Ausable River Aquatic Habitat Assessment

~ 2005 ~

Prepared by: Kari Killins, Mari Veliz & Shawn Staton (DFO)
Ausable Bayfield Conservation Authority

Prepared for:
Ausable River Recovery Team
Fisheries and Oceans Canada
Interdepartmental Recovery Fund

Draft: December 14, 2007

SPECIES AT RISK
AUSABLE RIVER RECOVERY

Executive Summary

In the summer and fall of 2005, Ausable Bayfield Conservation Authority staff conducted habitat assessments within the high priority zone where Endangered and Threatened fishes and mussels have been found in the Ausable River watershed. Habitat assessments were carried out in the Ausable River for a consecutive stretch starting near Exeter and finishing at the Ausable River Cut. Habitat assessments were also conducted on the Little Ausable River, a tributary of the Ausable River, starting near the village of Clandeboye and continuing downstream to the mouth of the Little Ausable. The assessments documented different habitat characteristics, most importantly river morphology, substrate type and turbidity. Habitat characterization and assessment helped to identify the areas in the river that meet the general requirements of the six target species at risk (SAR). Data collected from this assessment highlighted previously un-sampled areas with the appropriate conditions for the six target SAR. This project contributed to the identification of critical habitat for Ausable River SAR.

Acknowledgments:

The authors would like to thank the many individuals from the Ausable Bayfield Conservation Authority and Fisheries and Oceans that participated in the project. Funding was provided by the Interdepartmental Recovery Fund (IRF) and the Department of Fisheries and Oceans' Species at Risk Program (SARCEP).

Table of Contents

Introduction

The Ausable River, located on the northern fringe of the Carolinian Zone in southwestern Ontario, supports diverse and unique aquatic fauna. At least 26 species of freshwater mussels, 83 species of fishes, and 21 species of reptiles have been found here, making it one of the richest watersheds of its size in Canada. Many are rare and 16 aquatic species have been designated by COSEWIC (Committee on the Status of Endangered Wildlife in Canada), including six mussels, seven fishes and three reptiles.

A general aquatic habitat assessment was completed for the Ausable River watershed in the high priority conservation zone where all Endangered and Threatened fishes and mussels have been found (past or present). This zone consists of three main areas: the Ausable River from its mouth to Hay Swamp, the Old Ausable Channel (OAC), and the lower reaches of the Little Ausable River (ARRT 2005). This project focused habitat survey methodologies on wadeable stream reaches of the Ausable River (main channel) region below the Hay Swamp at Highway 83 downstream to 'The Cut', as well as the lower regions of the Little Ausable River (Figure 1). This study area took in all or portions of four sub-watersheds within the Ausable River watershed – the Upper, Middle and Lower Ausable River sub-watersheds and the Little Ausable River sub-watershed. Targeted Endangered and Threatened species known to occur presently or historically within this region include: black redhorse (*Moxostoma duquesnei*), eastern sand darter (*Ammocrypta pellucida*), wavy-rayed lampmussel (*Lampsilis fasciola*), snuffbox (*Epioblasma triquetra*), northern riffleshell and kidneyshell (*Ptychobranchus fasciolaris*).

Habitat surveys were conducted based on a modified methodology that has been successfully employed within the Sydenham River to provide a geo-referenced, linear habitat model (Staton *et al.* 2000). Habitat characterization and assessment allowed for the delineation of habitats that meet the general requirements of the six target species at risk (SAR). Although not a specific target species, this project could also provide valuable habitat suitability data for the river redhorse (*Moxostoma carinatum*) (Special Concern) which may now be extirpated from the watershed. This project represents the next step in a logical progression towards the identification of critical habitat for the six Endangered and Threatened species. The two fishes and four mussels require specific habitats for survival. Loss of these characteristic habitats is one of the primary reasons for the decline of each of the species. Eastern sand darter seem to prefer slow moving water over fine sand substrates, in large streams or rivers (Holm 2001), whereas black redhorse favour moderate-sized, clear streams or rivers with fast moving water and sand, gravel or bedrock substrates (Mandrak & Casselman 2004). All four of the Endangered mussels prefer stable areas of fine gravel or sand substrates for burrowing, and swift flowing water (ARRT 2005).

A synthesis of all available background information compiled by the Ausable River Recovery Team (ARRT) in 2003 indicated the primary threats to SAR populations in the Ausable River basin are sediment loadings causing siltation and turbidity, and nutrient enrichment. Secondary threats include channel alterations/loss, alterations to the flow regime, toxic contaminants, thermal changes and exotic species (ARRT 2005). The most significant threat for the majority of SAR appears to be siltation and associated turbidity caused by sedimentation. The majority of rare fish and mussel species are sensitive to siltation of their habitat (Richter *et al.* 1997). Overall, the fish and mussel SAR found in the Ausable River appear to be impacted by similar threats. The major threat to eastern sand darter seems to be the siltation or loss of its preferred habitat (Holm 2001). Similarly, another study suggests that the success of black redhorse populations may be limited by siltation (Mandrak & Casselman 2004). Poor water quality, habitat destruction, siltation and exotic species have been identified as reasons for the decline of mussels in the Ausable River (ARRT 2005).

Previous work within the study area has focused on background surveys to determine the population status and range of the six Endangered and Threatened fishes and mussels known from these reaches. Research (funded by the Federal Interdepartmental Recovery Fund in 2004) on the fishes included an analysis relating in-stream characteristics to SAR distributions; however, the habitat characterizations were site-specific. Results from this research will be integrated into habitat assessments completed in 2005. Habitat assessments were identified as urgent actions in the recovery strategy for both the eastern sand darter and black redhorse. Such surveys will help identify habitat suitability/availability for these species throughout the watershed, which is a necessary step in the logical progression towards the identification of critical habitat for the two fish species as well as for the four co-occurring mussel SAR. Once critical habitat has been identified and designated for each species, long-term protection of their habitat through the SARA (*Species at Risk Act*) can be provided.

The main objectives of this habitat assessment study were to:

- Apply a refined habitat assessment methodology (Staton *et al.* 2000) to priority reaches of the Ausable River and the Little Ausable River;
- Use a global information system (GIS) linked habitat model to identify suitable habitats for the six SAR throughout the survey region;
- Define general habitat characteristics of the study area as it relates to the habitat requirements of SAR; and,
- Identify suitable habitat for the six SAR that have not been previously surveyed.

These objectives in turn will address the high priority recovery activities identified in the recovery strategy (ARRT 2005):

- Evaluate the distribution, quantity and quality of sand habitats (eastern sand darter);
- Evaluate the distribution, quantity and quality of fast water habitats (black redhorse); and,
- Conduct background and analytical research for the identification of critical habitat (four Endangered mussels).

Methods

Study Area

Habitat assessments were conducted on the Ausable River and the Little Ausable River between August 11 and November 1, 2005 (Figure 1, Table 1). The completed habitat assessment methodology was applied to wadeable reaches of the main channel of the Ausable River from the Highway 83 bridge near Exeter, downstream to the Cut, which is located just west of Parkhill. This surveyed section of the Ausable River took in a distance of approximately 119 km (Table 1). The lower reaches of river downstream of the Cut are deep and slow, and do not contain riffle habitat with coarser substrates required by the six target SAR, and so were not included. The Little Ausable River was surveyed from its mouth, where it joins the Ausable River, upstream to the Denfield Road near the village of Clandeboye. The segments surveyed on the Little Ausable took in a distance of approximately 9 km. Black redhorse and wavy-rayed lampmussel have recently been found in these lower reaches of the Little Ausable River.

<u>Habitat Assessment Surveys</u>

An aquatic habitat assessment methodology was developed by adapting methods used in the *Sydenham River Aquatic Habitat Survey* (Staton *et al.* 2000). Methods were adjusted from the Sydenham study so that the general habitat requirements of the six target fish and mussel SAR could be captured in the Ausable River study. In addition, guidance from a national critical habitat case study for the black redhorse (Mandrak & Casselman 2004 on-going) was also consulted.

The revised methodology was field-tested and modified as necessary to fit the local conditions in the Ausable River. River surveys were done in segments according to road crossings (Figure 1, Table 1). Sections of the Ausable River were surveyed with the use of a canoe starting at one bridge and paddling downstream to the next. The Little Ausable River was assessed by starting at the mouth and wading upstream from one road crossing to the next, as it was too shallow to use the canoe. The length of survey segments assessed each day ranged from approximately 3 km to 9 km.

Habitat assessments included information regarding stream morphology (composition of pools, riffles, runs), turbidity levels, channel characteristics (width and depth), substrate composition and condition, instream vegetation, bank stability/riparian habitat and impacted areas, such as cow pasture (refer to Table 2 for data definitions).

Table 1. Ausable River and Little Ausable River habitat survey segments (Aug.-Oct. 2005).

Date	Ausable River	Segment ID	Segment Length (km)
Oct 12/05	Hwy 83 to Huron St.	A	3.9
Oct 13/05	Huron St. to Kirkton Rd.	B	4.73
Sept 8/05	Kirkton Rd. to Crediton Rd.	C	3.04
Oct 25/05	Crediton Rd. to Crediton Sd Rd. (site of old bridge)	D	4.04
Oct 26/05	Crediton Sd. Rd. to Mt Carmel Rd.	E	4.83
Sept 12/05	Mt. Carmel Dr. to Adare Dr.	F	3.28
Sept 23/05	Adare Dr. to Mooresville Dr.	G	2.92
Sept 27/05	Mooresville Dr. to McGillvray Dr.	H	3.27
Oct 14/05	McGillvray Dr. to Ausable Dr.	I	3.48
Sept 2/05	Ausable Dr. to W. Corner Dr.	J	2.98
Sept 7/05	W. Corner Dr. to Elginfield Rd.	K	5.01
Aug 11/05	Elginfield Rd. to Ailsa Craig Park	L	4.58
Aug 15/05	Ailsa Craig Park to New Ont. Rd	L	included in Aug 11/05 distance
Aug 17/05	New Ont. Rd. to Cassidy Rd (Gravel Lane)	M	4.19
Aug 18/05	Cassidy Rd to Nairn Rd. (3 Ridge Bridge)	N	2.45
Aug 24/05	Nairn Rd. to Coldstream Rd.	O	4.51
Aug 26/05	Coldstream Rd. to Poplar Hill Rd.	P	4.93
Sept 28/05	Poplar Hill Rd. to Cameron Rd.	Q	4.93
Aug 30/05	Cameron Rd. to Springbank Rd. bridge	R	5.89
Aug 29/05	Springbank Rd. to Glasgow St.	S	5.53
Sept 13/05	Glasgow St. to Hwy 81	T	included in Aug 30/05 distance
Sept 14/05	Hwy 81 to Island Rd.	U	10.71
Sept 15/05	Island Rd. to River Rd.	V	included in Sept 13/05 distance
Sept 19/05	River Rd. to Hungary Hollow	W	3.5
Sept 21/05	Hungary Hollow to Rock Glen CA	X	5.46
Sept 22/05	Rock Glen CA to Liard Farm off Hwy 79	Y	9.13
Sept 30/05	Liard Farm (Hwy 79) to Hwy 7 (Elginfield Rd.)	Z	3.91
Oct 4/05	Hwy 7 to Tow Rd. (Old Iron Bridge/The Cut)	AA	8.1
	Total:		**119.3**
Date	**Little Ausable**	**Segment ID**	**Segment Length (km)**
Oct 31/05	Mouth (off Ausable Rd) to Maguire Rd.	BB	2.75
Nov 1/05	Maguire Rd. to Neil Rd.	CC	2.83
Oct 27/05	Neil Rd. to Denfield Rd.	DD	3.25
	Total:		**8.83**

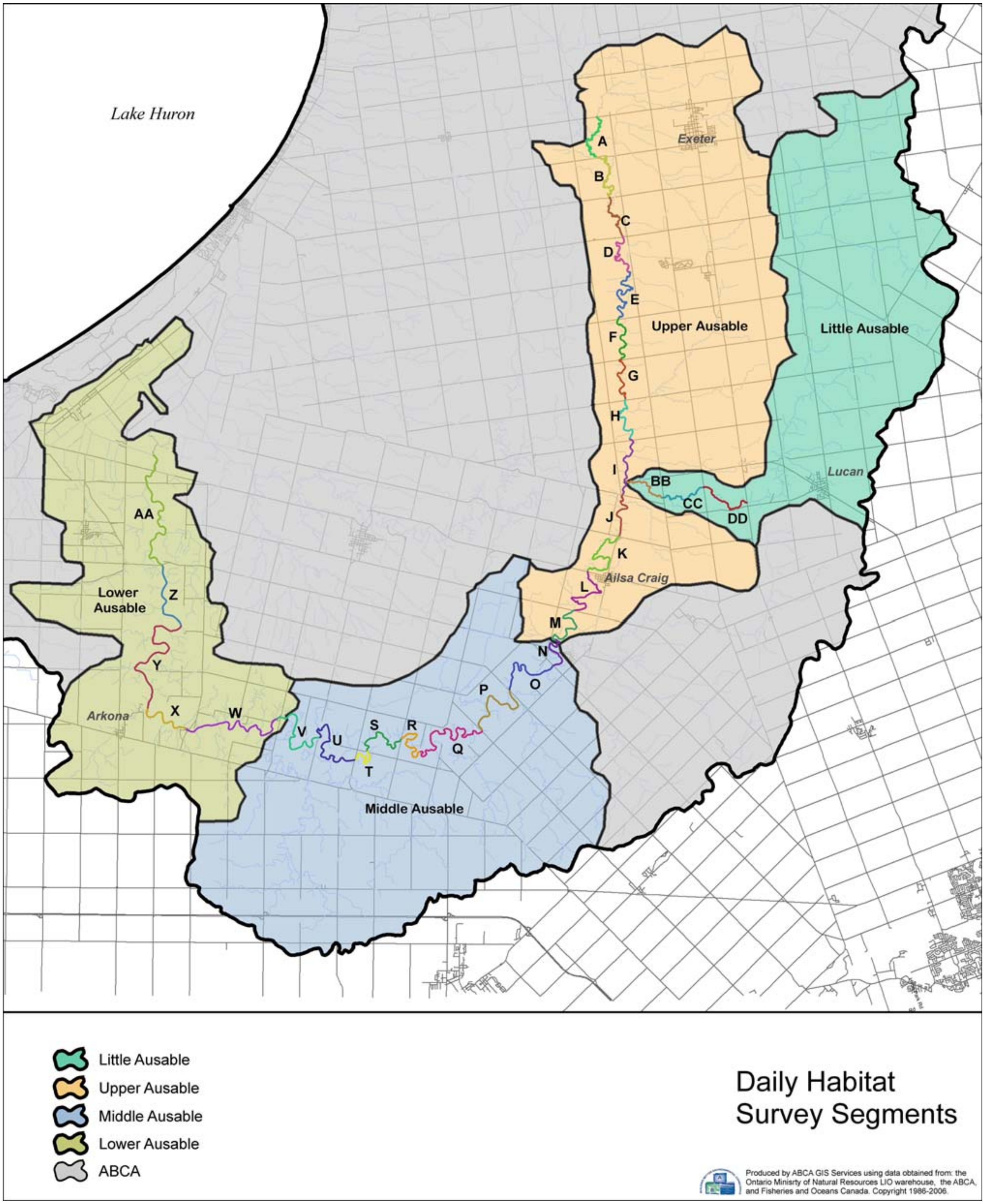


Figure 1. Segments surveyed by date and road crossing.

Table 2. Definition of habitat types noted in the Ausable River 2005 habitat assessment.

Stream Morphology	Defined by general stream velocity (m/s) and depth **Riffle** > 0.4 m/s **Run** 0.1 – 0.4 m/s **Pool** 0 – 0.1 m/s
Turbidity/Water Clarity	Defined by depth of clarity into the water column 0-25 cm **turbid** 0-40 cm **slightly turbid** > 40 cm **clear**
Width and Depth of Channel	Frequently estimated: width with canoe length as a guide and depth with paddles as a guide
Substrate Composition	Defined by percent composition of different substrate types/sizes (*Wentworth Scale*) **Clay** inorganic material with a greasy feel **Silt** inorganic material finer than sand **Sand** less than 0.3 cm in diameter - gritty **Gravel** between 0.3 and 2 cm in diameter **Pebble** between 2 and 8 cm in diameter **Cobble** between 8 and 25 cm in diameter **Boulder** > 25 cm in diameter **Bedrock** all exposed rock with no overburden **Detritus** organic material with large pieces i.e., sticks, leaves, dead plants **Muck** soft organic material made of silt/clay/organic material
Condition of Substrate in Riffle	Siltation: **heavy, moderate, light or none** Presence of *Cladophora*: **heavy, moderate, light or none**
Instream Vegetation	Presence or absence and description of emergent or submergent vegetation or algae
Bank Stability/Erosion	Description of stability Erosion: **none, light, moderate or severe**
Riparian Habitat/Shading	Description of riparian habitat and comment on shading.
River Impacts/Comments	Description of any river impacts noted along habitat survey segments.

Substrate composition was determined with the use of paddles where the river was too deep to get out of the canoe. However, the substrate in shallow areas could be determined visually. River depths were frequently measured and estimated with the use of 50 cm increments marked on the paddles. River width measurements were approximated using canoe length (5 m) as a guide. Other habitat characteristics that were recorded included: riparian land use and potential impacts, erosion and bank stability, riparian vegetation and macrophyte occurrence, shading and turbidity (water clarity). Various photos were taken during the surveying of each segment, depicting the stretch of river itself, and in some cases unique habitat characteristics. At the end of each section, the notes were reviewed by the surveyor and a habitat summary was written.

Notes on habitat characteristics made during the survey of each section were linked to coordinates generated with a Global Positioning System (GPS) unit (accuracy ~2 m). New coordinates (creating breaks in the stream segment) were taken whenever major changes in habitat or stream morphology were encountered (riffle, run or pool). Habitat changes were also recorded on an air photo, matching the appropriate section, as surveyors experienced some difficulty picking up satellites with the GPS in the early days of the survey. In these few cases, the air photos were relied on for the points of habitat change.

Geo-referenced habitat assessment data were then entered into the ABCA's ArcInfo GIS to create a linear, segmented aquatic habitat model. Quantitative site-specific habitat data (such as pebble counts, embeddedness), and species occurrence data collected in 2002 and 2004, were used to aid in interpreting habitat classes. The linear GIS habitat model was then used to map suitable habitats for the six SAR based on each species' general habitat preference. For example, substrate is an important determinant in the suitability of habitat for the four mussels and the eastern sand darter (Table 3). Together, with the current and historical SAR occurrence data, this mapping provides a starting point to determine critical habitat for these species.

The linear habitat model was analyzed at various scales of resolution for the four sub-watersheds within the study area. This analysis was supplemented with field notes from the 2005 habitat assessments, and site-specific habitat and/or species information collected in 2002 and 2004 surveys. This information was used to describe habitat conditions in the four sub-watersheds. An analysis of the habitat types and conditions as they relate to current and historical populations of SAR was also completed.

Suitable habitats for the six SAR were identified based on species preferences (Table 3) and these layers were overlain with recent (1998 – 2005) fish and mussel survey sites to determine priority areas that have not been adequately sampled. Sampling of these regions will be the focus of future work.

Table 3 – Ausable River SAR habitat preferences (taken from their respective COSEWIC status reports).

Species at Risk	COSEWIC Status	General Habitat Preferences
Eastern Sand Darter (*Ammocrypta pellucida*)	Threatened	Sandy bottoms of rivers, water can be clear or murky Currents can range from still to swift
Black Redhorse (*Moxostoma duquesnei*)	Threatened	Sand/gravel/bedrock substrate with minimal siltation, fairly strong current, riffle and pool areas of clear flowing waters
Northern Riffleshell (*Epioblasma torulosa rangiana*)	Endangered	Coarse sand and gravel with some cobble to firmly packed fine gravel in shallow riffle areas with swift current
Wavy-Rayed Lampmussel (*Lampsilis fasciola*)	Endangered	Steady flows/clear water in and around riffle areas in gravel or sand often stabilized with cobble or boulders
Snuffbox (*Epioblasma triquetra*)	Endangered	Shallow riffles with clear, swift-flowing water and firm coarse sand and gravel substrates
Kidneyshell (*Ptychobranchus fasciolaris*)	Endangered	Firmly packed coarse gravel and sand in moderately strong current, often near beds of aquatic vegetation

Geo-referenced habitat data were entered into ArcInfo GIS to create a linear, segmented aquatic habitat model. The linear GIS habitat model was then queried to display suitable habitats for the six SAR based on specific criteria for each species' habitat preference (Table 4). Current and historic SAR occurrence data were then overlain with the suitable habitat data to create maps for each of the species. These maps show where the SAR have been found previously, and where their ideal habitat is occurring according to the 2005 aquatic assessment study results. This mapping will provide a starting point for determining critical habitat for the six SAR.

The following criteria (Table 4) were used, based on the opinions of species experts and research previously conducted, to define which areas were considered suitable habitat. Scott Reid (pers. comm., 2006) provided expertise on black redhorse habitat requirements, and in addition a critical habitat case study on black redhorse was also consulted (Mandrak & Casselman 2004). Research conducted by Holm (2001) provided background information on eastern sand darter habitat. Mussel work completed by Metcalfe-Smith (2007) in the Sydenham River watershed was used to help define the parameters of suitable mussel habitat for the four mussel species. In addition, COSEWIC status reports that were available for the targeted species were also consulted.

General habitat preferences were refined and detailed to determine more specific requirements. Substrate composition, water clarity and stream morphology were the key determinants in identifying the suitable habitat for each of the six SAR.

Table 4 - Refined preferred habitat for the six targeted SAR. BRH – black redhorse; ESD – eastern sand darter; KS – kidneyshell; NRS – northern riffleshell; SB – snuffbox; WRLM – wavyrayed lampmussel.

SAR Habitat Suitability Criteria			
	Substrate Composition	**Clarity**	**Morphology**
BRH (primary habitat – red)	Boulder + Cobble + Gravel: > 60% & Substrate condition = none, low to moderate sedimentation	Slightly turbid - clear	Riffle
BRH (secondary habitat – green)	Boulder + Cobble: < 40%	Slightly turbid - clear	Runs and Pools
ESD grey	0-20% sand	n/a	n/a
ESD (tertiary habitat – orange)	21-40% sand	n/a	n/a
ESD (secondary habitat – green)	41-50% sand	n/a	n/a
ESD (primary habitat – red)	51-70% sand	n/a	n/a
KS, NRS, SB	Sand: > 15% [Gravel + Pebble]: > 20%	n/a	Riffle Run
WRLM (primary habitat – red)	Sand: > 15% [Gravel + Pebble]: > 20%	Clear	Riffle Run
WRLM (secondary habitat – green)	Sand: > 15% [Gravel + Pebble]: > 20%	Slightly turbid	Riffle Run

Results & Discussion

Overview Description of Habitat on a Sub-watershed Basis

The results of the 2005 survey indicated that habitat differed throughout the study region and specifically within each of the four sub-watersheds. The habitat assessments quantified these variations, which helped to explain why or why not certain river areas may provide suitable habitat for the SAR. Substrate type, turbidity and morphology were the key determinants in determining suitable habitat for each of the target SAR. Results from the study are summarized as percentages for comparison of these three key determinants between sub-watersheds (Tables 5 – 7). A site specific fisheries study conducted in 2004 found that substrate particle sizes were generally medium-sized in the Ausable headwaters, very fine in the Hay Swamp, moderately large through the Upper Ausable River, small through the Ailsa Craig-Middle Ausable area, large through the Ausable Gorge and small again downstream of the Gorge in the Lower Ausable (Stewart *et al.* 2005). Overall, the present study found similar results although it was a much more extensive survey, covering the entire length of the stream channel. It should be noted that some of the surveys were completed in the fall when the Ausable River typically appears less turbid. Stewart *et al.* (2005) found that total suspended solid concentrations decreased significantly from summer to fall (July to November).

Upper Ausable Sub-Watershed

The Upper Ausable sub-watershed was found to have finer substrates overall, with a high percentage of cobble (Table 5). Turbidity levels were mainly in the slightly turbid category (Table 6). Overall, this sub-watershed was comprised relatively of more pools, some runs and fewer riffles (Table 7).

Little Ausable Sub-Watershed

The Little Ausable sub-watershed had large, coarser substrate; cobble was the dominant substrate found, with boulder being relatively common as well (Table 5). Turbidity levels in the entire study stretch of the Little Ausable River were very low, with nearly all measurements falling into the ‘clear’ category (Table 6). Channel morphology in this sub-watershed was comprised primarily of pool areas, with numerous riffles and fewer runs (Table 7).

Middle Ausable Sub-Watershed

The Middle Ausable sub-watershed had the largest percentage of clay compared to the other three sub-watersheds, but also contained gravel, pebble and cobble (Table 5). Turbidity levels in the Middle Ausable were very high ; no clear sections were noted. The substrate type in this stretch of the Ausable River, in particular the clay areas, undoubtedly play a role in the high level of turbidity (Table 6). This portion of the study area was comprised mainly of pools, with some runs and few riffles (Table 7).

Lower Ausable Sub-Watershed

The Lower Ausable sub-watershed contained more sand and gravel compared to other sub-watersheds, but also had a substantial percentage of larger substrate in the form of cobble and boulder (Table 5). Turbidity levels in the Lower Ausable were generally high; however, a section of clearer water was present in the Ausable Gorge (Table 6). Many pools were noted in the Lower Ausable reach, but there were also a substantial number of runs. Riffles were fewer in this sub-watershed (Table 7).

Table 5. Summary of substrate composition (%) for Ausable River sub-watersheds.

Sub-watershed	Detritus	Muck	Clay	Silt	Sand	Gravel	Pebble	Cobble	Boulder
Little Ausable	0.2	0	0.1	3.2	14.1	13.4	11.9	39.1	18.0
Upper Ausable	5.9	2.3	4.1	10.3	17.4	15.7	13.1	25.9	5.4
Middle Ausable	0	0.1	8.0	1.0	6.0	25.7	21.1	31.2	6.9
Lower Ausable	0	0	2.7	5.2	23.1	22.6	15.7	21.9	8.9

Table 6. Water clarity (% of reaches with clear, slightly turbid and turbid waters) within surveyed Ausable River sub-watersheds.

Sub-watershed	Clear	Slightly Turbid	Turbid
Little Ausable	98.9	1.1	0
Upper Ausable	12.8	47.8	39.4
Middle Ausable	0	0	100
Lower Ausable	0	13.7	86.3

Table 7. Channel morphology (% riffle, run, pool) within surveyed Ausable River sub-watersheds.

Sub-watershed	Pool	Riffle	Run
Little Ausable	56.5	37.1	6.5
Upper Ausable	68.4	10.5	21.1
Middle Ausable	59.9	10	30.1
Lower Ausable	55.4	16.8	27.9

Analysis of Suitable Habitat and SAR Occurrence by Sub-watershed

Fishes

Current and historical black redhorse and eastern sand darter occurrence data showed areas within the targeted study region where the Threatened fish species have been previously documented (Figures 2 – 4). The black redhorse has been found at only one location, in August 2002, by Fisheries and Oceans Canada (ARRT 2005). Four adults were captured via electrofishing in the Little Ausable River sub-watershed (Figure 2). Similarly, there is only one record of the eastern sand darter from the watershed – a single adult was seined from the Ausable River, in the upper sub-watershed, just west of Ailsa Craig, in May 1928 (Hubbs & Brown 1929) (Figure 3). The mapping shows species occurrence and highlights what the study found to be their preferred habitat conditions, based on specific species preference queries (Figures 2 – 4, Table 4).

Black Redhorse

The Upper Ausable sub-watershed was found to have some desirable black redhorse habitat (Figure 2) based on preferences outlined in Table 4. Habitat suitability was divided into primary and secondary categories based on what research has determined are the specific requirements the species has (Table 4). Approximately 4% of the Upper Ausable sub-watershed contains primary habitat for black redhorse (Table 8). This would include riffle habitat with coarser substrates and high water clarity. This sub-watershed also contained approximately 28% secondary habitat (refer to Table 8), including pool and run areas that again have high water clarity with less coarse substrate. Black redhorse prefer well developed riffles with coarse substrates of boulder and cobble (primary habitat), but also require adjacent pools and runs with smaller substrates (secondary habitat) for feeding and resting (Scott Reid, pers. comm. 2006). The Upper Ausable provided a small amount of desirable black redhorse habitat. Larger areas of primary black redhorse habitat may not be present in the Upper Ausable due to the high percentage of finer substrates (Table 5) and the lower percentage of riffles (Table 7). Black redhorse are also less tolerant of elevated levels of turbidity and siltation (Scott Reid, pers. comm. 2006). There are few areas in the sub-watershed which provide the appropriate combination of suitable substrate and high water clarity. The upstream reaches of the Upper Ausable sub-watershed contains a substantial amount of secondary habitat (Figure 2); however, primary habitat (i.e. riffles) are lacking in these reaches making overall habitat conditions less desirable for black redhorse.

Table 8. Quantity (%) of suitable black redhorse habitat in Ausable River sub-watersheds.

Sub-watershed	Primary	Secondary	Not Desirable
Little Ausable	31.5	6.5	62
Lower Ausable	3.7	0	96.3
Middle Ausable	0	0	100
Upper Ausable	4.2	27.5	68.3

The Little Ausable sub-watershed provided, by far, the most suitable habitat for the black redhorse (Figure 2). This is also the sub-watershed where four black redhorse were captured in 2002. The substrate was mainly very course with a high percentage of boulder and cobble (Table 5), water clarity was extremely high (Table 6) and it contained numerous pools and riffles (Table 7). Appropriate adjacent secondary habitat was also available in some areas.

The Middle Ausable sub-watershed was found to provide no suitable habitat for black redhorse (Figure 2, Table 8). This is not surprising, given the high turbidity levels, lack of riffles and smaller substrate found in this region (Tables 5 – 7).

The Lower Ausable sub-watershed contained a small area of primary black redhorse habitat (Figure 2, Table 8). This area, near Arkona in what is known as the Ausable Gorge, had larger substrate, clearer water and a good number of riffles (Tables 5 – 7). However, it had no appropriate secondary habitat, due to the lack of finer substrates in pools and runs. There were large areas in the Lower Ausable that did not contain any suitable black redhorse habitat, due in large part, to the fact that the sub-watershed is mainly very turbid.

Eastern Sand Darter

The Upper Ausable sub-watershed was found to have potential eastern sand darter habitat based on preferences outlined in Table 4 (Figure 3). The sole criterion used to determine preferred eastern sand darter habitat was the amount of sand present in the substrate. Eastern sand darters require a very high percentage of sand substrate. In a 2001 study done in the Grand River, eastern sand darters were only found at sites containing a high proportion (40%) of sand substrate (Holm 2001). In fact, the majority of eastern sand darters found in the Grand River were at sites containing a much higher proportion of sand (75 – 80%) (Holm 2001).

Habitat categories were separated into primary, secondary and tertiary classes based on the amount of sand present (Figure 3, Table 4). The upper reaches of the Upper Ausable sub-watershed seem to contain the most sand substrate, thereby providing the most suitable eastern sand darter habitat (Figure 3, Table 9). This sub-watershed primarily contains areas composed of 21 – 40% sand. However, there are a few areas containing even higher percentages of sand (Figure 3). Some areas in the Upper Ausable were not highlighted as suitable habitat due to lack of sandy substrates. The only eastern sand darter caught in the Ausable River (in 1928 near Ailsa Craig) was captured in the Upper Ausable sub-watershed in an area now found to have a lower percentage of sand substrates (Figure 3).

Table 9. Quantity (%) of suitable habitat for eastern sand darter in each sub-watershed.

Sub-watershed	**Primary** (51-70% sand)	**Secondary** (41-50% sand)	**Tertiary** (21-40% sand)	**Less than 20% Sand**
Little Ausable	0	1.9	19	79.1
Lower Ausable	0	21.1	19	59.9
Middle Ausable	0	0	0.4	99.6
Upper Ausable	1.5	6.3	20.9	71.3

The Little Ausable sub-watershed contained some sandy habitat, mainly in the 21 – 40% range, with one area containing 41 – 50% sand (Figure 3, Table 9). Overall, most of this sub-watershed fell into the 20% or less category (Table 9). This sub-watershed has a higher percentage of large substrate in the form of cobble and boulder (Table 5).

The Middle Ausable sub-watershed (Figure 4) was found to have very little eastern sand darter habitat (Table 9). Most of the river here was found to be in the 20% sand or less category. There were a few small areas in the 21 – 40% sand category, but generally this sub-watershed had higher percentages of clay, gravel, pebble and boulder, with little sand (Table 5).

The Lower Ausable sub-watershed had a large area of sandy habitat suitable for eastern sand darter (Figure 4). It had a high percentage of secondary habitat (41 – 50% sand) at the downstream most reaches of the study area, and also a fairly substantial section of tertiary habitat (21 – 40% sand) (Table 9). Areas not highlighted as suitable habitat did not have suitable levels of sand substrate.

Overall, the Ausable River has limited areas with a high percentage of sand. Thus, future searches for the elusive eastern sand darter in the Ausable River will need to target the limited reaches of available habitat.

Mussels

Current and historical SAR mussel occurrence data showed areas within the targeted study region where the four Endangered mussels have been previously found. Species occurrence data were collected by DFO and ABCA from 1993 to 2005. The following maps depict locations where kidneyshell, northern riffleshell, snuffbox and wavy-rayed lampmussel were found in various conditions (fresh shells, weathered shells, live specimens). The mapping shows species occurrence and highlights what the study found to be their most preferred habitat conditions based on specific species preference queries (Figures 5 – 8, Table 4). Kidneyshell, northern riffleshell and snuffbox were grouped together because they share similar habitat preferences (Table 4).

Kidneyshell, Northern Riffleshell & Snuffbox

The Upper Ausable sub-watershed was found to contain about 10% of suitable habitat for the kidneyshell, northern riffleshell and snuffbox (Figures 5 – 7, Table 10). The same suitable habitat criteria were used for the kidneyshell, northern riffleshell and snuffbox (Table 4). This included a high percentage of finer substrate (sand, gravel and pebble) in riffle-run areas. Water clarity was not considered as part of the suitable habitat for these particular species, based on previous research completed on these mussels (Dextrase *et al*. 2003). Suitable habitat was evident primarily in the middle section of the Upper Ausable sub-watershed (Figures 5 – 7). Stretches containing a high percentage of fine substrates combined with riffle-run areas are those which were highlighted (Tables 5, 7). Areas not highlighted as suitable habitat were those that did not contain the right combination of sand, gravel and pebble. Live northern riffleshell and kidneyshell were found in the areas of suitable habitat, whereas no live snuffbox have been found to date in this sub-watershed.

Table 10 – Quantity (%) of suitable habitat for the kidneyshell, northern riffleshell and snuffbox in each sub-watershed.

Sub-watershed	Suitable Habitat	Not Suitable Habitat
Little Ausable	4.4	95.6
Lower Ausable	31.6	68.4
Middle Ausable	4.6	95.4
Upper Ausable	9.7	90.3

The Little Ausable sub-watershed was found to contain about 4% suitable habitat for the three species (Table 10). Kidneyshell, northern riffleshell and snuffbox have not been found (live specimens, fresh shells or weathered shells) in the Little Ausable study area (Figures 5 – 7). This sub-watershed primarily contains substrates composed of large substrates in the form of cobble and boulder, and has a very low amount of finer substrates such as sand and gravel that are preferred by these species (Table 5).

The Middle Ausable sub-watershed also had very little suitable habitat, with only 5% identified (Table 10). This was due to the absence of appropriate substrate that the mussels require. Overall, the Middle Ausable had the highest percentage of clay and a substantial amount of cobble, with the sand and gravel component being lower (Table 5). This sub-watershed was also shown to have the lowest percentage of riffles, which the mussels prefer, and it has a high percentage of pool habitat, which is not part of the mussels' preferred criteria (Table 7). However, there are small areas containing habitat that may be appropriate for the three SAR mussels. Live northern riffleshell and live kidneyshell have both been found at uppermost reaches of the sub-watershed near Nairn (Figures 5, 6). Live snuffbox have not been found at this location, but a weathered shell was noted (Figure 7).

The Lower Ausable sub-watershed contained the highest percentage of suitable habitat for the kidneyshell, northern riffleshell and snuffbox (Table 10). Sand, gravel and pebble substrates were found to be abundant in this sub-watershed (Table 5). The Lower Ausable also contained a reasonably high amount of riffle-run areas (Table 7). No live kidneyshell or northern riffleshell have been found in this sub-watershed; however, one live snuffbox has been found near the most downstream reaches of the study area (Figures 5 – 7). The Lower Ausable contains a large amount of suitable habitat, with the exception of the most downstream end of the study region (Figures 5 – 7). This was due, in large part, to the deep pooled nature of this area of the river.

Wavy-Rayed Lampmussel

The Upper Ausable sub-watershed was found to contain very small amounts of primary and secondary wavy-rayed lampmussel habitat (Figure 8, Table 11). The wavy-rayed lampmussel prefers substrates composed primarily of sand, gravel and pebble, in riffle-run areas, but it differs from the other three targeted SAR mussels, in that it prefers clear water and is not as tolerant of turbidity (Metcalfe-Smith *et al*. 2002). Habitat suitability for the wavy-rayed lampmussel was divided into primary and secondary categories based on water clarity. Primary habitat refers to clear water and secondary habitat refers to slightly turbid water (Table 4). The Upper Ausable contains less than 1% of primary habitat and 5% secondary habitat for this species. Water clarity was a major limiting factor with respect to suitable habitat in the Upper Ausable, as a large portion of the Upper Ausable was found to be turbid (Table 6). Although almost half of the sub-watershed had slightly turbid waters, much of these reaches were not identified as secondary habitat due to a limited amount of suitable substrates (i.e., sand and gravel). Live wavy-rayed lampmussel have been found in this sub-watershed in areas that were categorized as turbid (Figure 8). In fact, the live records do not overlap with what was identified as primary suitable habitat, perhaps indicating that the species is more tolerant of turbidity than previously believed. It may also be that these records represent the remnants of a declining population.

Table 11. Quantity (%) of suitable habitat for wavy-rayed lampmussel in the Ausable River sub-watersheds.

	Primary Habitat	Secondary Habitat	Not Suitable
Little Ausable	4.4	0	95.6
Lower Ausable	0	5.5	94.5
Middle Ausable	0	0	100
Upper Ausable	0.4	5.0	94.5

The Little Ausable sub-watershed was found to contain very little primary habitat, and no secondary habitat (Table 11). Only one live animal has ever been found in this sub-watershed. Secondary habitat, which includes slightly turbid water, is virtually non-existent in the Little Ausable sub-watershed, as turbidity levels in this area are almost zero (Table 6). Although water clarity in the Little Ausable is ideal for wavy-rayed lampmussel, the substrate is not. This species requires sand and gravel, and overall, the Little Ausable has a far greater composition of coarser substrate such as cobble and boulders (Table 5).

The Middle Ausable sub-watershed did not contain suitable habitat for the wavy-rayed lampmussel (Table 11). The entire sub-watershed is very turbid (Table 6), there are far more pools than riffles (Table 7), and substrate is somewhat coarser and contained more clay than any other sub-watershed (Table 5). Records of live specimens and fresh shells were found in the uppermost reaches of this sub-watershed, but these records did not overlap with any suitable habitat identified by this study as a result of high turbidity levels (Figure 8).

The Lower Ausable sub-watershed contains approximately 6% secondary habitat and no primary habitat (Figure 8, Table 11) due to high levels of turbidity (Table 6). Suitable habitat for this species was identified in areas of better water clarity (only slightly turbid in some areas in the Lower Ausable) and the presence of appropriate substrates (Table 4). Although there are no records of wavy-rayed lampmussel from the Lower Ausable, it appears that some suitable habitat (secondary) is present.

Identification of Suitable Survey Sites for Future Work

Based on the results of this study, there are several reaches with suitable habitat that have not been sampled, or not been sampled adequately for the six target SAR. Based on habitat study field notes and Figures 2 – 8, showing suitable habitat areas, future sampling areas with the greatest potential were identified on Figures 9 – 16. These maps also show where previous sampling has taken place, and where target species have been found, to aid in the identification of sites for future work.

Black Redhorse

There are a few areas in the Upper Ausable sub-watershed (Figure 9) that appear suitable for black redhorse. The area immediately upstream and downstream of the Little Ausable River's outlet had the appropriate substrate and water clarity to provide primary habitat, and should be investigated further. Given that black redhorse have been captured near the mouth of the Little Ausable River, they may be moving into the main Ausable River. This area of the study region was recorded in the field notes as having coarse substrate with numerous riffles and runs. High levels of cobble and boulder substrates were present, and water was noted as being extremely clear.

The Little Ausable sub-watershed (Figure 9) provides primary and secondary habitat. Given that black redhorse have been collected here (DFO 2002), and that these reaches contain favourable habitat (very clear water and coarse substrate), this area should be targeted for further sampling.

The Lower Ausable sub-watershed (Figure 10) was also found to contain habitat that should be investigated for the presence of black redhorse. The Ausable Gorge area near Arkona (Figure 10), which has not been surveyed, was highlighted as being appropriate for redhorse species. The primary habitat identified was noted to have a steeper gradient creating many riffle-run areas (specifically, runs were noted to be deep and fast-flowing), good water clarity and large substrate.

Eastern Sand Darter

There are a few key areas that need to be further explored in the Upper Ausable sub-watershed for eastern sand darter (Figure 11). There are reaches with a substantially high sand content. Sections of the river that contained tertiary, secondary and primary habitat between Crediton Road and Adare Drive were noted to have almost continuous sand substrates in some reaches.

In the Little Ausable sub-watershed there is a potential sampling area that contains some secondary and tertiary levels of sand substrate upstream of the Little Ausable's outlet (Figure 11). Sand was noted in some of the pooled areas in the river.

In the Lower Ausable sub-watershed there were also reaches that contained a high percentage of sand substrate, that have not yet been investigated for the eastern sand darter (Figure 12). Areas near the downstream most reaches of the study region were identified on the mapping, and field notes documented that sand was the most prevalent substrate, and that it was evident on and near the banks of the river as well as the riverbed.

Kidneyshell, Northern Riffleshell & Snuffbox

The Upper Ausable sub-watershed has numerous areas that were highlighted as suitable habitat for these three mussel species (Figure 13). In the Mount Carmel Drive to Adare Drive region, substrate was noted to contain an abundance of sand, gravel and live animals. Other appropriate sites were flagged as we moved downstream closer to Ailsa Craig (Figure 13). In particular, the area between Ausable Drive and West Corner Drive was noted to have high amounts of sand and gravel, with riffle areas containing good mussel habitat.

The Little Ausable sub-watershed (Figure 13) had some suitable habitat that has not been sampled. There are areas with suitable substrate that could be further investigated. Areas containing sand and gravel that would be appropriate mussel habitat were noted.

The Middle Ausable sub-watershed had some areas of suitable target mussel habitat, but not a substantial amount (Figure 14). These small sections could be further investigated.

The Lower Ausable sub-watershed (Figure 14) in the area between Arkona and Elginfield Road had a large amount of suitable habitat that should definitely be investigated further. It was noted that the highlighted areas contained abundant sand and gravel.

Wavy-Rayed Lampmussel

The Upper Ausable sub-watershed had several small areas of primary and secondary habitat in the vicinity (upstream and downstream) of Mount Carmel Drive (Figure 15). Appropriate substrate and clear water conditions for the wavy-rayed lampmussel were noted. Field notes describe the stretch downstream of Mount Carmel Drive as containing very good mussel habitat in terms of substrate composition. There were sites flagged near the outlet of the Little Ausable River where water clarity is high. Areas of appropriate wavy-rayed lampmussel habitat were also found upstream of Ailsa Craig. An abundance of sand and gravel were noted throughout this stretch.

The Little Ausable sub-watershed had a few areas that were identified as appropriate sampling sites for wavy–rayed lampmussel (Figure 15). Limited areas of sand and gravel were noted; however; much of the substrate is coarse in this sub-watershed.

A section in the Lower Ausable sub-watershed area near Arkona, was flagged to have some secondary habitat that should be further investigated (Figure 16). Water clarity was slightly clear and substrate was sandy with some gravel in areas through this stretch.

Conclusions

Habitat characterization and assessment completed as part of this study allowed for the delineation of habitats that met the general requirements of the six target SAR in each of the four sub-watersheds. The two fishes and four mussels require specific habitats for survival, and degradation of these habitats is through to be one of the primary reasons for the decline of these species. In particular, siltation and turbidity are considered the primary threats to the health of aquatic SAR and their habitat in the Ausable River (ARRT 2005).

These surveys have identified areas of habitat suitability and availability for the six SAR throughout the study region. The identification of habitat suitability and availability has in turn highlighted certain areas that have not been adequately or previously sampled for the targeted species. These areas will be the focus of future work.

Overall, it appears that the lack of a substantial combination of sand, gravel and pebble in riffle-run areas, was a limiting factor in habitat availability for the northern riffleshell, kidneyshell and snuffbox. These same factors also limited the amount of suitable habitat for wavy-rayed lampmussel habitat. In addition, the wavy-rayed lampmussel was found to be even further limited, and to have even less suitable habitat available due to its preference for clear water which are very limited within the study area.

Similarly, suitable habitat for black redhorse was also confined to limited areas with low turbidity and clearer water. In the case of the eastern sand darter, sand content was the crucial factor in determining areas of suitable habitat. There were relatively few areas found within the study region that contained large quantities of sand substrate, thus limiting suitable habitat that would be attractive to the eastern sand darter.

The results of this study indicate that the Ausable River watershed has potential to provide suitable habitat for the six targeted SAR. It is also evident that there are areas still unexplored in the watershed that may be inhabited by fish and mussel SAR. In general, substrate type and turbidity seem to be the limiting factors in available suitable habitat for the fishes and mussels. Turbidity and siltation may be responsible for the decline of these fishes and mussels, given each of the six SAR species are sensitive to increased sedimentation. Future fish and mussel surveys are needed to determine if species are present in these suitable habitats. Furthermore, upon confirmation of the distribution and abundance of these SAR, the Ausable River Recovery Team will need to further investigate their habitat stressors.

Recommendations

There is a definite need to conduct surveys for fish and mussel species in those regions found by this study to provide suitable habitats that have not been adequately sampled.

SAR Mussels

It is strongly recommended that mussel surveys be conducted in the Upper and Lower Ausable sub-watersheds for the northern riffleshell, kidneyshell and snuffbox. Potential suitable habitat exists in the Little Ausable and Middle Ausable sub-watersheds, however these areas have less suitable habitat than the Upper and Lower Ausable sub-watersheds.

It is recommended that the less turbid areas of the Upper and Little Ausable sub-watersheds be surveyed for wavy-rayed lampmussel. The Lower Ausable also contained some stretches of clear water that could be investigated for the presence of wavy-rayed lampmussel.

SAR Fishes

It is strongly recommended that surveys be conducted in particular areas of the Upper Ausable sub-watershed and in the Little Ausable sub-watershed for black redhorse. Given that the species has been found at one location on the Little Ausable River and that water clarity is high in these areas, it is likely that black redhorse may be present at additional locations within similar reaches. The Ausable Gorge area, found in the Lower Ausable sub-watershed, provides clear water and coarse substrate, and should, therefore, also be investigated for black redhorse.

It is strongly recommended that areas of high sand content in the Upper and Lower Ausable sub-watersheds be investigated for eastern sand darter.

In general, it is recommended that Beneficial Management Practices (BMPs), such as the planting of riparian vegetation or fencing livestock from waterways, and other stewardship activities be promoted and implemented with local watershed landowners. These kinds of activities would help to prevent sedimentation leading to turbidity in the high priority conservation zone where all Endangered and Threatened fishes and mussels have been found. These BMP actions have been recommended as part of the Ausable River Recovery Strategy and would greatly aid in decreasing sediment and nutrient inputs.

References

ARRT (Ausable River Recovery Team). 2005. Recovery Strategy for Species at Risk in the Ausable River: An Ecosystem Approach, 2005-2010. Draft recovery strategy submitted to RENEW Secretariat.

Dextrase, A., K. Barrett, S. Staton, D. Zanatta, J. Metcalfe-Smith, M. Nelson, T. Heiman, D. McGoldrick. 2003. Species at Risk in the Ausable River Watershed DRAFT. Ontario.

Holm, E. and N. E. Mandrak. 1994. COSEWIC status report on the eastern sand darter *Ammocrypta pellucida* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa.

Holm, E. 2001. The eastern sand darter in the Grand River, Ontario. Centre for Biodiversity and Conservation Biology, Royal Ontario Museum. Toronto, Ontario.

Hubbs, C.L. and D.E.S. Brown. 1929. Materials for a Distributional Study of Ontario Fishes. Transactions of the Royal Canadian Institute, Vol. XVII, Part 1. University of Toronto Press. Toronto, Ontario.

Mandrak, N.E. and S. Casselman. 2004. Black Redhorse (*Moxostoma duquesnei*) Critical Habitat Case Study. Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada. Burlington, Ontario.

Mandrak, N.E. and S.M. Reid. 2005. COSEWIC status report on the black redhorse *Moxostoma duquesnei* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa.

Metcalfe-Smith, J.L. and D.J. McGoldrick. 2002. Update on the Status of the Wavy-rayed Lampmussel (*Lampsilis fasciola*) in Ontario waters. Aquatic Ecosystem Impacts Research Branch, National Water Research Institute. Burlington, Ontario.

Metcalfe-Smith, J.L., D.J. McGoldrick, D.T. Zanatta and L.C. Grapentine. 2007. Development of a Monitoring Program for Tracking the Recovery of Endangered Freshwater Mussels in the Sydenham River, Ontario. WSTD Contribution No. 07-510.

Metcalfe-Smith and D.T. Zanatta. 2003. COSEWIC status report on the kidneyshell *Ptychobranchus fasciolaris* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa.

Nelson, M., M. Veliz, S. Staton and E. Dolmage. 2003. Towards a Recovery Strategy for Species at Risk in the Ausable River: Synthesis of Background Information. Ausable Bayfield Conservation Authority and Fisheries and Oceans Canada. Ontario.

Reid, Scott. 2006. Aquatic Species at Risk Recovery Planning Biologist, Ontario Ministry of Natural Resources, personal communication.

Richter, B.D., D.P. Braun, M.A. Mendelson, and L.L. Master. 1997. Threats to imperilled fresh water fauna. Conservation Biology. 11: 1081-1093.

Staton, S., D. Woolnough and K. McNichols. 2000. Sydenham River Aquatic Habitat Survey. National Water Research Institute Burlington and University of Guelph. Ontario.

Stewart J., M. Veliz, K. Killins and S. Staton. 2005. Distribution and Habitat Characteristics of SAR Fishes in the Ausable - 2004. Ausable Bayfield Conservation Authority and Fisheries and Oceans Canada. Ontario.

Watson E.T., J.L. Metcalfe-Smith and J. Di Maio. 2002. COSEWIC status report on the snuffbox *Epioblasma triquetra* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa.

Figures

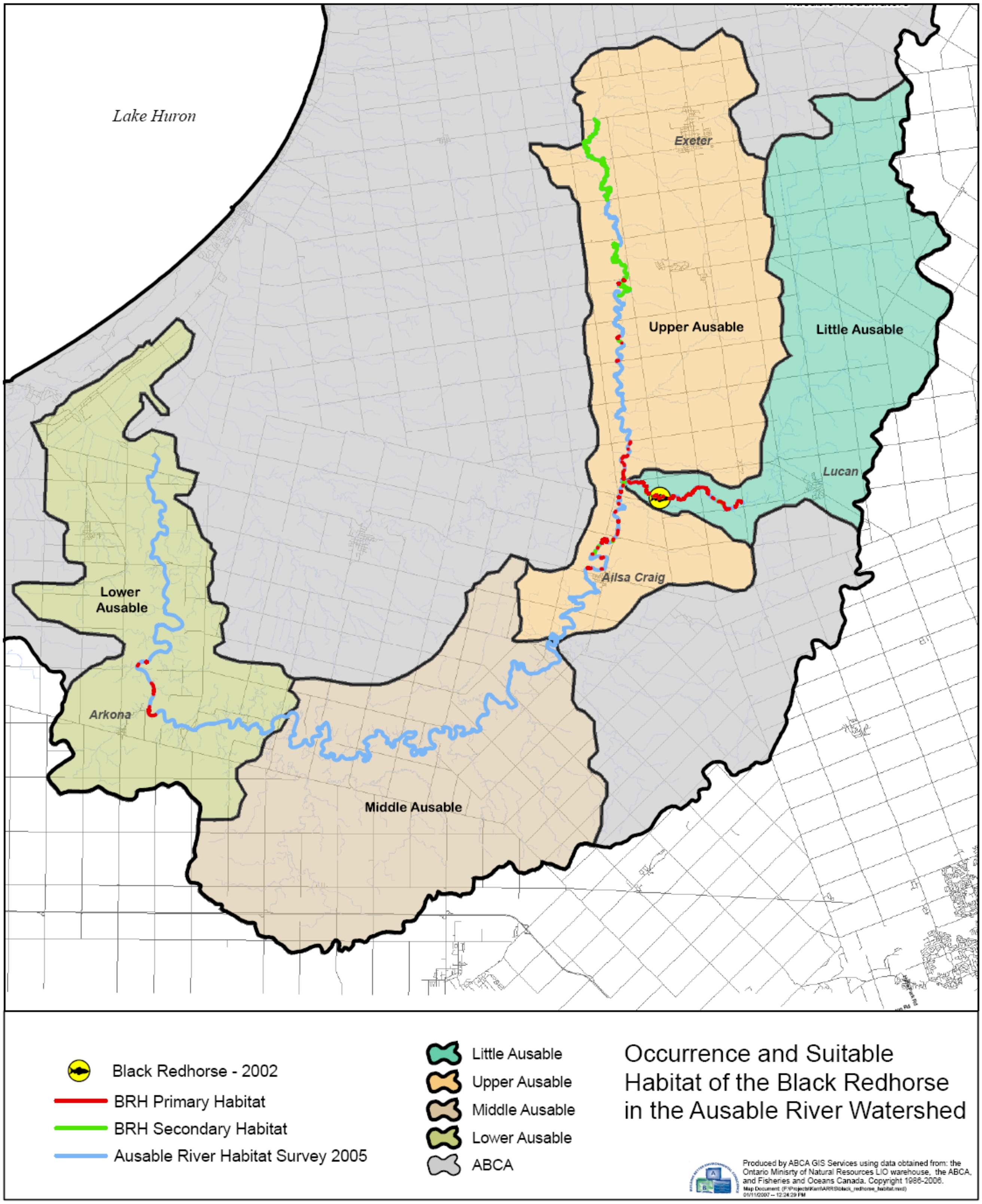

Lake Huron
Exeter
Upper Ausable
Little Ausable
Lucan
Ailsa Craig
Lower
Ausable
Arkona
Middle Ausable
Black Redhorse - 2002
BRH Primary Habitat
BRH Secondary Habitat
Ausable River Habitat Survey 2005
Little Ausable
Upper Ausable
Middle Ausable
Lower Ausable
ABCA
Occurrence and Suitable
Habitat of the Black Redhorse
in the Ausable River Watershed
Produced by ABCA GIS Services using data obtained from: the
Ontario Minisrty of Natural Resources LIO warehouse, the ABCA,
and Fisheries and Oceans Canada. Copyright 1986-2006.
01/11/2007 -- 12:24:29 PM

Figure 2.

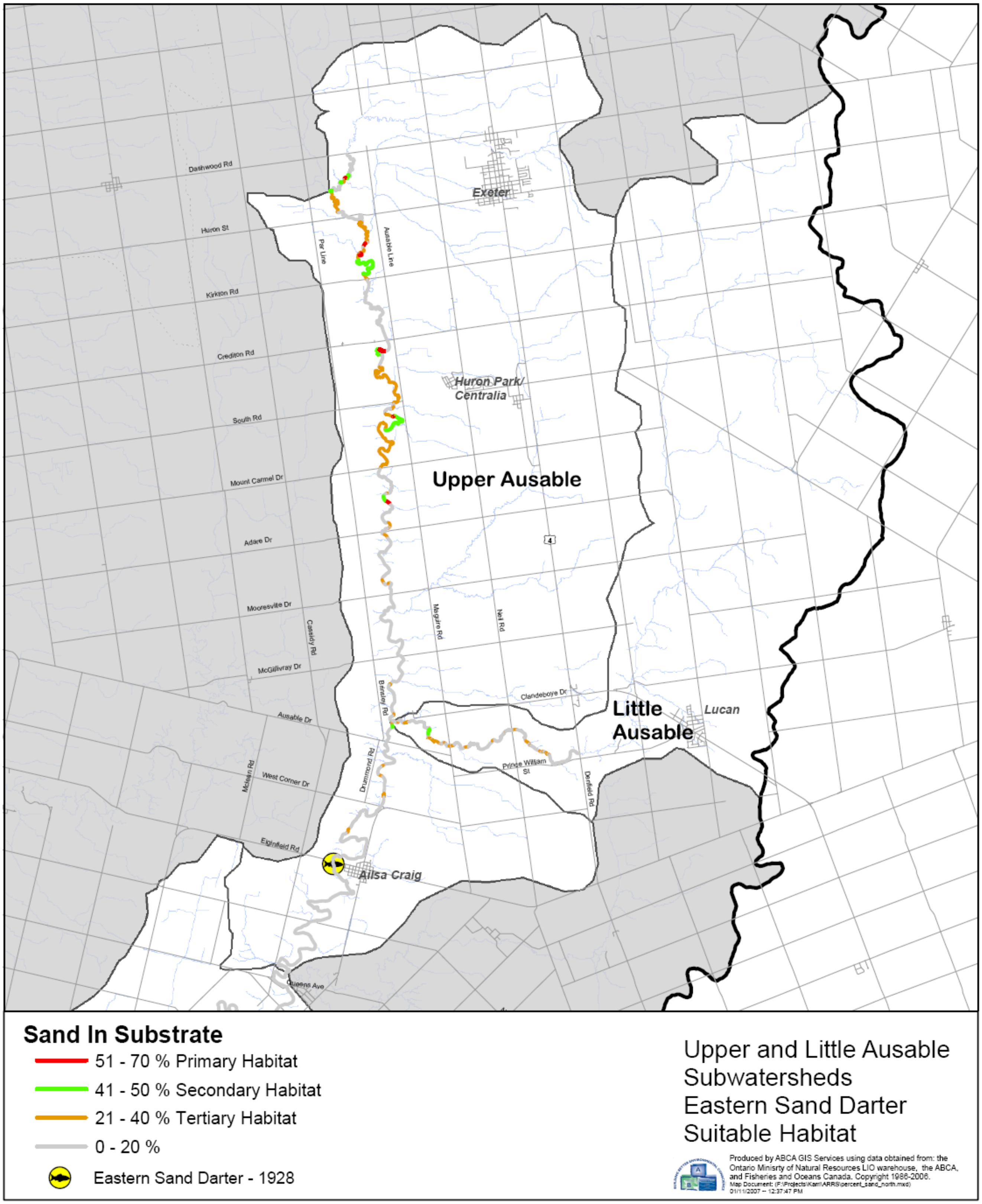

Dashwood Rd
Huron St
Kirkton Rd
Crediton Rd
South Rd
Mount Carmel Dr
Adare Dr
Mooresville Dr
McGillivray Dr
Ausable Dr
West Corner Dr
Elginfield Rd
Queens Ave
Par Line
Ausable Line
Cassidy Rd
Mclean Rd
Drummond Rd
Maguire Rd
Neil Rd
Clandeboye Dr
Prince William St
Denfield Rd
Exeter
Huron Park/ Centralia
Upper Ausable
Little Ausable
Lucan
Ailsa Craig
Sand In Substrate
51 - 70 % Primary Habitat
41 - 50 % Secondary Habitat
21 - 40 % Tertiary Habitat
0 - 20 %
Eastern Sand Darter - 1928
Upper and Little Ausable Subwatersheds Eastern Sand Darter Suitable Habitat
Produced by ABCA GIS Services using data obtained from: the Ontario Minisrty of Natural Resources LIO warehouse, the ABCA, and Fisheries and Oceans Canada. Copyright 1986-2006.

Figure 3.

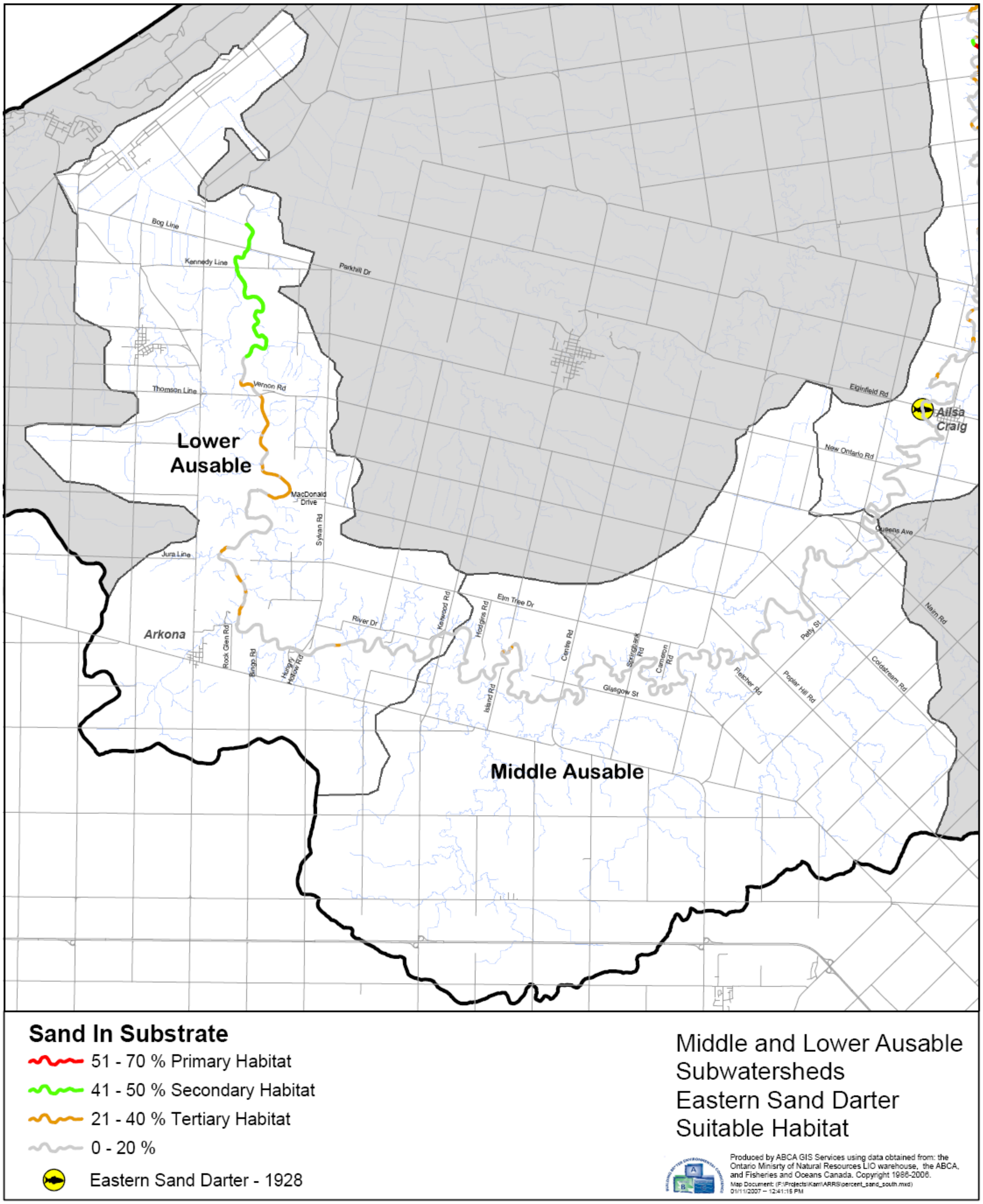
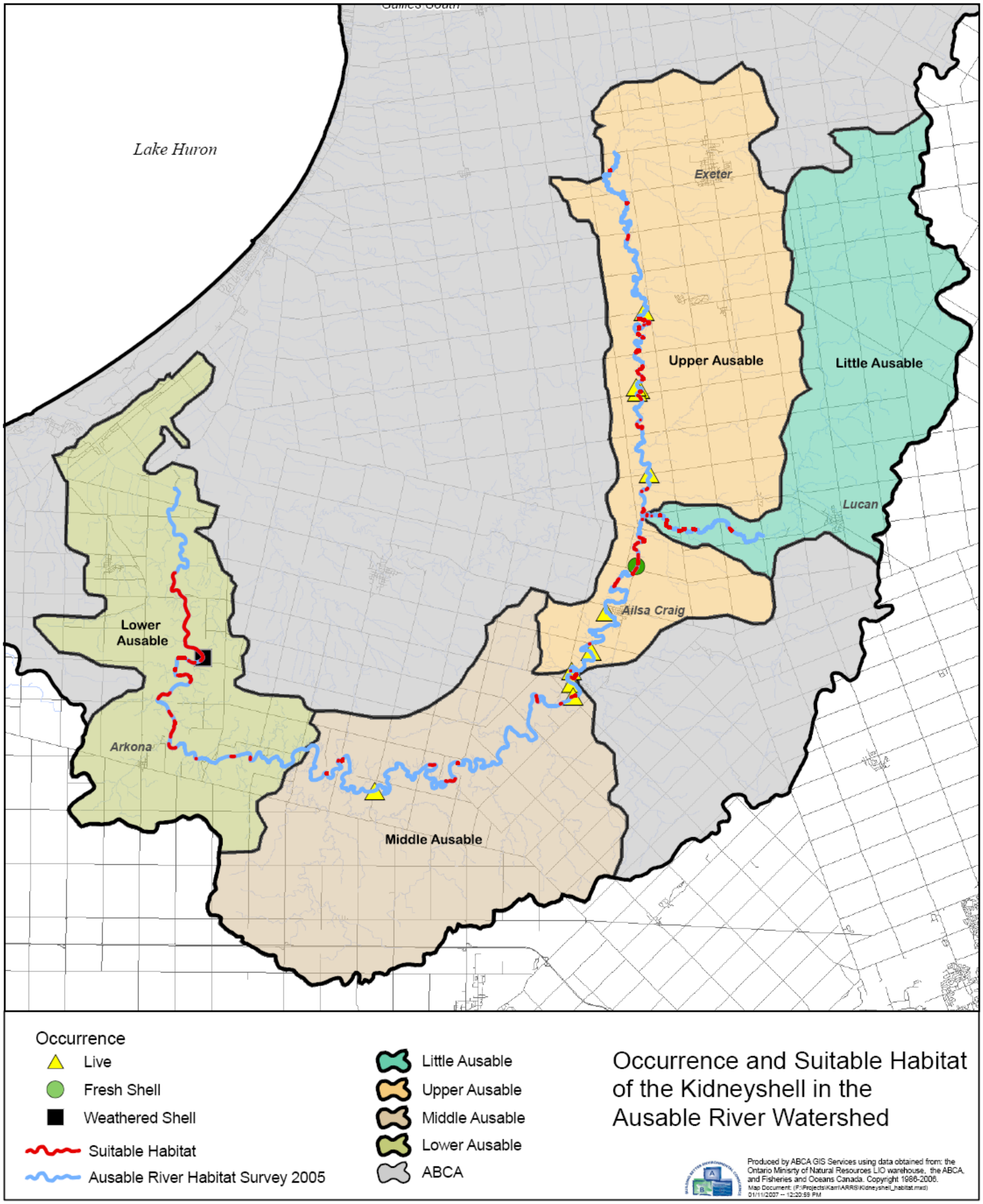

Lower Ausable
Middle Ausable
Arkona
Ailsa Craig
Bog Line
Kennedy Line
Parkhill Dr
Thomson Line
Vernon Rd
MacDonald Drive
Sylvan Rd
Jura Line
River Dr
Rock Glen Rd
Bingo Rd
Hungry Hollow Rd
Kerwood Rd
Hodgins Rd
Elm Tree Dr
Centre Rd
Springbank Rd
Cameron Rd
Glasgow St
Island Rd
Elginfield Rd
New Ontario Rd
Queens Ave
Petty St
Fletcher Rd
Poplar Hill Rd
Coldstream Rd
Nairn Rd
Sand In Substrate
51 - 70 % Primary Habitat
41 - 50 % Secondary Habitat
21 - 40 % Tertiary Habitat
0 - 20 %
Eastern Sand Darter - 1928
Middle and Lower Ausable Subwatersheds
Eastern Sand Darter Suitable Habitat
Produced by ABCA GIS Services using data obtained from: the Ontario Minisrty of Natural Resources LIO warehouse, the ABCA, and Fisheries and Oceans Canada. Copyright 1986-2006.

Figure 4.



Lake Huron
Exeter
Upper Ausable
Little Ausable
Lucan
Ailsa Craig
Lower Ausable
Arkona
Middle Ausable
Occurrence
Live
Fresh Shell
Weathered Shell
Suitable Habitat
Ausable River Habitat Survey 2005
Little Ausable
Upper Ausable
Middle Ausable
Lower Ausable
ABCA
Occurrence and Suitable Habitat of the Kidneyshell in the Ausable River Watershed

Figure 5.

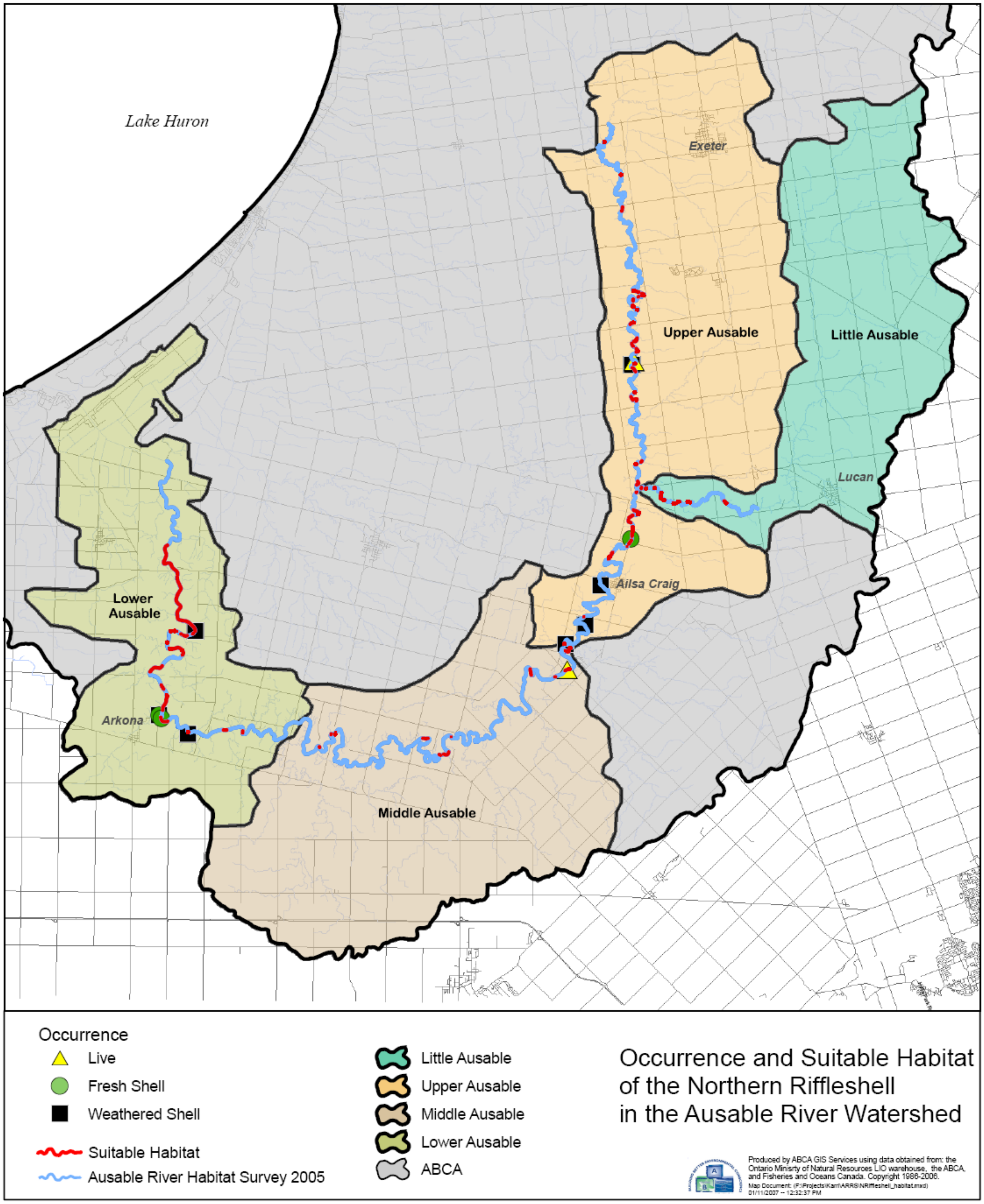

Lake Huron
Exeter
Upper Ausable
Little Ausable
Lucan
Ailsa Craig
Lower Ausable
Arkona
Middle Ausable
Occurrence
Live
Fresh Shell
Weathered Shell
Suitable Habitat
Ausable River Habitat Survey 2005
Little Ausable
Upper Ausable
Middle Ausable
Lower Ausable
ABCA
Occurrence and Suitable Habitat of the Northern Riffleshell in the Ausable River Watershed
Produced by ABCA GIS Services using data obtained from: the Ontario Minisrty of Natural Resources LIO warehouse, the ABCA, and Fisheries and Oceans Canada. Copyright 1986-2006.
Map Document: (F:\Projects\Karr\ARRS\NRiffleshell_habitat.mxd)
01/11/2007 -- 12:32:37 PM

Figure 6.

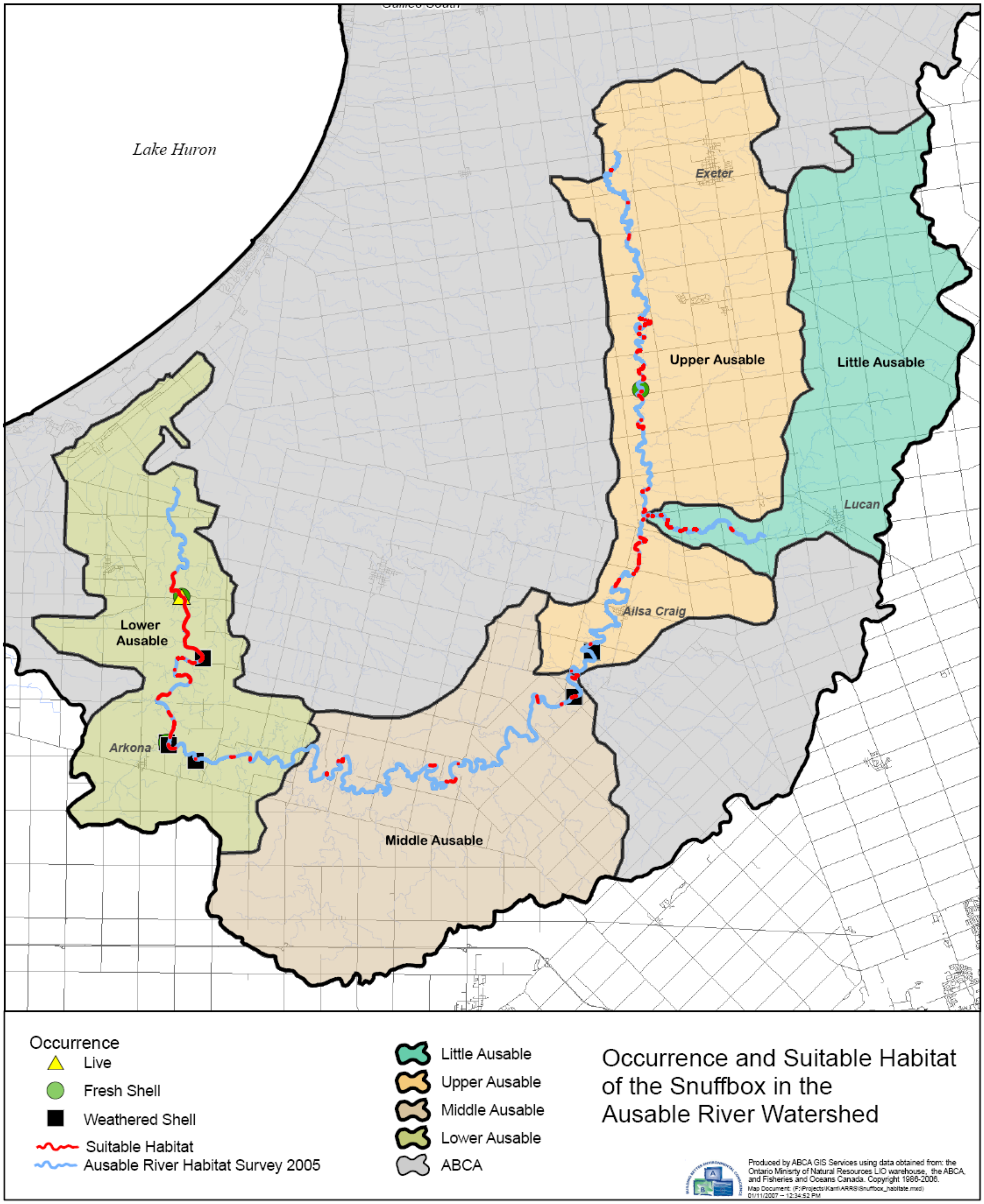
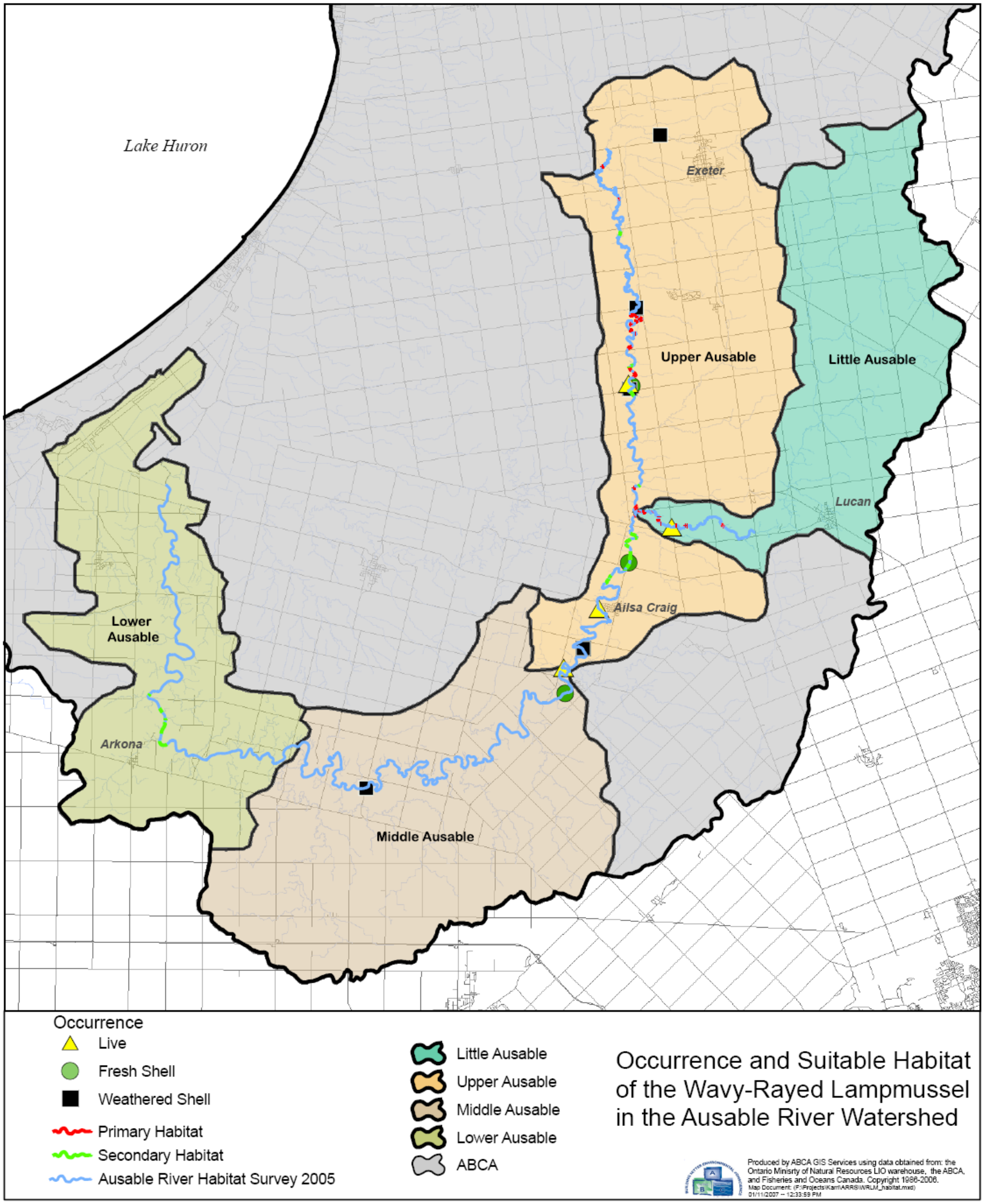

Lake Huron
Exeter
Upper Ausable
Little Ausable
Lucan
Ailsa Craig
Lower Ausable
Arkona
Middle Ausable
Occurrence
Live
Fresh Shell
Weathered Shell
Suitable Habitat
Ausable River Habitat Survey 2005
Little Ausable
Upper Ausable
Middle Ausable
Lower Ausable
ABCA
Occurrence and Suitable Habitat of the Snuffbox in the Ausable River Watershed

Figure 7.



Lake Huron
Exeter
Upper Ausable
Little Ausable
Lucan
Ailsa Craig
Lower Ausable
Arkona
Middle Ausable
Occurrence
Live
Fresh Shell
Weathered Shell
Primary Habitat
Secondary Habitat
Ausable River Habitat Survey 2005
Little Ausable
Upper Ausable
Middle Ausable
Lower Ausable
ABCA
Occurrence and Suitable Habitat of the Wavy-Rayed Lampmussel in the Ausable River Watershed
Produced by ABCA GIS Services using data obtained from: the Ontario Minisrty of Natural Resources LIO warehouse, the ABCA, and Fisheries and Oceans Canada. Copyright 1986-2006.
Map Document: (F:\Projects\Karr\ARRS\WRLM_habitat.mxd)
01/11/2007 -- 12:33:59 PM

Figure 8.

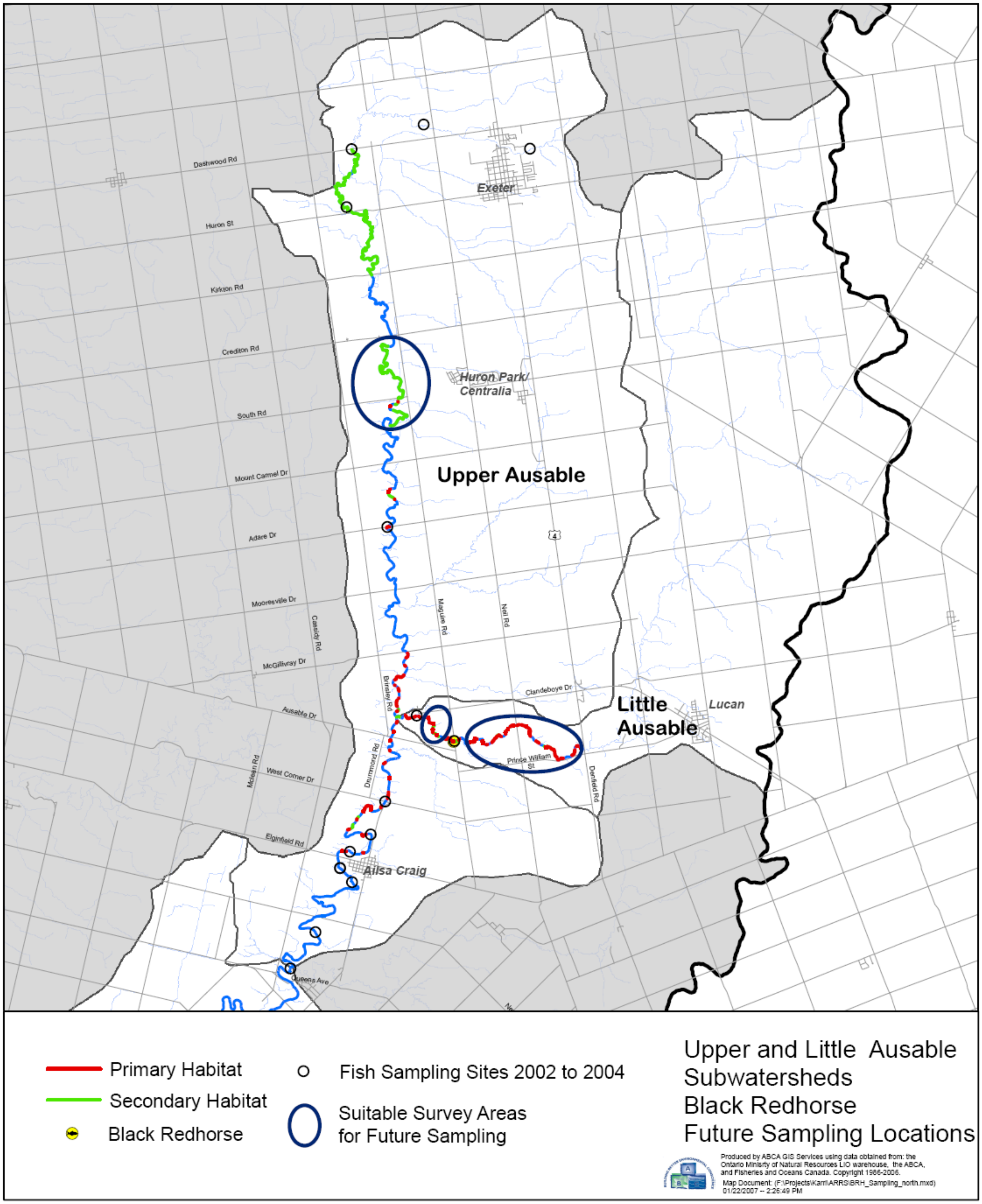

Dashwood Rd
Huron St
Kirkton Rd
Crediton Rd
South Rd
Mount Carmel Dr
Adare Dr
Mooresville Dr
McGillivray Dr
Ausable Dr
West Corner Dr
Elginfield Rd
Queens Ave
Cassidy Rd
Brinsley Rd
Maguire Rd
Neil Rd
Drummond Rd
Mclean Rd
Clandeboye Dr
Prince William St
Denfield Rd
Exeter
Huron Park/ Centralia
Upper Ausable
Little Ausable
Lucan
Ailsa Craig
Primary Habitat
Secondary Habitat
Black Redhorse
Fish Sampling Sites 2002 to 2004
Suitable Survey Areas for Future Sampling
Upper and Little Ausable Subwatersheds
Black Redhorse
Future Sampling Locations
Produced by ABCA GIS Services using data obtained from: the Ontario Ministry of Natural Resources LIO warehouse, the ABCA, and Fisheries and Oceans Canada. Copyright 1986-2006.
Map Document: (F:\Projects\Karri\ARRS\BRH_Sampling_north.mxd)
01/22/2007 -- 2:26:49 PM

Figure 9.

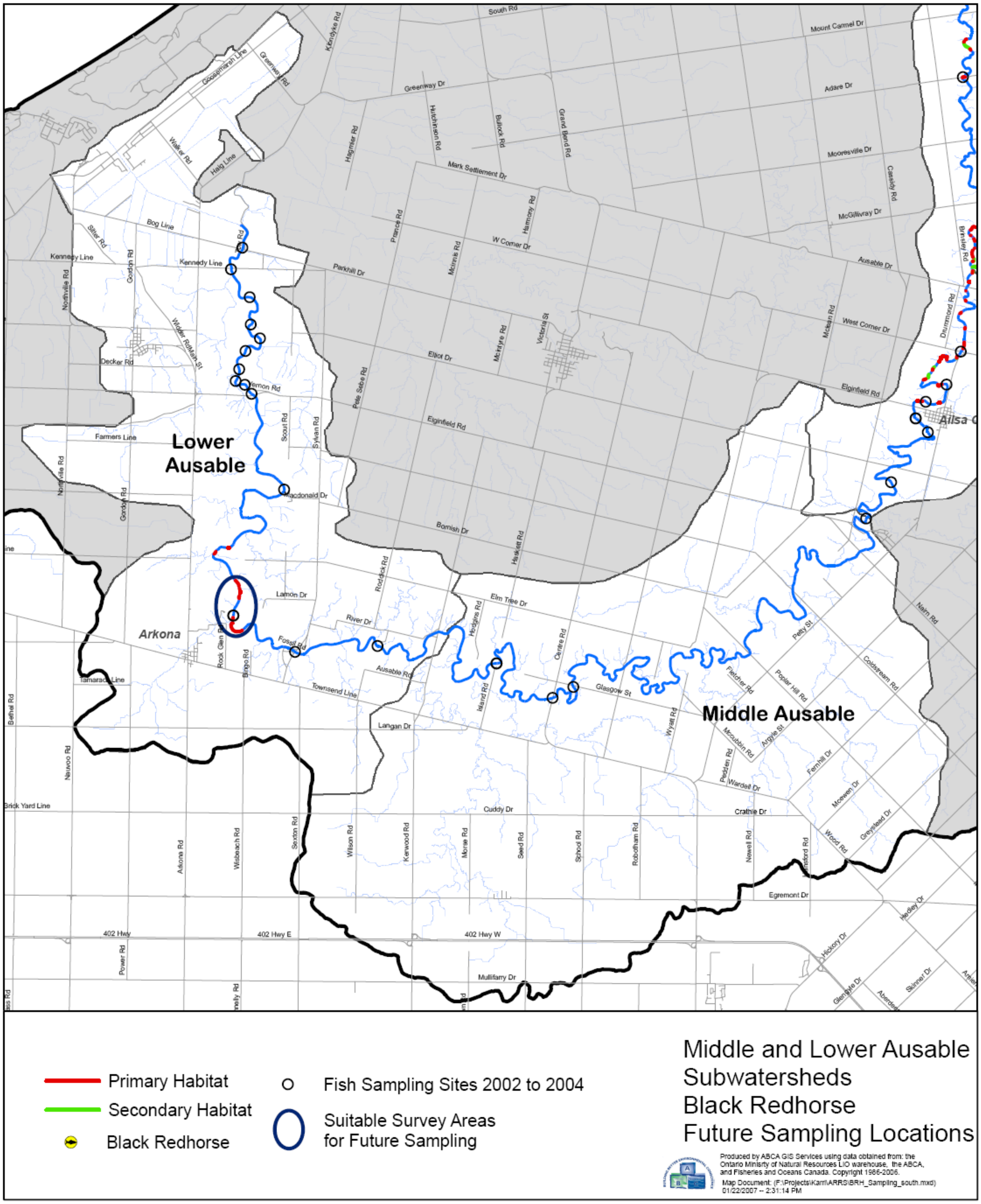

Lower Ausable
Middle Ausable
Arkona
Primary Habitat
Secondary Habitat
Black Redhorse
Fish Sampling Sites 2002 to 2004
Suitable Survey Areas for Future Sampling
Middle and Lower Ausable Subwatersheds
Black Redhorse
Future Sampling Locations

Figure 10.

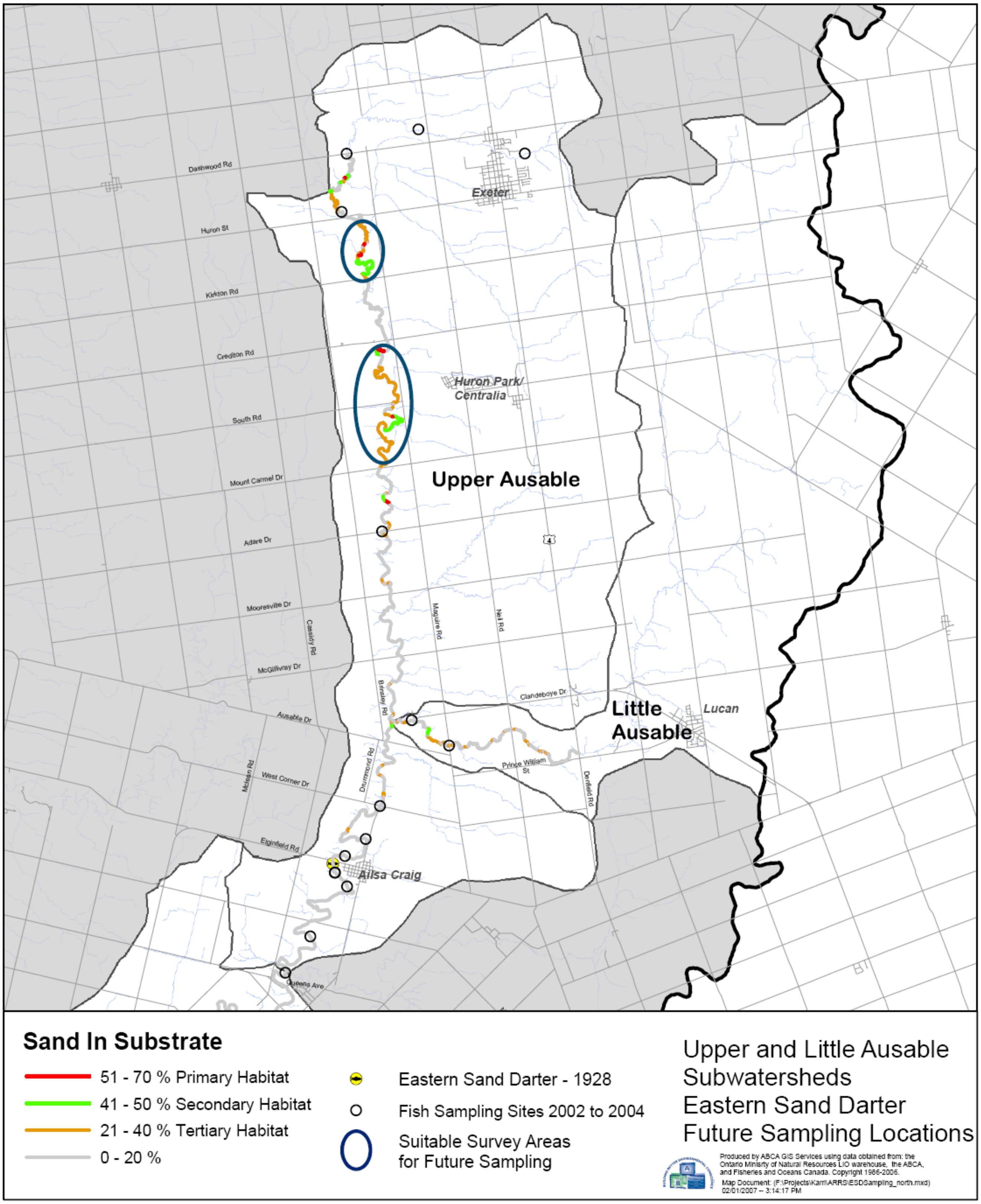

Dashwood Rd
Huron St
Kirkton Rd
Crediton Rd
South Rd
Mount Carmel Dr
Adare Dr
Mooresville Dr
McGillivray Dr
Ausable Dr
West Corner Dr
Elginfield Rd
Queens Ave
Cassidy Rd
Mclean Rd
Drummond Rd
Brinsley Rd
Maguire Rd
Neil Rd
Clandeboye Dr
Prince William St
Denfield Rd
Exeter
Huron Park/ Centralia
Upper Ausable
Little Ausable
Lucan
Ailsa Craig
Sand In Substrate
51 - 70 % Primary Habitat
41 - 50 % Secondary Habitat
21 - 40 % Tertiary Habitat
0 - 20 %
Eastern Sand Darter - 1928
Fish Sampling Sites 2002 to 2004
Suitable Survey Areas for Future Sampling
Upper and Little Ausable Subwatersheds
Eastern Sand Darter
Future Sampling Locations
Produced by ABCA GIS Services using data obtained from: the Ontario Ministry of Natural Resources LIO warehouse, the ABCA, and Fisheries and Oceans Canada. Copyright 1986-2006.
Map Document: (F:\Projects\Karr\ARRS\ESDSampling_north.mxd)
02/01/2007 -- 3:14:17 PM

Figure 11.

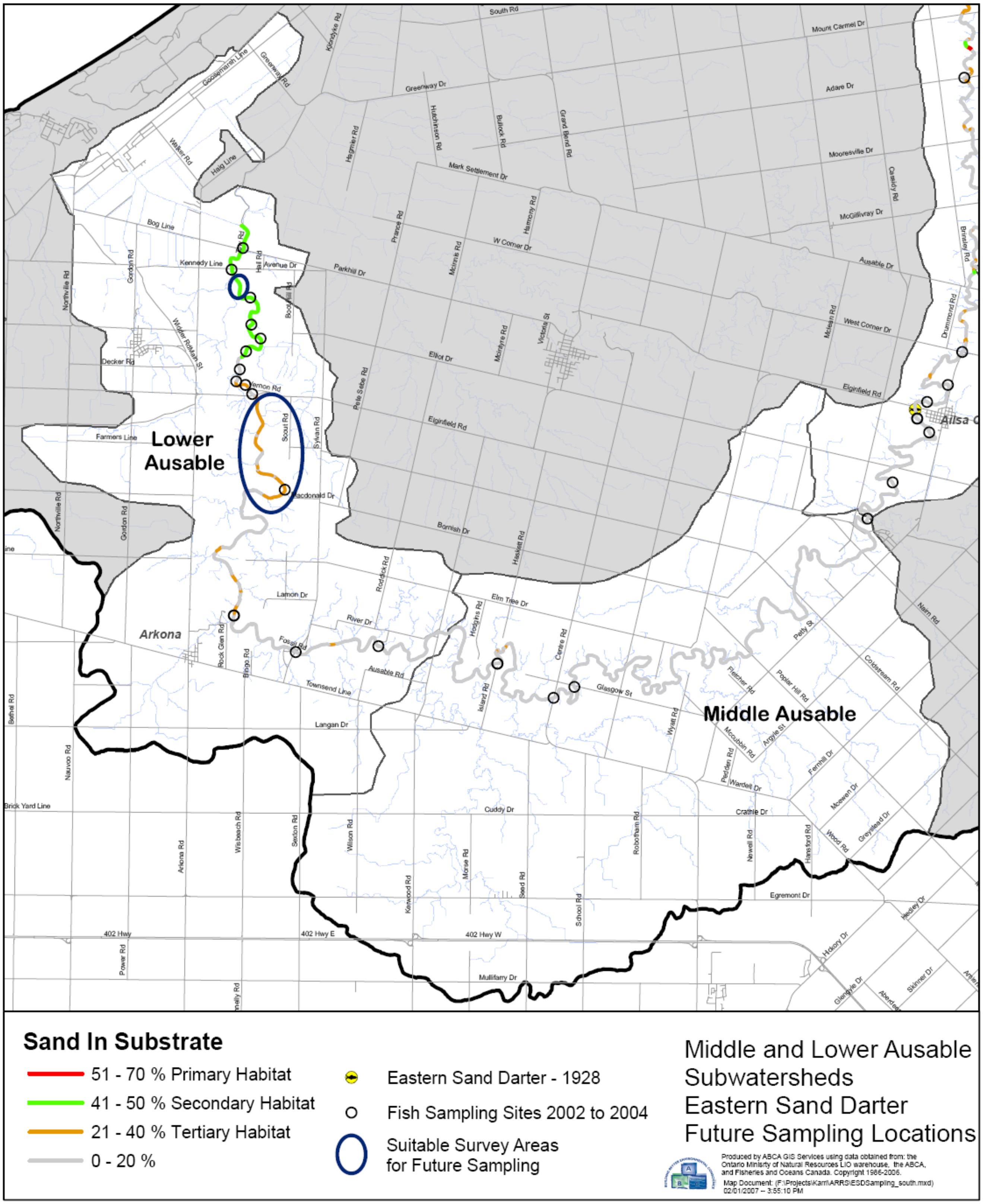

Lower Ausable
Middle Ausable
Arkona
Sand In Substrate
51 - 70 % Primary Habitat
41 - 50 % Secondary Habitat
21 - 40 % Tertiary Habitat
0 - 20 %
Eastern Sand Darter - 1928
Fish Sampling Sites 2002 to 2004
Suitable Survey Areas for Future Sampling
Middle and Lower Ausable Subwatersheds
Eastern Sand Darter
Future Sampling Locations

Figure 12.

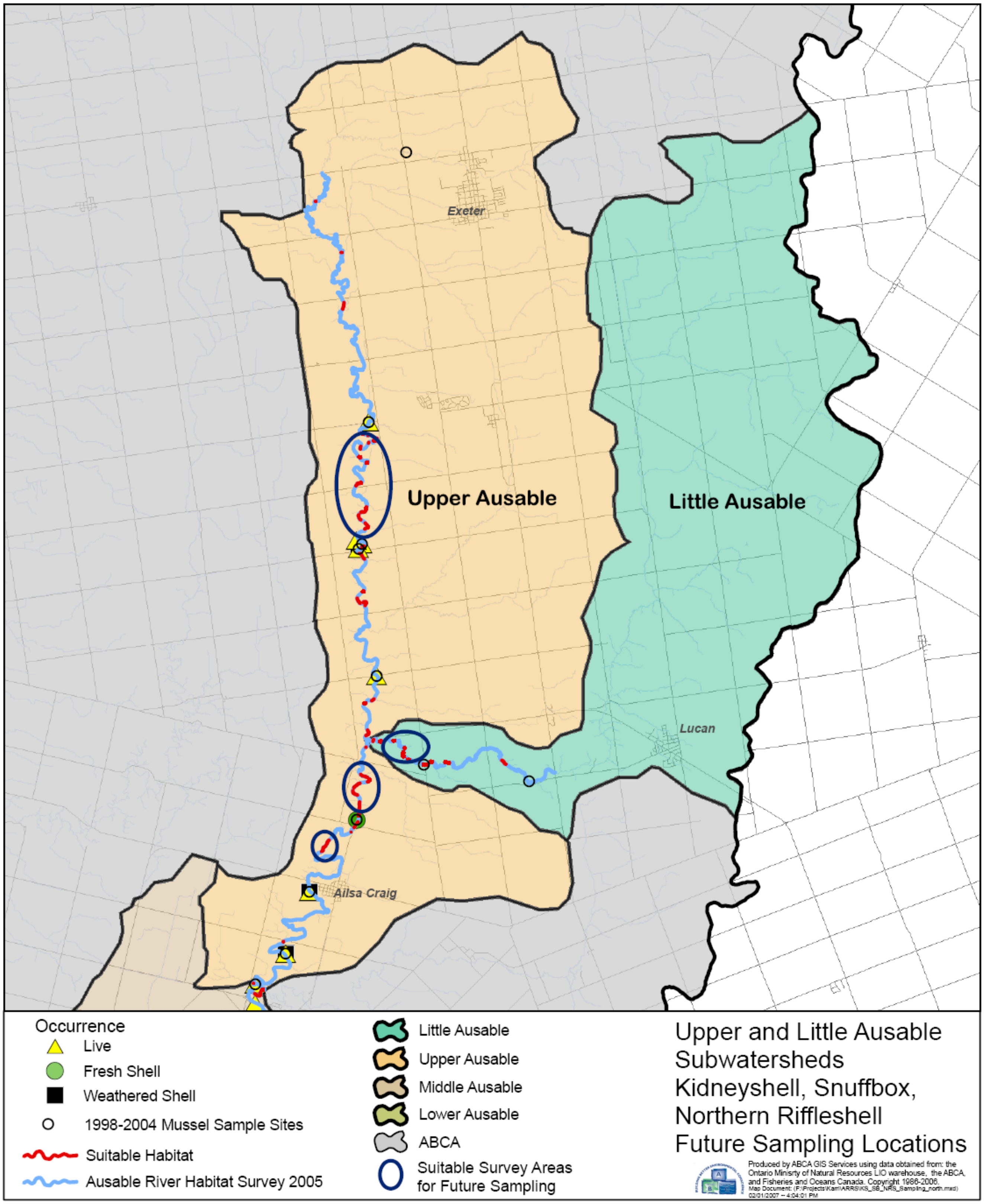

Exeter
Upper Ausable
Little Ausable
Lucan
Ailsa Craig
Occurrence
Live
Fresh Shell
Weathered Shell
1998-2004 Mussel Sample Sites
Suitable Habitat
Ausable River Habitat Survey 2005
Little Ausable
Upper Ausable
Middle Ausable
Lower Ausable
ABCA
Suitable Survey Areas
for Future Sampling
Upper and Little Ausable
Subwatersheds
Kidneyshell, Snuffbox,
Northern Riffleshell
Future Sampling Locations

Figure 13.

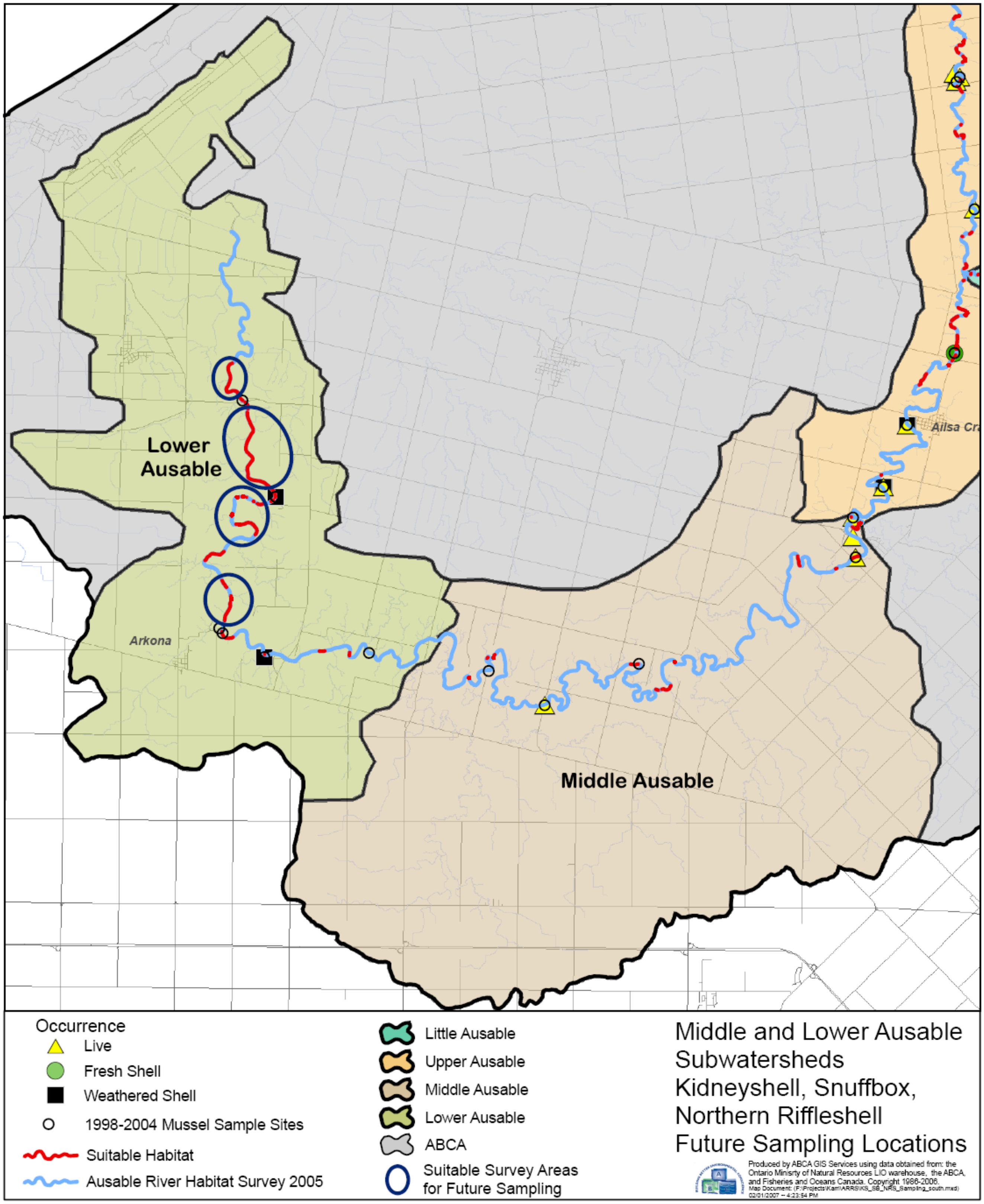
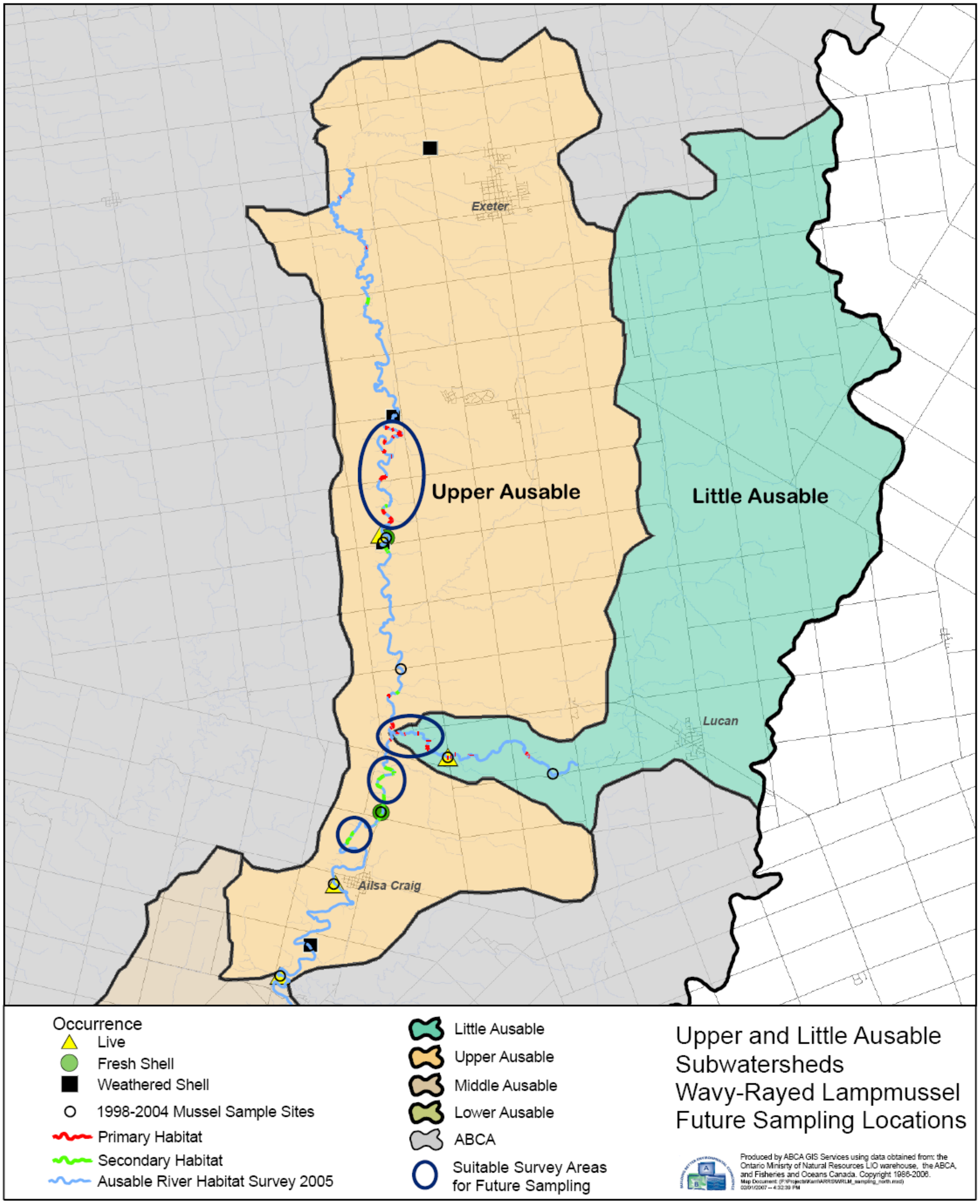

Lower
Ausable
Arkona
Middle Ausable
Ailsa Cr
Occurrence
Live
Fresh Shell
Weathered Shell
1998-2004 Mussel Sample Sites
Suitable Habitat
Ausable River Habitat Survey 2005
Little Ausable
Upper Ausable
Middle Ausable
Lower Ausable
ABCA
Suitable Survey Areas
for Future Sampling
Middle and Lower Ausable
Subwatersheds
Kidneyshell, Snuffbox,
Northern Riffleshell
Future Sampling Locations
Produced by ABCA GIS Services using data obtained from: the
Ontario Minisrty of Natural Resources LIO warehouse, the ABCA,
and Fisheries and Oceans Canada. Copyright 1986-2006.
Map Document: (F:\Projects\Kari\ARRS\KS_SB_NRS_Sampling_south.mxd)
02/01/2007 -- 4:23:54 PM

Figure 14.


Exeter
Upper Ausable
Little Ausable
Lucan
Ailsa Craig
Occurrence
Live
Fresh Shell
Weathered Shell
1998-2004 Mussel Sample Sites
Primary Habitat
Secondary Habitat
Ausable River Habitat Survey 2005
Little Ausable
Upper Ausable
Middle Ausable
Lower Ausable
ABCA
Suitable Survey Areas for Future Sampling
Upper and Little Ausable Subwatersheds
Wavy-Rayed Lampmussel
Future Sampling Locations
Figure 15.

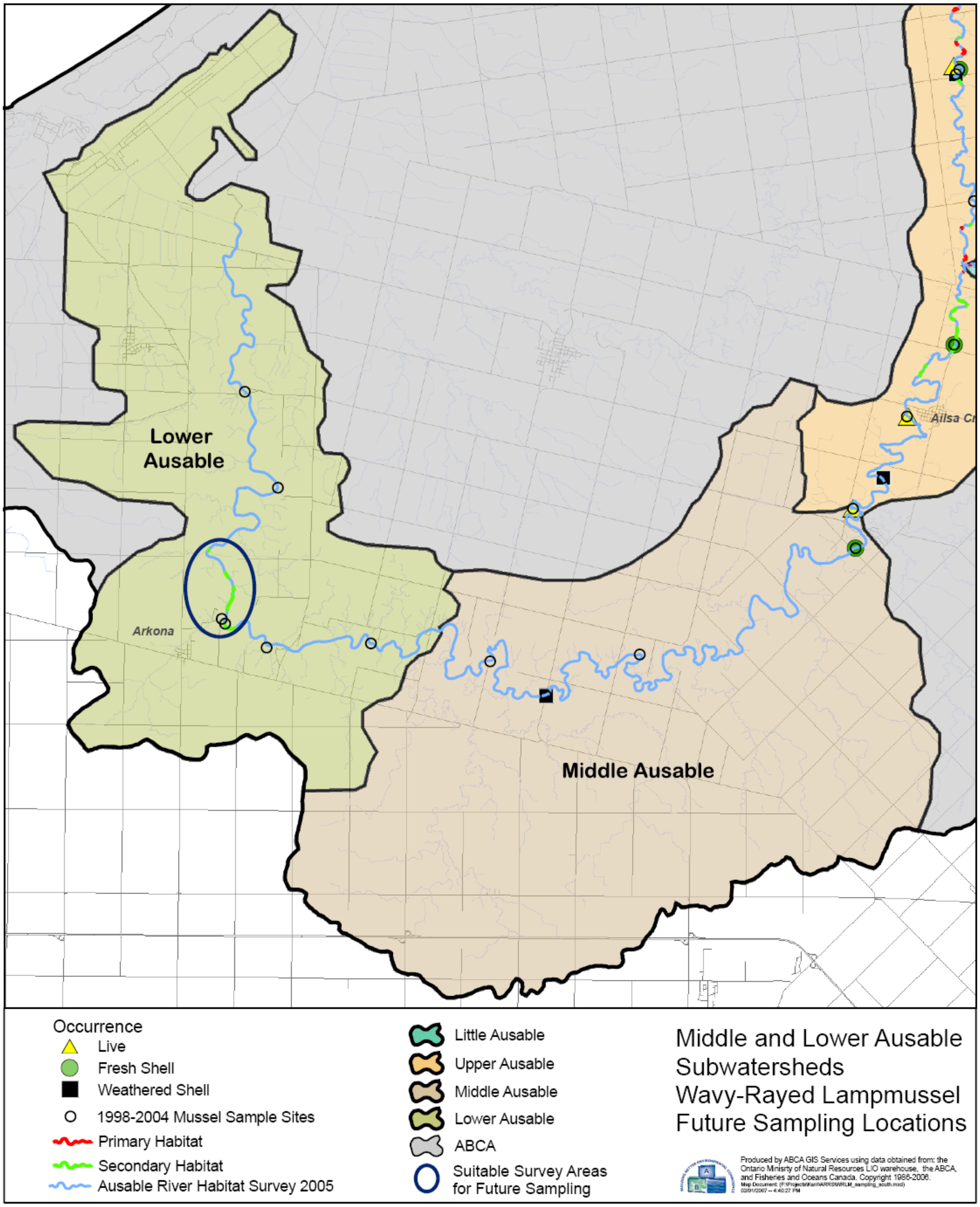

Lower
Ausable
Arkona
Ailsa Cr
Middle Ausable
Occurrence
Live
Fresh Shell
Weathered Shell
1998-2004 Mussel Sample Sites
Primary Habitat
Secondary Habitat
Ausable River Habitat Survey 2005
Little Ausable
Upper Ausable
Middle Ausable
Lower Ausable
ABCA
Suitable Survey Areas
for Future Sampling
Middle and Lower Ausable
Subwatersheds
Wavy-Rayed Lampmussel
Future Sampling Locations

Figure 16.