Broads Local Access forum
9 September 2015
Agenda Item No 8

Hickling Broad Enhancement Project Proposal

Report by Director of Operations and Senior Waterways and Recreation Officer

Summary: This report sets out the details of a proposal for a master plan project for the enhancement of Hickling Broad. It sets out the background and context to the project, as well as explaining the stakeholder involvement to date.

Recommendation:

That the views of the BLAF are sought on the following matters:

(i) Does the Forum accept that the priority for work this year should be dredging in the northern part of the Broad to maintain access to staithes, businesses and clubs? The details of the proposal including the draft vision, and preference for the project elements as set out in Section 6.2;

(ii) Does the Forum have detailed comments on the proposals insofar as they relate to habitat creation, erosion protection and island restoration?;

(iii) The level of support for the project in general;

(iv) Suggestions for access enhancements, particularly with regard to water access, that can be considered during the project development.

1 Background

1.1 In September 2014 work started to consider the feasibility of large scale dredging works at Hickling Broad, as a result of the increasing number of complaints from users of the area as well as the local Parish Council, Sailing Club and adjacent businesses.

1.2 Since then, the Broads Authority has confirmed that the Hickling project was a priority and adopted the following strategic objective for 2015/16:

'Develop a long-term approach for the management of Hickling Broad, building on scientific evidence from the Broads Lake Review. In the short term, progress development of a number of smaller projects to meet immediate concerns.'

1.3 A workshop to discuss the outputs of the Lake Review was held earlier in the year which a number of members attended, and this work provided a

comprehensive scientific assessment of all previous lake restoration work in the Broads and its impacts and effectiveness.

1.4 The outputs from the Review included a dossier in respect of Hickling Broad, which included consideration of management options to improve the ecological condition of the Broad, and in combination with the acknowledge need to dredge for navigation and access needs, provide a powerful driver for the development of a multi benefit project.

2 Project Development

2.1 In order to develop long-term approach for the management of Hickling Broad an officer Project Group has been established to include all the required expertise and experience. A consultative approach has been adopted with a wide range of stakeholders and interested parties in order to help identify the project objectives.

2.2 The overarching aim is to develop a multi benefit project across all the Broads Authority's statutory purposes although because of the need for sediment removal the primary focus is on navigation and in-lake enhancement work. However, the Authority also continues to work with partners through the Internal Drainage Board led Brograve Partnership and the wider Broadland Rivers Catchment Partnership on the development and support for adoption of catchment measures to improve the aquatic environment. An assessment of the rural diversification options for the Upper Thurne catchment is proposed as part of the proposed external funding bid that will be required to fund the project. . Although it is recognised that source control measures provide a more sustainable and long term solution and can contribute a wide range of benefits beyond food production, they are voluntary. In addition any changes to water level and agricultural management need to be made with these long term benefits in mind as they are likely to be high cost. The Authority is therefore promoting in-lake measures to enhance the broad in the shorter term, for the benefit of all interests.

2.3 As a starting point it has been useful to look to review the current adopted vision for Hickling which is captured within the Upper Thurne Water Space Management Plan. A workshop was held with the Upper Thurne Working Group (UTWG) in early June 2015 which reviewed the baseline data and also considered the opportunities and issues that an enhancement project could promote. Using the workshop outputs, officers have been aided to develop an interim vision which could be delivered in the short – medium term, pending further catchment measures. A project proposal document which includes a draft revised interim vision statement as well as the agreed project areas and guiding principles has been drafted and is attached as Appendix 1, upon which members views are sought. The proposal document also considers the plans in the context of planning policies, and identifies the potential issues/ dis-benefits that need careful monitoring and mitigation measures.

2.4 Throughout the development additional high level discussions have also been held with partner organisations which include the Environment Agency,

Natural England, and the Norfolk Wildlife Trust the landowner. A detailed technical meeting to review the Natural England application, and pre-planning advice has been sought to aid the consenting processes, and further stakeholder consultation has also been undertaken with the Broads Forum. Specific advice in respect of prymnesium has also been sought from the John Innes Institute and data shared with a prymnesium researcher, Johannes Hagström, in Sweden.

3 Project Plan and Timescales

3.1 Given the urgent need for dredging to maintain access to Hickling village and associated facilities/businesses following the deferral of the project from last year, Natural England consent has been sought for initial works to complete erosion protection at Hill Common and undertake some additional dredging at the north end of the navigation channel which are due to be carried out in November 2015. This work has planning permission in place, and will also be a useful local trial of the Nicospan technique for providing bankside protection and stabilisation. To support the application an Environmental Report has been prepared which details the proposed works, sets out the Habitats Risk Assessment and includes the detailed monitoring plan.

3.2 Additional budget of £34,500 is required to purchase/ hire the additional resources needed to complete these works. The dredging method proposed is to conventionally dredge using in house labour and plant as far as possible, but to reduce the risk of Prymnesium, additional mitigations are proposed which includes the addition of a ‘moon pool’ to the excavator, and additional silt curtains. To maximise the volume of material which can be deposited in Duck Broad Island, it is also planned to hire a concrete pump to offload, which will allow the rear of the island to be reached.

3.3 It is proposed that other elements of the vision would be delivered in a phased approach over future years, subject to further feasibility work and detailed design, funding availability and individual planning and other consents as required. Taking account of the physical and environmental constraints of operating on the site an annual window for dredging work has been identified as a maximum of 12 weeks per annum, although there is a possibility that construction works could take place outside this period. Therefore, to deliver the vision as a whole is likely to be a medium – long term commitment of up to 10 years. It should be noted that this commitment would mean a reduction in the amount of dredging completed elsewhere in the Broads whilst this project is ongoing.

3.4 Given the complexity of the site in terms of environmental factors, engineering feasibility and the monitoring requirements it must be stressed that plans at this stage are outline only. It will be important to retain a flexible approach to project delivery and will be subject to change depending on monitoring results. It is therefore proposed that regular reporting on progress to members and stakeholders would be undertaken throughout the project life.

4 Funding

4.1 The Authority is currently investigating the possibility for European external funding and has submitted an Expression of Interest form for Interreg North Sea Region funding with a number of European partners. The Authority has submitted a number of work packages for lake, fen and catchment management under an initial budget of £1,400,000. These include:

- Hickling Broad Enhancement Project
- Economic assessment of diversification in the Upper Thurne catchment
- Beneficial reuse of fen/peat arising's
- Supporting school's curriculum development
- Developing volunteer surveyors
- Developing a water code and communication with water users

5 Desirable Outcomes

5.1 It is envisaged that the outcomes from the delivery of the Hickling Broad Enhancement Project would include;

- Achievement of agreed waterway depths in the marked channel and identified priority areas, improving access to the staithe and local clubs and businesses
- Improved aquatic environment in sheltered bays providing more reed bed, better water quality, water plants and higher numbers of water birds
- beneficial reuse opportunities for dredged material
- increased expertise and understanding in matters relating to water quality in Hickling Broad, including dealing with Prymnesium
- improved understanding by local communities, visitors and partners of the requirement to, and importance of, undertaking integrated water management projects to enhance the special qualities of the Broads
- Consideration of the potential for delivery of enhanced access as prioritised by the Integrated Access Strategy action plan (due for review 2015) particularly with regard to moorings, navigation and footpaths.

6 Summary

6.1 Through the consultation process officers have developed proposals for a multiple benefit project on Hickling Broad, and this has received wide ranging in principle support from stakeholders. On this basis the Local Access Forum is asked to endorse the project in principle, and is also asked to provide detailed comments on the acceptability of the project elements.

6.2 In particular, members' views are sought on the following:

(a) Interim vision as set out in proposal document
(b) Project elements:
  - Dredging and beneficial reuse of sediment
  - Bank restoration works

- Creation of refuge areas/ island construction
- Research needs

It would be helpful if members provide guidance on which areas are favoured/ supported and should be prioritised for the early stage delivery work.

7 Next Steps

7.1 Following consideration by the Forum and the Navigation Committee further consultation will be carried out including a presentation on the masterplan approach to the Planning Committee prior to the master plan being considered by the Broads Authority at the end of September to endorse the approach.

7.2 It is also planned to carry out further consultation with members of the public and local residents at the Thurne Parish Forum, and dates are currently being canvassed for this meeting. A meeting is also being sought with the Hickling Broads Sailing Club and Norfolk and Suffolk Boating Association to discuss the proposals in more detail.

7.3 A response to the Interreg Expression of interest is expected in November, and should this be supportive, detailed design work for the full application will have to be completed by Feb 2016.

Background papers:	None
Author:	Trudi Wakelin, Adrian Clarke
Date of report:	27 August 2015
Broads Plan Objectives:	BD4.1
Background papers:	APPENDIX 1 – Project proposal

APPENDIX 1
Aug 2015

Hickling Broad Enhancement project proposal

Background

The Broads Authority has identified the following strategic objective for 2015/16:

'Develop a long-term approach for the management of Hickling Broad, building on scientific evidence from the Broads Lake Review. In the short term, progress development of a number of smaller projects to meet immediate concerns.'

The Lake Review included a dossier on Hickling Broad, which reviewed all known data through case history. This lead to a number of conclusions:

- Hickling cannot be viewed in isolation and its water quality is highly responsive to the drainage and agricultural management within its general catchment, but especially of Horsey Mere
- External factors which cannot be controlled, such as weather and tidal conditions and bird numbers, influence the effectiveness of any management activities
- Water plants respond to, but also promote changes in environmental parameters, so underlying change mechanisms can prove hard to discern
- Although the mechanisms which originally switched the lake are well understood, the decline of Chara and other vegetation species in Hickling in the early 2000's cannot be explained with any certainty, and therefore the confidence in the effectiveness of any form of management is low.

Three connected management options were identified;

1. Changes in catchment management through reversion of arable land to grazing pasture at some locations and conversion to shallower drainage would lead to reductions in iron, phosphorous and salinity inputs to the benefit of Horsey Mere, Hickling Broad and the Upper Thurne
2. Source control, possibly accompanied by increased freshwater input from the Catfield catchment, would reduce phosphorous inputs and improve flushing and dilution,
3. Sediment removal – whilst the nutrient reduction potential of sediment removal is unlikely to be significant, it may create benefits of bed stabilisation, seed bank exposure, and habitat creation using dredged material.

The Broads Authority continues to work through both the Internal Drainage Board led Brograve Partnership and the wider Broadland River Catchment Partnership to adopt catchment measures aimed to improve the aquatic environment. An assessment of the rural diversification options for the Upper Thurne catchment is proposed as part of the proposed external funding bid. Although it is recognised that source control

measures provide a more long term and sustainable solution and can deliver a wide range of benefits beyond food production, they are voluntary. In addition any changes to water level and agricultural management need to be made with these long term benefits in mind as they are likely to be high cost. The Broads Authority is therefore promoting measures to enhance Hickling Broad in the shorter term, for the benefit of all interests.

Proposed Vision

In-lake enhancement measures have resulted in refuge areas in quiet bays and sheltered areas, which provide conditions for water plants to flourish and suitable habitat for fish and birds. These areas are managed for their habitat and wildlife conservation value. The marked channel is managed to maintain agreed depth and water plant cutting specifications, to allow boat users to access the staithe and local businesses, as well as to enable the local clubs to enjoy their recreational activities. Dredged material is deployed beneficially, with sediment used to restore eroded reed swamp, construct lakeside bank protection, and regularly top up bank restoration and island areas, as well as being spread to local arable land. Regular monitoring continues to build scientific understanding of the Broad and its management. Partnership research is continuing in order to gain an understanding of the ecological dynamics of Prymnesium and to run trials to reduce nutrient and salinity inputs from the catchment.

In Lake Enhancements

Appendix i lists a review of potential benefits for a sediment removal programme and its relevance to Hickling Broad, and reviews the benefits in the context of the Authority's statutory purposes.

To develop these proposals the Authority consulted the Upper Thurne Working Group at a workshop event on 9 June 2015, where the context of the Lake Review and current baseline data were presented. This Group includes representatives of key stakeholders, including statutory bodies (EA/NE/IDB), user groups (sailing/angling/windsurfing), RSPB, local parish council and business interests, landowners (NWT/NT/Mills Estate).

With the objective of seeking to develop a multiple benefit project that will deliver a range of enhancements in the short to medium term for Hickling Broad, the workshop considered opportunities and possible risks. A high level of consensus was achieved over the following projects:

- **Dredging of the navigation channel** – here the priority is the necessary dredging at the north end of the channel to maintain essential access to the staithe, businesses and facilities in the area. It was also agreed that the channel could be used as a silt trap to draw mobile sediment from the surrounding areas, and the effectiveness of this as a technique should be monitored.
- **Bank restoration works** – benefits were recognised to restore eroded banks around the perimeter of the broad, to reduce erosion and sediment input, to

create new edge habitat and to increase shoreline complexity helping biodiversity.

- **Creation of refuge areas** – the creation of refuges was noted to be of benefit to allow water plants to recolonise in the sheltered areas, improve habitat and to provide refuges for fish as well as for birds. Specific areas suggested included Churchill's Bay and to extend Pleasure Island. Additionally, a further suggestion was to trial the installation of a groyne or spit construction to act as a barrier to reduce the fetch and allow natural accretion of sediment to form an island feature.
- **Beneficial reuse of sediment** – it was agreed that material arising from dredging activities should be used beneficially where possible, either in the construction of bank restoration or for island features, or by land spreading to local agricultural land.
- **Research needs** – there is a need to carry out initial research as part of the feasibility phase, to include investigations into fish populations and usage and to confirm the presence of any spawning/ nursery areas in the proposed footprint of the dredging/ construction works. Cooperation with current and future Prymnesium research will also be required throughout the life of the project to include the sharing of all water quality data and field trials of a mobile toxicity test. Subject to the views of stakeholders it may also be appropriate to undertake small scale trials of sediment removal to determine any benefit to propagule germination or bio-manipulation in exclosure areas.

The following principles were also agreed;

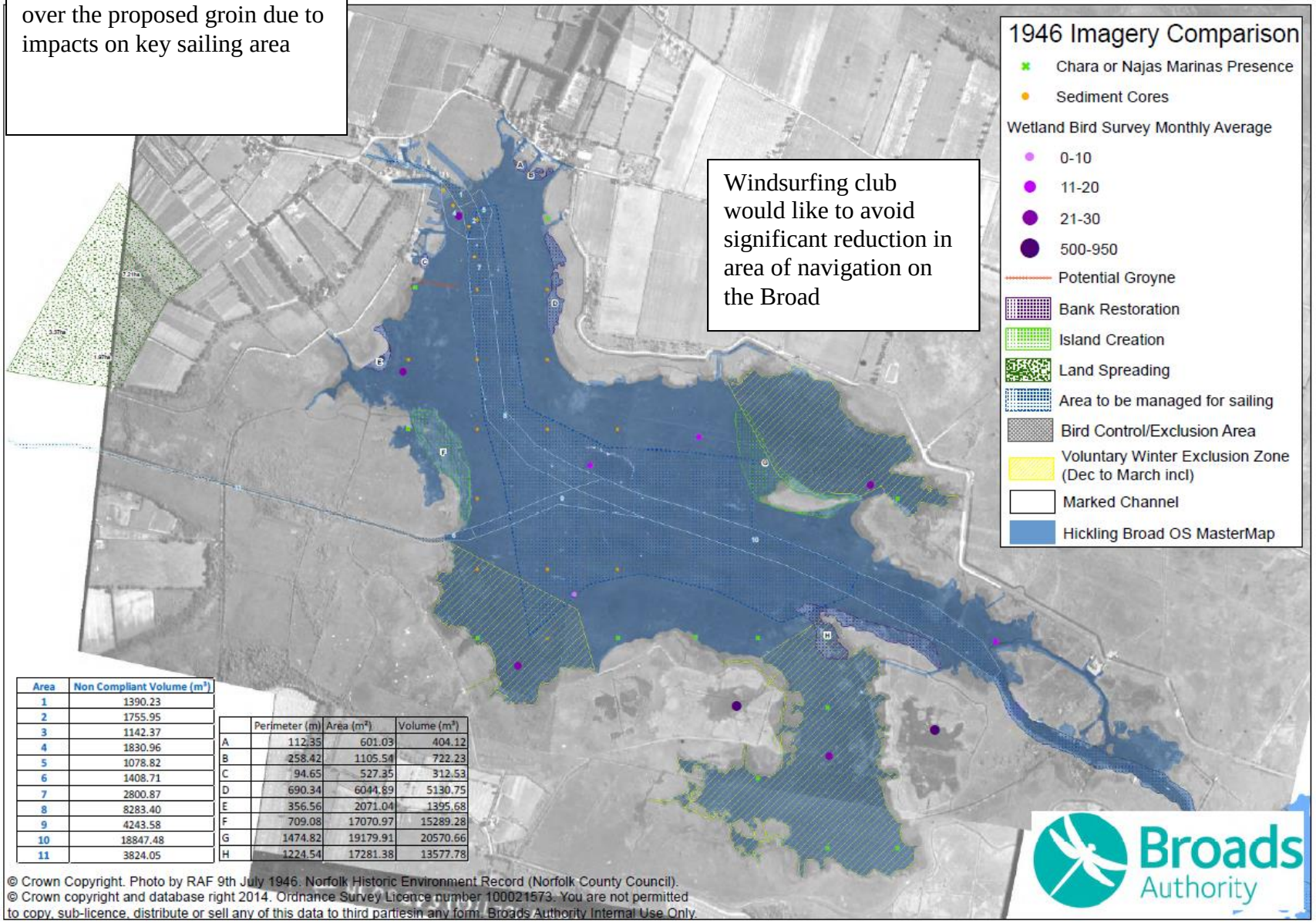
- Works should be carried out in accordance with the agreed strategic vision, with strategic consents/ licences gained where possible to reduce the risk of individual project elements being refused/delayed throughout the project period
- Experimental works should proceed only following successful small scale trials
- A phased approach to the delivery of the vision should be adopted
- Robust and thorough monitoring will be required to collect data on the impacts and successes of the project delivery and inform subsequent phases
- In lake reconstruction works should largely follow the historic 1946 lines
- Precautionary approaches should be adopted – including agreed mitigation measures/ timings etc. so that there is no avoidable delay due to lack of full scientific certainty. Hence the purpose of well-monitored and phased research pilots leading to full scale experiments.

The delivery of each of these project areas will result in improved conditions for the environment, for navigation and for recreation. Local socio- economic benefits from the works will also be generated, as well as improved understanding of the ecological functioning of the lakes.

Figure 1 shows the proposal in a visual layout, and identifies the environmentally sensitive features of the site.

Windsurfing and Sailing club have responded to the consultation with concerns over the proposed groin due to impacts on key sailing area

Windsurfing club would like to avoid significant reduction in area of navigation on the Broad



Area	Non Compliant Volume (m³)
1	1390.23
2	1755.95
3	1142.37
4	1830.96
5	1078.82
6	1408.71
7	2800.87
8	8283.40
9	4243.58
10	18847.48
11	3824.05

	Perimeter (m)	Area (m²)	Volume (m³)
A	112.35	601.03	404.12
B	258.42	1105.54	722.23
C	94.65	527.35	312.53
D	690.34	6044.89	5130.75
E	356.56	2071.04	1395.68
F	709.08	17070.97	15289.28
G	1474.82	19179.91	20570.66
H	1224.54	17281.38	13577.78

Fig 1

Estimated Costs for the various elements within Hickling Broad

Section (see Fig 1)	Potential Solution	Approx. Installation Cost per M	Total Approx. cost inc. plant/labour	Length / Area	Approx. Construction Timings	Comments
A + B Hill Common Erosion Protection	Nicospan geotextile with timber poles	£30	£11,123.10	370.77m 1,706.57m2	3 weeks	Installation of fabric surround, installing goose guard and planting. Back filling with dredge material would be a separate operation.
C + D	Nicospan geotextile with timber poles	£30	£23,549.70	784.99m 6,572.24m2	6 weeks	Installation of fabric surround, installing goose guard and planting. Back filling with dredge material would be a separate operation
E	Nicospan geotextile with timber poles	£30	£10,966.80	356.56m 2071.04m2	3 weeks	Installation of fabric surround, installing goose guard and planting. Back filling with dredge material would be a separate operation
F	Bagger-Buffer (geo-textile mini tube)	£40	£28,363.20	709.08m 17070.97m2	8 weeks	Untried within the Broads although the Dutch have used this with great success.
G(a)	Gabion Baskets as per Duck Island	£60	£88,489.20	1474.82m 19179.91m2	20 weeks	Using the same techniques as we employed at Duck Island. The ‘croissant’ could be built up in cells to give strength and allow for areas to be filled and planted.
G(b)	Geotube as per Salhouse project	£385	£567,490.00	1474.82m 19179.91m2	40 weeks	Using the same techniques as we employed at Salhouse Broad. The ‘croissant’ could be built up in phases and filled to a higher level over a number of years
H	Nicospan geotextile with timber poles	£30	£36,736.20	1224.54m 17281.38m2	10 weeks	Installation of fabric surround, installing goose guard and planting. Back filling with dredge material would be a separate operation.

Mud-pumping	To dredge channel and back filling of constructed areas/ land spreading	£20 per m3	£800,000.00	40,000m3 in channel, noted volumes may increase subject to levels of mobilisation in the Broad	60 weeks	Mud-pumping could be used for the soft, silty mud mainly found in the main navigation channel. Duration depends upon weather conditions and distant to pump, but estimated based on previous outputs achieved. Annual surveying required to monitor slumping/ mobilisation and repeat dredging requirements.
Grab Dredging	Dredge into barges and offloaded into constructed areas	£20 per m3	£140,000	7,000m3 in Channel	12 weeks	Grab dredging will be needed to remove the harder, consolidated sediments; these are generally located around the Pleasure Beach & sailing Club area.

Feasibility work in autumn 2015 is being carried out to determine ground conditions and appropriate engineering designs to inform the proposed priority phasing. This may include trial stages for differing techniques/materials/designs, as well as indicating the anticipated timescale for delivery. Examples of previous techniques used in the Broads are included in Appendix ii.

If the proposal are endorsed it is proposed that each element would be delivered individually and would therefore be subject to separate funding arrangements unless significant external funding can be won. Individual planning consents will also be required. These will include detailed design and methodology based on full consultation. It is anticipated that each element will be delivered as part of a phased approach to delivering the whole vision and to ensuring multiple benefits. An initial 'trial' to demonstrate that any innovative design will work successfully will be assessed before larger scale activity / works take place on a phased basis.

A robust evaluation and monitoring strategy has been developed to identify the parameters that will be evaluated and the schedule of data collection. The analysis of the data will help to inform both the design of each element as well as understanding the impact of the works during and after construction.

The Broads Authority's consultative committees (Broads Forum and Navigation Committee) have been involved to help shape the vision and broad support has been expressed to date. The views of the Planning Committee will also be sought on the master plan prior to seeking the endorsement of the Broads Authority.

Potential impacts
Key considerations for the proposal are likely to relate to hydrology, landscape impact, ecology and habitat considerations, and the impacts on water space and navigation (including in relation to use of dredgings). An initial assessment against these aspects and the relevant policy framework has been completed below;

Broads Core Strategy DPD

Policy CS1 – Landscape protection and enhancement – the project will help to restore landscape features such as islands which have been lost to erosion as identified in the 1946 aerial photographs. Bank protection measures will safeguard the site from further erosion, and recreate lost reed bed and open water mosaic habitat.

Policy CS3 – Navigable water space – the project will allow the navigation channel to be dredged so as to secure access to the staithe, as well as to reduce the long term need for dredging by reducing sediment input from bank erosion. Navigation hazards such as island remnants which currently need to be marked as a hazard will be removed by being restored using dredged sediment. This will also remove the need for visually intrusive marking. Monitoring will determine the benefit to the wider open water of dredging the navigation channel and using it as a silt trap to draw in mobile sediment from the surrounding area. Innovative solutions such as groyne/ palisade will be tested to measure their effectiveness as low cost, sustainable measures to help manage sediment. Successful schemes may be replicated elsewhere.

Policy CS4 – Creation of new resources. The proposed island restoration or creation would, as well as creating new reed bed, establish refuge areas where water plants, fish and birds would be able to flourish. This would be enhanced as a result of lower turbidity from reducing the fetch over the water which generates wind induced sediment disturbance, and also as a result of separation from boating activity. This should help to provide new areas for species, particularly those of conservation priority to extend their range in the Broad.

Policy CS15 – Use of dredging – the project has been designed to beneficially reuse sediment from the Broad. An assessment of engineering properties will be carried out. But it is proposed that very loose unconsolidated material will be pumped to adjacent, arable land for land spreading, or within lagooned areas, for bank reinstatement or island creation. Firmer material will be used directly within construction elements. This may also include the reuse of historic sediment from previous deposits on the lake banks. The design of the phasing will take account of the need to return to each area following consolidation of the dredged sediments, so that topping up can maximise the capacity in each area as well as ensuring that final levels are suitable for reed bed restoration.

Policy CS20 – Flood risk – as the new habitat features will be created at or below high water, and will be constructed from material dredged from the water body. There should be neutral impact on water levels, and hence no increased flood risk to adjacent communities. The developments are all located within the waterbody, so any future plans for flood risk mitigation measures would not be impaired.

Broads Development Management Policies DPD

Policy DP1 – Natural environment – the proposal will improve the mosaic of open water and reed bed and complexity to the lake edge which will result in greater number of niches for wetland species such as fish and quiet feeding area for bittern. Restoration of areas of reed bed will minimise further sediment input into the open water with added beneficial impact for the open water environment, as well as creating refuge areas for water birds and water plants by introducing shelter areas.

Policy DP13 – Bank protection – by including bank protection within the proposal on areas that have significantly eroded since 1946, further erosion will be arrested. This will help to protect the land and to benefit the water environment by removing a diffuse source of sediment input. Soft techniques will adopted such as geotextiles or gabions, in preference to adopting a piled edge, and vegetation will be established. Appropriate temporary navigation marks will be included until the vegetation is fully established to provide a clear visual indicator of the new edge.

Policy DP29 – Development on sites with a high probability of flooding – the features created will be designed in such a manner as regularly to inundate designed floodable areas, to ensure that the desired vegetation is supported and to prevent the growth of scrub. As the development will be at or below high water, and will be constructed from material dredged from the water body, there should be a neutral impact on water levels and therefore no increased flood risk to adjacent areas.

This project is necessary to support the socio economic needs of the local community, by maintaining access to the village by boating visitors to the boatyard and local pubs, and also to ensure that the local recreation clubs such as sailing and windsurfing can continue to enjoy their activities. The Parish Council has recently invested in improvements to the staithe and slipway area. Numerous complaints have been received from local people about the current lack of maintenance dredging which is adversely affecting their activities.

Environmental report

An Environmental report has been prepared for submission to Natural England which details the proposed initial dredging and bank protection works, sets out the Habitats Risk Assessment screening and Appropriate Assessment and also includes the proposed detailed monitoring plan to be undertaken.

This is currently being reviewed by Natural England, and if agreed is intended to form the basis of a standard methodology, which can be replicated to each element and modified as required for the site specific conditions and design. It is intended that sharing the monitoring and mitigation plans with stakeholders and interested parties will help to provide reassurance that an appropriate precautionary approach is being adopted.

Consultation responses to date

The views of the Broads Forum have expressed that a 'do nothing' approach is not a viable option, given the poor environmental condition of the Broad, its failure to achieve either statutory targets or its potential, and the worsening position in respect of access and navigation through ongoing shallowing. Advice from the John Innes Institute has also indicated that the 'do nothing' option would also be inadvisable given the potential for boat disturbance of sediment to provide a contributory factor in prymnesium blooms, and that an increase in under keel clearance would be beneficial to prevent uncontrolled sediment disturbance.

Detailed comments have also been received in respect of the proposed groin structure, in respect of possible impacts on key sailing area as noted on Figure 1, as well as indicating a desire to minimise the loss of water space in the navigation area.

Following endorsement of the principles by the Broads Authority, further consultation is proposed with Hickling Broad Sailing Club, and a Parish Forum is proposed to be held in the area for members of the public and local residents.

Function	Comment	Benefit for dredging for			Other benefits
		conservation	navigation	promoting enjoyment	
Reduction of internal loading	Non-retentive sediment due to competitive binding of iron by sulphide. Therefore internal loading is naturally limited	Low	Low	Low	
Increased water depth	Hickling is shallow and turbid (unless dominated by plants). Deepening is unlikely to improve submerged light climate unless there is an accompanying equivalent reduction in turbidity. Current dominant species have rhizomes and independent of light regime but could be reduced unless dredging avoids existing beds.	Low	High	High	High benefit for tourism by improving access in navigation channel to local businesses and local community. Additional benefits also for angling, nature watching, tourism, landscape value by increased access through restoration of water depth in agreed areas and reduction of mechanical disturbance by boats in shallow water which has the potential to trigger prymnesium event through ongoing release of nutrient (unproven)
Bed stabilisation	Wind and boats stirring up the sediment is a source of turbidity. Increasing depth by removing fine sediment should increase clarity. Hickling sediment is, however, already comparatively cohesive and unlikely to limit water plants.	Mod	Low	Mod	Moderate benefit for angling, nature watching, tourism, landscape value by increased water clarity
Propagule bank exposure	Hickling historically dominated by water plants, some seeds may germinate after sediment removal.	Mod	Low	Mod	Moderate benefit for angling, nature watching, tourism, landscape value by increased water plants
Bank reclamation	Opportunity to reclaim and restore sections of eroded bank, especially in areas of reed dieback and goose grazing. Potential benefits to water plants through increased shoreline complexity and reduced wave reflection from steep eroded banks.	High	High	High	High benefit for navigation by lower bank erosion High potential benefit for angling dependant on location and design delivering improved fish habitat High benefit for nature watching, tourism and landscape value by increased reed edge High benefit for landowners to prevent loss of land/reed area
Contaminant removal	Opportunity to reduce the concentration of heavy metals (copper, tin).	Low	Low	Low	low benefit as tests indicate low levels of heavy metals
Creation of hydraulic refugia	Water plants are likely to colonise sheltered bays. Imaginative used of dredged material to create bunds or islands could significantly increase shelter and help water plants re-establish.	High	Mod	High	Navigation benefit dependant on location e.g. island over a navigation hazard may be high benefit. Islands obstructing sailing may be low benefit. Beneficial use of sediment in constructing refuges would be of high benefit to assist with navigation dredging High benefit for angling, nature watching, tourism by increased water plants, fish habitat and bird refuge areas Landscape benefit dependant on location and design

Examples of Previous Techniques used in the Broads **Appendix ii**

The Broads Authority have undertaken a variety of projects making use of dredged sediment on agricultural land or in projects to protect or restore eroded reed beds and river banks. A few examples of recent projects are outlined below.

1. Land Spreading

Where an agronomist can show there will be agricultural benefit sediment can be spread onto agricultural land as a soil conditioner. When intending to spread sediment onto land it is common practice to remove the sediment from the waterbody with a suction dredger. A cutter suction dredger typically pumps a 85% water / 15% sediment mix which needs de-watering before spreading. Settlement lagoons are an established method of de-watering and have been used many times on the Broads and a few examples are given below. Another method is to pump the sediment mix into geotextile bags which under pressure and over time allow water to drain and sediment to consolidate.

Example 1: Barton Broad

Between 1996 and 2001 sediment was dredged from Barton Broad de-watered and spread on adjacent agricultural land.

Sediment	Volume	Dredging technique	Dewatering technique	Cost
Soft organic silt	305,000m3	Cutter suction dredger	Settlement lagoons	£10/m3

Photo 1: Barton Broad settlement lagoons

Example 2: Ormesby Broad

In 2010 sediment removed from Ormesby Broad was pumped into dewatering lagoons and later spread on agricultural land on the same site.

Sediment	Volume	Dredging technique	Dewatering technique	Cost
Soft organic silt	15,000m3	Small suction dredger	Settlement lagoons	£8/m3

Example 3: Upton Little Broad

In 2011 highly organic silt was removed from an isolated broad and pumped into geotextile bags and later spread onto agricultural land, with the geotextile recycled in erosion protection works.

Sediment	Volume	Dredging technique	Dewatering technique	Cost
Highly organic silt and algal matter	4500m3	Small suction dredger	Non-woven geotextile bags	£20/m 3

Photo 2: Geotextile bags starting to be filled at Upton

Example 4: River Bure, Coltishall Lock Channel

In 2015 soft sediment overlying a hard sand and gravel bed was removed and pumped into settlement lagoons on adjacent agricultural land. Given the granular nature of the sub soil the sediment dewatered rapidly and is awaiting spreading.

Sediment	Volume	Dredging technique	Dewatering technique	Cost
Soft organic sandy silt	2000m3	Small suction dredger	Settlement lagoons	£15/m3

Photo 3: Constructing settlement lagoons near Coltishall

2. In-line Erosion Protection

Where bank erosion is an issue structures can be installed to protect the bank and retain sediment backfill. Recently timber post and geotextile structures have been trialled in the Broads to restore and protect the original bank line and make use of sediment backfill. An example is given below.

Example 5: River Ant, Hall Fen

Principally an erosion protection project involving a simple geotextile retaining structure in front of an eroding bank. Due to the layout the capacity for sediment backfill was very limited however the structure proved a backfill depth of at least 0.6m could be successfully retained.

Sediment	Volume	Dredging technique	Retaining structure	Cost
Soft silt	100m3	360 excavator	Nicospan with anchored timber posts	£65/m3 (for 24m length)

Photo 4: Nicospan erosion protection structure planted with bur-reed.

3. Reed Swamp Reclamation

In some locations sediment can be beneficially used to reclaim areas of eroded or degraded reed swamp. In such areas forming a stable retaining structure on very soft ground can be difficult. Geotextile tubes and gabion baskets have recently been used as effective retaining structures as outlined below.

Example 6: Heigham Sound

In 2012 soft silts were dredged from Heigham Sound and pumped approximately 1800m to a former soke dyke on marshland. The landowner wanted to create a reedbed and the soke dyke effectively formed a ready-made settlement lagoon. This is a refinement of traditional bankside disposal.

Sediment	Volume	Dredging technique	Retaining structure	Cost
Soft organic silt	10,000m3	Cutter suction dredger	Soke dyke as ready-made lagoon	£9/m3

Photo 5: sediment pumped from Heigham Sound filling former soke dyke.

Example 7: Duck Broad

A bespoke gabion structure has been the solution to reform the perimeter of an eroded reed bed and retain dredged sediment. The steel cage baskets are linked together to form a mass gravity structure stable on the very soft bed material. The baskets were planted with reed and then sediment pumped into the internal lagoon area to recreate the reed bed land mass.

Sediment	Volume	Dredging technique	Retaining structure	Cost
Soft organic silt	14,000m3	Cutter suction dredger	Bespoke gabions with geotextile liner and filled with dredged material	£25/m 3

Photo 6: Duck Broad Island recreation using gabion baskets

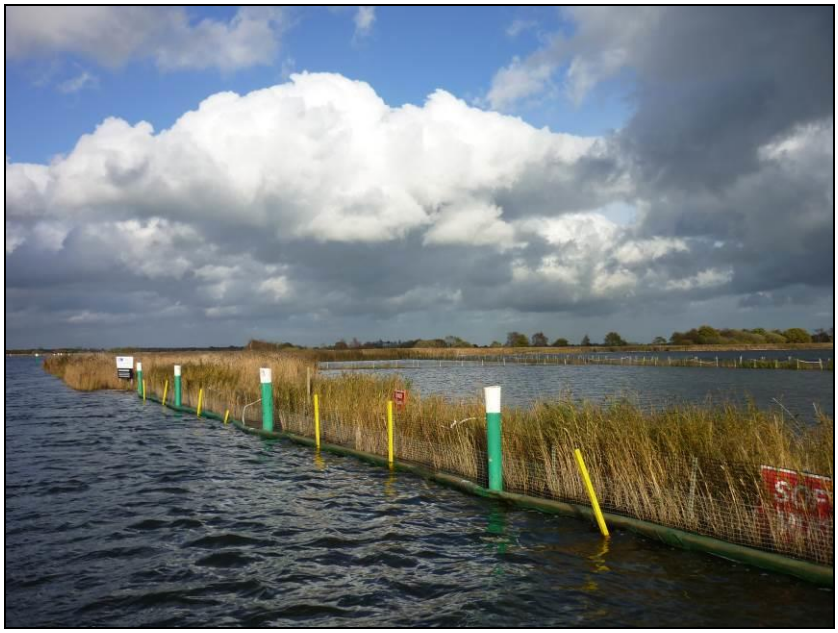


Photo 7: View of the perimeter baskets from the water with reed beginning to establish.

Example 8: Salhouse Broad

In 2012 sediment dredged from the River Bure was used to recreate an eroded reed swamp on the edge of Salhouse Broad. To form the reed swamp edge and retain the backfill an 8.5m diameter geotextile tube was used and pumped full of sediment in-situ using a concrete pump. The concrete pump was used as it could pump a much denser mix of sediment than a dredging pump which was necessary to form a stable mass retaining structure in the tube.

Sediment	Volume	Dredging technique	Retaining structure	Cost
Soft silt	12,000m3	360 excavator and piston concrete pump	Geotextile tube filled with sediment	£21/m3

Photo 8: Newly restored reed swamp area retained by geotextile tube at Salhouse Broad.

Photo 9: View of the restored reed swamp from the water.

Appendix iii

Prymnesium and how the risk is mitigated against whilst carrying out works within the Hickling area.

- BA is not responsible for the fisheries aspect of the Broads –the EA has statutory responsibility for fisheries and is in receipt of rod licence income
- Prymnesium is a naturally occurring algae, it is found year round in the Upper Thurne. Prymnesium is only found in 'brackish' waters, it cannot survive in a Freshwater environment.

Broads Authority Prymnesium Measures

- Pre work monitoring starts 6 months before planned works – we monitor Prymnesium cells counts, water temperature, conductivity (saline values), nutrient levels, water level & rain fall.
- We work to minimise 'suspended sediments' by using silt curtains, moon pools and mud-pumping (to remove sediments) where appropriate.
- We work when water temperatures are 8 degrees and less. This means working between Nov- Feb when weather conditions on Hickling are at their worst.
- We continually monitor - Prymnesium cells counts, water temperature, conductivity (saline values), nutrient levels, water level & rain fall as we work.
- We set ourselves robust 'Thresholds' and developed a risk matrix and decision tree to ensure consistency is maintained with regards to the Environmental Operating standards.
- We have carried out extensive research in 'Prymnesium Cysts', alleged to be present in the sediments within Hickling (it has been alleged that these cysts are stirred up with the sediment aiding the growth of Prymnesium) and can find no evidence of such cysts.
- No scientific data or research has definitively linked a Prymnesium bloom to dredging.
- BA has invested thousands of pounds in research, sampling & testing to ensure we work following the latest environmental best practise.