INLAND WATERWAYS ASSOCIATION

Guidelines for water transfer via navigable waterways

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Version Control

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Preamble

Introduction of water transfer via an existing navigable waterway (or to restore a navigable waterway) will invariably result in a range of advantages and disadvantages. From an Inland Waterways Association (IWA) perspective, water transfer should introduce additional water supply to ensure year-round navigation in Transfer Lengths and Navigation Lengths (as defined below), even during drought periods, and to provide improved water supplies for navigation in Input Lengths and Output Lengths. Other advantages and disadvantages should be considered on their merits but should result in a substantial overall improvement in the Transfer Length and no overall degradation in other lengths.

The promoters and subsequent developers, operators and maintainers of any water transfer scheme are, jointly, referred to hereafter as the Promoters. These guidelines set out a range of topics of interest to boaters which should be considered by the Promoters of any scheme to transfer water via navigable waterways. The topics are described under the following headings which should be assessed in feasibility studies, and subsequently developed in detail designs:

1. Water management and water consumption
2. Flow control and hydraulics
3. Dredging, bank raising, weirs and sluices
4. Pumping systems and gravity bypasses

5. Water storage provision
6. System control
7. Implementation and decommissioning
8. Reference documents

The arrangements relating to a water transfer via a navigable waterway will need to be set out in contractual form between the parties. While some financial information will be confidential, so far as practical the agreements should be made available in the public domain to assure the boating community that the scheme provides appropriate benefits.

1. Water management and water consumption

A. It should be recognised that a water transfer will alter the water consumption and losses from a waterway such that any stated transfer capacity is nominal since the output is likely to be less than the input under most circumstances.

B. The following lengths of pre-existing navigable waterway may be affected by the introduction of a water transfer scheme:

   a. Those lengths of canal and waterway directly used for the transfer, together with any arms or other canals at the same elevation, not currently isolated by locks causing a change of water level, and any supply reservoirs. Such lengths are referred to hereafter as the Transfer Length(s).
   b. Those lengths of canal and waterway currently supplied with water from the Transfer Length for navigation and routine operations, by gravity. Such lengths are referred to hereafter as the Navigation Length(s).
   c. Those lengths of canal and waterway which may be supplied with water from the Transfer Length (including via Navigation Lengths), by gravity or by pumping, for any purpose. Such lengths are referred to hereafter as the Output Length(s).
   d. Those lengths of canal and waterway which may supply water to the Transfer Length, by gravity or by pumping, for any purpose. Such lengths are referred to hereafter as the Input Length(s).
   e. Those lengths of waterway connected to the Transfer Length by both gravity and pumping can be categorised as both Input Length and Output Length.

C. Depending on the control regime adopted, the introduction of additional water supplies may result in increased water levels in the Transfer Lengths, decreased water levels in the Transfer Lengths, or some increases and some decreases. Such water level changes may affect:

   a. Seepage losses
   b. Evaporation losses
   c. Lockage consumption (including at locks linking to Navigation Lengths, Input Lengths or Output Lengths)
   d. Leakage at locks (including at locks linking to Navigation Lengths, Input Lengths or Output Lengths)
   e. Operation and maintenance consumption
   f. Flows or levels in watercourses supplying water to or discharging water from the Transfer Lengths
   g. Groundwater levels adjacent to the Transfer Lengths

   and may require adjustments to:

   h. Bank levels
   i. Bed levels (to maintain adequate draft for navigation)

j. Bypass and spill weir levels
k. Lock coping levels
l. Lock gate heights
m. Bridge levels (to maintain adequate headroom for navigation)
n. Drainage pipework discharging into the waterway.

D. Historically, CRT and other navigation authorities have tended to manage water supplies on an ad hoc basis developed from historic precedent and actual water availability. However, with part of the water supply in a navigable waterway being attributable to the Promoters, a comprehensive water management strategy needs to be agreed, with operating rules for all conceived scenarios – in particular at maximum transfer, zero transfer, floods and droughts – covering all of the Transfer Lengths, the Navigation Lengths, the Input Lengths and the Output Lengths. Agreement of such matters needs to be underpinned by water resource modelling with adequate sensitivity testing to reflect uncertainties.

E. In addition, hydraulic modelling will be needed to assess water levels throughout the system and how they vary with usage and time. Usage should cover a range of potential transfers and may include or exclude transfers to/from Navigation Lengths, Input Lengths and Output Lengths. Time should cover stable operations, start-up, planned shut-down, emergency shut-down, control system failure, power failure and similar matters.

F. Development of the transfer scheme may result in changes to EA Abstraction Licence conditions, either positive or negative in effect. These will need to be accounted for in the hydraulic and water resource models, and the results in commercial agreements.

2. Flow control and hydraulics

A. Flow in a waterway can be managed in four ways:

a. Uncontrolled flow – water discharges by gravity over fixed weirs with no control over the volume discharged.
b. Upstream control – operation of sluices or pumps is controlled based on the water level in the pound upstream of the relevant control structure; if the water level rises then more water is released. The control system can be mechanical or electrical.
c. Downstream control – operation of sluices or pumps is controlled based on the water level in the pound downstream of the relevant control structure; if the water level falls then more water is released. The control system can be mechanical or electrical.
d. System control - operation of sluices or pumps is controlled centrally based on rules taking into account water levels throughout the system, current sluice gate settings and current pump operations.
e. System control is electrical / electronic; upstream and downstream control of gravity flows may be mechanical or electrical / electronic.

B. Hydraulic effects flow through open water channels at approximately 5 minutes per kilometre, though this rate can be significantly affected by variations in channel cross section, restrictions, junctions and meteorological effects. While system control can respond instantaneously throughout the system to an event, such as a pump failure or a jammed sluice, systems with upstream or downstream control can take several hours to respond to an event only a few kilometres away. The potential impact of power failures, equipment failures and control system failures, which could include grounding of vessels due to drain down, or spill of surplus water to waste, will need to be assessed in the hydraulic model to ensure that no unacceptable results ensue.

C. The hydraulic model should also be used to ascertain the full range of potential water levels throughout the Transfer Lengths to ensure that adequate provision is made for dredging, bank raising and, if necessary, bridge raising. Attention will also need to be given to the crest level of all weirs and of any potential for overflow at locks. Wherever a piece of moveable equipment is introduced (such as pumps, sluices, adjustable weir crests, water level monitoring devices and similar), attention needs to be given to the hydraulic effects if the item of equipment fails in an open, closed or intermediate position.

D. Water flow affects navigation. Attention should be given to:
   a. Velocity of flow in main canal and waterway sections
   b. Velocity of flow at short restrictions (such as bridge holes)
   c. Velocity of flow at long restrictions (such as aqueducts or tunnels)
   d. When a vessel passes through a restriction such as a bridge hole, tunnel or aqueduct, the water velocity in the opposite direction can increase significantly
   e. Velocity of transverse flow (such as at lock bypass inlets and outlets, whether pumped or gravity).

E. Water flow can cause scour of silt (and, in extreme cases, of clay and sand as well). Attention should be given to:
   a. The flow velocity to keep a material in suspension is lower than that required to cause the initial scour
   b. The average flow rate in a waterway is less of an issue than localised higher velocity flows such as at bridge abutments or piers, at changes in channel direction, upstream and downstream of control structures, or even at a vessel jammed at right angles across a waterway
   c. When a vessel passes through a restriction such as a bridge hole, tunnel or aqueduct, the water velocity in the opposite direction can increase significantly, introducing localised scour
   d. Scour can be caused by the wash from a vessel's propellor, or by impact of a vessel with the bed or side of a waterway
   e. There are some reports that materials on the bed or side of a navigable waterway may be more susceptible to scour than is indicated by experimental data
   f. Where does scoured material settle out of suspension (typically 100m-200m downstream of a restriction, as velocity reduces), and how will this settled material be managed to avoid obstruction to navigation.

3. Dredging, bank raising, weirs and sluices

A. Water transfer via a canal requires a hydraulic gradient to be created in each pound to create the required flow of water. This can be achieved by raising the water level at one end of the pound (by transferring water into the pound) or by lowering the water level at the other end of the pound (by abstracting water from the pound). Or both methods can be used in combination.

B. Raising the canal water level may require the canal banks and weirs (and possibly bridges and lock structures) to be raised to maintain freeboard and headroom, while lowering the canal water level may require dredging to maintain operating draft for vessels. Both approaches may require adjustments to moorings and other canal infrastructure to cope with varying water levels. The canal must also operate safely and effectively when no water transfer is taking place.

C. Dredging
    a. IWA encourages dredging to the original bed profile as part of the works to implement a water transfer scheme, reinstating the original heritage dimensions.
    b. In many cases dredging would increase the depth of water available. Such increase could permit the passage of vessels with deeper draft (including commercial vessels) and / or could permit the canal minimum water level to be lowered to create a hydraulic gradient without increasing top water level with associated bank raising
    c. Dredging is also likely to be lower cost and less technically complex than raising canal banks and associated infrastructure.
    d. A lower water level in the waterway may result in reduced water levels in the local groundwater and watercourses. This could affect building foundations, positively or negatively.

D. Bank raising
    a. Bank raising is not technically simple.
    b. A typical canal bank consists of a clay core and face with a hardcore cap of some type forming the towpath. To raise the bank, the towpath needs to be stripped out, the clay core extended upwards (with a suitably watertight join) and the towpath reinstated to current standards – which may require any embankment to be extended horizontally with additional land take. The water level may need to be lowered and navigation suspended while the towpath is stripped out.
    c. Some canal banks are protected with sheet piling, which may need to be extended or otherwise re-engineered if the bank is to be raised.
    d. There are also brick and stone bank washwalls which may need to be raised compliant with heritage considerations.
    e. Utilities (either alongside or across the waterway, above or below ground) may be affected by bank raising and watertightness of the waterway may be affected by historic utility trenches if water levels are raised.
    f. Piped drainage and streams discharging into the waterway may cease to function correctly if water levels are raised, requiring appropriate remedial action.
    g. There may be headroom issues if the towpath is to be raised beneath bridges.
    h. Bank raising may give rise to visual intrusion issues at properties immediately adjacent to waterway towpaths.
    i. A higher water level in the waterway may result in increased water levels in the local groundwater and watercourses. This could affect local drainage, building foundations and any cellars / basements or structures close to water level.
    j. Consider the extent of work needed to moorings, landing stages, connected marinas etc. due to varied and variable water levels.
    k. Consider construction and maintenance access, often restricted to the width of the towpath which may not be stable under construction equipment loadings.

l. Consider the extent to which works may need to be carried out from within the waterway (including relevant headroom limits), and the effects that may have on navigation for other vessels.
m. Consider the extent of ground investigations needed to establish the stability of embanked sections of canal with increased loads from bank raising and increased water depth; ensure such investigations do not penetrate puddle clay or other forms of waterproof membrane, and that any holes created are appropriately backfilled.

E. Weirs and sluices
   a. Water levels in canal pounds are normally controlled by two types of fixed crest weir:
      i. A bypass weir adjacent to each lock with a crest level set at normal top water level. This weir passes normal operation flows, in excess of lockage and leakage, around the lock to the next downstream pound.
      ii. One or more spill weirs along the length of the pound with a crest level about 100mm above the bypass weir. These weirs pass flood discharges and other surplus water to waste.
      iii. The combined capacity of the various weirs, while still leaving 100mm freeboard to bank top, should exceed the expected flood flow in the pound.
   b. If the water level in the pound is to be raised to carry the water transfer, thought has to be given to how the weir levels are to be adjusted while still passing normal operation flows when no transfer is in progress, how floods are passed, and how any adjustable elements fail safe in all circumstances.
   c. Canal and river sluices are normally operated to manage inflows to the waterway, to manage outflows from the waterway, or to manage floods. Operating rules for all such existing or new sluices will need to be developed and agreed, both with and without the transfer in operation.

4. Pumping systems and gravity bypasses at locks

A. Inlets and outlets should be at least 1.5 boat lengths clear of the lock entrance (or bridge if there is one) to eliminate transverse flows while manoeuvring into the lock.
B. Inlets and outlets should, to the extent practical, be aligned along the canal or cut, not at right angles to the canal or cut.
C. All flows, longitudinal or transverse, limited to acceptable velocities. Consider localised high velocities and turbulence, not just average velocities.
D. Moorings for at least two boats awaiting passage on bank opposite inlet or outlet.
E. Assuming the lock is to remain in operation (or at least in water) during construction, consider stability of lock wall while trenching for pipes or culverts.
F. Consider safety around inlets, outlets and any open channel sections, including safety of persons in the water.
G. Consider rubbish screens and rubbish rakes or other cleaning methods.
H. Consider electrical supplies and control systems for pumping and any control sluices.
I. Consider energy dissipation for bypass.

5. **Water storage provision**

A water transfer scheme may, or may not, incorporate online or offline water storage reservoirs, existing or new. Storage may simplify system control as speed of response becomes less of an issue. Beyond that, a reservoir can be treated as any other open waterway with its own spill weirs, inlet and outlet structures, leakage and evaporation losses.

6. **System control**

A. The control system should ensure that the transfer system fails safe in all circumstances. Minimum water levels must not be breached as that could lead to grounding of craft. Spill weir capacities must not be exceeded, and freeboard to bank top must be maintained, though ideally nothing would be spilled to waste.

B. A combined hydraulic and control model is needed able to model, as a minimum, the following over at least a 24-hour cycle, for both summer and winter and for normal, flood and drought situations.

   a. Canal operation before the transfer scheme is implemented (to provide a baseline condition against which to compare other results)
   b. Canal operation with zero water transfer
   c. Canal operation with maximum water transfer
   d. Canal operation with a range of other water transfers
   e. Start-up, from zero water transfer to maximum water transfer
   f. Planned shut-down, from maximum water transfer to zero water transfer
   g. Power failure at each pump station separately, and at any other powered control apparatus
   h. Communications/SCADA failure
   i. Instrumentation failure or false reading
   j. Response of control system to normal fluctuations in water level due to canal usage
   k. Partial blockage or equipment failure not monitored by the control system (for example, vessel jammed across the canal or across a bypass or pump station inlet, blocked rubbish screen, jammed moveable sluice gate, misused lock gate paddle, and similar)
   l. Other scenarios developed during feasibility and design studies.

7. **Implementation and decommissioning**

A. What are the advantages and disadvantages of the scheme to the canal network, to CRT and to boaters, and how are these matters communicated to the public in advance of implementation?

B. What organisations are to be responsible for overall management and control of the scheme and for design, construction, commissioning, operation, maintenance and decommissioning? How is the scheme to be financed? What is the proposed contract structure between the various parties?

C. What is the time schedule for design, construction and commissioning?

D. How is the condition of the existing waterway assets to be assessed, given that they may be up to 250 years old and, in many cases, not visible or accessible for inspection? Which organisation(s) take responsibility for asset condition risk, and do those organisation(s) have the financial capacity to carry those risks (including penalties for delay and any periods when the transfer is out of use)?
E. What is the experience of the proposed design organisation in the restoration of waterways and waterway structures?
F. What is the experience of the proposed construction organisation in the restoration of waterways and waterway structures?
G. What is the experience of the proposed operation and maintenance organisation?
H. Are any volunteers to be involved in operation and maintenance and, if so, what are the proposed commercial arrangements to replace the volunteer organisation if it fails to achieve the required standards?
I. What are the arrangements for training the operation and maintenance staff, including replacement staff?
J. What are the arrangements for maintaining and upgrading the hydraulic and water resource models during the operating life of the transfer to reflect both software upgrades (or software withdrawal) and any changes to the waterways (both the Transfer Length and any other connected Lengths)?
K. What is the planned duration of the commercial arrangements to operate and maintain the transfer? What are the options for upgrade, renewal, operation, maintenance or decommissioning following expiry of those commercial arrangements?
L. What are the life expectancies of the various assets, both existing and new, and what are the arrangements for management of the asset renewal (lifecycle) budget, including at handback or expiry?
M. What are the plans for decommissioning of the transfer leading to reinstatement of the original waterway arrangements?
N. Other matters for consideration include:
    i. Construction access
    ii. Maintenance access
    iii. Construction laydown areas
    iv. Maintenance depot location(s)
    v. Identify utilities in the vicinity of the waterway, both below ground and above ground, and including disused utilities which may still affect watertightness
    vi. Response to actions by members of the public: misuse of locks, navigation errors, malicious damage
    vii. Mitigation and response to pollution incidents and introduced contaminants such as urban and rural runoff, fuel spills or chemical spills in the waterway or into drains discharging into the waterway, agricultural wastes, malicious vandalism.

8. Reference documents

There are other documents relevant to the planning and implementation of a water transfer scheme in the IWA library at https://waterways.org.uk/about-us/library. These include papers on navigation, environment, sustainability and heritage such as:

- Standards for Construction, Restoration and Maintenance of Inland Waterways
- IWA Policy on Moorings on Navigable Waterways
- IWA Policy on Freight on Inland Waterways
- Towpaths Policy
- Locks and Moveable Bridges Policy
- IWA Policy on the Provision of Boaters' Facilities
- Vegetation Management Policy
- Heritage Policy
- IWA Policy on Residential Boating
- Practical Restoration Handbook
- Briefing Note: Dredging
- Briefing Note: Provision of Boaters' Facilities
- Joint IWA and CRT Guidance for Restoration Groups (multiple documents)
- Review of UK Inland Waterways Transportation from the Hydrodynamics Point of View

External documents containing information relevant to the planning and design of water transfer via navigable waterways include:

- The Canal & River Trust 's "Code of Practice for Works Affecting the Canal & River Trust"
- Lock Design Manual published by the Ministry of Transport, Public Works and Water Management (Netherlands) in 2014

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