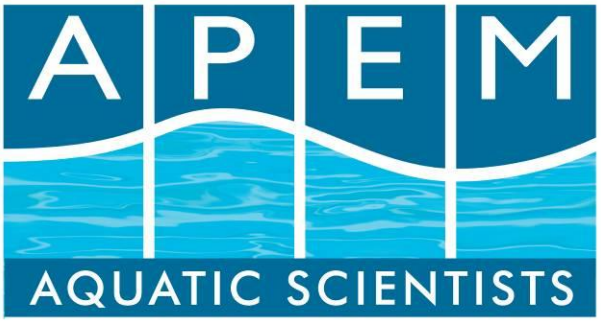
ENVIRONMENT AGENCY

AN INVESTIGATION INTO THE ABUNDANCE AND DISTRIBUTION OF KEY BARBEL HABITATS IN THE RIVER WENSUM 2009

SCIENTIFIC REPORT

February 2010

APEM REF: EA 410956



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1 INTRODUCTION

The present study was initiated following the recommendations from previous investigations of the spawning and recruitment success of barbel within the River Wensum (APEM, 2009). During 2009, spawning surveys were conducted in June followed by juvenile distribution and abundance surveys in late July. Both surveys were successful in identifying both spawning and nursery habitats, and have thus filled a previous knowledge gap with respect to the specific habitat preferences of barbel during the key life stages responsible for governing recruitment success.

"Habitat preferences of larval and juvenile barbel *Barbus barbus* have only seldom been investigated, although the presence of sufficient suitable habitats for the young stages constitutes one of the most important factors influencing reproductive success in riverine fishes" (Frehof, 1994).

With respect to the above quotation, the qualification, quantification and distribution of key functional habitats specific to the performance of the Wensum barbel population was prioritised for further study during the Autumn of 2009. Following the characterisation of 0+ juvenile rearing habitats as shallow marginal bays and spawning areas being composed of clean gravel with water velocities exceeding 0.5m/sec., preliminary scoping from aerial photography identified an abundance of potential nursery habitat either immediately downstream or adjacent to potential spawning sites. As such, a walkover habitat assessment was conducted to identify the quality, abundance and distribution of such habitats with specific attention to the juxtaposition of these areas to suitable spawning areas. In accordance with the potential for many of the flow controlling structures along the Wensum to compromise the free migratory passage of adult barbel (Coombes *et al.*, 2007), these structures were used to delimit the study reaches and facilitate an assessment of the habitat quality available within each of these impoundments.

It is anticipated that the results of the habitat assessment will inform future surveys and facilitate better focused survey design to detect the habitats utilised by spawning adults and 0+ barbel.

2 METHODOLOGY

2.1 Survey reach

A walkover survey of 26.9 km of the River Wensum was undertaken during September 2009, based on the standardised protocols outlined in APEM (2007). The survey reach selected for investigation was located between Lyng Weir (NGR TG072179) and Hellesdon Mill (NGR TG198104). This was broken down into four survey stretches as defined below and presented in Figure 2.1:

Stretch 1 – Lyng (NGR TG072179) to Lenwade (NGR TG102181)
Stretch 2 – Lenwade (NGR TG102181) to Taverham (NGR TG157137)
Stretch 3 – Taverham (NGR TG157137) to Costessey (NGR TG176127)
Stretch 4 – Costessey (NGR TG176127) to Hellesdon (NGR TG198104)

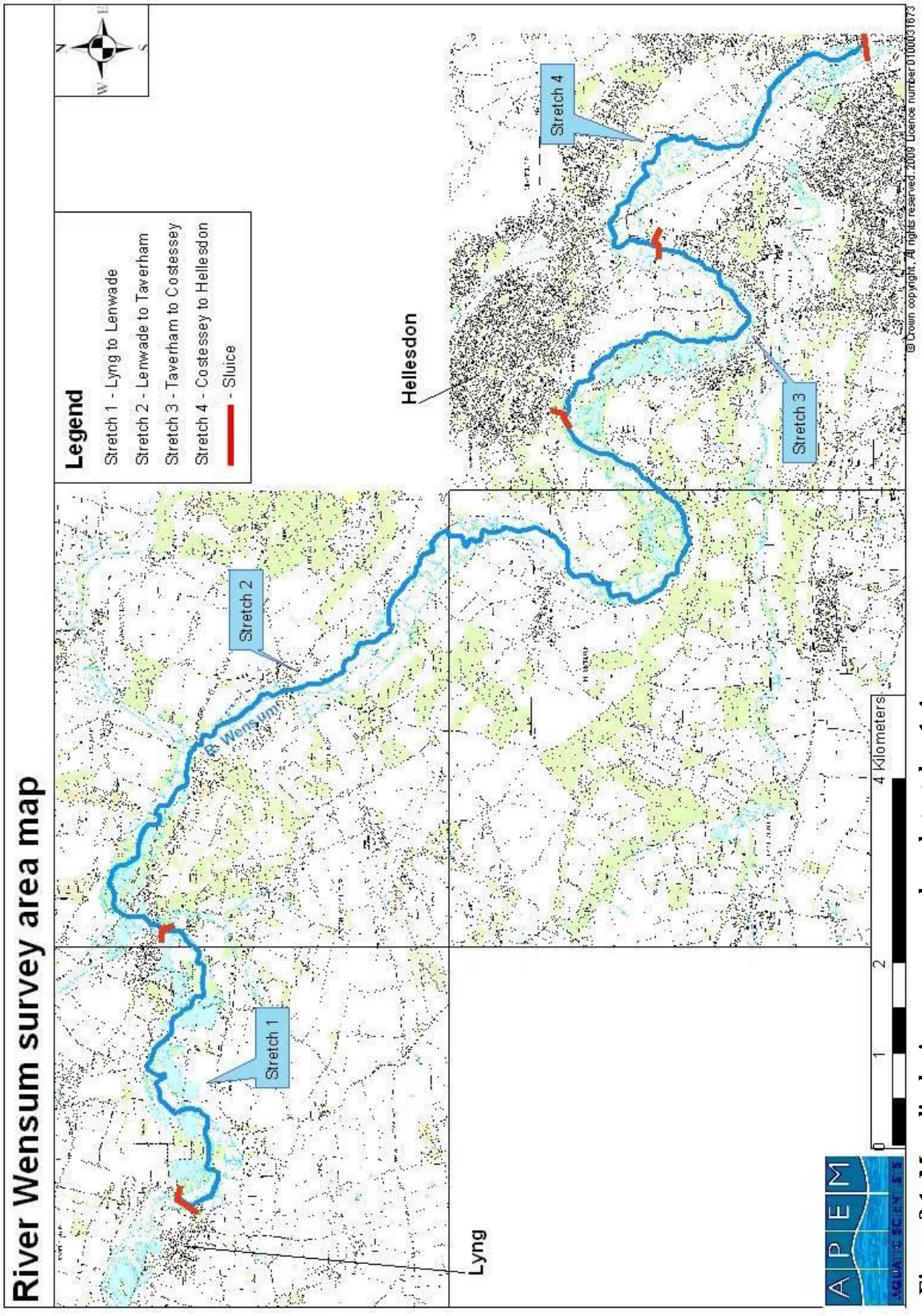


Figure 2.1. Map displaying survey reach and stretches 1-4

2.2 Coarse fish habitat mapping

To provide a quantitative assessment of the in stream and riparian riverine habitats and geomorphological features of interest, the standardised survey method (APEM, 2007) was modified to incorporate quantitative visual assessments of habitat features that are functionally important to barbel. The survey was undertaken by a team of two highly experienced surveyors, whilst the river was in favourable conditions i.e. low flow and relatively clear instream visibility. Due to land access issues, the surveyors used an 11' inflatable Zodiac boat to navigate downstream. This method had the added advantage of allowing the in-channel habitat assessment to be carried out in more detail than a standard bankside walkover.

The field mapping technique involved hand annotation on a high-resolution map (OS 1 km tiles) at a scale of 1:10,000. The river outline and salient geographic location points are selected from a digital map and printed onto waterproof paper (approximately 300-500m of river length per A3 sheet). These maps offer a high level of detail, enabling very accurate mapping of in stream habitat characteristics.

Habitat features observed along the river were then able to be drawn directly onto the A3 maps, with the boundaries of the different habitat classifications being recorded to represent their actual position within the river using a series of icons. The icons are then linked via a pencil stroke to the riverbank, delineating the extent of that particular habitat feature (Figure 2.2). For consistency, substratum features and vegetation (aquatic and terrestrial) were also labelled. Other prominent features (e.g. log jams, macrophyte beds, bridges) were also noted, together with trees, electricity pylons and bridges, which aid in locating the surveyor's position on the ground and calibrating during the digitisation process.

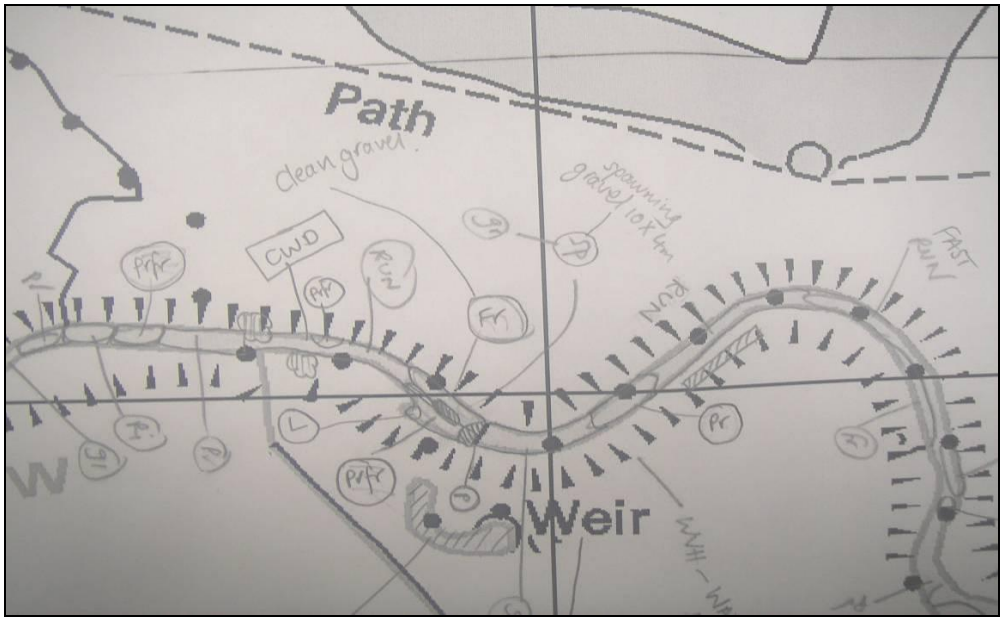


Figure 2.2. Example of habitat walkover survey notation from the field.

This produces a mosaic of the different habitat types drawn along the whole section of the river, which allows the area of each individual habitat type to be calculated. The categories used to classify the different habitat types are shown in Table 2.1.

Table 2.1. Classification of habitat type (APEM, 2007)

	Depth (m)			Velocity (m/s)			
	A	**B**	**C**	**1**	**2**	**3**	
Habitat Type	0–0.49	0.5-1.0	>1.0	0.05-0.15	0.16-0.40	>0.4	**Description**
Standing Water (SW)	A-C			0			No perceivable flow, variable depths
Eddy (ED)	A-C			1-3			Vortexing water, mixed flow / depth
Riffle (RI)	A			3			Fast flowing, shallow, audible
Glide (GL)	A-C			1-3			Unbroken surface, often entire channel
Run (R)	A-C			1-3			Broken Surface, often interface between habitat

In accordance with the classifications presented in Table 2.1, a section of glide with depth greater than 1m and sluggish flow (0.05-0.15 m/s), typical of a regulated lowland waterway, would be categorised as GLC1. In contrast, a shallow run (< 50 cm) and fast flow (0.4 m/s), typical of steep gradient upland rivers would be categorised as RA3. The depth and velocity categories used were comparatively broad, but these have been selected to facilitate direct comparisons across other studies conducted nationally and to reflect the known preferences of barbel and other coarse fish species.

2.2.1 Other habitat features

The coarse fish habitat walkover method can be tailored to meet the objectives of an individual survey. For the purpose of this study, the method was modified to record barbel spawning habitat and juvenile rearing habitats as defined in Table 2.2. The characters defined in Table 2.2 are based on preliminary results from previous recruitment studies (APEM, 2009). On this basis it is expected that using these data to spatially target future studies of habitat utilisation, the resolution of microhabitat requirements during barbel ontogeny will become more clearly defined.

Table 2.2 Definition of habitats used by key life stages of barbel in the River Wensum

Habitat Type	Definition
Spawning	• Run/glide flow type • Less than 50 cm deep • Velocities in excess of 0.5m/sec • Substrate composed of clean and uncompacted gravel
Optimal juvenile nursery	• Marginal shallow bays set back from main channel. • Depths between 1 and 30cm • No discernible flow • Substrate composed of >50 % gravel and sand with low silt content. • Lack of riparian shading allows temperatures to become elevated during warm weather
Sub-optimal juvenile nursery	• Shallow bays within margins of main channel. • Depths between 1 and 30cm • Negligible to minimal flow • Substrate composed of >30 % gravel and sand with higher silt content • May be subject to some riparian shading

2.2.2 Data inputting and quantification

Upon completion of the walkover survey, results were digitised using GIS ArcView version 9.2. This has facilitated the production of a series of maps which along with additional survey outputs are presented on the DVD accompanying this report. ArcView also allows the rapid quantification of the spatial availability of each habitat feature of interest and as such, habitat summary tables have been presented within the results section of this report.

3 RESULTS

The main outputs of this study are presented on the accompanying DVD, with instructions for interrogating the electronic content provided in Appendix I of this document. Accordingly, the presentation of results within this document has been limited to presenting an audit summary of the habitat types, including surface area and percentage composition, within each of the four survey reaches (Tables 3.1 – 3.8). In combination with a spatial comparison of the availability of key habitats for barbel recruitment between reaches (Table 3.9), these data form the basis of the discussion and future recommendations for habitat management.

Stretch 1 Lyng - Lenwade

Survey length – 4.7km
Evidence of barriers to dispersal – No
Length of poached bank – 179m

Table 3.1. Summary of habitat types throughout stretch 1

Habitat Type	Area m^2	% Total Area
Eddy	593	0.76
Glide	66315	84.87
Pool	1426	1.83
Riffle	204	0.26
Run	8959	11.47
Torrent	148	0.19
Barbel spawning	121	0.15
Optimal juvenile barbel rearing	0	0.00
Sub-optimal juvenile barbel rearing	368	0.47
Optimal juvenile lamprey	23	0.03

Table 3.2. Sub classification of main habitat types in stretch 1 (after APEM, 2007)

Habitat Type	Sub Habitat Type	Area m^2
Eddy	C2	593
Glide	B1	3440
	B2	5778
	B3	0
	C1	50893
	C2	6203
Run	A1	0
	A2	0
	A3	578
	B1	284
	B2	1963
	B3	1798
	C1	555
	C2	3716
	C3	63

Stretch 2 Lenwade - Taverham

Survey length – 13.1km
Evidence of barriers to dispersal – No
Length of poached bank – 592m

Table 3.3. Summary of habitat types throughout stretch 2

Habitat Type	Area m^2	% Total Area
Eddy	412	0.22
Glide	112357	59.03
Pool	4113	2.16
Riffle	474	0.25
Run	69782	36.66
Torrent	396	0.21
Barbel spawning	1693	0.89
Optimal juvenile barbel rearing	1004	0.53
Sub-optimal juvenile barbel rearing	64	0.03
Optimal juvenile lamprey	38	0.02

Table 3.4. Sub classification of main habitat types in stretch 2 (after APEM, 2007)

Habitat Type	Sub Habitat Type	Area m^2
Eddy	B1	412
	C1	38
	C2	902
Glide	B1	13354
	B2	16853
	B3	0
	C1	58775
	C2	23374
Run	A1	0
	A2	5402
	A3	3287
	B1	1036
	B2	33493
	B3	9944
	C1	4886
	C2	11265
	C3	464

Stretch 3 Taverham - Costessey

Survey length – 4.1km
Evidence of barriers to dispersal – No
Length of poached bank – 189m

Table 3.5. Summary of habitat types throughout stretch 3

Habitat Type	Area m^2	% Total Area
Eddy	610	1.00
Glide	52070	85.58
Pool	38	0.06
Riffle	133	0.22
Run	7357	12.09
Torrent	204	0.34
Barbel spawning	147	0.24
Optimal juvenile barbel rearing	76	0.12
Sub-optimal juvenile barbel rearing	207	0.34
Optimal juvenile lamprey	0	0.00

Table 3.6. Sub classification of main habitat types in stretch 3 (after APEM, 2007)

Habitat Type	Sub Habitat Type	Area m^2
Eddy	B1	38
	C1	490
	C2	82
Glide	B1	10219
	B2	1837
	B3	1781
	C1	35632
	C2	2598
Run	A1	43
	A2	955
	A3	1418
	B1	0
	B2	3657
	B3	407
	C1	0
	C2	874
	C3	0

Stretch 4 Costessey - Hellesdon

Survey length – 4.9km
Evidence of barriers to dispersal – No
Length of poached bank – 129m

Table 3.7. Summary of habitat types throughout stretch 4

Habitat Type	Area m^2	% Total Area
Eddy	0	0.00
Glide	72917	94.11
Pool	270	0.35
Riffle	0	0.00
Run	3141	4.05
Torrent	0	0.00
Barbel spawning	551	0.71
Optimal juvenile barbel rearing	87	0.11
Sub-optimal juvenile barbel rearing	513	0.66
Optimal juvenile lamprey	0	0.00

Table 3.8. Sub classification of main habitat types in stretch 4 (after APEM, 2007)

Habitat Type	Sub Habitat Type	Area m^2
Glide	B1	2148
	B2	2019
	B3	0
	C1	62760
	C2	5987
Run	A1	88
	A2	0
	A3	1394
	B1	0
	B2	532
	B3	1126
	C1	0
	C2	0
	C3	0

Table 3.9. Spatial comparison (between reaches) of the abundance of habitats used by key life stages of barbel.

	Stretch 1		Stretch 2		Stretch 3		Stretch 4	
Habitat Type	**Area m^2**	**% Total Area**	**Area m^2**	**% Total Area**	**Area m^2**	**% Total Area**	**Area m^2**	**% Total Area**
Barbel spawning	121	0.15	1693	0.89	147	0.24	551	0.71
Optimal juvenile barbel rearing	0	0.00	1004	0.53	76	0.12	87	0.11
Sub-optimal juvenile barbel rearing	368	0.03	64	0.03	207	0.34	513	0.66

4 DISCUSSION

With reference to the tables (3.1 – 3.9) presented in the results section, each stretch has been discussed separately in order to highlight any major differences in habitat throughout the entire survey reach. Recommendations for future survey work and restoration have also been provided and again are discussed on a stretch by stretch basis.

4.1 Stretch 1 Lyng- Lenwade

Within this stretch, small areas of potential spawning habitat were observed to be restricted to the tail end of the weir on the main river and within the adjacent mill stream. The limited distribution of these habitats was considered to be due to the elevated turbulence of flow in these areas which has aided the dispersal of fine sediments and thus maintained some patches of clean gravel. Indeed, due to extensive macrophyte growth and reduced velocities throughout the remainder of the reach, areas of gravel were observed to be overlaid with a layer of fine silt, thus prohibiting the utilisation of these habitats for spawning purposes.

Optimal juvenile nursery habitats were lacking from this stretch, however some sub-optimal areas which could potentially be utilised by 0+ barbel had been created by cattle poaching within the lower 1.5 kilometres of the reach. Such areas are therefore spatially distanced from the only areas where spawning is likely to occur.

In general, the flow in the lower reach of stretch 1 was sluggish and the substrate largely covered by a layer of fine silt. The depth was generally uniform and fish habitat homogeneous overall. There was also a high proportion of aquatic vegetation present (submerged and emergent). While the habitat characteristics described may provide some suitable holding areas for adult barbel, it is considered that successful recruitment is likely to be mainly compromised by a lack of marginal rearing habitats, particularly within close proximity of spawning gravels towards the top of the reach.

4.2 Stretch 2 Lenwade- Taverham

The upper 4 km of stretch 2 was observed to support the greatest abundance of spawning habitat recorded during the entire survey. The majority of juvenile barbel rearing habitat within stretch 2 was also recorded within the upper 4 km and was therefore considered to be easily accessible by newly emerged larvae. Several groins and weir structures have been installed in the middle reaches (B. Matthews), increasing the general diversity of flow. The gravel within this area was generally clean and this is the only area where fertilised barbel eggs were recorded during the June 2009 survey. Located downstream of this stretch at Ringland, exists a good example of optimal nursery habitat, where 0+ barbel were recorded in July 2009 (APEM, 2009), thus confirming the successful utilisation of both spawning and nursery habitats within this reach. Further downstream, high levels of poaching were observed which had created some sub-optimal juvenile rearing habitats, although the substrate in these areas was observed to be dominated by silt and thus considered to be far from ideal for juveniles. The water in the lower half of stretch 2 was typically deep and slow-flowing, which had promoted the extensive growth of aquatic vegetation.

In general, the River Wensum between Lenwade and Taverham is considered to provide the most suitable physical habitat to support a self sustainable barbel population and should therefore provide an opportunity to further study the performance of this species on the Wensum.

4.3 Stretch 3 Taverham- Costessey

Within this 4.1km stretch, the greatest diversity of instream habitats was recorded in the upper 1 km and immediately downstream of Taverham Mill. A total of nine patches of potential spawning habitat were identified, with four potential areas to satisfy nursery requirements also recorded within the upper 0.5km; although only one of these areas was considered to be optimal. In general, this stretch was similar to Stretch 1, with habitats becoming progressively homogeneous downstream. Despite anecdotal reports of barbel spawning within this stretch, previous surveys conducted by APEM in 2008 and 2009 have failed to detect either barbel eggs, larvae or juveniles within this stretch.

4.4 Stretch 4 Costessey - Hellesdon

Stretch 4 was typified by sluggish glide flows and a heavily silted substrate. As also observed in Stretches 1 and 3, the turbulence of water immediately downstream of Costessey sluice was responsible for maintaining some areas of clean gravel and five of the six potential spawning areas within the entire stretch were limited to this area.
With respect to the availability of nursery habitats, two distinct areas of optimal habitat were identified towards the top of the reach, with another eight areas of sub-optimal value distributed throughout the reach.
In general, this stretch currently has the potential to support a self sustaining population of barbel, however this is largely dependent on the spawning success of the resident adults within the limited spatial availability of potential spawning habitats.

4.5 General

Throughout the 26.9km of the river surveyed, siltation was identified as a key driver of habitat degradation, with levels of fine sediment deposition increasing progressively with distance downstream from each of the impoundments. With the exception of Stretch 2 (Lenwade to Taverham), spawning habitats are generally limited, with a general paucity of nursery habitats throughout.

Many of the flow controlling structures along the Wensum are also likely to compromise the ability of fish to move between the four study reaches and thus limit access to key habitats and consequently, the genetic diversity of the stock. Although some of these structures may be passable by adult barbel under spate flow conditions, if high flows are not synchronised with a fish's propensity to migrate prior to spawning then opportunities to navigate these structures may be limited. In addition, where juveniles have to move downstream to find suitable nursery habitats, the downstream traverse of barriers may have the potential to isolate recruits from upstream spawning habitats. Indeed, the capture of several 1+ barbel at below Hellesdon Mill in July 2009, would suggest that if these individuals reach adulthood, then their reproductive success may well be governed by the quality of habitats which are available downstream of the Mill impoundment. While the qualification and quantification of the impacts of these structures on migration lies beyond the scope of the present study, an assessment of the physical attributes of each structure is provided in the Wensum Restoration Strategy (Coombes *et al*., 2007).

5 RECOMENDATIONS

5.1 Recommendations for future survey work

The data presented within this report and the accompanying DVD will assist considerably in effectively focussing future survey design. Indeed, future surveys can now be spatially focussed to monitor the key habitats most likely to be utilised by spawning adults and 0+ barbel. This enhancement to the study will provide a more substantial sample size which will facilitate fine scale resolution analysis of the habitats required by barbel throughout each life stage. Accordingly, these data will be vital to inform the future direction of fisheries management practices such as habitat preservation/creation on the Wensum in the coming years.

During the walkover survey, a number of locations which are representative of key habitats were labelled as recommended sites for future investigation during the summer of 2010. In light of the spatial distribution of these habitats and the experience gained from the present and previous surveys, it is suggested that a boat based approach is used to conduct both egg and juvenile surveys using a combination of hand netting, Point Abundance Sampling (PAS) and seine netting techniques.

5.2 Preliminary recommendations for restoration

Until a more robust understanding of the functional relationships between physical habitat and barbel ontogeny is realised, it is not recommended that any restoration measures are actioned. Indeed, if and when habitat manipulations are considered appropriate, it would be most pertinent to ensure that sufficient ecological baseline data are available against which assess the ecological response to the scheme and conduct cost benefit analyses to inform future restoration schemes nationally.

With respect to the caution previously advised, the following text provides some preliminary suggestions as to how future habitat improvements may be affected within each stretch.

5.2.1 Stretch 1 Lyng- Lenwade

No optimal juvenile barbel rearing habitat was identified within stretch 1; however, three potential spawning sites were recorded towards the upstream limit of the stretch. It is therefore considered that the creation of addition marginal nursery habitat (bays) in close proximity to potential spawning sites may enhance recruitment success.

While the suggestion that the provision of a permanent connection with the gravel pits downstream of Lyng Bridge may be considered as a contentious issue, it is strongly recommended that this management option is given appropriate consideration.

5.2.2 Stretch 2 Lenwade- Taverham

The diversity of habitats within the upper reaches of stretch 2 would appear to largely fulfil the requirements of barbel throughout each stage of their life history. Further downstream however, flow diversity is reduced and cattle poaching has been identified as a key driver of the increase levels of sedimentation. Due to a lack of optimal nursery habitats further downstream, the stretch 1km downstream of Marriot's Way (NGR TG 12212 17773) could be targeted for the creation of marginal bays, as these would accommodate any larvae or juveniles which may have been flushed from the upstream spawning sites during periods of elevated flow. In addition, this stretch currently has a number of areas of sub-optimal juvenile barbel rearing habitat which could be improved through reduced siltation. The quality of these existing habitats to 0+ barbel, could potentially be enhanced through the strategic provision of fencing to reduce the localised impacts of poaching. Indeed, during the walkover survey, 201m of river bank within the 939m surveyed downstream of Marriot's Way was considered to be impacted by poaching.

5.2.3 Stretch 3 Taverham- Costessey

Potential spawning habitats were observed to be limited to upstream 1km of river which lies immediately downstream of Taverham Mill, however there was a paucity of juvenile nursery habitat below this stretch. Accordingly, the creation of marginal bays, distributed throughout the stretch would be likely to enhance recruitment prospects.

5.2.4 Stretch 4 Costessey- Hellesdon

Potential spawning habitats were limited the weir pool at Costessy, with nursery habitats mainly being restricted to sub-optimal habitat quality. Accordingly, existing nursery habitats could be enhanced through strategic fencing to locally exclude cattle and the further creation of additional bays

5.2.5 Additional comments

The survey also recorded the presence of Japanese Knotweed at Hellesdon. This was restricted to two distinct patches and it is therefore recommended that this is removed to prevent local establishment of this alien species. (see GIS for positions).

6 REFERENCES

APEM (2009). An investigation into the success of barbel and other coarse fish recruitment in the River Wensum 2008. Report to the Environment Agency. APEM report 410597. 30pp.

Coombes, M., Curini, A., Howard Keeble, A., Green, T. and Soar, P. (2007). River Wensum Restoration Strategy. Natural England Research Reports, Number 024.

Clough, S., Dennis, P. and Martyn, D. (2007). A technique for mapping fish habitats in lowland rivers. APEM Scientific Report.

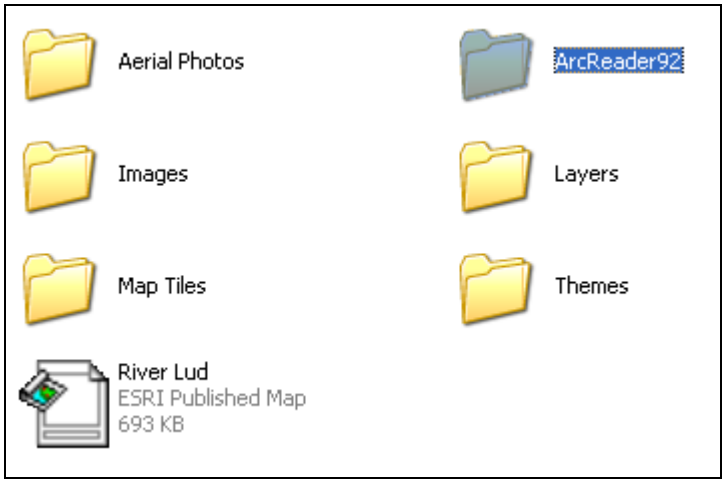
Freyhof, J. (1994) Distribution of YOY-barbel *Barbus barbus* (L) in the River Sieg Germany. In: *Conservation of Endangered Freshwater Fish Species in Europe.* Kirchhofer, A *et al*., (Eds.) Advances in Life Sciences. Birkhauser: Basel.

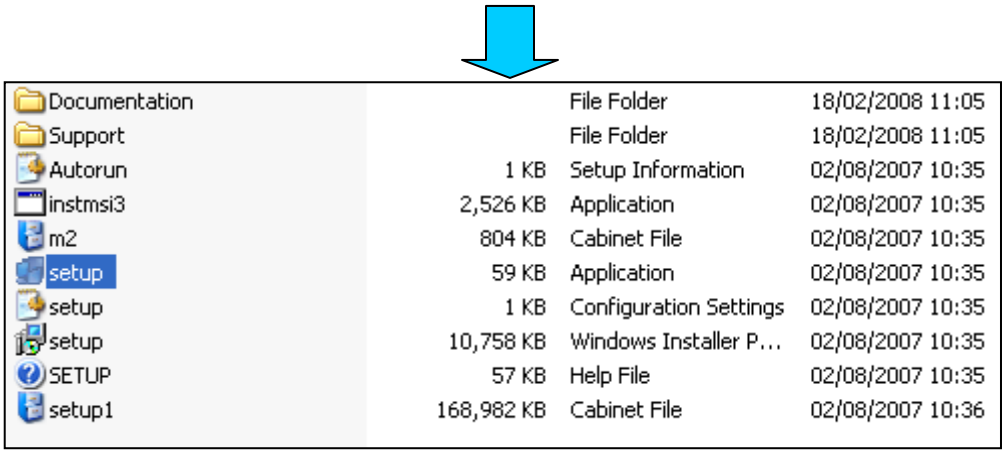
APPENDIX I – ARCREADER INSTALLATION AND USE

Electronic copies of maps for the River Ise have been provided on the DVD accompanying this report. All the images, habitat observations and siltation sources observed during the walkover survey conducted in September 2009 are linked to the map. ArcReader (the GIS viewing software) must first be installed by running the ArcReader executable file which can be downloaded free from the ESRI website (http://www.esriuk.com/) and which has been included on the DVD provided. The following documentation will guide the reader through the installation and use of ArcReader, software which will enable the reader to view and interact with the map provided.

Installation of ArcReader

To install ArcReader, click on the folder titled "ArcReader 9.2" and then the first file titled "setup":





Documentation		File Folder	18/02/2008 11:05
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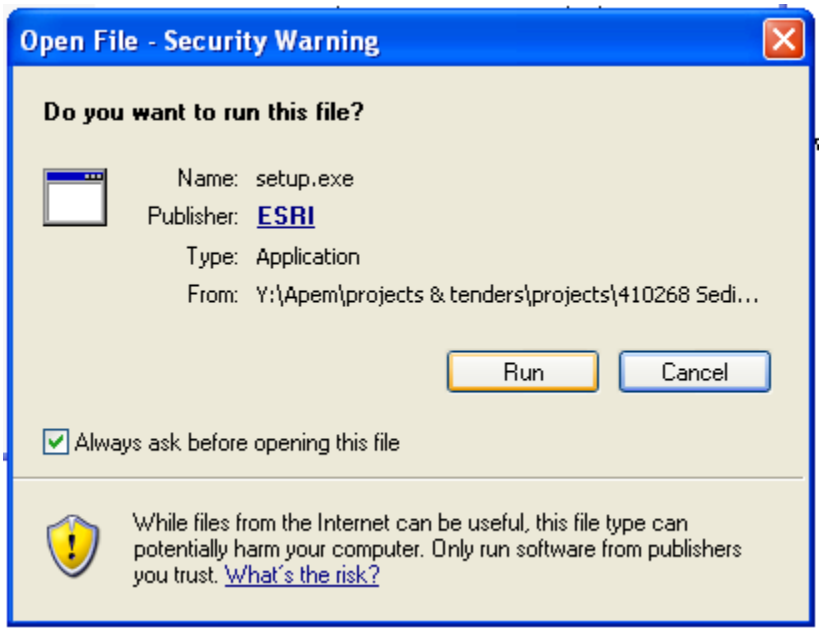
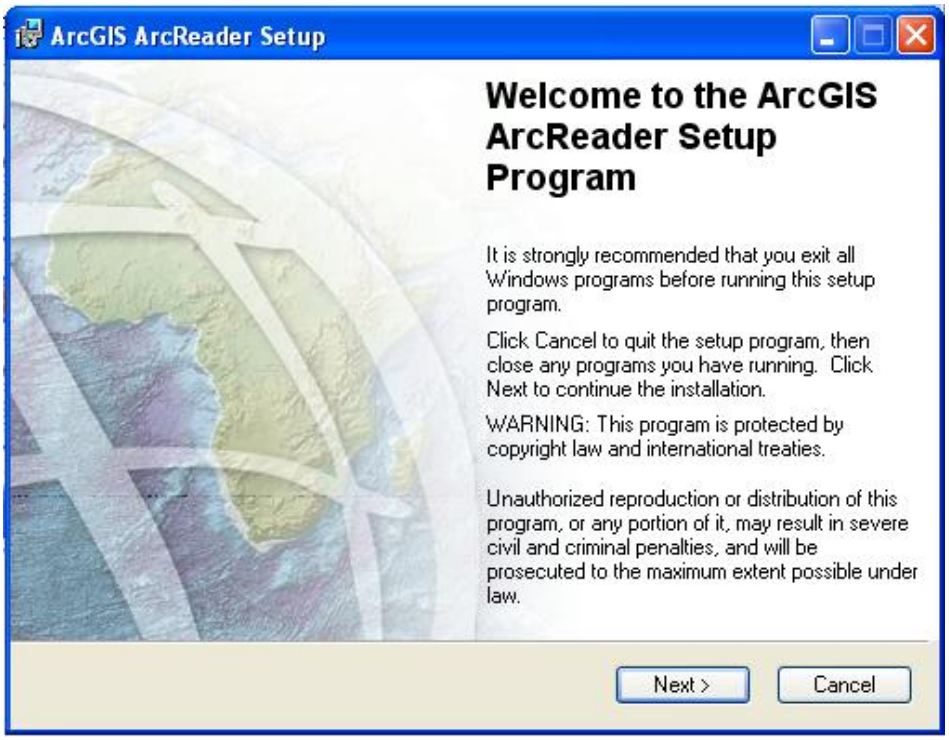
instmsi3	2,526 KB	Application	02/08/2007 10:35
m2	804 KB	Cabinet File	02/08/2007 10:35
setup	59 KB	Application	02/08/2007 10:35
setup	1 KB	Configuration Settings	02/08/2007 10:35
setup	10,758 KB	Windows Installer P...	02/08/2007 10:35
SETUP	57 KB	Help File	02/08/2007 10:35
setup1	168,982 KB	Cabinet File	02/08/2007 10:36

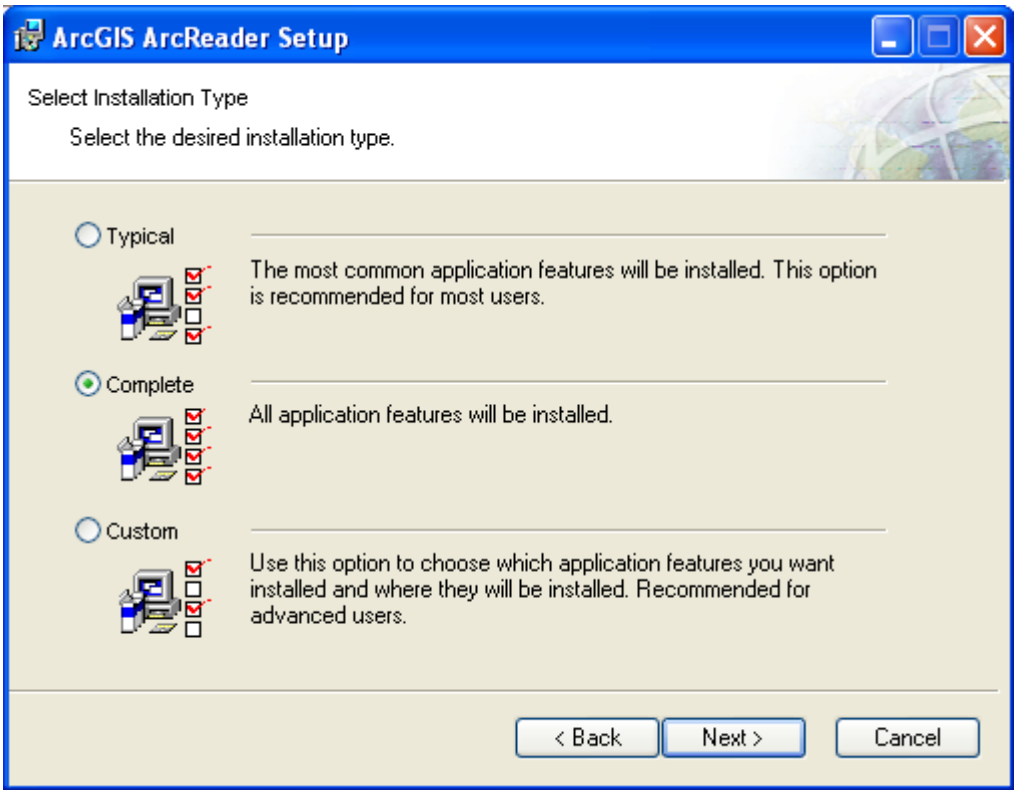
The following dialogue box may appear (depending on the specific configuration of your computer). If it does, click “Run”:



The installation wizard for ArcReader 9.2 will then be launched, which will appear as this window:



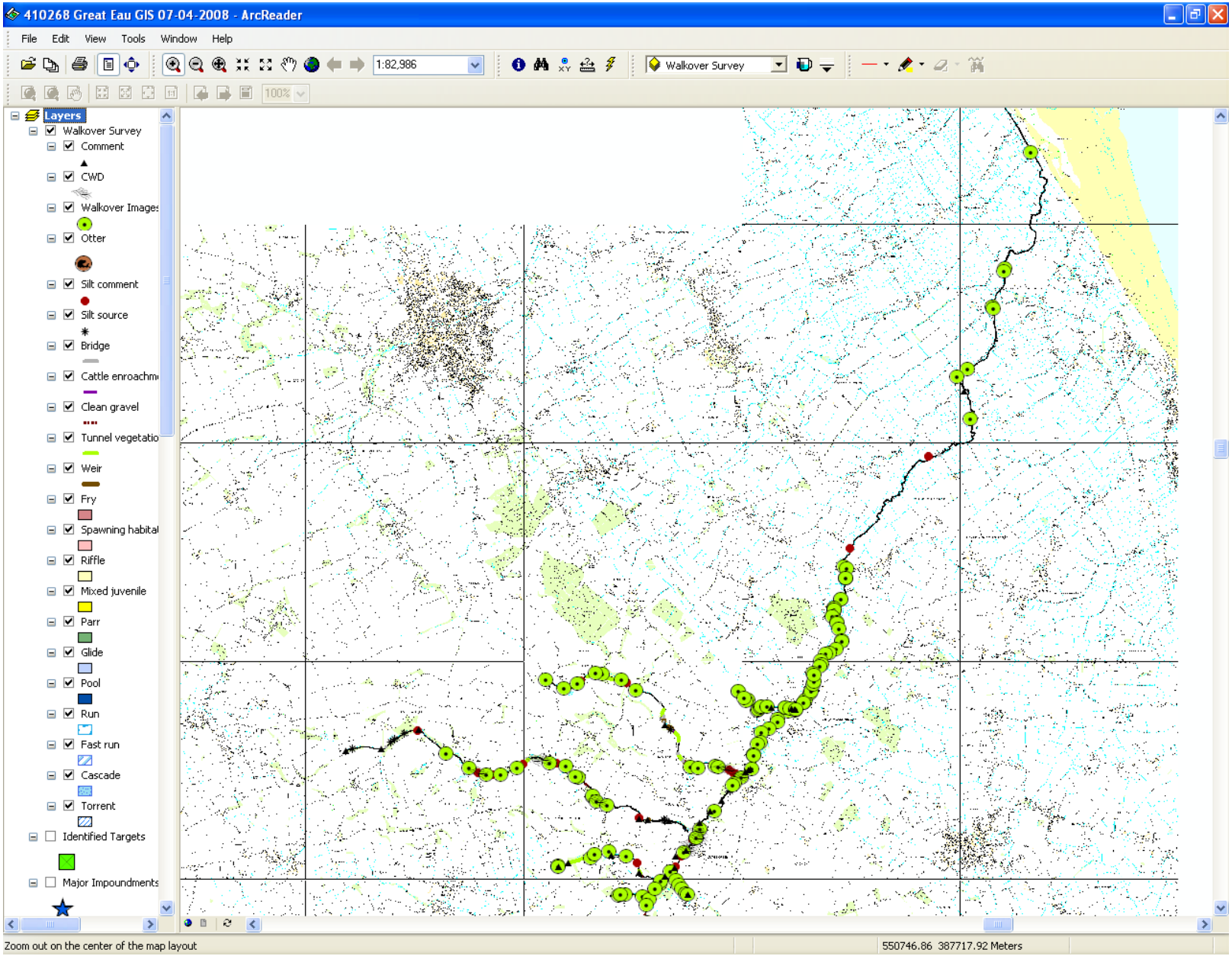
Click “Next” and follow the installation instructions. It is recommended that you install the complete version of ArcReader when this dialogue box appears:



Using ArcReader

Once ArcReader is installed you may open and view the maps provided on the DVDs accompanying this report, along with all the data linked to them. Open the published map, which will appear on the DVD with the following icon:

This will launch ArcReader, and the map produced will appear similar to the image shown on the following page.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File Edit View Tools Window Help
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Silt source
Bridge
Cattle enroachm
Clean gravel
Tunnel vegetatio
Weir
Fry
Spawning habitat
Riffle
Mixed juvenile
Parr
Glide
Pool
Run
Fast run
Cascade
Torrent
Identified Targets
Major Impoundments
Zoom out on the center of the map layout
550746.86 387717.92 Meters

The left hand frame of the ArcReader window contains a table of contents of all the available data. Clicking in the box beside each parameter either activates or deactivates that particular dataset. Activated datasets will appear on the map in the main frame of the ArcReader window, and a tick mark will appear in the box beside the parameter name in the left frame. The map will initially open with all the data collected during the walkover survey activated. Data can only be accessed if the dataset is activated in the left frame and its symbols are displayed on the map.

Various tools are available as buttons along the top of the ArcReader window. Resting your mouse pointer over the top of these buttons will bring up a brief explanation of each tool, however, a description of each tool is provided here as an aid. The most important tools in terms of viewing the data provided with the map are indicated with a red box below:

1. Opens files, as in any other windows based program.

2. Produces a dropdown clickable list of recently opened files.

3. Prints the current view of the map.

4. Toggles the left frame table of contents open and closed

5. Toggles the application to and from full screen mode.

6. Zoom in tool. To use this tool click on the button and then click on the particular area of the map you wish to zoom in to.

7. Zoom out tool. Used in the same way as the zoom in tool.

8. Continuous zoom/pan tool. Clicking this tool allows you to zoom in and out by holding down the left button on your mouse and moving your mouse forward or backward, and to pan in all directions by holding down the right button on your mouse and moving it in the direction you wish to pan to.

9. Fixed zoom in button. Clicking on this button will zoom the map in at a fixed interval.

10. Fixed zoom out button. Used in the same way as the fixed zoom in button.

11. Pan tool which allows you to drag the map to the desired view. Use it by clicking on the button, then holding the left mouse button down while moving your mouse.

12. This button zooms the view out to show everything that is plotted on the map

13. Go back to previous extent – clicking this button takes you back to the last view shown (useful if you have zoomed in or out too far).

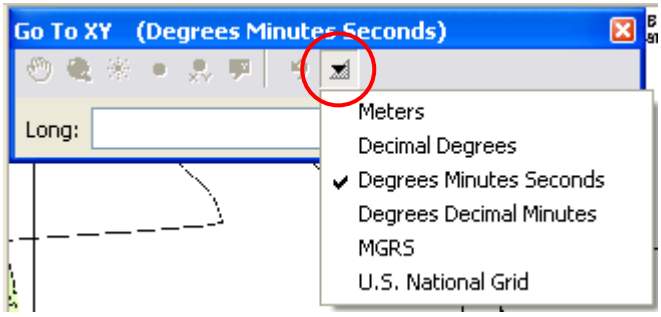
14. Go to next extent – works in the same way as "go back to previous extent" except that it takes you to the view which followed the current view (if there is one).

15. Drop down list with various map scales you can zoom to.

16. Identify: this is a very important tool. This tool is used to access the images that are linked to the symbols on the map. This tool allows you to click on symbols on the map to open an informational dialogue box. The dialogue box may contain comments, eastings and northings of the location, and links to available images which you may click on.

17. This is a find tool which will locate search parameters on the map. This tool is not particularly useful for the current application.

18. Allows you to zoom to a specific coordinate on the map. Clicking on the encircled arrow in the illustration below will display a drop down menu of various coordinate system options.



19. Measuring tool. Allows you to measure the distance between points on the map. You can measure curved distances in segments by clicking on the start point, moving your mouse to the end of the first segment and clicking once, then continuing on to the end of the next segment. Double-clicking ends the measuring session.

20. Hyperlink tool – this is also a very important tool. With this tool you can click on any of the symbols, and any hyperlinked images. If there is more than one image available, a list will appear from which you may select an image to open and view.

21. The next three tools are used in conjunction with one another. This item is a layer list control which allows you to select a layer with which to work.

22. Transparency tool – this tool allows you to make the symbols associated with the layer selected in 21 above entirely transparent or transparent to some degree.

23. Swipe tool – allows you to temporarily remove the layer/layers selected in 21. To use, click on this button, then click and hold the left mouse button on the map and move in the mouse in the direction of the points/items you wish to clear. Once you let go of the mouse button the items will reappear. This tool may be useful if many points are on top of one another, or in order to quickly view features of the OS tiles which may be obscured by map symbols.

24. A pen tool with a drop down menu enabling you to choose different thicknesses of line.

25. Highlight tool. When you use either the pen tool or the highlight tool, the eraser tool becomes usable:

 It is equipped with a drop down menu with options for eraser types.

Description of the Layers

All of the data obtained during the walkover survey are contained within one group called “Walkover Survey”. The remaining datasets (layers) were all created during the desk based analysis.