Water management structures for conservation

Technical case study series

INTRODUCTION

This series of technical case studies provides examples of water management structures or techniques that have been employed on a variety of wetland sites to further nature conservation objectives.

The practical information contained within each case study aims to give the reader an introduction to the cost, installation and operation of structures from simple pipe dams and drop board sluices to tilting weirs, wind pumps and impermeable membranes.

Importantly, it also aims to provide context to the decision making process gone through by the site managers when deciding on the types of structures to install.

Fig 1: Wetland habitat at RSPB Otmoor nature reserve

Where the natural hydrological regime of a wetland remains in tact the best conservation action is to understand and safeguard the naturally functioning hydrology.

Version 1.0; June 2008
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The RSPB provides a programme of practical habitat management training and advice on a range of wetland habitats and topics.

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The New Rivers & Wildlife Handbook	24-041	£14.95
The Reedbed Management Handbook	24-090	£13.45
The Wet Grassland Guide	24-115	£14.95
The European Wet Grassland Guide	24-130	£9.99
The Habitat Management for Invertebrates Handbook	24-141	£12.45
Habitat Creation Handbook for the Minerals Industry	24-202	£24.99
The bittern in Europe	24-282	

ACKNOWLEDGEMENTS:

Information, advice and assistance for these case studies was gratefully received from a wide number of wetland managers and advisors. Many also provided additional photographs and diagrams. Thank you for your time and support.

NB: Specific acknowledgements and references can be found on the corresponding case study sheets.

Water management structures for conservation

Penstock weir

Technical case study No. 1 : Otmoor, Oxfordshire

Version 1.0; June 2008
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CASE STUDY KEY FACTS

LOCATION: RSPB Otmoor Nature reserve, Oxon.

HABITAT: Reedbed lagoons/water storage reservoir

USE OF STRUCTURE: To control water levels within the reed-bed/reservoir and allow discharge of water to irrigate the adjacent lowland wet grassland.

APPROXIMATE COST: £5000 parts and installation (1997 prices)

SUPPLIER/CONTRACTOR: Local contractor

BREAKDOWN OF REQUIRED COMPONENTS:

- Penstock weir
- 600mm twin wall plastic pipe
- Headwall
- Stone filled gabions at outfall to reduce erosion
- Gauge board
- Safety rails

LICENSING REQUIREMENTS: Yes (Reedbed lagoon falls under Reservoir Act requirements)

REASON FOR CHOICE: Required a robust structure, that was safe to operate, and met wider conditions of Reservoir Act. Needed to have sufficient capacity to discharge water as required and withstand high flows/erosion, with large range of control. Remote location required a lockable mechanism to avoid tampering.

WATER CONTROL AREA: 11ha.

USE: Excess winter rain fall is pumped from the adjacent lowland wet grassland area in to the lagoon and stored. During spring, as water levels on the grassland naturally reduce, the sluice is opened to allow water to be discharged back on to the area through a network of interconnected ditches. This maintains moist grassland conditions, and water filled scrapes and gutters, for breeding waders and ditch flora.

Fig 1: Penstock weir & gauge board

During the early years of establishment of the reedbed vegetation within the lagoon, the water levels could be lowered in stages to provide planting zones for reedbed plugs. Water levels are also lowered during the Autumn to allow access for reedbed management operations.

OPERATION: The lifting gate ***(See Fig 1)*** is raised by turning an operating wheel from the safety platform above the structure. This allows water to flow under the structure and in to the connecting pipe/ ditch. The rate of water flowing through the stricture can be increased/ decreased through further adjustment of the lifting gate. Gate can be locked in required open/closed position, by using a padlock and chain on the operating wheel of the sluice.

The integral gauge board allows a fine degree of water control to be achieved, however, this can only be achieved by regular cheeks of water levels and corresponding adjustment of gate height. Once required water levels are reached, the gate can be fully closed.

INSTALLATION: Installation was carried out at the same time as the reedbed lagoon/water storage reservoir constriction. This was undertaken by a local contracting firm using 360 excavators. The stricture was sited on a concrete pad to create a firm base upon which to locate the sluice ***(See Fig 2).***

Fig 2: Concrete pad for base

The lagoon bunds and sluice were set at the required height of operation using laser levelling equipment, which ensured that the correct operating height was set for the intake point. The concrete headwall and spill way were then installed and keyed in to the reedbed bunds to ensure a satisfactory seal. A sump was dug at the at the intake point, to reduce silt build up and vegetation growth. A gauge board was installed at the same time to guide water level management.

Fig 3: Twin wall plastic pipe

600m twin wall plastic pipe ***(See Fig 3)*** was connected to the sluice to carry water through the bund and be discharged in to an adjacent ditch, which in turn feeds in to the wider lowland wet grassland area. Stone gabions were installed at the outfall point to reduce erosion. An adjacent spillway was also installed to comply with Reservoir Act requirements at time of extreme high water levels.

MAINTENANCE: Low maintenance. Vegetation clearance is annually required around the intake. Maintaining a sump adjacent to the in take is also required, to reduce silt build up. After 10 years of regular operation, no further maintenance has been required

PROS: Simple and safe to operate. Can allow for a continuous flow of water out of the penned area, and/or in to the receiving area, which may be desirable. (eg to encourage a throughput of water through a system to reduce stagnation).

Fig 4: The reedbed lagoon/water storage reservoir at Otmoor

In this case study, a continuous feed of water is allowed to flow in to the lower lying wet grassland habitat, thus replenishing losses to evaporation, and keeping habitat in optimum condition.

This type of structure also allows for an almost complete drawdown of water in the penned area, if structure installed appropriately, which may be desirable (to allow access for machinery for eg). NB: compare with overflow weir, where this is not usually possible

CONS: A desired water level cannot be set in the same way as an overflow weir/drop board sluice.

- Once the gate is raised, regular checking is required to ascertain when required levels in the penned area have been reached, at which point the structure must be closed.
- With operating experience/flow calculations, it is possible to estimate the discharge rates and relate this to gate height and opening duration etc. to gain a better feel for operation. Therefore, this type of sluice may be less suitable for a remote or un-staffed area.
- It may also be less suitable for a site that receives widely fluctuating inflows of water, when a constant penned level is required. An overflow weir may be more suitable in that instance.

Fig 5: A traditional wooden penstock weir

OTHER: Penstock weirs are commonly found on traditional water meadow systems, where a constant throughput of water was generally required. Originally made of wood, more recent types are constructed from metal and/or plastics. In the photo opposite ***(see Fig 5),*** there are three adjacent lifting gates to provide a greater range and capacity of water control

ACKNOWLEDGEMENTS: With thanks to Neil Lambert for case study information and assistance.

Water management structures for conservation

Overflow weir

Technical case study No. 2: Otmoor, Oxfordshire

Version 1.0; June 2008
Compiled by Nick Droy, RSPB Wetlands Advisor.
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CASE STUDY KEY FACTS

LOCATION: RSPB Otmoor reserve, Oxfordshire

HABITAT: Pump drained arable land on heavy clay soils reverted to lowland wet grassland.

USE OF STRUCTURE: To control water levels across a new area of arable reversion to lowland wet grassland, to ensure damp spring conditions and summer drawdown to facilitate management

APPROXIMATE COST: £14000 (£8500-parts & £5500-installation)

SUPPLIER/CONTRACTOR: Aquatic control.co.uk

BREAKDOWN OF REQUIRED COMPONENTS:

- ACE KWT KOS 1 – 3.04 - Weir Penstock 1000mm wide x 800mm high - £3000/item *(NB: Incl. price of drawings).*
- JKH '1000 series Spillway' x 2 (1 @ inlet and 1 @ outlet). Made to measure - £1300/item
- ACE 'KWT RKR –R-O 1.02 Flap valve' (incl. seals and attachments) for pipe outlet - £550/item
- JKH 'J' chamber' - £1000/item
- Safety Handrail - £625/item
- 600mm twin wall pipe - 12m @ £75/m

LICENSING REQUIREMENTS: YES

REASON FOR CHOICE: Needed long lasting structure that was safe and time efficient to operate, and provided a fine level of water control. Tilting weir was not a viable option because use would be restricted during times of high flow.

REASON FOR CHOICE: *(continued from previous page)* Drop board sluice might have been difficult to operate due to health and safety reasons and practical concerns of operation during time of high flow. Less fine control possible. High water volumes and flow at both intake and outfall of structure meant that a pipe dam would not be practical or safe to operate.

WATER CONTROL AREA: 24ha.

USE: The reversion field was separated hydrologically from the receiving outfall drainage ditch (classed as 'main river') by a large earth bund. An internal perimeter 'drainage' ditch runs parallel to this bund along the internal field boundary.

Fig 1: Overflow weir

Excess water from the reversion field, eventually drains in to this internal ditch. Water then flows from this ditch, through the new weir structure ***(See Fig 1).*** and on through the connected 12m of twin wall pipe, which is installed through the earth bund. The pipe then empties, via the spillway stricture in to the 'man river' drainage ditch on the other side of the bund.

OPERATION: Required water level is set by the height of weir overflow plate, which is adjusted manually using a turning wheel on the safety-operating platform. ***(See Fig 2).*** A separate gauge board installed adjacent to the weir will eventually guide required levels, as will experience from operation. The site's water levels were formally drained by electric pumps, which needed to be switched on when required, so the new weir saves a lot of operating time.

A further benefit of this type of control structure is that the required levels can be set (by appropriate setting of weir plate height) and left for as long as is required. Any excess water (eg water above the height of the weir plate) that accumulates on site will automatically overtop the weir and be discharged in to the 'main river' discharge ditch.

Fig 2: Operator platform

INSTALLATION: Local firm, White Horse Contractors, installed structure using a 360 excavator. ***(See Fig 3).*** Needed reasonable level of precision to install weir structure at correct elevation and location to ensure correct operation. Installation took approx 3-4 days to complete .

Fig 3: Installation of tilting weir

Site manager employed surveying company to undertake a topographical survey of the field prior to installation. Site manager used this information to plan habitat restoration plan, including required water level regime. This then informed the installation (incl relative height) of the weir structure.

The topographical data allowed the site manager to calculate required weir pipe inlet level (and the corresponding range of water control) relative to required water levels in the reversion field, and to assess the height of the sluice outfall and receiving 'main river' bed/water levels.

INSTALLATION: ***(continued from previous page)*** This was a particularly important consideration at this site as the height differential, or 'fall', between the inlet and the outfall was relatively little, with water levels in the receiving 'main river' widely fluctuate according to rainfall. In some periods, the weir outfall pipe will be submerged. To ensure that water does not flow 'in reverse' back on to the field during these periods, a one way non-return flat valve was fitted to the outfall pipe ***(See Fig 4).***

Fig 4: non-return flat valve

NB: Professional topographical survey cost approx £800 (for 24ha field). Approx £40/ha. Spec: 20m grid, using standard gps - 5cm/10cm/20cm resolution produced.

MAINTENANCE: May need to de silt collecting chamber in structure periodically, and maintain a sump outside of the collection chamber to further limit silt entering structure in the first place.

PROS: Similar management principle to drop boards, but safer to operate, more fine control, longer lasting, no drop boards to loose, operating handle removable to avoid tampering.

Fig 5: Lowland wet grassland at RSPB Otmoor reserve

CONS: This type of structure is not suitable for allowing complete drainage of a ditch/area as the weir plate (even when lowered to full intake) will be sitting proud of the ditch base by the height of the weir plate itself (it does not lower 'in to the ground, but sits on the base of the chamber).

Therefore, need to set level of structure very carefully to ensure that full height range of control provided by this sluice (eg height of the adjustable weir plate – 800mm in this example) has the potential to be fully utilised as and when required. A way of avoiding this issue could be to use a traditional upward lifting penstock weir.

ACKNOWLEDGEMENTS: With thanks to David Wilding for case study information and assistance.

Water management structures for conservation

Impervious membrane

Case study No. 3: Ouse Washes, Cambridgeshire

Version 1.0; June 2008
Compiled by Nick Droy, RSPB Wetlands Advisor.
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CASE STUDY KEY FACTS

LOCATION: RSPB Ouse Washes reserve, Cambridgeshire

HABITAT: Arable reversion to lowland wet grassland on peat soils (within a wider area of pump drained land)

USE OF STRUCTURE: To isolate the site hydrologically from the adjacent pump drained farmland, in order to allow a higher water table to be maintained in to spring/summer across the maximum area of land.

APPROXIMATE COST: £5.27/metre – (1300 m installed)

SUPPLIER/CONTRACTOR: Fen Ditching Company Ltd, Wisbech, Cambs

BREAKDOWN OF REQUIRED COMPONENTS:

- 1200g Plastic polythene membrane (in this example, the sheet was 2 metres in depth)
- Trenching box (which was custom made by the contractors for this project)
- 2 x Excavators

LICENSING REQUIREMENTS: Consultation undertaken with IDB and EA

REASON FOR CHOICE: Relatively cheap, simple and quick operation to install. Long lasting, virtually maintenance free. Allows maximum/optimal area of land to be managed as LWG. Small working 'footprint', and little damage/disruption caused to site/management operations during installation phase.

A previous phase of installation investigated the use of clay won on site to create an impervious barrier. However, the seam of clay was unpredictable and amounts proved insufficient for the purposes required

WATER CONTROL AREA: 31 ha. A previous phase of work undertaken in 2001 controlled a 46ha block of land.

Fig 1: Installation of plastic sheeting

USE: The fields are hydrolgically isolated from the low level drainage system by a vertical sheet of plastic two meters deep. The site lies within a broader area that is subject to land drainage operations conducted by the local IDB. In addition, the peat soils on site are fairly porous and free draining, and hence in field water table conditions are strongly influenced by the IDB low level drains.

Without some form of hydrological isolation from the drainage effects of this drain, it would prove very difficult to maintain a high water table across the site. This is desirable in order to maintain seasonally damp grassland conditions in to spring/early summer, with additional water filled pools, ditches and scrapes.

Fig 2: Custom made trenching box

INSTALLATION: Installation involved inserting the plastic sheeting vertically in to the soil to a depth of 2m. NB: An impermeable clay layer was located at approx 1 metre depth, so installation of the sheet to 2 m ensured a continuous vertical seal and minimised seepage loss.

The contractors had installed a similar membrane on a different part of the site previously and had subsequently developed their custom made trenching box to make installation more safe and efficient.

Fig 3: Excavating the trench

1) Once the line of the membrane is marked out at ground level, the first digger opens up a section of trench ***(see Fig 3),*** approx. 10m long the width of trenching box, (approx 750mm), within which the trenching box is placed.

2) The plastic sheeting is then dispensed in the trench from the box ***(see Fig 2)*** via the 'spool', as it is dragged along the trench base by the bucket of the opening digger, unrolling sheet as it goes.

3) After approx 10m of sheet has been unrolled in the trench, (and is being held taught by the trenching box), the second digger backfills the trench with spoil ***(see Fig 1)*** ensuring the membrane remains upright in the trench. Installation is complete. The first digger will then open up the next section of trench, and operations will be repeated.

Installation was carried out in February, but late summer /autumn would ensure ground conditions were most favourable. Approximately 200m of membrane were installed per day using this method (25m/hr).

PROS: Long lasting, no maintenance, (virtually) permanent solution.

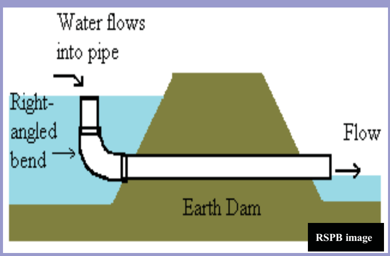
CONS: Hydrological isolation is not necessary a beneficial or sustainable end point for a wetland site.

ACKNOWLEDGEMENTS: With thanks to John Reeves for case study information and assistance.

Water management structures for conservation

Pipe dam

Technical case study No. 4 : Berney Marshes, Norfolk



CASE STUDY KEY FACTS

LOCATION: RSPB Berney marshes reserve, Norfolk.

HABITAT: Arable reversion to wet grassland on silty clay soils.

USE OF STRUCTURE: To maintain & manage high ditch water levels across the site which feed water in to a network of shallow scrapes and gutters, which are utilised by breeding waders.

APPROXIMATE COST: £200-£300 (approx)

SUPPLIER/CONTRACTOR: Twin wall plastic pipe is widely available from agricultural/drainage suppliers.

BREAKDOWN OF REQUIRED COMPONENTS:

- 300mm twin wall plastic pipe (non perforated) approx £10/m (NB: a range of sizes of pipe are available).
- Right angled bend - £70-90/item
- Rubber seal- £5/item
- 360 excavator or similar—£350/day (construction takes 1-2 hours)
- Soil (preferably clay) to construct dam
- Laser level (optional if required)

LICENSING REQUIREMENTS: Yes

REASON FOR CHOICE: A tried and trusted water management structure for conservation sites. Simple and cheap to install, using readily available components/equipment. Little maintenance, simple to operate (if operator platform installed). The low cost has enabled a number of pipe dams to be installed across the site.

WATER CONTROL AREA: 20-40ha (various)

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USE: Excess winter rainfall is retained in a series of ditches across the site, which in turn feed water in to shallow scrapes and footdrain features across the wet grassland area ***(see Fig 1***). The water levels in these wet features are kept 'brim full' in late winter and early spring to provide maximum feeding edge for breeding waders such as redshank and lapwing.

Fig 1: Shallow footdrain feature on wet grassland

These high water levels create controlled and limited surface splashing, which provides additional feeding areas, and retards some grass growth, thus contributing to maintaining ideal sward conditions for breeding birds.

The series of pipe dams across the site allow water level control on individual management units to be achieved, providing a fine level of control for the site manger ***(see Fig 2)***. Water can be gradually released through the dams if required, lowering the water level throughout spring to provide a continuous supply of muddy edge for feeding.

Fig 2: Pipe dam controlling water movement between ditch(R) and footdrain(L)

Because there are a number of these structures, some areas may be 'drawn down', whilst others are not, providing a wide variety of conditions to be maintained. Grazing can then be introduced on some management units once water levels allow, providing early stock access for grazier's cattle, whilst other areas are kept wetter, and for longer, to ensure sufficient feeding areas for waders in to early summer.

The dams themselves are designed to provide crossing/access points for stock and machinery around the site, which is an important consideration on this site with a high density of footdrains and scrape features.

Fig 3: Adjustment of pipe control

OPERATION: Right angled bend is rotated to raise or lower intake point to required levels. By lowering the pipe further, more water flows though and vice versa ***(see Fig 8).*** In some circumstances additional short sections of pipe can be inserted in to the right angled bend to increase water retaining capacity (if bund height/field topography allows– ***see Fig 3***)

Fig 4: Water flowing through control pipe

Whichever method is used, by adjusting the intake pipe height relative to water level in ditch, water can be allowed to flow through the structure (or not) thus adjusting water levels upstream of the structure ***(see Fig 4).***

INSTALLATION: Relatively straight forward using 360 excavator or similar to create earth dam structure, within which pipe is installed ***(see Fig 5)***. Clay is ideal material for dam. More permeable substrates (such as peat for eg) must be constructed in layers and compacted well. Can be completed within 1/2 day.

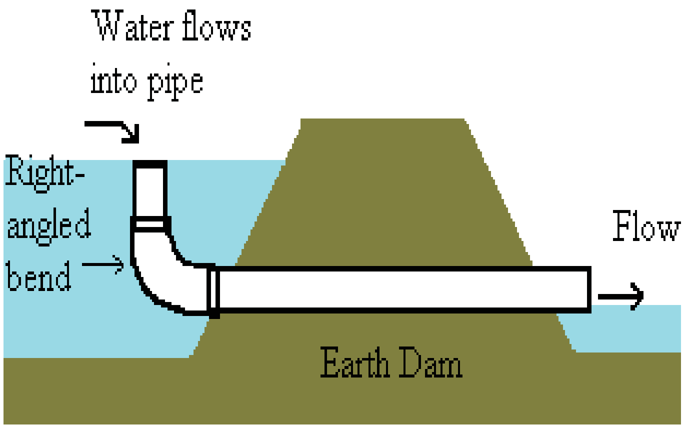

Fig 5: Basic pipe dam design

1. Decide the required height for the main horizontal section of pipe, as this sets the lowest water level at which the pipe will be able to discharge/drain water downstream. A laser level will allow very accurate positioning if this is required. In many cases, this can be judged by site eye based upon knowledge/ experience. It is also a good idea to keep pipe at least slightly elevated above the base on the upstream ditch, to reduce siltation/blockages.

Fig 6: Twin wall pipe and right angled bend

2. Ensure reasonable base for soil dam by removing turf/ clearing ditch base before construction. Do not use this material in the main dam constriction. If required, key in the base of the dam by approx 20-40cm in to a suitable substrata to minimise leakage in freer draining soils and to ensure stability of structure during periods of high flow/flood.

3. Excavate spoil for dam by over widening adjacent channel, or locating suitable source of material nearby. Build up the base of the dam in layers, until the pipe is ready to be laid on top. Ensure the spoil is compacted regularly by the excavator bucket and/or tracking the machinery across to dam. This is particularly important for peat soils which form less effective structures.

4. Cover the pipe with successive layers of soil, ensuring that the pipe is buried at a minimum depth of 30-50cm from eventual dam top, if to be used as a vehicle crossing point. Ensure that a sufficient length of pipe extends from both ends of the dam to allow a right angled bend to be fitted and to allow free discharge of water in to the ditch. Any excess can be trimmed off following construction. Dig sump at pipe intake point to prevent siltation. Consider erosion control requirements for discharge point.

Fig 7: Right angled bend
(& operator access platform)

5. Ensure a gradient to the upstream/downstream faces of the dam, of between 1:2 and 1:3, to reduce erosion and ensure overall stability. Ensure top width of dam is suitable for purpose eg wide enough to be used as a vehicle crossing point or to allow stock access if required. In general, clay dams may be constructed across channels up to approx 5m wide. Peat dams should be particularly well compacted, and their effective width will be less. Ensure eventual dam top is above expected water levels, and allow at least 10% for settlement.

Fig 8: Adjustment of water levels using 'Osma pipe' right angled bend

INSTALLATION: ***(continued from previous page)***

6. Fix rubber seal and right angled bend to horizontal pipe to enable water control. Additional sections of pipe may be placed on top of the bend to allow a greater height of water to be retained (subject to bund height/field levels). Depending on situation, an simple operator platform may be constructed to facilitate access to pipe end. Consider fencing pipe ends/bund edges to limit stock access if necessary.

MAINTENANCE: Maintain sump periodically. Pipes should last minimum of 5-10 years .

PROS: Simple, cheap, effective, trued and tested. Allows fine levels of water control to be achieved. Allows a constant water height to be set and maintained without further adjustment if required.

CONS: Sometimes difficult for operator to access control point safely (access platform helps in this respect). High water pressure from downstream end can 'force off' the right angled bend at times of flood etc. May not be suitable for locations with high velocity of flow due to erosional pressures on soil dam.

Fig 9: Non return flap valve

OTHER: In certain circumstances, a non return flap valve can be fitted on the upstream pipe end instead of a right angled bend, which allows water to flow upstream through structure at time of high flows, but prevents water draining back though structure when water levels drop downstream, thus 'capturing' additional water inputs ***(see Fig 9)***.

Osma pipe can be used instead of twin wall pipe, and can be purchased from standard builders merchants ***(see Fig 8)***. Being rigid, this has the advantage of being less buoyant than twin wall pipe, and prevents the upstream pipe end/right angled bend being 'lifted' by high water levels (which may reduce the parameters within which water can be discharged through the structure).

ACKNOWLEDGEMENTS: With thanks to Mark Smart, Adam Rowlands, Scott Paterson, Robin Harvey and Drew Mcvey for case study information and assistance.

Drop board sluice

Technical case study No. 5 : Berney Marshes, Norfolk

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CASE STUDY KEY FACTS

LOCATION: RSPB Berney marshes reserve, Norfolk.

HABITAT: Arable reversion to wet grassland on silty clay soils.

USE OF STRUCTURE: To maintain & manage high ditch water levels across the site which feed water in to a network of shallow scrapes and gutters, which are utilised by breeding waders.

APPROXIMATE COST: £300-400 (approx)

SUPPLIER/CONTRACTOR: Designed by site staff and constructed by local contractor

BREAKDOWN OF REQUIRED COMPONENTS:

- Metal sluice frame: £250 approx (custom made locally)
- Softwood drop boards: £10 approx (total)
- 600mm twin wall plastic pipe (non perforated) - £20/m approx
  NB: a range of sizes of pipe are available.
- 360 excavator or similar £350/day approx. (2hrs required)

LICENSING REQUIREMENTS: YES

REASON FOR CHOICE: Needed a robust and cost effective structure, which was easy to maintain and operate.

WATER CONTROL AREA: 20-40 ha (various)

USE: Maintaining and controlling water in main water management ditches which feed water in to shallow scrapes and ditch features for breeding wader feeding areas. Also allows summer draw down of water levels to facilitate habitat management operations.

RSPB charity England and Wales no. 207076, Scotland no. SCO37654

OPERATION: Simple. Insert sluice boards to required (water) height ***(see Fig 1)***. Water may be either held back behind structure, or sluice boards used as a top height, above which water may 'overtop' in a controlled fashion to maintain water level at known height. Water is discharged through the sluice in to a main ditch.

Fig 1: Drop board sluice

INSTALLATION: Relatively straight forward

Fig 2: 360 excavator installing sluice structure

using 360 excavator or similar to create earth dam structure, within which drop board sluice structure is installed ***(see Fig 2)***. Clay is ideal material for dam. Material was dug from surrounding ditch and scrape features. Alternatively, section of ditch immediately upstream of structure, could be enlarged to win material for dam. More permeable substrates (such as peat for eg) must be constructed in layers and compacted well. Can be completed within 1/2 day.

1. Temporary dam created to ensure dry working conditions. Line of connecting pipe was excavated from internal ditch across short section of field to a main carrier ditch.

2. Sluice structure was attached to pipe in work yard previously, and the whole unit was lowered in to position using the excavator ***(see Fig 3)***. The level for the structure was calculated from site experince and confirmed using a laser level to ensure accuracy. NB: The design of the sluice structure means that a range of water control across a range of approx 80-100cm is possible (eg greater than simply the dimensions of the connecting pipe). This could be factored up or down for each new structure dependant upon requirements and situation.

Fig 3: Lowering the sluice unit in to position

3. Once the sluice was in position, soil was re-instated to key structure in to retaining bank, ensuring it was compacted well to maintain a good seal and limit leakage ***(see Fig 4)***. The silty clay soils on site were well suited for this. The ends of the dam were given a slope of approx 1:2 to ensure stability and resistance to erosion.

Fig 4: Dam construction

4. Boards could then be put in place and the structure was operational. Rubber seals were used to edge the boards and receiving slot, to maintain a water tight seal. These were made from refrigerated lorry door seals ***(see Figs 5 & 6)***. Post and rail fencing was installed at the sluice end to exclude stock access.

MAINTENANCE: Expected to be low. Occasionally boards may need to replaced if they become warped or damaged, but because they are made of standard treated softwood, this will be very cheap and simple to do. Rubber seals may eventually degrade, but could be quickly replaced.

Fig 5: Detail of rubber seal on structure

PROS: Custom made nature of the sluice ensures that structure is fit for purpose and easy to replicate if required. Using softwood boards is a very cost effective solution. 600mm pipe ensures large drainage capacity if required.

CONS: Very fine control of water levels is not usually possible. Water levels can only be adjusted in increments as per the height of each additional board. (although board heights can be varied in size to give greater flexibility)

Operation of the sluice may be difficult at times due to limited (steep) access. A simple wooden operator platform could be installed if required. Spare boards may be mislaid when not in use (and not in structure). Some 'off the shelf' designs provide an integral lockable store for boards.

Fig 6: Drop board with rubber seal

ACKNOWLEDGEMENTS: With thanks to Mark Smart for case study information and assistance.

Fig 7: Berney Marshes nature reserve

Water management structures for conservation

Wind powered pump

Technical case study No. 6 : Berney Marshes, Norfolk

Version 1.0; June 2008
Compiled by Nick Droy, RSPB Wetlands Advisor.
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CASE STUDY KEY FACTS

LOCATION: RSPB Berney marshes reserve, Norfolk.

HABITAT: Arable reversion to wet grassland on silty clay soils.

USE OF STRUCTURE: To lift water from lower level ditch in to main water control unit in order to provide additional water source for wet grassland. The pump also acts to circulate water around the wet ditch system to maintain appropriate salinity levels in ditches (associated SSSI features), and reduce stagnation of water in slow moving ditches.

APPROXIMATE COST: £15-20k (approx)

SUPPLIER/CONTRACTOR: RSPB design made by local contractor

BREAKDOWN OF REQUIRED COMPONENTS:

- Wind pump
- Sleepers (to construct pump chambers)
- Twin wall plastic pipe (non perforated)
- 360 excavator or similar
- Laser level equipment (if required)

LICENSING REQUIREMENTS: YES

REASON FOR CHOICE: Sustainable, low (operating) cost option. Remote site with no electric link. Diesel pump would require regular fuel checks and operation/maintenance.

WATER CONTROL AREA: 40ha approx.

USE: To lift water from lower level ditch in to main water control unit in order to provide additional water source for wet grassland. The pump also acts to circulate water around the wet ditch system to maintain appropriate salinity levels in ditches (associated SSSI features), and reduce stagnation of water in slow moving ditches.

Fig 1: Pump chamber construction

OPERATION: The windmill is approx 4m high with 4 sails, driving an impellor unit/centrifugal pump ***(see Fig 2).***

Fig 2: The impellor unit

- Once wind pump is engaged or 'switched on', wind drives an impellor which draws water in to first chamber from low-level ditch .

- It then forces this water in to adjacent (smaller) chamber, until it reaches height of outlet pipe and discharges out in to higher level outfall ditch.

- Each pump is designed for the individual application as the inlet and outlet pipes need to be positioned at the correct levels to maximise the amount of water that will be pumped.

- A pump that only lifts water up 150mm will be more efficient than one that lifts water 1000mm.

- Once water level reaches outfall pipe height, water flows in to higher-level ditch. Needs suitable levels of wind to function.

- For a lift of 90cm you need a wind speed in excess of 10 km/h, for lower lifts you need less.

- Flow rate is a combination of wind speed and the height that you want to lift the water. Rates measured at a pump that lifts water 90cm were recorded at 12 litres per second in a 17kmh wind.

Fig 3: Installing the pump chamber

Fig 4: Installation was completed within one day

Pump may be 'turned off' when required, or left to permanently run (when appropriate wind availability). In very high or gusty wind speeds, the pump unit must be disconnected from the wind sail to avoid damage.

INSTALLATION: Main assembly of pump/windmill was undertaken in work yard, and then transported to site ***(see Fig 1).***

1. Pumping chambers/housing was constructed using wooden 'sleepers' without the need for expensive

INSTALLATION: ***(continued from previous page)*** and permanent concrete. Experienced 360 operator and site warden completed installation within 1 day.

2. Pump chamber unit was constructed in work yard using timber sleepers, secured at both ends by sheet metal. Site was excavated to required depth, (based upon intake and outfall heights), and chamber installed to correct level ***(see Fig 3).***

Fig 5: Sail unit is secured to pumping chamber

3. Pump unit was then installed and subsequently connected to sail unit ***(see Fig 4).*** Sail unit is secured to sleeper chamber ***(see Fig 5).*** Twin wall pipes were installed at intake and outfall points, in feed and discharge ditches

4. Fencing was erected around the windmill unit plus the intake/outfall points to exclude cattle ***(see Fig 6).***

MAINTENANCE: Very low

PROS: Sustainable, low running costs, no need to install electric supply. Simple mechanism, so less to go wrong. In keeping with local landscapes and traditions. Green. Little noise. Ensures enhanced water circulation around site.

CONS: High set up costs. Reliant on availability of wind. May be visually intrusive in some landscapes. Lower capacity compared to many electric/diesel pumps. Needs to be switched on again after high winds.

Fig 6: Wind pump in operation

ACKNOWLEDGEMENTS: With thanks to Mark Smart for case study information and assistance.

Plastic piling drop board sluice

Technical case study No. 7: Cayton & Flixton Carrs, Yorks.

Version 1.0; February 2009
Compiled by Nick Droy, RSPB Wetlands Advisor.
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CASE STUDY KEY FACTS

LOCATION: Grove Farm, Cayton & Flixton Carrs, Yorkshire.

HABITAT: Wet grassland on peat soils, within (the canalised) floodplain of the River Hertford, supporting breeding waders.

USE OF STRUCTURE: To retain high ditch water levels in what was previously a main field drain, in order to impede in-field drainage and create moist soil conditions for breeding waders.

APPROXIMATE COST: £2000 (supplied and installed)

SUPPLIER/CONTRACTOR: APE Aldridge Piling/local contractors

BREAKDOWN OF REQUIRED COMPONENTS:

- Plastic 'multilock' sheet pilling: 6 x 3.0m and 6 x 2.0m pile lengths. £ 800 total (incl. delivery and VAT)
- Metal dropboard frame 1.0m x 1.5m fabricatated locally to fit space of two pile sheets. £215 total (fabrication and delivery)
- Softwood dropboards. 6 x boards (13cm x 10cm x 95 cm) . approx £20
- Seal for dropboards. 3mm rubber strapping (tree tie roll). approx £3/roll
- Access platform. 2 x boards (15cm x 7.5cm x 2m) approx. £40

LICENSING REQUIREMENTS: The local IDB were consulted re: the setting of the top or maximum (water retaining) level of the sluice structure (to ensure no adverse impacts on neighbouring (non agreement) land. The ditch itself was not under IDB control.

REASON FOR CHOICE: The farmer required a cost effective structure to be installed, which was simple to operate and maintain. The main ditch, within which it sits, receives flashy flows from upstream and needed to be robust enough to withstand erosional pressures from high flow rates. Due to the permeable, deep peat soils on site, a structure was required that minimised seepage of water around the structure via the adjacent soil/bank sides.

REASON FOR CHOICE: *(continued from previous page)* The relatively lightweight nature of the pile dam structure means that the structure does not require a foundation or concrete base slab in the base of ditch. This is particularly important given the soft peaty soils on site, as this reduces the risk of subsidence, which a heavier structure (eg a brick or concrete sluice), might incur.

Fig 1: Cayton & Flixton Carrs

WATER CONTROL AREA: 15 ha (although capacity is larger)

USE: The sluice controls water flowing through one the main field drainage ditches, within this farm site. The ditch formally drained the surrounding grassland via a standard under-field drainage system, but is now controlled in order to maintain damp soil conditions and discrete areas of standing water in spring *(See Fig 1)*. Summer drawdown is important to facilitate management and operation in winter ensures excess winter water is allowed to leave the site when required.

Complete draw down of the ditch is unlikely to be required (as could be achieved via a penstock type sluice for eg), with the main function being to hold higher ditch water levels in to spring/summer. The structure does not need particularly 'fine' control of water levels to be achievable – levels will be set in late winter, and the boards will remain in place throughout spring and summer.

Some adjustment might be required to evacuate peak flashy flows, such as are common in late summer/early autumn rainstorms, and the wide opening /large capacity of the structure will allow this to be quickly and simply achieved if required.

OPERATION: Simple softwood dropboards *(See Fig 2)* are inserted in to the structure to the required (water) level, and held in place using wooden 'chocks'.

- Initially buoyant, the softwood boards soon absorb water, becoming heavy. Pressure of the retained head of water will hold them firmly in place but some rubber sealing strips (tree ties in this case study) and a means to maintain downward pressure helps reduce leaks between individual boards (hence wooden chocks). The size of dropboards (95 x 13 x 10cm) means they are easily removed by a single person from the adjacent plank bridge platform.


Fig 2: Dropboards and wooden chocks

- In late winter, dropboards are inserted to maintain higher water levels in the ditch to a set level, which retains/backs up water in the ditch. Maintaining high water levels in the ditch also impedes the operation of the relict under field drainage system, by restricting flow from the system outfalls, which will be retained at present. Excess water (above the required height set by the top of the drop boards) is able to overtop the structure and discharge from site.

- A simple operator platform adjacent to the structure ensures safe access is maintained during operation/maintenance.

Fig 3: Inserting a dropboard

INSTALLATION: ***(See Fig 4)*** The general sitting if the structure (including elevation) was set 'by eye', by the landowner and project officer.

Fig 4: Installation of sluice

1. The main structure was made from individual plastic 'multilock' sheet pilings of varying lengths ***(See Fig 5)*** . Each piling was manually driven in to place through the soil by a sledge hammer. (but this could be done using a mini digger bucket or similar). It was important to remove the surface turf, to make the installation/driving of the piles easier.

2. The piles were driven to a depth of 1-2m, which was achievable on the soft peat soil on site, but might be more difficult on clay soils with a greater resistance (the piles might bend/crack under pressure when being driven in to the ground). During installation, the tops of the pilings were protected with a length of timber stob, to avoid damage to the plastic tops.

Fig 5: 'Multilock' sheets

3. The central piles were 2.0m long and driven into base of ditch. (Lowest level of sluice opening was set to normal summer flow levels). These were driven as deep as they would go without damaging or disturbing pile tops. Cutting of the sheets was undesirable as the smooth machine-cut top was essential for the sealing at the base of metal sluice frame.

4. The wide 'wings' of the structure are keyed in to the banks by approx. 2m and are buried 1-2m below ground/ditch bed to reduce this seepage loss. Additional 2m long wooden stakes were driven vertically through the hexagonal pilings either side of the metal sluice frame to provide additional strength and rigidity to the structure. The metal sluice frame was bolted through the plastic pilings in to these stakes for extra strength though strength of pile sections alone was probably adequate to take the load of full head of water, given that 'wings' are keyed substantially into each bank. ***(See Fig 6).***

Fig 6: Sluice frame & wooden supports

5. Each piling links to the next one via a simple receiving slot, forming a robust and virtually water tight seal and making assembly relatively straightforward. Contractor installing piles reported that it was relatively easy to join up the interlocks but important to do this a bit at a time. EG. don't fully insert first pile before interlocking the next one along. Shorter piles were used in the centre (two piles sunk to few inch above bed) and at outermost positions.

6. The frame which receives the wooden drop boards was custom built using a local engineering firm, and bolted on to the piling structure. The farmer had it double dip-galvanized to extend life. The frame was a designed to be a tight fit at the sides (it required driving in by sledgehammer), and therefore sealant was not necessary to create a watertight seal (but are available in cartridge gun or strip form from pile supplier).

7. The seal beneath the metal sluice frame was simply formed by 2 (half metre) lengths of pile capping laid over the hexagonal pile tops before the metal structure was driven down. The weight of frame (50-70kg) seems to seal it sufficiently. No cutting of the pile sheets was required, as they were driven in to equal depths. The pile capping was trimmed to length using a hacksaw.

Fig 7: Operator platform

8. The structure was located approx 10m upstream from the intersection/outfall of the ditch in to an adjacent low-level IDB drainage ditch to minimise seepage loss of water from the site. A simple operator platform was constructed on the downstream (generally lower water levels and hence easier access) side of the structure, using tanalised softwood to allow safe and easy access ***(See Fig 7)***.

9. The dropboards were constructed from standard tanalised softwood ***(See Fig 8)***. 3mm rubber strapping (tree tie roll) was attached to the bottom of each board as a seal between drop boards. The seal on the vertical face of the boards was adequate due to the pressure of the water.

10. Installation was completed within 2 days by 2 contractors. (N.B. includes some on-farm welding adjustments on day one and sourcing of timber and fixings after commencing work.)

MAINTENANCE: Maintenance is expected to be low. Dropboards may need to be replaced in time, but this will be a simple and cheap operation. Occasional de-silting of the ditch immediately upstream of the sluice may be periodically required.

PROS: Robust and cost effective. Simple to source, install and operate. Relatively lightweight design means low risk of subsidence in soft peat soils on site. Can be left in set position for long periods, in order to maintain pre set water level, without the need for regular checks or adjustment by farmer. Suitable where ditch too deep/wide or flow too great to use simple earth bund/pipe dam arrangement.

Fig 8: Softwood dropboards

Good where final penning levels are initially uncertain as can add or remove boards to adjust field water tables. Large capacity means that structure can rapidly evacuate surplus water during high flows.

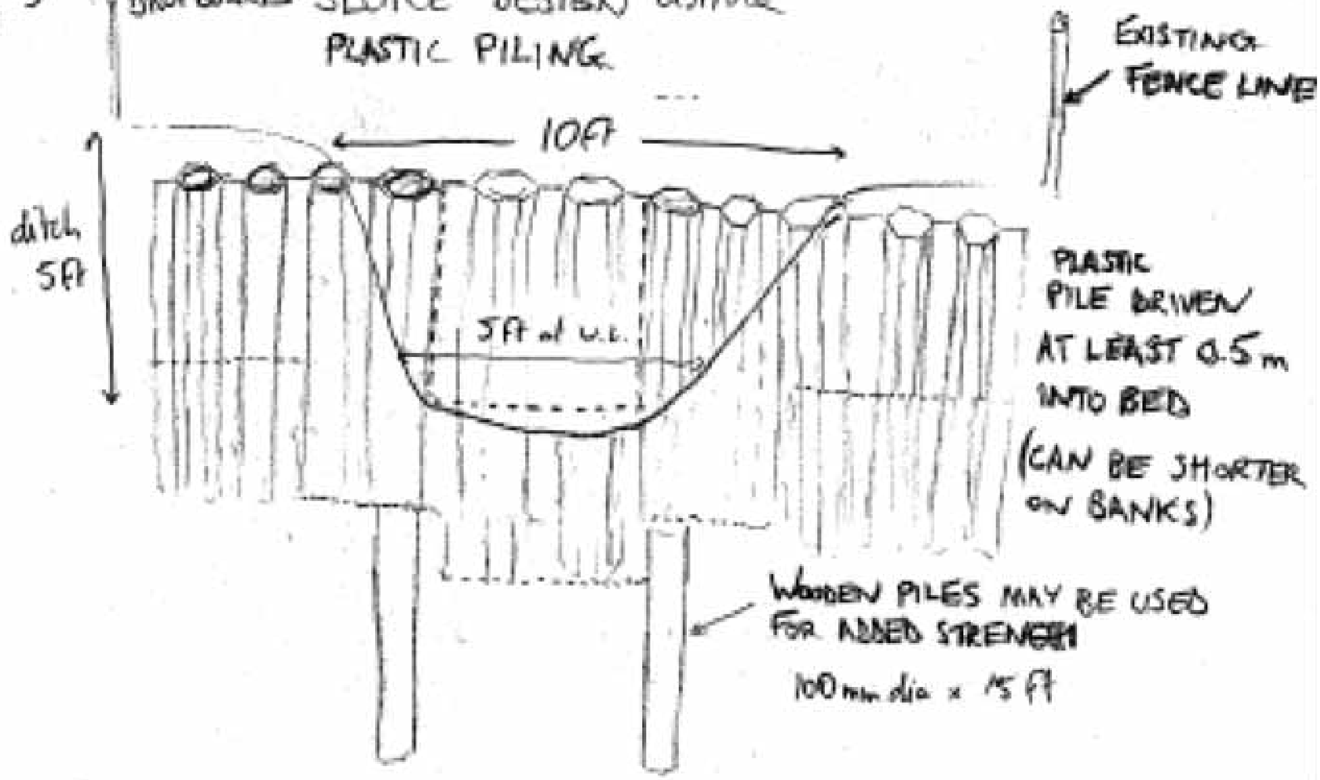
CONS: May be difficult to 'push' pilings in to heavy soils (such as clay). In this situation, excavation of a receiving trench to insert pilings in to may be required. Requires local contactor to make metal sluice frame, as not readily available 'off the shelf'. Some drainage manufacturers eg JKH may be able to make to measure. Easily tampered with (- not a concern on this site as remote from public.) A means of locking the boards to prevent removal could be added easily.

ACKNOWLEDGEMENTS: With thanks to Tim Burkinshaw for case study information and assistance

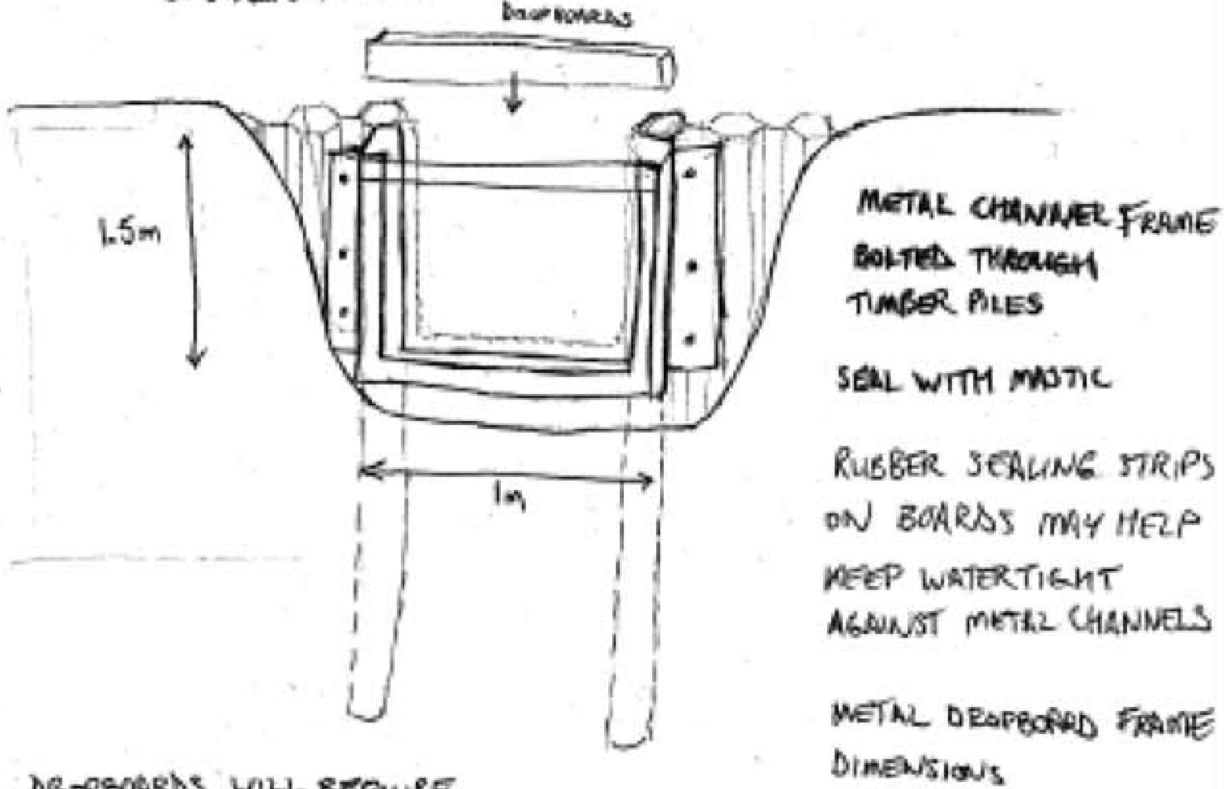
FURTHER INFORMATION: The RSPB produces a range of practical wetland management leaflets and handbooks, and also runs a programme of professional training courses for the wetland manger. Please contact Nick Droy, RSPB Wetlands Advisor (nick.droy@rspb.org.uk) for further information.

REFERENCES: RSPB, EN and ITE (1997) The Wet Grassland Guide: Managing floodplain and coastal wet grasslands for wildlife (ISBN 0 903138 86 7)

Fig 5 DROPBOARD SLUICE DESIGN USING PLASTIC PILING



UPSTREAM VIEW



DROPBOARDS WILL REQUIRE STAPLES OR HOOKS TO ENABLE RAISING + REMOVAL AT END OF SPRING BREEDING SEASON BY MEANS OF TRACTOR.

Water management techniques for conservation

Overflow sluice*

(*Designed by Dinsdale Moorland Serivices)

Technical case study No.8: Wigglesworth, Yorks.

Version 1.0; February 2009
Compiled by Nick Droy,
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CASE STUDY KEY FACTS

LOCATION: Wigglesworth, Yorkshire.

HABITAT: Wet grassland and fen on silty/clay soils within the floodplain of the River Ribble.

USE OF STRUCTURE: To control water flowing through one the main drainage ditches exiting the site, in order to maintain damp soil conditions and discrete areas of standing water in spring.

APPROXIMATE COST: £8000 (supplied and installed)

DESIGNER/CONTRACTOR: Dinsdale Moorland Services

BREAKDOWN OF REQUIRED COMPONENTS:

- Main structure comes in 3 pre fabricated pieces
- Sluice barrier
- Fixing bolts and ratchet winch to lift/lower barrier
- Access platform. (treated soft wood)

LICENSING REQUIREMENTS: Land drainage consent from the Environment Agency

REASON FOR CHOICE: The structure controls water within a main drainage ditch, which drains water from across approx 100ha. (including land outside of the raised water level area). High (flood) flows are regular, so the structure needs to be robust enough to withstand this, and have sufficient capacity to allow excess water to exit the site quickly when required. The structure allows set (known) water levels to be maintained, which is important to the overall site management plan objectives.

WATER CONTROL AREA: 100 ha

Fig 1: Wet grassland habitat

USE: The structure is operated year round to maintain required water levels in the ditch (which influences in field conditions). In late winter, the structure will be raised to maintain higher water levels in the ditch to a set level. The structure will be lowered from June/July onwards (dependant on weather conditions/water levels) to allow water to slowly draw down from the site, and facilitate stock grazing and rush management.

High (flood) flows are regular, so the structure needs to be robust enough to withstand this, and have sufficient capacity to allow excess water to exit the site quickly when required. The structure allows set (known) water levels to be maintained, which is important to the overall site management plan objectives.

OPERATION:

- In late winter the structure is raised to maintain higher water levels in the ditch to a set level, which in turn, retains/backs up water in the network of ditches and scrapes created on site ***(See Fig 1)***. Maintaining high water levels in the ditch also impedes the operation of the relict under field tile drainage system, by restricting flow from the system outfalls. Excess water (above the required height set by the top of the barrier) is able to overtop the structure and discharge from site.

Fig 2: Sluice operation

Fig 3: Retaining bolts

- A ratchet system, attached to the overhead frame, is used by the operator to raise the control barrier to the required height, and retaining bolts used to 'fix' the barrier in place ***(See Fig 2 & 3)***. The barrier itself is constructed of a single metal plate, backed by a rubber covering (as seen in Fig 2) on one side to ensure a good seal.

- Water pressure upon the barrier is high during peak flows (as with most structures), which means adjustment of the retaining bolts requires care, when raising or lowering the barrier. An operator platform adjacent to the structure ensures safe access is maintained during operation/maintenance.

INSTALLATION:

Fig 4: Side plates

1. A detailed levelling survey was undertaken prior to installation of the sluice, which allowed precise setting of the structure and known water level (height) requirements.

2. The main structure came in three prefabricated steel sections which were placed in position using two 360 Hymac machines. (The unit weighs approx 2 tonnes).

3. The side plates of the structure ***(See Fig 4)*** are keyed back in to each bank by approx 2m, and the ditch bottom by approx 1m, to reduce erosion and maintain strength and integrity of structure. Installation was completed within approx. two days.

4. A simple operator platform was constructed on the downstream side of the structure, using tanalised softwood to allow safe and easy access ***(See Fig 5)***.

Fig 5: Operator platform

MAINTENANCE: Maintenance is expected to be low in the early years of operation. Greasing of bolts and barrier system will be required, as will some cleaning of debris/silt that will accumulate within and around the barrier plate and retaining housing.

Fig 6: Discharge during high flows

PROS:

- Robust, cost effective and long lasting structure.
- Allows fine control of water levels to be set.
- Large discharge capacity ensures excess water can be quickly discharged through the structure when barrier is lowered. ***(See Fig 6)***.
- Locking system could be engineered to prevent unauthorised operation.
- Required water level height can be set, and excess water allowed to overtop structure, maintaining required level.

CONS:

- Requires ratchet system to raise/lower barrier due to weight.
- Bolts need to be adjusted to release and fix plate, which may be under water during periods of high flow and require care to locate and adjust.
- Unit is heavy and requires machinery to lower in to place/install, so sluice location requires suitable access for machinery.

ACKNOWLEDGEMENTS: With thanks to Adrian Shepherd and Tim Youngs for case study information and assistance.

FURTHER INFORMATION:

The RSPB produces a range of practical wetland management leaflets and handbooks, and also runs a programme of professional training courses for the wetland manger. Please contact Nick Droy, RSPB Wetlands Advisor (nick.droy@rspb.org.uk) for further information.

REFERENCES:

RSPB, EN and ITE (1997) The Wet Grassland Guide: Managing floodplain and coastal wet grasslands for wildlife (ISBN 0 903138 86 7)