitat types in the Dresden Island dam tailwater when we compared existing conditions to predicted conditions with flow moving through the predicted powerhouse and without any spillage over the head and tainter gates. The main difference was an increase in the deepest and faster habitats (i.e., higher Froude numbers) with flows concentrated through the predicted powerhouse. Our experience with large rivers in the Midwest U.S. supports the importance of fast deep habitat attributes to riverine fish assemblages which is quantitatively indicated by the interaction of depth and currently velocity in the Froude number. All things being equal, increasing flow increases habitat niches available for fish species and reflects greater habitat space. In other words increases in water depth and in cumulative increases in current velocity ranges (e.g., moving from habitats with only shallow-slow features to those with shallow-slow plus shallow-fast plus deep-fast features, etc.) represents increased niches for fluvial dependent species. Thus, increasing base-flow, especially when draped over a mosaic of natural physical structures (e.g., substrates, cover types) increases overall habitat diversity. Data from Ohio indicates that in natural streams increasing the number of potential habitat "niches" is correlated with the capacity to support sensitive fish species (Figure 14). The importance of tailwater areas in otherwise impounded rivers are important for a wider range of niches for flow (e.g., fluvial) and pollution sensitive fish species. The tailwater areas provide the "best" habitats (i.e., highest QHEI and Hydro-QHEI scores) in the Lower DesPlaines and upper Illinois Rivers. While we provided site-specific predictions about changes in spawning habitats with the operation of the proposed hydroelectric facility for the fluvial species of interest, other habitat features (e.g., those tracked by the Froude number), are of equal importance for other life history stages of these fish species.

We have shown with data from other Midwestern rivers that sites with the deepest, fastest habitats (measured by the Hydro-QHEI) are associated with the highest number of sensitive and intolerant fish species (Figure 15). Such rivers have the largest number of niches and offer complex eco-hydraulic conditions. The specific sites on the Scioto River (Figure 14) with the most complex eco-hydraulic conditions were typically the sites that harbored the intolerant species and obligate fluvial species. Plots of the probability of capture of individual sucker species in Ohio vs. Hydro-QHEI shows that for the most habitat-sensitive of these species (river redhorse, black redhorse, shorthead redhorse) the probability of occurrence increases continually with increasing Hydro-QHEI, whereas the habitat tolerant white sucker does not vary in its capture rate with the Hydro-QHEI (Figure 16). For species in the Dresden Island dam tailwater, such as river redhorse, even though shallower spawning shoals are needed, the adjacent deeper areas are often important for staging immediately prior to spawning, for feeding, and for enduring particularly harsh environmental bottlenecks (e.g., extended low flow periods). It is not surprising then that the increases in flow habitats are related to increases in sensitive fish species (Figure 14), most of which are fluvial specialists or fluvial dependents and correlated with increasing average depth and current velocity. This pattern is similar to that described when using the Froude number as an indicator of the hydraulic features of a river. Based on the modeling data alone, the

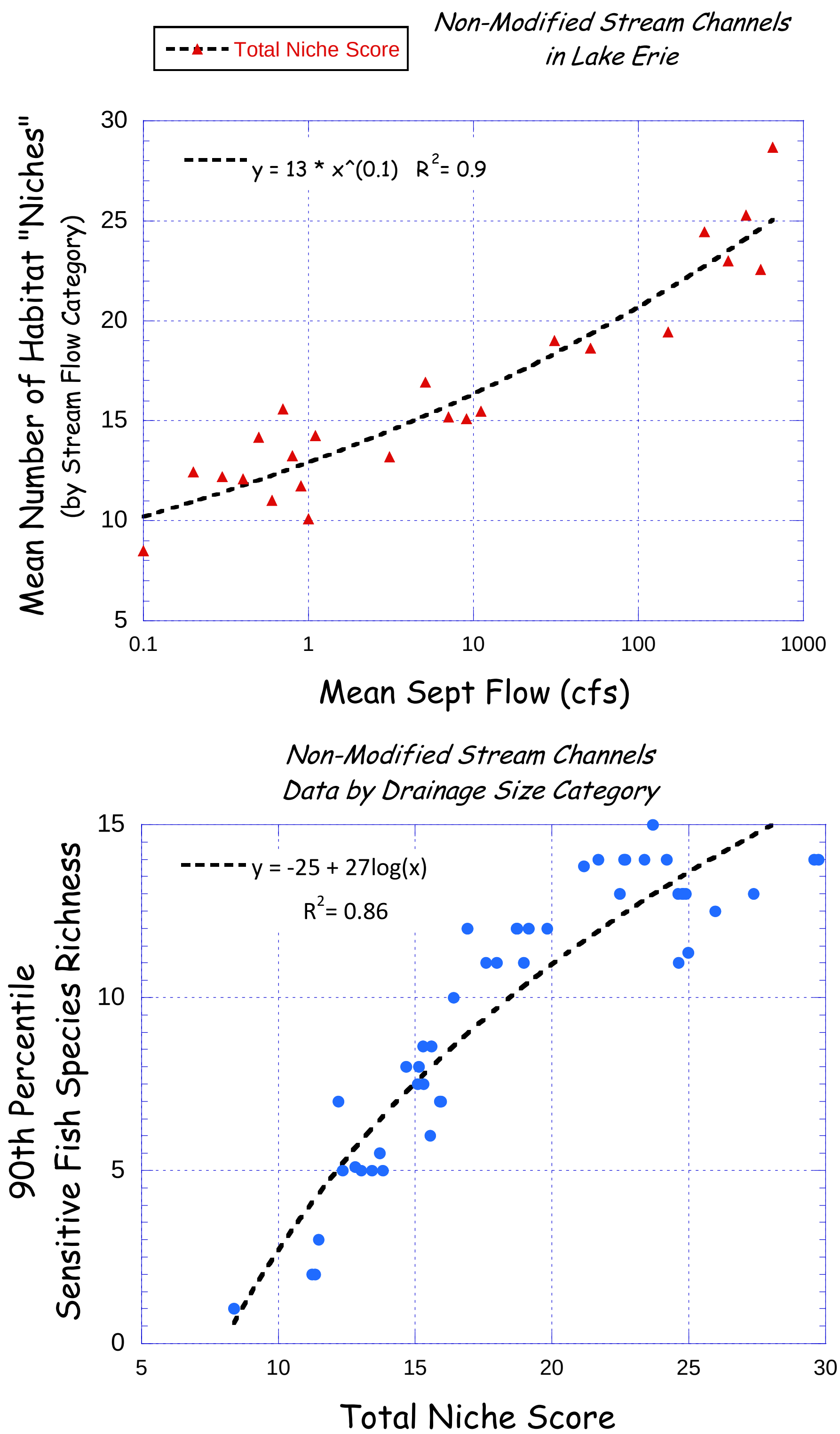
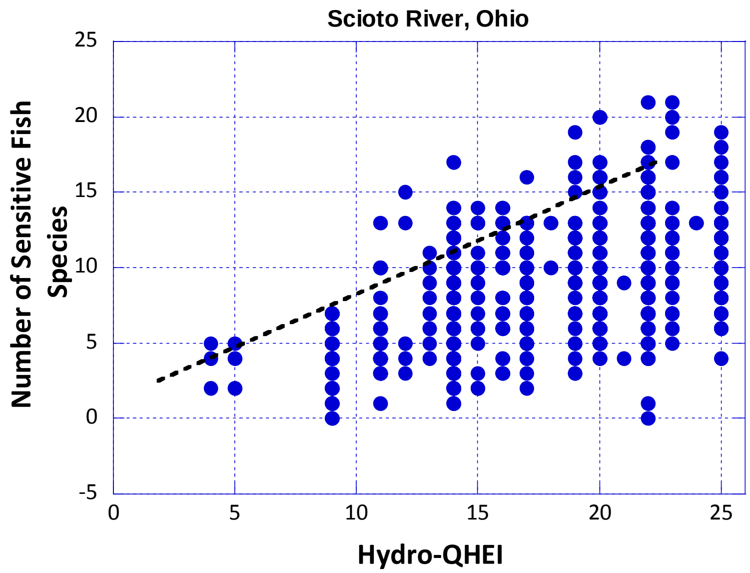


Figure 14. Plots of mean September flow (cfs) vs. the mean number of habitat niches in Ohio natural streams and rivers (top) and a plot of total niche score vs. the 90th percentile of sensitive fish species (predominantly fluvial specialist or dependent species) in these rivers.



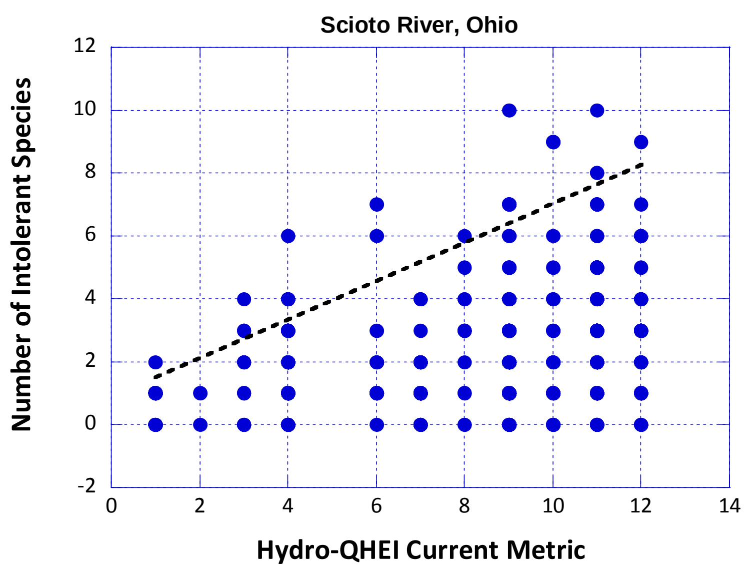


Figure 15. Number of intolerant fish species vs. Hydro-QHEI current metric score (top) and number of sensitive fish species vs. total Hydro-QHEI score (bottom) for boatable sites in the Scioto River (Ohio).

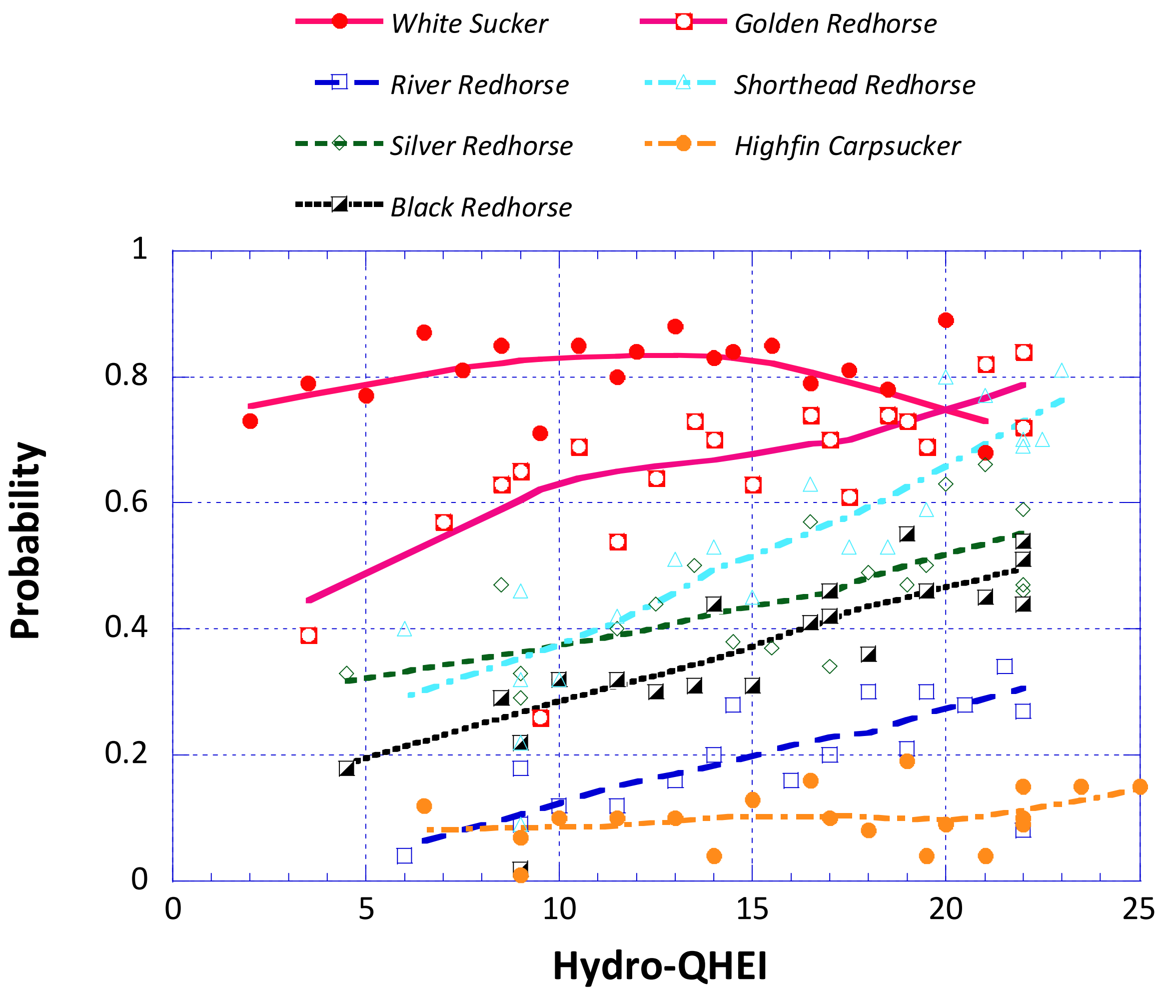


Figure 16. Probability of occurrence plots of sucker species in Ohio relative to the Hydro-QHEI.

results suggest that the predicted conditions would result in either neutral or positive habitat benefits for the fluvial fish species in the Lower DesPlaines and Upper Illinois Rivers.

Caveats

Although the hydraulic modeling results suggest that the concentration of flows through the proposed powerhouse would have a mostly neutral effect on fluvial habitats for most species, other factors could influence this predicted outcome. It would have been useful to have some documentation of specific locations in the Dresden Island tailwaters that are actually used for spawning and other key life stages for the fluvial species of concern. Kleinschmidt (2010) noted in their fluvial geomorphology study that areas immediately below the Dresden Island dam were filled with concrete by the U.S. Army Corp of Engineers because of erosional hazards to the dam under scouring flows. It is likely that these habitat areas are presently not available or highly marginal for fish habitat or spawning. Kleinschmidt (2010) further observed that areas immediately downstream from the Dresden Island dam have become armored by high flows winnowing out gravels and fine substrates. Armoring immediately below dams has also been reported by other investigators (Parker and Southerland 1990, Vericat et al. 2006). The armoring of the substrates closest to the dam would make these unsuitable for spawning for many of the fluvial species that are also lithophilic spawners that depend on mobile gravel and small cobble sized materials with interstitial spaces in which their eggs can develop. Under these two scenarios, the predicted establishment of addition of suitable spawning habitats adjacent to the tailwater area would seem beneficial to the fluvial species. As noted above the substrates will likely have some degree of re-distribution when the flow patterns are changed (Kleinschmidt 2010). Because larger substrates are effectively trapped by the dams in this system, gravel materials could be insufficient to re-establish high quality spawning areas, or such re-establishment could take a long period of time.

Adaptive Management Options

Our conclusions about the predicted effects of the proposed hydroelectric facility are based on the data that was made available to us for this study. As previously discussed, it would have been useful to have a study that documented existing locations where the key fish species of concern currently spawn in the tailwater area. For example, redhorse and other species such as hornyhead chub have been documented as using areas with fine-gravel to small cobbles where they either construct redds/nests or excavate into these gravels during their spawning activities. One potentially negative scenario could be a “shortage” of gravel and small gravel sized material for spawning beds and the failure to re-establish these in the newly available fast water areas. There has been work with supplementing gravel materials in rivers to enhance spawning habitats (McManamay et al. 2011). The predicted plan to excavate the tailrace area of the hydropower facility should produce clean substrate materials and one option being considered was to use these for bank stabilization. An alternative approach would be to sort and stockpile the gravel sized materials to enhance spawning areas if they fail to completely re-establish in the tailwater area.

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APPENDIX B

SUPPLEMENTAL EVALUATION OF PROJECT HYDRAULICS AND FISH HABITAT

SUPPLEMENTAL EVALUATION OF PROJECT HYDRAULICS AND FISH HABITAT

DRESDEN ISLAND LOCK & DAM
(FERC NO. 12626)

Prepared for:

Northern Illinois Hydropower, LLC
Joliet, Illinois

Prepared by:

Kleinschmidt

Pittsfield, Maine
www.KleinschmidtUSA.com

December 2013

SUPPLEMENTAL EVALUATION OF PROJECT HYDRAULICS AND FISH HABITAT

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December 2013

EXECUTIVE SUMMARY

Northern Illinois Hydropower (NIH) proposes to construct and operate a hydropower project (Project) adjacent to and using the existing United States Army Corps of Engineers (USACE) Dresden Island Lock and Dam, near Channahon, Illinois. The development of the Project will result in changes to the location of some flow releases under various flow conditions. These changes have the potential to affect downstream fish habitat. Previous studies have identified the critical species in the river and their habitat criteria for depth and velocity (MBI, 2012). With the use of a 2-dimensional hydrodynamic model, these parameters may be quantified for both the existing and proposed conditions, allowing an assessment of potential changes to total habitat area. The focus of this updated modeling was to evaluate potential changes in habitat resulting from the construction of a revised design of the Project, and the reallocation of portions of river flows from the tainter gates to the powerhouse. The proposed operations include an allocation of the first 1000 cfs of available flow at the Dresden Island Dam as a minimum habitat flow. Because the minimum flow needed to 'start' one unit for generation is roughly 400 cfs, the net effect is that the first 1400 cfs by-passes the powerhouse and then, as flows increase, flows through the Project increase while flows through the USACE gates remain relatively constant at 1000 cfs until river flows reach 9000 cfs, at which point the Project has reached the maximum generation capacity.

Habitat was modeled for ten representative species at three different flow rates:

- 1600 cfs total project inflow, which would includes a single unit powerhouse generation of 600 cfs and a 1000 cfs minimum flow through the tainter gates
- 9000 cfs total flow, (a full powerhouse of 8000 cfs and 1000 cfs min. flow)
- 15000 cfs total flow, (a full powerhouse of 8000 cfs and 7000 cfs at the tainter gates)

The spatially distributed depths and velocities in the river below the dam were extracted for each condition (existing and proposed), and for each flow. The total habitat area was tabulated under each condition and flow rate. The model considered a region as habitat only where numerical criteria for each species for both depth and velocity was achieved. Changes in habitat are presented as tables for the ten species and figures comparing existing and proposed conditions for three select species listed as threatened or endangered by the Illinois Department of Natural Resources. Analyses show both incremental gains and losses of habitat under the proposed

operating conditions. Readers should be aware that representative flows and conditions were modeled out of an infinite set of potential scenarios, but are meant to represent a range of potential river flows and operating conditions. Regardless, these general approaches demonstrate marginal changes in overall habitat availability, with moderate increases in habitat distribution for some species under some flow conditions.

SUPPLEMENTAL EVALUATION OF PROJECT HYDRAULICS AND FISH HABITAT

DRESDEN ISLAND HYDROELECTRIC PROJECT
(FERC NO. 12626)

NORTHERN ILLINOIS HYDROPOWER, LLC
JOLIET, ILLINOIS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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SUPPLEMENTAL EVALUATION OF PROJECT HYDRAULICS AND FISH HABITAT

DRESDEN ISLAND HYDROELECTRIC PROJECT (FERC NO. 12626)

NORTHERN ILLINOIS HYDROPOWER, LLC JOLIET, ILLINOIS

1.0 INTRODUCTION

Northern Illinois Hydropower (NIH) proposes to construct and operate a hydropower project (Project) adjacent to and using the existing United States Army Corps of Engineers (USACE) Dresden Island Lock and Dam, near Channahon, Illinois. The Project would be located close to the right abutment of the Dresden Island Dam and will use existing gate openings. Operations are planned to allocate the first 1,000 cfs of river flow to instream purposes, that is a 'by-pass' flow, after which the next 8,000 cfs of available flow could be allocated to the powerhouse. In response to comments and questions from the Illinois Environmental Protection Agency (IEPA) and the Illinois Department of Natural Resources (IDNR), the following report reviews the potential effects of the proposed powerhouse on fish habitat below Dresden Island Dam.

All references to left and right are with respect to a viewer looking downstream. All elevations, depths and velocities are reported in Standard International metric units. The vertical datum is NAVD88, and the horizontal coordinate system is UTM Zone 16N (meters), NAD83.

2.0 DESIGN CONDITONS

2.1 OPERATIONS

The proposed operations include a by-pass of the first 1000 cfs of available flow at the Dresden Island Dam. Because the minimum flow needed to 'start' one unit for generation is approximately 400 cfs, the net effect is that the first 1400 cfs by-passes the Project and then, as flows increase, flows through the powerhouse increase while flows through the USACE gates remain relatively constant at 1000 cfs until river flows reach 9000 cfs at which point the powerhouse has reached capacity. Because NIH has no control over USACE operations, for this modeling we assumed a mix of tainter gate openings as shown in Table 1 and Table 2.

TABLE 1 EXISTING CONDITIONS FLOW ALLOCATIONS

	SCENARIO	TOTAL L&D RIVER FLOW (CFS)	POWERHOUSE (CFS)	TAINTERS-SOUTH (CFS)	TAINTERS-MIDDLE (CFS)	TAINTERS-NORTH (CFS)
EXISTING	Case-1	1600	0	0	0	1600
	Case-2	9000	0	1000	0	0
	Case-3	15000	0	5000	5000	5000

TABLE 2 PROPOSED CONDITIONS FLOW ALLOCATIONS

	SCENARIO	TOTAL L&D RIVER FLOW (CFS)	POWERHOUSE (CFS)	TAINTERS-SOUTH (CFS)	TAINTERS-MIDDLE (CFS)	TAINTERS-NORTH (CFS)
PROPOSED	Case-1	1600	600	1000	0	0
	Case-2	9000	8000	1000	0	0
	Case-3	15000	8000	2333	2333	2333

Additionally, in the proposed conditions, other than the minor modifications to channel geometry because of construction of the Project no other changes to the stream bed have been made.

2.2 FISH HABITAT

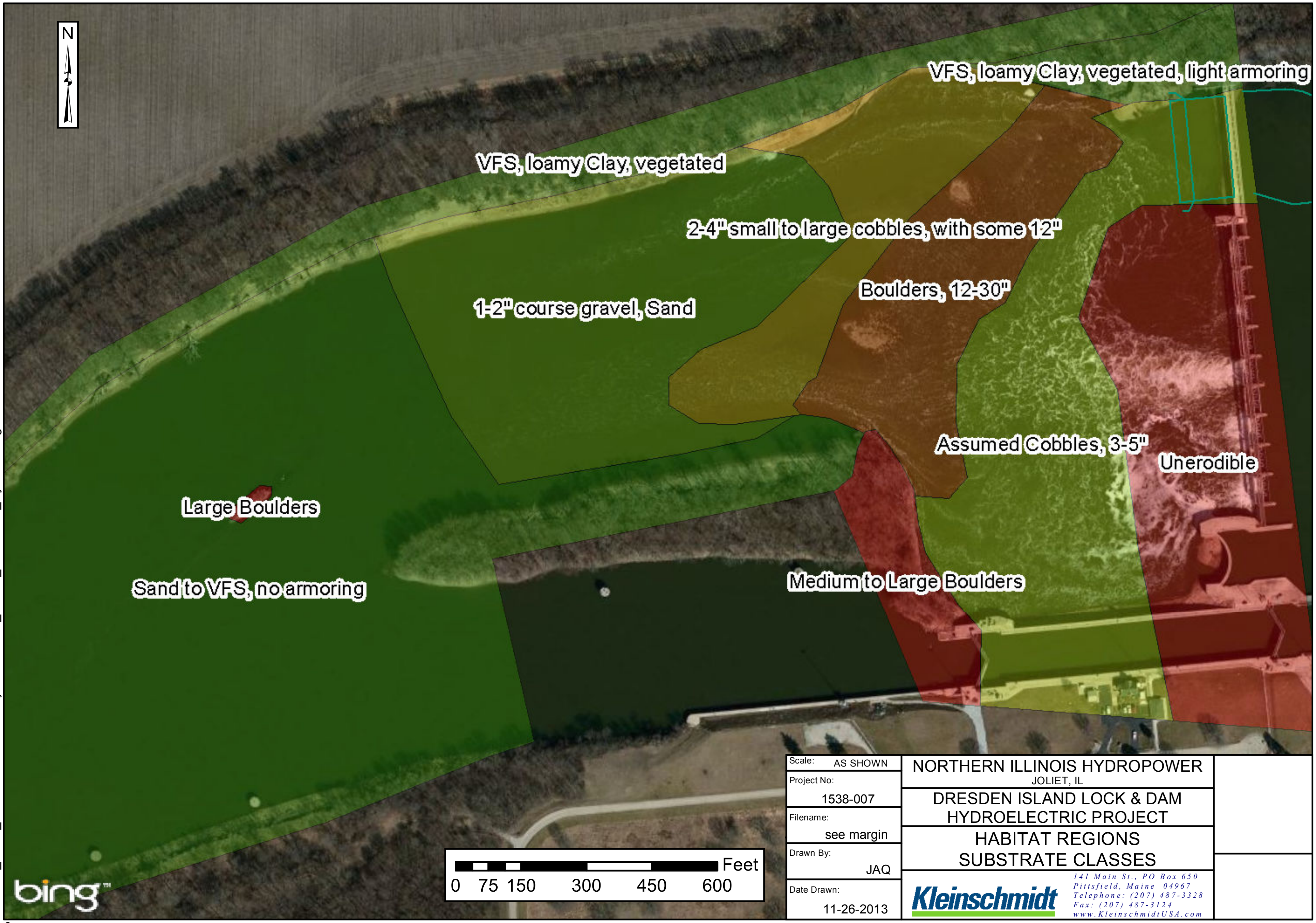
Metrics for suitability of fish habitat for several species were summarized in a site specific report by Midwest Biodiversity Institute (MBI, 2012)[1], Table 2 - *Spawning habitat preferences in terms of current velocity (m/s), depth (m) and substrate from the literature or on aquatic fishery web sites*. Using that information, this report analyzed habitat for ten representative species. This information is summarized in Table 3.

TABLE 3 SUMMARY OF CRITICAL SPECIES AND HABITAT METRICS

SPECIES	VELOCITY (M/S)	DEPTH (M)	SUBSTRATE
River Redhorse	0.6-1.0	0.2-1.2	Cobble-Gravel
Golden Redhorse	0.19-0.45	0.12-0.24	Cobble-Gravel
Black Redhorse	0.17-1.29	0.12-0.37	Cobble-Gravel
Great Redhorse	0.038-1.169	0.1-1.0	Cobble-Gravel
Shorthead Redhorse	0.5-1.1	1.5-2.5	Cobble-Gravel
Smallmouth Bass	<0.04	0.55-0.85	Cobble-Gravel
Hornyhead Chub	0.18-0.36	0.15-0.91	Gravel
Northern Hog Sucker	0.3-0.8	0.3-1.6	Cobble-Gravel
Sauger	0.33-0.98	0.6-5.5	Sand-Boulder
Pallid Shiner	<0.05	0.4-1.5	Sand

Substrates below Dresden Island Dam had previously been surveyed for material size. Figure 1 shows the substrates below Dresden Island Dam.

[1] *An Analysis of Predicted Changes in Fish Habitat Downstream of the Dresden Island Dam from a Proposed Hydroelectric Facility*, Midwest Biodiversity Institute, 2012.



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Project No: 1538-007	DRESDEN ISLAND LOCK & DAM HYDROELECTRIC PROJECT
Filename: see margin	HABITAT REGIONS SUBSTRATE CLASSES
Drawn By: JAQ	
Date Drawn: 11-26-2013	Kleinschmidt 141 Main St., PO Box 650 Pittsfield, Maine 04967 Telephone: (207) 487-3328 Fax: (207) 487-3124 www.KleinschmidtUSA.com

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The model used these habitat metrics to determine if a particular region of the tailrace was, or was not, 'habitat'. Total habitat area for each of the species was tabulated under existing conditions, and then compared to the proposed conditions.

2.3 Hydrodynamic Modeling

2.3.1 Approach & Methodology

A 2-dimensional finite element hydrodynamic model was developed to assess the channel stability and fish habitat. A 2D model is required in this channel due to the complex flow patterns not readily described using a 1-dimensional approach. This includes variable water surface elevations across the channel, large eddies and non-effective flow regions, islands, and multiple inflow locations. The 2D model utilizes shallow-water equations with depth averaged velocity; this approximation is appropriate throughout this study domain.

The TELEMAC-MASCARET software was used for this analysis[2]. TELEMAC is a well tested and validated software package utilized throughout the world. Pre and post-processing of hydraulics and habitat areas was completed using data extracted from an ArcGIS database[3]. Geometry development, visualization, and review of the hydrodynamic model were completed using the BlueKenue[4] software package.

2.4 Geometry & Domain

Model domain extended from where an existing powerline crosses the navigation channel below the dam to upstream to the dam and extending between both sides of the river. A portion of the lock channel was represented, although bathymetry was not readily available. Throughout the domain, a variable resolution was utilized to limit computational time. The downstream boundary, mostly controlled by backwater used a 7 meter cell length, which was reduced to 3 meters near the dam.

[2] http://www.opentelemac.org/
[3] http://www.esri.com
[4] http://www.nrc-cnrc.gc.ca/eng/solutions/advisory/blue_kenue_index.html

2.5 BOUNDARY CONDITIONS: FLOW RATES & WATER LEVELS

Two commonly used criteria for fish habitat are depth and velocity, which may be extracted from the hydraulic model results. Three different flow rates were modeled for fish habitat downstream of Dresden Island Dam. Flow is allocated for the Existing and Proposed conditions as shown in Table 1 and Table 2. Lower flow rates were not assessed in this study as Project operations would not affect habitat. Figure 2 presents the tailwater rating curve in the navigation channel below Dresden Island.

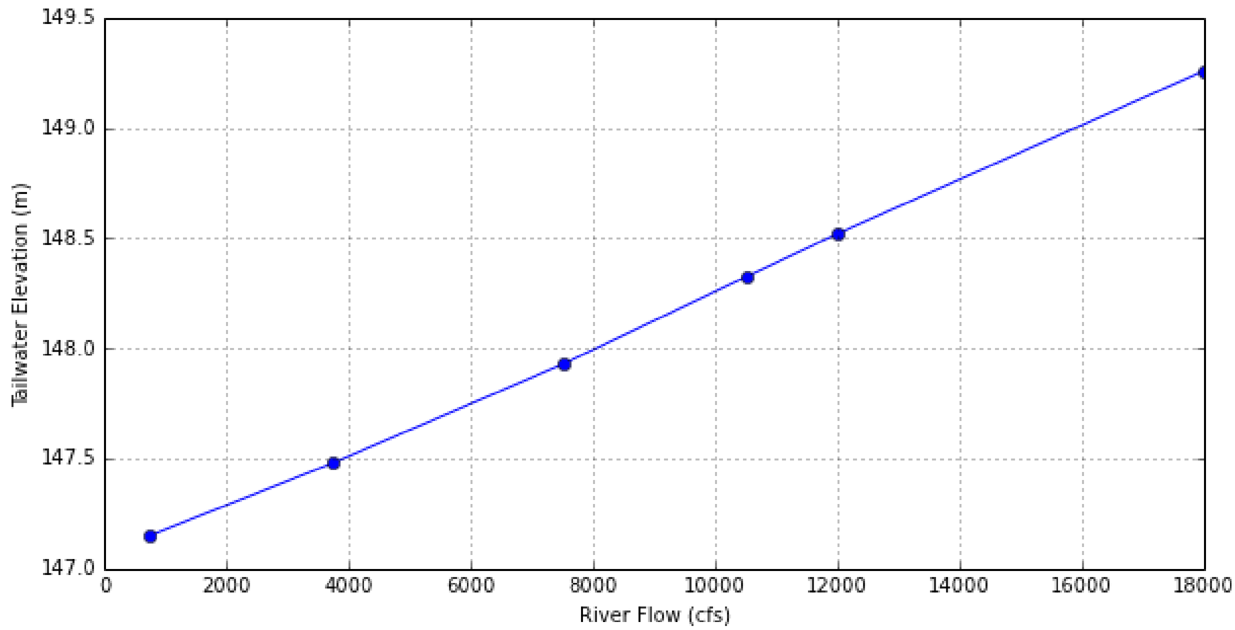


FIGURE 2 TAILWATER RATING CURVE IN NAVIGATION CHANNEL BELOW DRESDEN ISLAND

For each of the three river flow rates, for both the existing and proposed conditions, the depth and velocity results were exported as DTM point files. These points are not on a regular grid and are difficult to interpret directly, therefore a Natural Neighbor (exact) interpolation technique was employed to create a gridded raster at 1m intervals. This approach allows easy visualization and calculations of results along a continuous surface. For example, the total wetted area is simply a count of the cells with depth greater than zero, resulting in total area in square meters. The data was clipped to the same region for both existing and proposed conditions for equal comparison of total habitat areas.

3.0 MODEL HYDRODYNAMIC & HABITAT RESULTS

The hydrodynamics are inextricably linked to the habitat in the channel. The following summarizes the hydraulics of depth and velocity at two different flow rates, and the resulting total habitat areas in the reach below Dresden Island Dam.

3.1 HYDRODYNAMIC RESULTS

Models were run for the 1,600, 9,000 and 15,000 cfs conditions for both the existing and proposed conditions. For each, the depth and velocity were extracted for further processing. Figures 3-Figures 5 below show the different velocities for each proposed condition. Additionally, the figures provide an indication of where velocities may vary between each case, and where the channel may be wetted between the cases.

All figures are shown in metric units; FPS units are not directly available from Telemac.

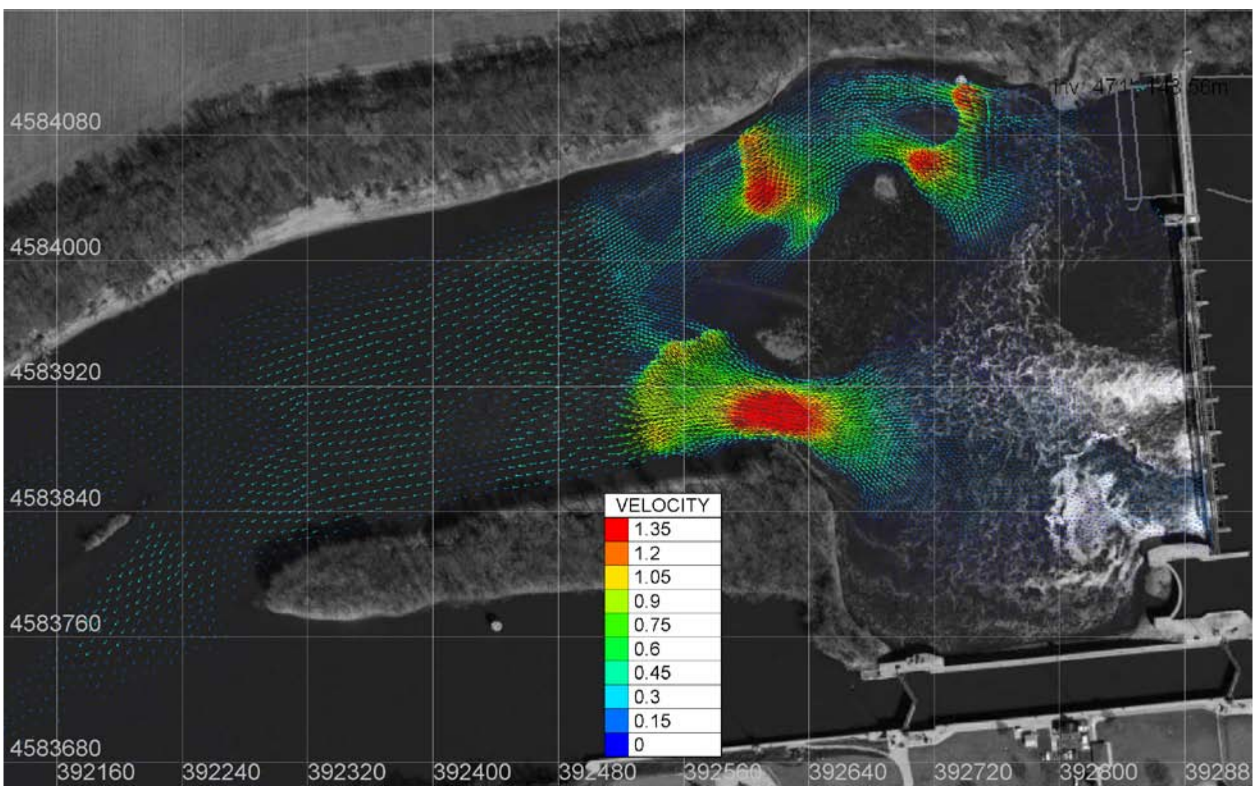


FIGURE 3 PROPOSED VELOCITY AT 1600 CFS

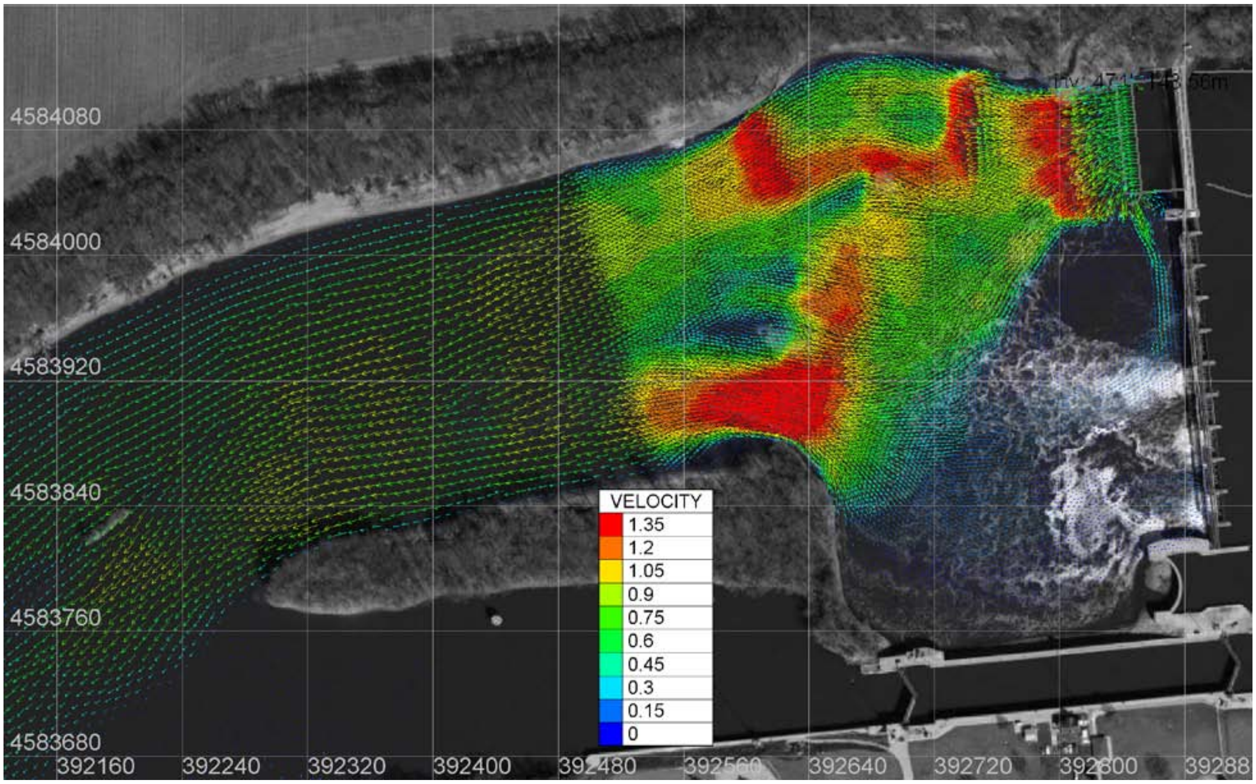


FIGURE 4 PROPOSED VELOCITY AT 9000 CFS

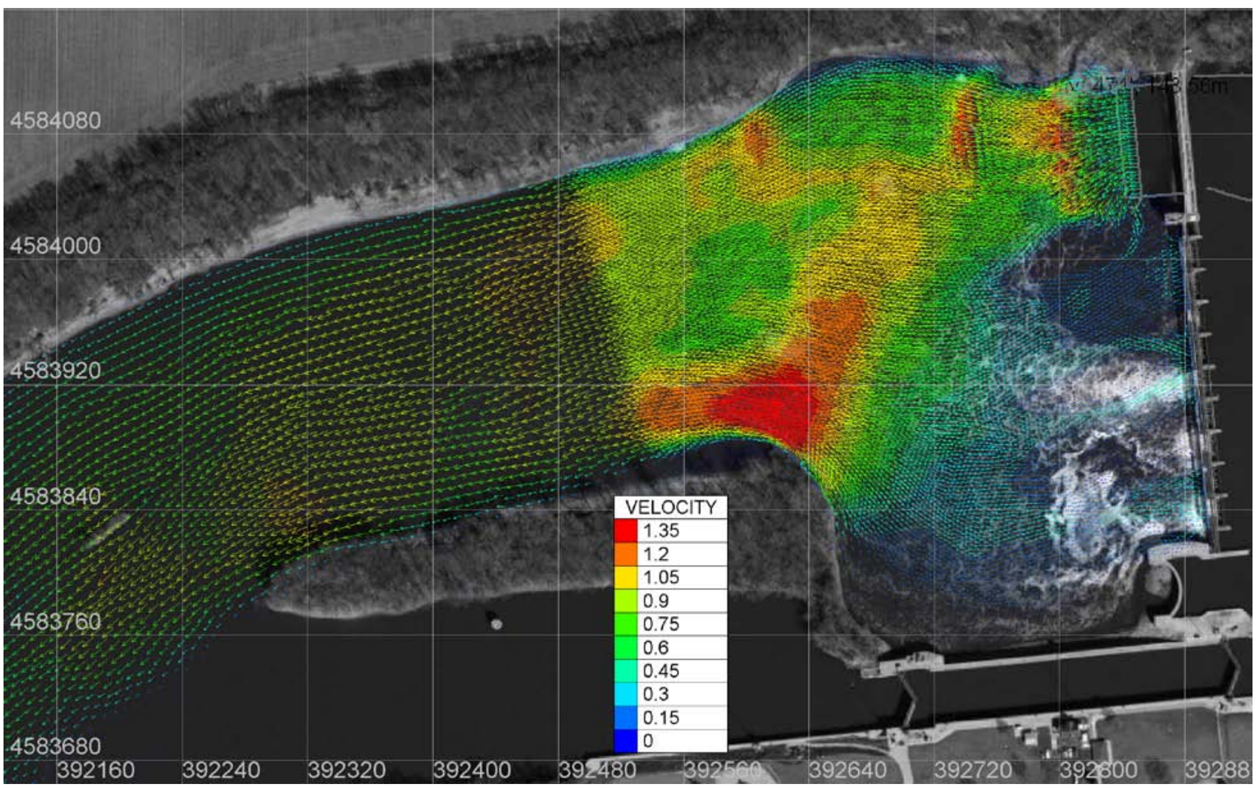


FIGURE 5 PROPOSED VELOCITY AT 6000 CFS

3.2 HABITAT RESULTS

The metrics for the ten different fish species were evaluated using the hydrodynamic model results. For each 1m square, the depth and velocity were simultaneously evaluated to determine whether both criteria were satisfied. When this occurred, that cell is considered suitable habitat for that species, otherwise the cell was not considered as suitable habitat. Various approaches may utilize fitness functions (similar to IFIM studies) which describe the level of fitness for each criterion. The approach employed in this study does not use gradated fitness functions, but rather binary systems of either acceptable habitat (1), or not acceptable habitat (0). As such, when the velocity decreases by a slight level, it may be sufficient to completely remove (or add) that area as suitable habitat between conditions.

This information was processed using a Python script with the ArcPy module to streamline the data processing. Once the binary raster is calculated for each species and flow condition, a simple sum of the 1's provides the total available habitat area in square meters. Changes in habitat for each species are presented in Table 4 - Table 6 for each proposed flow.

TABLE 4 SUMMARY OF HABITAT AREAS BY SPECIES (1600 CFS)

1600 cfs	Existing Conditions (m^2)	Proposed Conditions (m^2)	Area Change (m^2)	Percent Change (%)
Black Redhorse	5281	5375	94	1.8%
Golden Redhorse	336	287	-49	-14.6%
Greater Redhorse	97957	99312	1355	1.4%
Hornyhead Chub	6989	6311	-678	-9.7%
Northern Hog Sucker	44010	45153	1143	2.6%
Pallid Shiner	13414	14035	621	4.6%
River Redhorse	4204	4610	406	9.7%
Sauger	33799	34197	398	1.2%
Smallmouth Bass	5072	4319	-753	-14.8%
Shorthead Redhorse	0	0	0	0.0%
	211062	**213599**	**2537**	**1.2%**

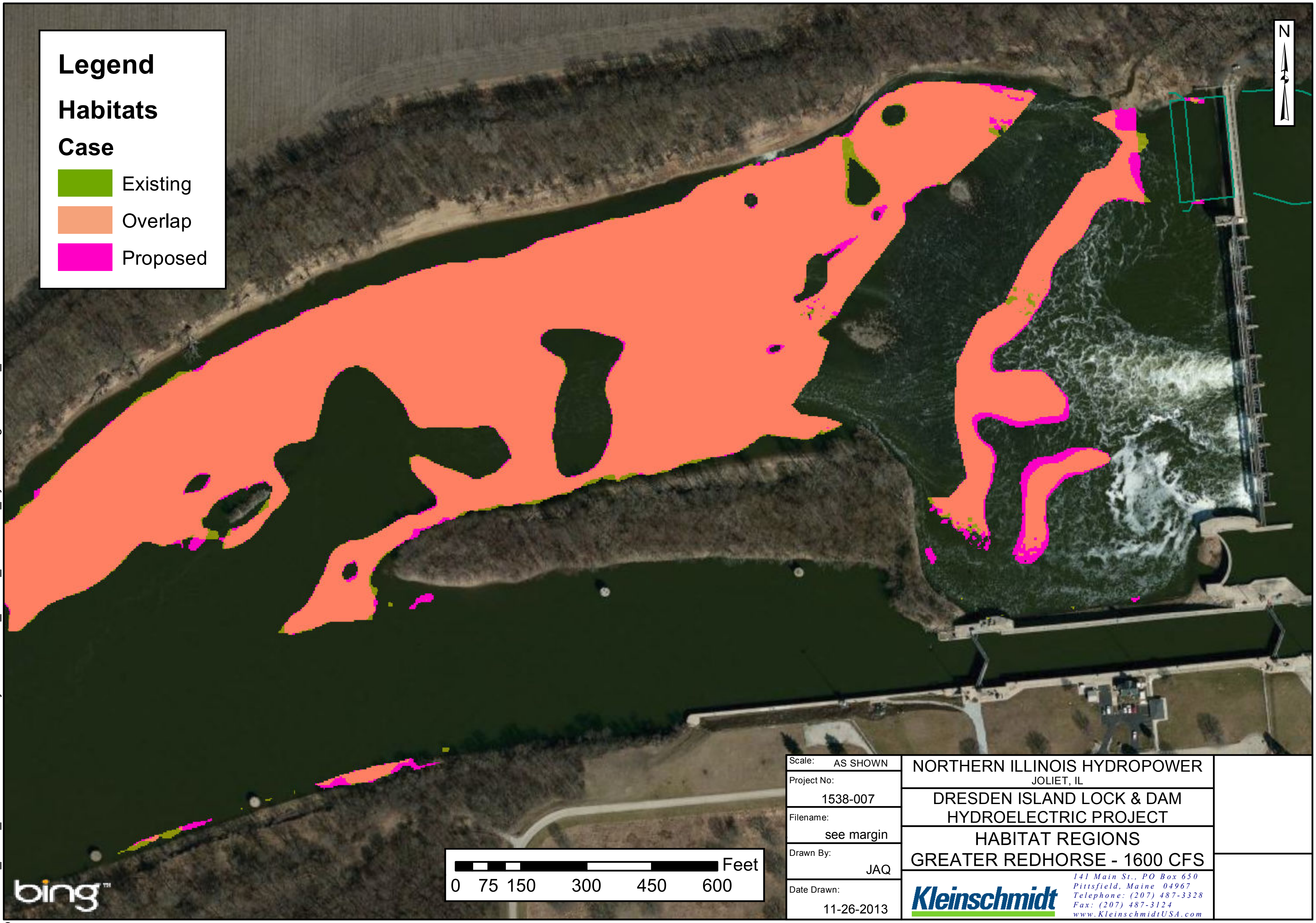
TABLE 5 SUMMARY OF HABITAT AREAS BY SPECIES (9000 CFS)

9000 cfs	Existing Conditions (m^2)	Proposed Conditions (m^2)	Area Change (m^2)	Percent Change (%)
Black Redhorse	826	780	-46	-5.6%
Golden Redhorse	66	83	17	25.8%
Greater Redhorse	21548	21558	10	0.0%
Hornyhead Chub	457	496	39	8.5%
Northern Hog Sucker	40812	36856	-3956	-9.7%
Pallid Shiner	3247	2278	-969	-29.8%
River Redhorse	5730	5523	-207	-3.6%
Sauger	168534	162462	-6072	-3.6%
Smallmouth Bass	1141	683	-458	-40.1%
Shorthead Redhorse	71572	71532	-40	-0.1%
	313933	**302251**	**-11682**	**-3.7%**

TABLE 6 SUMMARY OF HABITAT AREAS BY SPECIES (15000 CFS)

15000 cfs	Existing Conditions (m^2)	Proposed Conditions (m^2)	Area Change (m^2)	Percent Change (%)
Black Redhorse	407	350	-57	-14.0%
Golden Redhorse	48	43	-5	-10.4%
Greater Redhorse	8750	8255	-495	-5.7%
Hornyhead Chub	354	240	-114	-32.2%
Northern Hog Sucker	9376	8972	-404	-4.3%
Pallid Shiner	1286	1222	-64	-5.0%
River Redhorse	361	354	-7	-1.9%
Sauger	165200	161305	-3895	-2.4%
Smallmouth Bass	372	483	111	29.8%
Shorthead Redhorse	83034	80984	-2050	-2.5%
	269188	**262208**	**-6980**	**-2.6%**

Habitat for three Illinois Threatened and Endangered Species under the three flow conditions is shown in Figures 6 - 14. The Figures show where the habitat adjusts to a modified flow pattern and show regions of overlap, and areas of new habitat. In general, the patterns are relatively close between the two conditions.



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Date Drawn:	11-26-2013

NORTHERN ILLINOIS HYDROPOWER
JOLIET, IL

DRESDEN ISLAND LOCK & DAM
HYDROELECTRIC PROJECT

HABITAT REGIONS
GREATER REDHORSE - 1600 CFS

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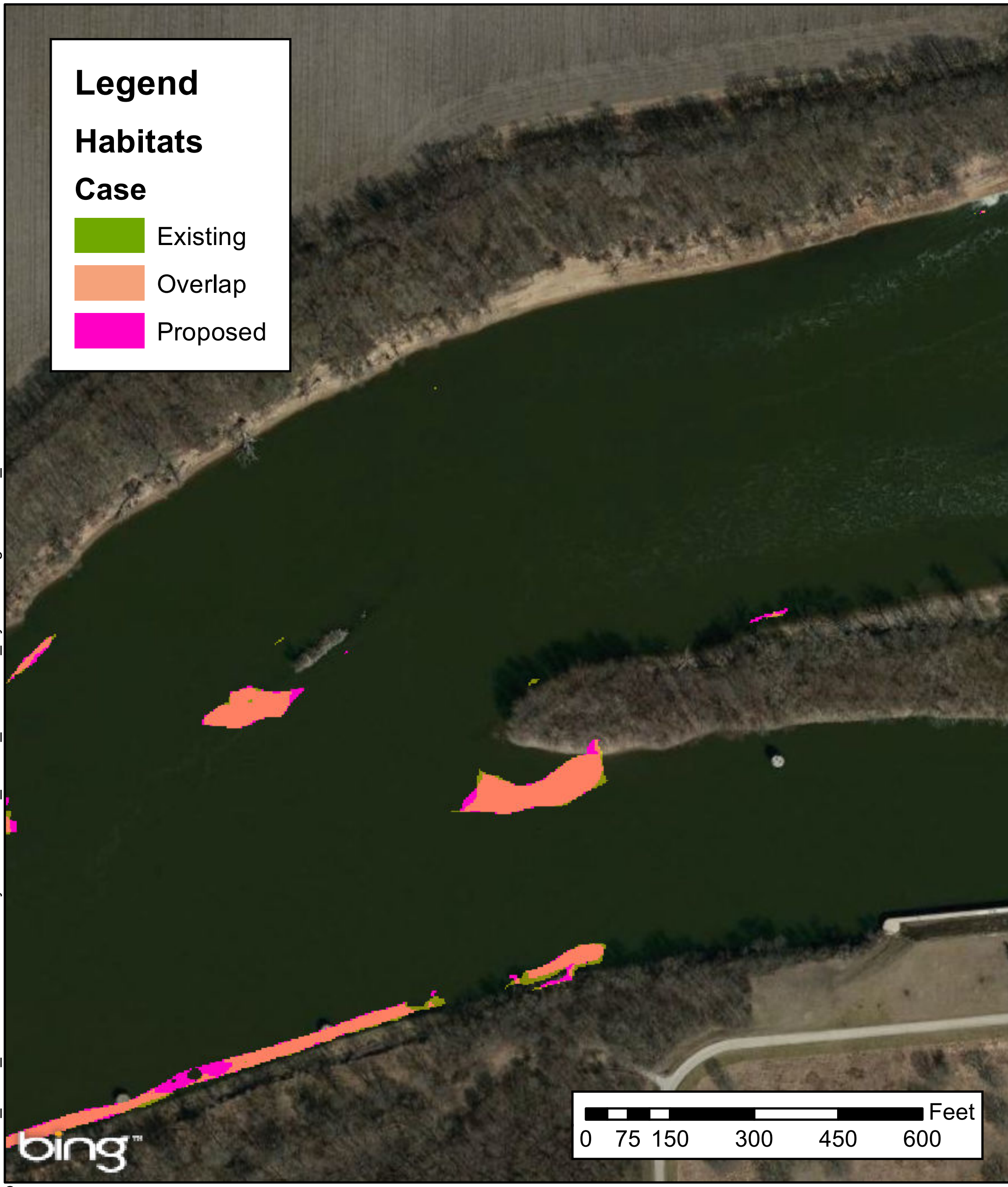

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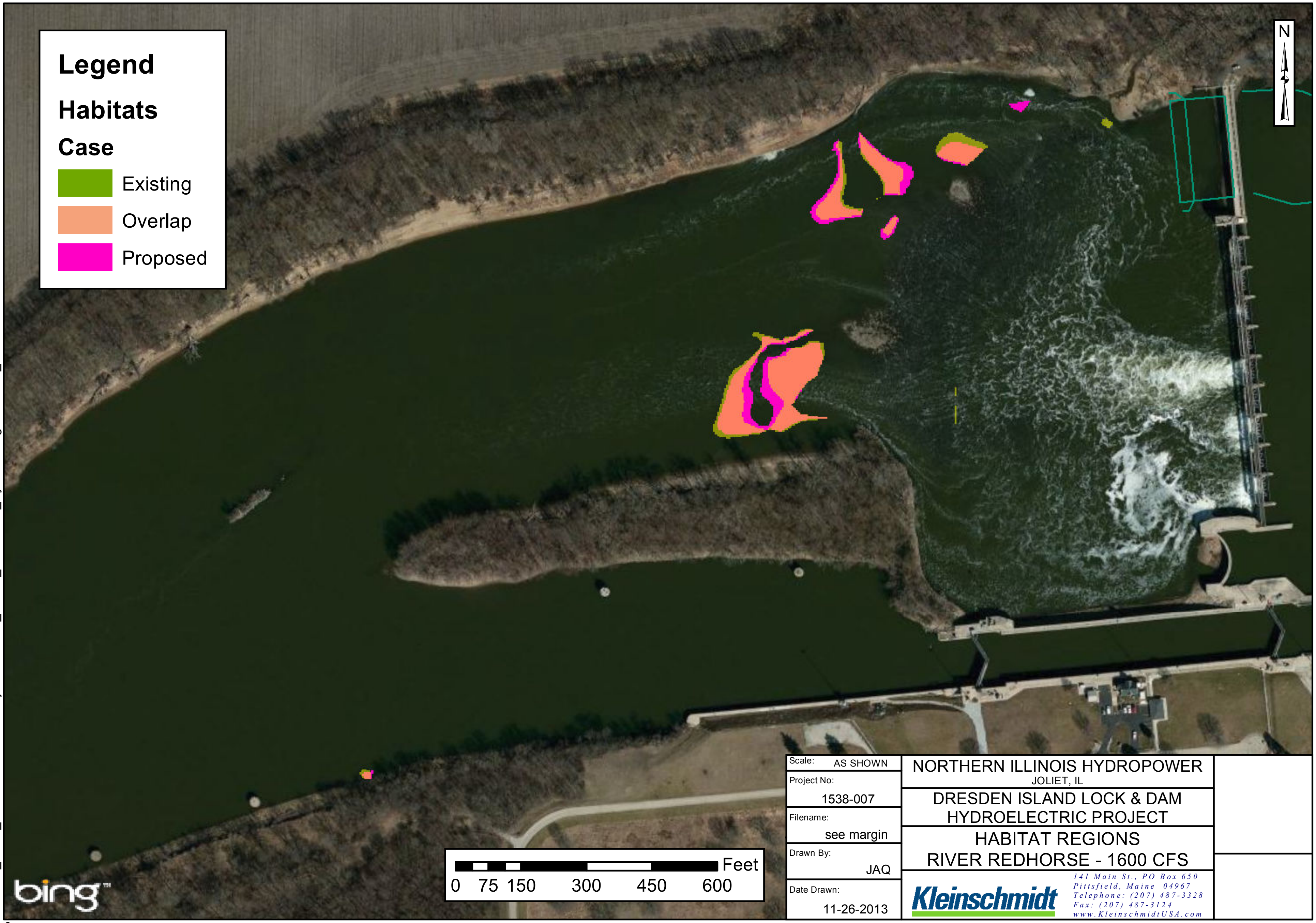

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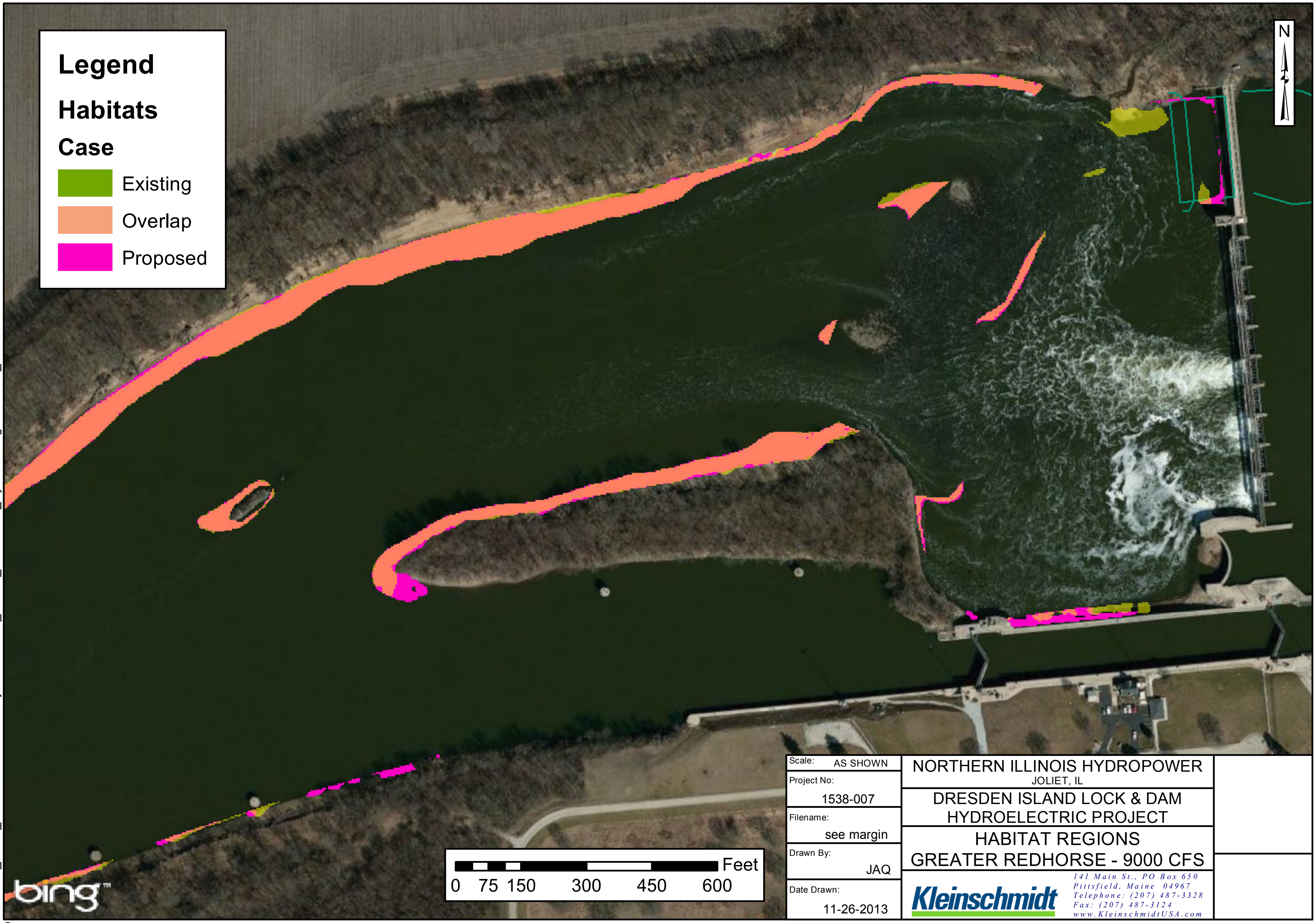

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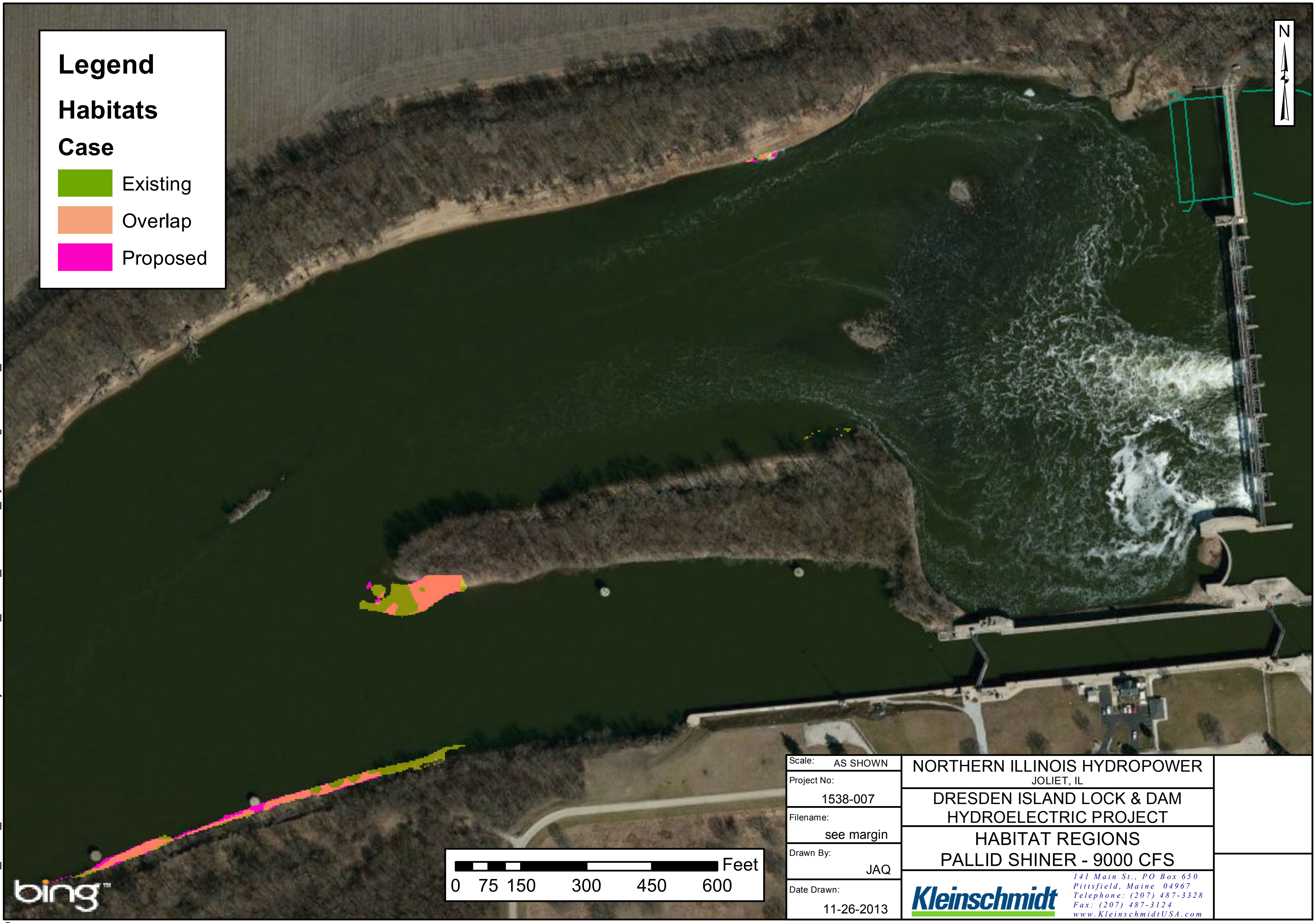

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Project No: 1538-007	DRESDEN ISLAND LOCK & DAM HYDROELECTRIC PROJECT
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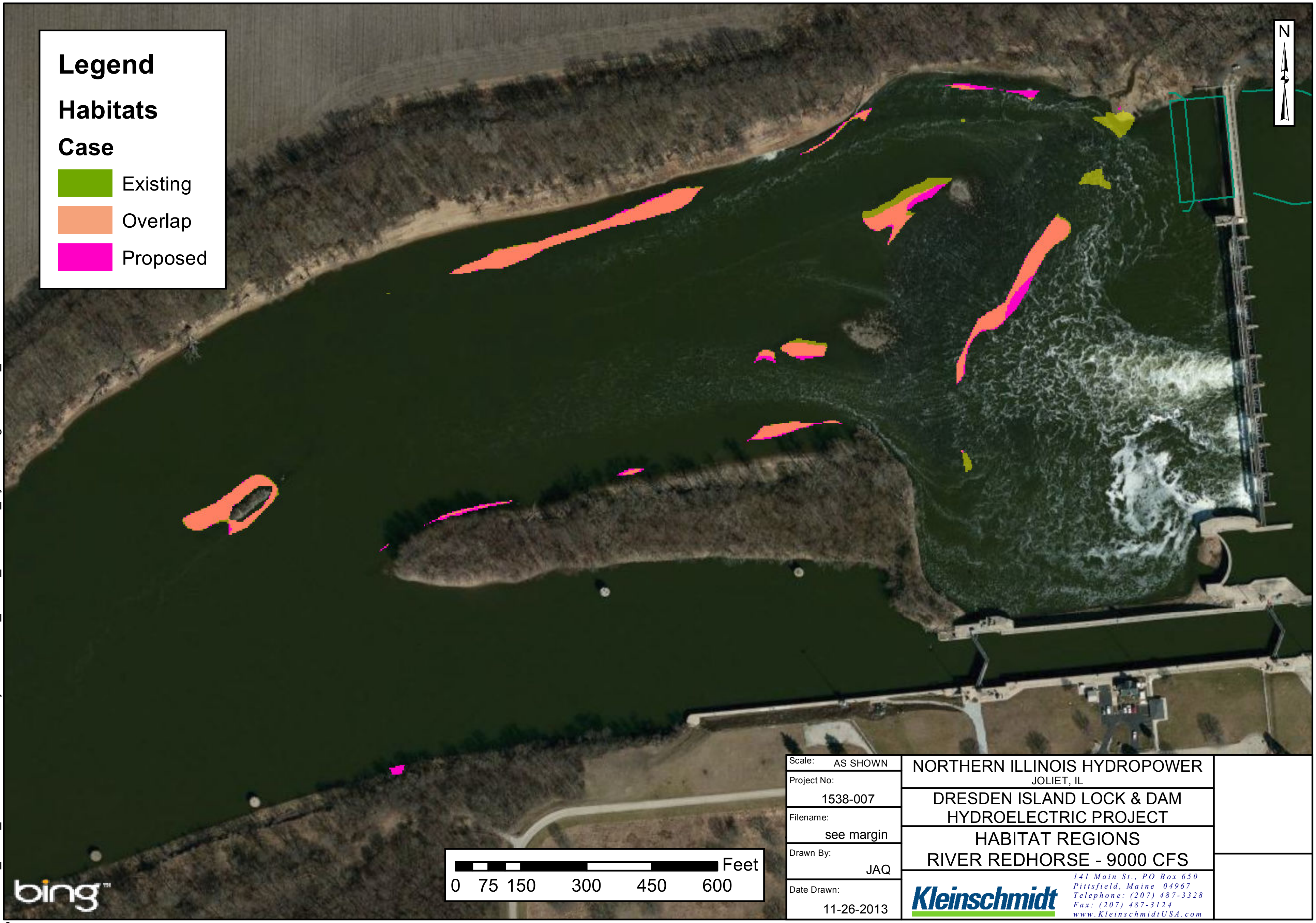

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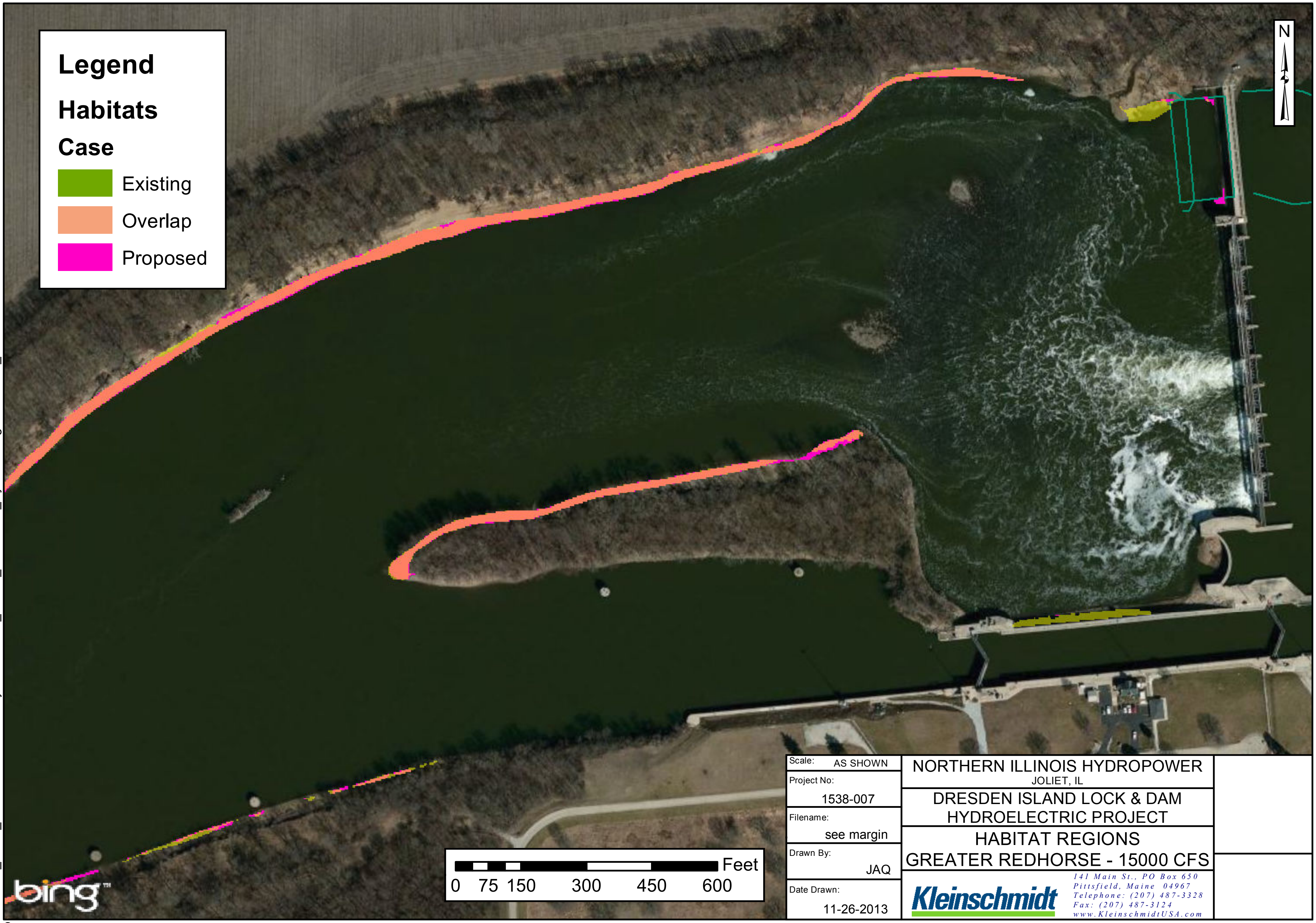

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Filename: see margin	HABITAT REGIONS PALLID SHINER - 15000 CFS
Drawn By: JAQ	
Date Drawn: 11-26-2013	Kleinschmidt

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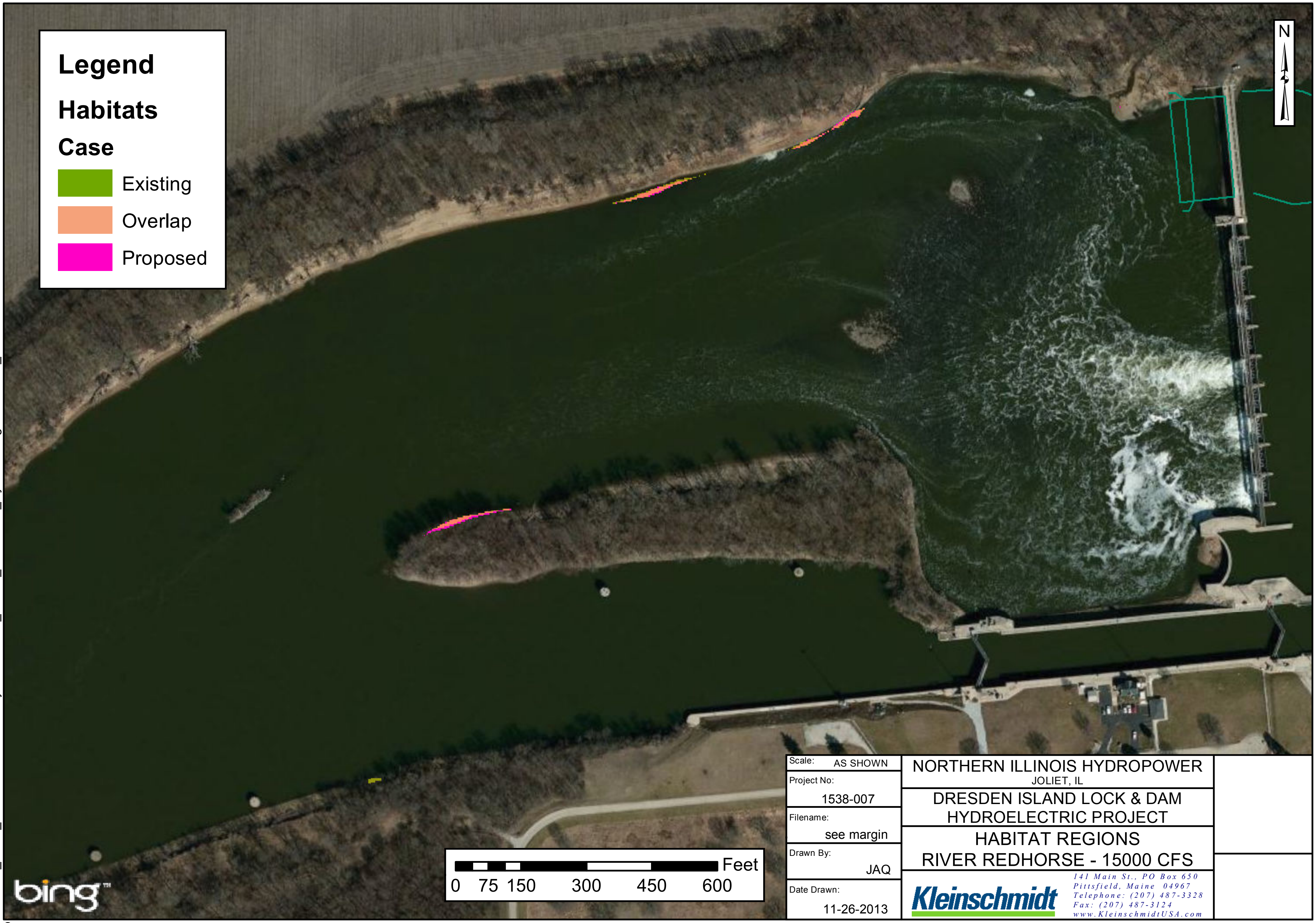

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4.0 DISCUSSION

Clearly, without any by-pass flow requirement, addition of the Project to the Dresden Island Dam would cause some modification to existing habitat below the dam. With the 1000 cfs by-pass flow, at flows above 1600 cfs, development of the Project still shifts flows somewhat towards the river right bank of the Dresden Island Dam; however, Dresden Island already causes a natural deflection of water towards river right, and therefore changes in habitat distribution are very minor. Indeed habitat conditions for those species preferring deeper faster water are somewhat enhanced, while other habitats are slightly reduced. Regardless, these habitat areas below Dresden Island Dam shift annually already due to periodic high flow events, and the USACE periodically adjusting gate operations.

Current USACE gate operating protocols include regular tainter gate rotations to avoid scour below the dam. As these operations change, especially at low flows, portions of the river channel may experience very low depths or velocities, followed by higher velocities and depths with a different gate operating selection. This results in a shifting of the depths and velocities as river flows or USACE operations change. The addition of the Project may or may not result in a change in USACE operations, but will clearly establish an area, except in conditions where flows are less than 1400 cfs, with a relatively constant wetted channel. With the allocation of a consistent minimum flow, in addition to flows from the powerhouse, and depending upon future practices, the channel will maintain a more consistent pattern of depths and velocities. This consistency, combined with marginal changes in total habitat area for a range of species under the proposed conditions, should stabilize the overall habitat quality in the downstream channel. As NIH has indicated in its 401 application and other documents and discussions with State and Federal agencies, an opportunity exists for adaptive management of flow distribution after construction of the proposed Project.

Additionally, clean rock and other materials removed from the river bed for construction of the powerhouse are available for constructing habits modification structures that could create areas of different depths and velocities as well as deflect flow within the channel. Therefore, addition of the Project, while it modifies current conditions, in combination with habitat modification and USACE gate operations, presents an opportunity to enhance aquatic habitat below Dresden Island Dam.

5.0 SUMMARY

Modeling of the existing and proposed operations show limited changes to habitat distribution and did not identify any major detrimental effects to habitat. The modeling effort did highlight the fact that just as adding the proposed Project affects habitat quantity and distribution, although so does simply altering existing gate operations. Opportunities exist to improve total habitat, especially at low flows when suitable habitat is critical (even without Project operations), using rock and other materials removed from the river bed during construction. The development of the Dresden Island Hydropower Project has the potential to not only maintain existing habitat, but also improve habitat through a designed approach.

Designed approaches include developing a cooperative gate sequencing operation that would help maintain consistent flow release locations. This consistent flow allocation pattern would, over time, result in the establishment of consistent habitats, beneficial to a range of species. There are also opportunities to lightly re-grade portions of the channel immediately below the proposed project or to add boulders to increase total habitat area or divert flows. NIH has committed to working cooperatively with the USACE, and the IDNR to establish reasonable operating protocols and habitat adjustments that increase habitat and do not interfere with the USACE's mission or operations.

6.0 REFERENCES

An Analysis of Predicted Changes in Fish Habitat Downstream of the Dresden Island Dam from a Proposed Hydroelectric Facility, Midwest Biodiversity Institute, 2012.