Table 10.1 Part 2 Continued

Waterway and extent	Waterway Ref. No.	Craft Dimensions^{z} (metres)) Length	Beam	Static Draught	Superstructure Width	Superstructure Height	Group	Lock Dimensions (metres) Length	Width	Sill Depth	Notes
Shropshire Union Canal											
Ellesmere Port to Chester	21b	12.40	2.95	1.07	1.73	2.31		22.76	4.42	1;47	
Chester to Bunbury	21b	21.85	2.74	1.07	1.73	2.31		22.91	4.22	1.47	
Bunbury to Barbridge Junction	21b	21.64	2.13	0.76*	1.56	1.83	A*	–	–	–	
Barbridge Junction to Audlem	21a	21.64	2.13	0.76*	1.56	1.83	A*	23.37	2.23	1.52	
Audlem to Autherley Junction	21a	21.79	2.20	0.89*	1.85	1.83	A*	22.91	2.19^{n}	1.22	
Middlewich Branch	21c	21.95	2.19	0.76*	1.50	1.98	A*	23.47	2.19	1.37	n) Cholmondeston lock 2.16
Branch from Chester to R. Dee	21b	12.19	3.81	0.91	1.22	2.44	J	23.16	4.48	1.52	
Llangollen Branch Hurleston Junction to Pontcysyllte	21d	21.95	2.11	0.76^{m}	1.58	1.91		22.17	2.13	1.16	m) recommended dredged depth 1.05, (see text)
Pontycysyllte to Llangollen	21d	14.17	2.11	0.74^{m}	1.58	1.68		–	–	–^{x}	
Llangollen to Llantisilio	21d	–	–	–	–	–^{l}		–	–	–	l) Boats are not advised
River Soar Navigation From its Junction with the R. Trent to Leicester	27b	21.34	4.37	1.14	1.83	2.13	L	22.25	4.57	1.17^{k}	k) Loughborough lock 1.07
Staffordshire and Worcestershire Canal											
Great Haywood Junction to Gailey lock tail	18	21.95	2.16	0.76*	2.16	2.08	A*	22.86	2.19	1.37	
Gailey Lock to Autherley Junction	18	21.79	2.19	0.89	1.85	1.88	A	22.86	2.19^{j}	1.37	j) Gailey lock only
Autherley Junction to Stourport	18	21.95	2.13	0.84	1.75	1.98	A	22.86	2.19	1.37	
River Stort Navigation	1b	21.95	3.25	0.81*	1.83	2.11		27.74	4.11	0.99	
Stourbridge Canal	19	21.34	2.08	0.61	1.32	1.83		21.64	2.16	1.52	
Stratford on Avon Canal King's Norton Junction to Kingswood Junction	7	21.41	2.13	0.91	1.73	1.98	A	22.91	2.23	1.33	
Trent Navigation Shardlow to Meadow Lane Lock tail	28	11.28	3.35	0.91	2.74	2.57		26.21	4.47	1.24	* maximum draught taken as 0.90 (see text)
Trent and Mersey Canal Preston Brook to Croxton	23a	21.95	2.74	1.04	2.74	1.83		–	4.50	1.30	

(Continued on next page)

Table 10.1 Part 2 Continued

Waterway and extent	Waterway Ref. No.	Craft Dimensions^{z} (metres) Length	Beam	Static Draught	Superstructure Width	Superstructure Height	Group	Lock Dimensions (metres) Length	Width	Sill Depth	Notes
Croxton to King's Lock, Middlewich	23a	21.95	2.11	0.76*	1.52	1.91	A*	22.81	2.51	1.37	
Middlewich to Trentham Lock	23a	21.34	2.15	0.76*	1.62	1.78	A*	22.48	2.23	1.35	
Trentham Lock to Great Haywood Junction	23a	21.79	2.15	0.76*	1.91	2.01	A*	22.56	2.26	1.22	
Great Haywood Junction to Dallow Lane Lock Burton-on-Trent	23a	21.95	2.16	0.76*	1.50	1.92	A*	22.25	2.29	1.07	
Dallow Lane lock to Derwent Mouth (junction with River Trent)	23b	21.24	4.29	0.99	2.64	2.23	K	23.77	4.32^{i}	1.04	i) Stenson lock 4.27
River Ure Navigation From its junction with the Ripon Canal to Swale Nab	33b	17.37	4.34	1.98^{h}	4.34	3.05		18.59	4.60	1.55	h) Fully laden, between locks only
Witham Navigation Lincoln to Stamp End Lock	30b	22.86	4.67	1.52	3.05	3.66		24.79	5.49	1.98	
Stamp End lock to Boston	30b	21.41	4.27	0.84	1.83	2.13	J	24.79	5.49	1.98	
Worcester and Birmingham Canal	17	21.95	2.19	0.91	1.78	1.83	A	22.91 25.19^{g}	2.21 5.79^{g}	1.62 2.13^{g}	g) into Diglis Basin from River Severn
											*Maximum draught taken as 0.9 (see text)

Table 10.2

Grouped Beam and Draught Standards for Cruising Waterways

Maximum Craft Dimensions in each Group

(see paragraph 10.3.13)

Group	Beam(m)	Draught(m)
A	2.13	0.90
B	2.13	1.05
C	2.13	1.20
J	4.34	0.90
K	4.34	1.05
L	4.34	1.20

CHAPTER ELEVEN

MAINTENANCE METHODS AND STRATEGY

CHAPTER TEN

MAINTENANCE STANDARDS FOR COMMERCIAL AND CRUISING WATERWAYS

Chapter 10

Maintenance Standards for Commercial and Cruising Waterways:

10.1 *Terms of Reference*

10.1.1 We are asked to consider and define the standards of maintenance which the Board's various obligations imply for individual waterways. This chapter refers only to Commercial and Cruising waterways; Remainder waterways are dealt with in Chapter 15.

10.1.2 The primary obligations are those imposed by statute; as discussed in Chapter 3 the Transport Act 1968 made far reaching changes in this respect and its provisions will be considered first. It will also be necessary to consider what other statutory obligations remain from earlier legislation (including the multitudinous originating Acts), or may have come into effect since 1968 or are applicable from general legislation (e.g. the Water Acts).

10.1.3 In addition there will be those obligations that arise at common law or from considerations of public safety. Other obligations, perhaps of a local or specific nature, may have been assumed by usage or under contract which, in practice, may be equally binding and of material significance.

10.1.4 Standards of maintenance will call for consideration under two aspects, quantitative and qualitative. By the former is meant the physical dimensions of the waterway and its structures in order that the relevant craft may be properly accommodated – by the latter the suitability of the materials and design of the various component parts for the part they play in forming a substantial waterway and enabling it to be maintained effectively and economically.

10.1.5 In this chapter we shall take these various considerations into account but as there is an interplay of factors we shall not necessarily follow the foregoing review closely in every case. As far as practicable, however, we shall deal first with the dimensional aspects and conclude with the more general. We shall also discuss the Board's views of their obligations regarding standards where appropriate.

10.2 *Transport Act 1968*

10.2.1 Section 104 of the Transport Act 1968 subdivides the Board's waterways and specifies that the "Commercial waterways" shall be principally available for the commercial carriage of freight; and that the "Cruising waterways" shall be principally available for cruising, fishing and other recreational purposes.

10.2.2 Section 105 of the Transport Act 1968 states, in part

" (1) With a view to securing the general availability of the commercial and cruising waterways for public use, it shall be the duty of the Waterways Board, subject to the provisions of this section:

(a) to maintain the commercial waterways in a suitable condition for use by commercial freight-carrying vessels and

(b) to maintain the cruising waterways in a suitable condition for use by cruising craft, that is to say, vessels constructed or adapted for the carriage of passengers and driven by mechanical power.

(2) Neither paragraph (a) not paragraph (b) of subsection (1) of this section shall impose on the Board any duty to maintain a waterway, or any part of a waterway, in a suitable condition for use by any vessel of the kind mentioned in that paragraph unless the dimensions of the vessel (that is to say, its length, width, height of superstructure and draught) –

(a) correspond to, or are less than, those of a vessel of that kind which customarily used that waterway or part during the period of nine months ending with 8th December 1967; or

(b) if the waterway or part has been restored or improved since that date, are such as to make it suitable for use on that waterway or part;

but, save as aforesaid, the duty imposed by that paragraph shall extend to any vessel of the kind therein mentioned as respects the dimensions of which paragraph (a) or (b) of this subsection is satisfied."

10.2.3 With a view to identifying the craft referred to in Section 105(2) (a) of the Transport Act 1968 the Board have produced from information in their possession an official compendium entitled "Dimensions of Craft Customarily Using the Waterways during 1967". These craft dimensions (now stated in metric units) are reproduced in Table 10.1. For comparative purposes the present limiting lock dimensions are also listed in Table 10.1 for each waterway.

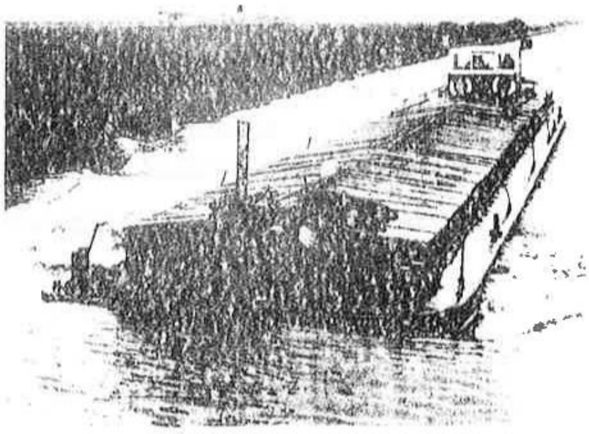


Plate 10.1 Self-powered commercial barge on the Aire and Calder Navigation. Also showing steel pile bank protection.

10.2.4 It should be noted that there is no obligation to make provision for commercial freight-carrying vessels on Cruising waterways. A few such vessels were in 1967 still in regular operation on certain waterways subsequently designated as in the Cruising category, but they were not identified as such in the BWB compendium, nor consequently in Table 10.1 We have therefore had to use our judgement in applying the data of Table 10.1 in such cases, and have done so in conjunction with other factors referred to in paragraph 10.3.14.

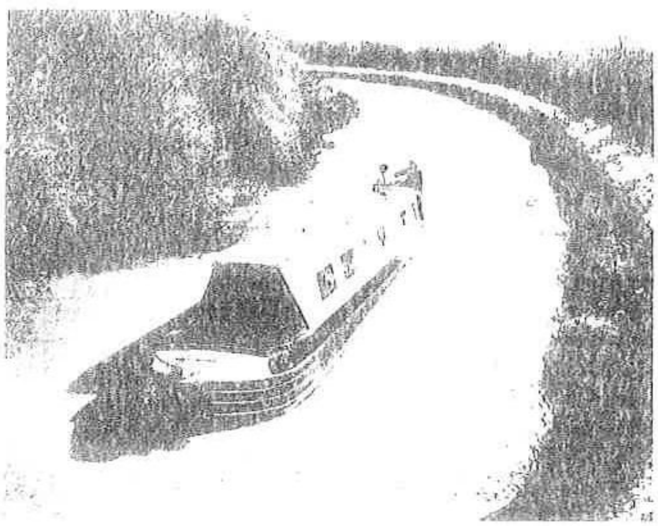


Plate 10.2 Winter cruising – a traditional style narrow boat on the Grand Union Canal (PFP)

10.3 *Waterway Profiles*

10.3.1 The first standards to be considered are those of the dimensions of the waterways relative to the craft for whose navigation they must be maintained. The critical craft length, beam, draught and headroom for each waterway are set out in Table 10.1 and are, with the exceptions detailed in paragraph 10.3.15 below, those of the BWB official compendium already mentioned.

10.3.2 Length of craft is usually not a critical factor, provided that it does not exceed the usable length of the controlling lock chamber and does not impede manoeuvrability.

10.3.3 For satisfactory navigation it is considered that the width of any waterway, at bed level, should normally be sufficient to allow for vessels to pass each other at normal speed in safety. At water level, it should be considerably more than twice the beam of the vessel in order that the cross sectional area of the waterway may be large enough in relation to the immersed cross sectional area of the vessel. These requirements will not, in general, involve significant widening works on the waterways for the craft of Table 10.1

10.3.4 Controlled experiments and other hydraulic research over the years have shown that to minimise resistance to the motion of vessels through the water, and the accompanying formation of waves and wash, the ratio of these areas should preferably be 5:1, normally at least 4:1 and only at bridges, aqueducts, etc., should it ever be less than 3½:1.

10.3.5 In compiling dimensional standards it has not been considered appropriate to specify values for this cross-sectional ratio, as the maximum channel sizes for most inland waterways are limited by their original constructional dimensions. It can be argued that speed and hydraulic efficiency are not of major importance for cruising craft, and allowing for the increasing popularity of cruisers of fibreglass and other light construction, with their smaller immersed cross section, we find that the profiles deduced from the craft dimensional standards are satisfactory even though the area ratio for Table 10.1 craft is seldom much greater than 3½:1. For commercial waterways the area ratio is a more important consideration, though we have not recommended alterations of existing profiles simply on this account as we consider that the cost of any such improvements should be related to the commercial trading operation rather than to maintenance.

10.3.6 Where adequate width is available at water level it is possible to form stable slopes from bed level up to the towpath and offside banks. Following normal practice we have taken a value of 1 in 2 for these slopes. Where adequate width at water level is not available, this will result in an appreciable depth of water level is not available, this will result in an appreciable depth of water remaining at the banks, and a water wall of some kind must be provided.

10.3.7 Greater depths of water will be required alongside banks in certain places, e.g. at wharves and moorings or in locations where a restricted width of waterway is unavoidable. Certain lengths, particularly summit pounds, were constructed deeper than the rest of the waterway so that water could be stored for use in dry periods or to smooth out irregular lock usage.

10.3.8 As regards draught, the standard depth of water has been arrived at by allowing an appropriate margin below the keel to cover (a) underkeel clearance, (b) a reasonable variation of water level below normal or weir level, (c) squat of vessels in motion and (d) siltation between dredging operations. It is considered that the following margins are appropriate:–

(i) for inland artificial waterways and river navigations used by vessels with a static draught up to but not exceeding 2m.
(a) + (b) + (c) = 150mm.
and (d) = 150mm.

(ii) for river navigations and waterways used by vessels with a static draught exceeding 2m.
(a) + (b) + (c) = 300mm.
and (d) = 250mm.

On some lengths of Cruising waterways essential maintenance craft, particularly dredging hoppers, are of deeper draught than the cruising craft. In such cases the siltation allowance (d) need not normally be included.

10.3.9 In applying the above standards it has been borne in mind that many of the waterways were constructed (or have since been enlarged) for specific craft. There are some cases where to provide a channel width to allow two Table 10.1 craft to pass would involve widening the canal beyond its original or improved dimensions. It is considered that such a widening would not be covered by Section 105 (2) of the Transport Act 1968.

10.3.10 It is also essential to ensure that no waterway profile is adopted which might involve dredging out any of the clay lining where it exists, or otherwise affect the watertightness of the bed without proper preparatory works.

10.3.11 It may not be sufficient to base standards of width and depth solely on the beam and draught of relevant vessels. Considerations of bulk water transportation, maintenance craft, speed of navigation and the density of traffic may make it advisable to define individual standards on a more generous basis.

10.3.12 The number of vessels using a waterway may not be directly relevant to the implications of Section 105, but may become important if there should be a large increase in traffic.

10.3.13 We consider that it is unrealistic to be concerned with small dimensional differences in deducing waterway profiles from the multitude of individual beam and draught dimensions detailed in Table 10.1, and for Cruising waterways we have adopted the more practical approach of defining a small number of groups (standard narrow – and broad – gauge craft, and 150mm intervals of draught) to use for this purpose. The maximum beam and draught dimensions for each group are given in Table 10.2, and where one of these groups has been used it is noted in the "group" column of the Table. Elsewhere the individual Table 10.1 dimensions have been used.

10.3.14 A considerable number of converted traditional narrow boats (used as hire cruisers, passenger, camping, restaurant and hotel boats as well as private cruisers) travel the network regularly and extensively. Many of these have draughts of around 900mm, and we have received documentary evidence that several of them did in fact use certain waterways during the nine months ended 8th December, 1967, even though not included in Table 10.1. We have also received reports of cruising boats with draughts of one metre and more, but feel that the evidence as to customary usage at this figure is not conclusive. Furthermore, it is a general requirement of the BWB to allow for maintenance craft (dredgers, tugs and in particular dredging hoppers) to navigate throughout the system, and to this end their 1970 Survey included for a minimum dredged depth of 1220mm.

10.3.15 We therefore recommend that in general a draught dimension of at least 900mm should be applied throughout the cruising network. The equivalent dredged depth from paragraph 10.3.8 will be 1200mm, so that occasional commercial, cruising or maintenance craft with a static draught of about one metre will be able to navigate, albeit without the full allowances for underkeel clearance, low water level and squat. When there is no evidence of regular use by deep-draughted narrow boats however, or where the requirement to pass maintenance craft is flexible (for example where dredging hoppers do not need to navigate as the waterway lends itself to landbased dredging) the dimensions in Table 10.1 will govern. A case in point is the Llangollen Branch of the Shropshire Union Canal, where a draught restriction of 750mm has been in force for some time, and it is considered that a dredged depth of 1050mm is appropriate.

10.3.16 There are a number of cases on Commercial waterways in which it is known that the Table 10.1 craft ply only between specific points, and only travel laden in one direction. Here, if it is clear that the waterway is operating satisfactorily under such a regime, we have adopted an eccentric profile incorporating in effect a 'single track' for the Table 10.1 craft but a 'double track' for craft of the same beam and a lesser draught – corresponding to the unladen draught of the Table 10.1 craft or the maximum draught of the other traffic normally using the length. Thus on a 'broad' canal where the Table 10.1 craft has a draught of, say 1200mm (Group L), but nearly all the other users are cruising craft with a draught of less than 900mm, the final profile would allow for a 'single track' appropriate to Group L superimposed on a 'double track' for Group J craft.

10.3.17 We have, therefore, arrived at the required profile for each waterway by applying the above considerations, i.e. paragraphs 10.3.3 and 10.3.8, to the Table 10.1 craft (or grouped craft where applicable) in the first instance. If this would involve widening works, as mentioned in paragraph 10.3.9, then a profile has been adopted which allows free passage of one Table 10.1 craft within the channel, and also allows group cruising craft of lesser draught (a) to pass each other and (b) to pass the Table 10.1 craft everywhere (except at locks, bridges and similar local restrictions). The essential features of waterway profiles discussed in this Section are illustrated in Fig. 10.1.

10.4 *Bank Protection and Dredging*

10.4.1 The banks of the waterways have two primary functions, to contain the water within its intended bounds and to prevent leakage and seepage. In more detail they serve one or more of the following purposes:

(a) to provide freeboard above normal water level as a safeguard against overtopping from waves or flood water

(b) to provide an impervious barrier against leakage and seepage, so as to prevent loss of water and to aovid risk of breaches.

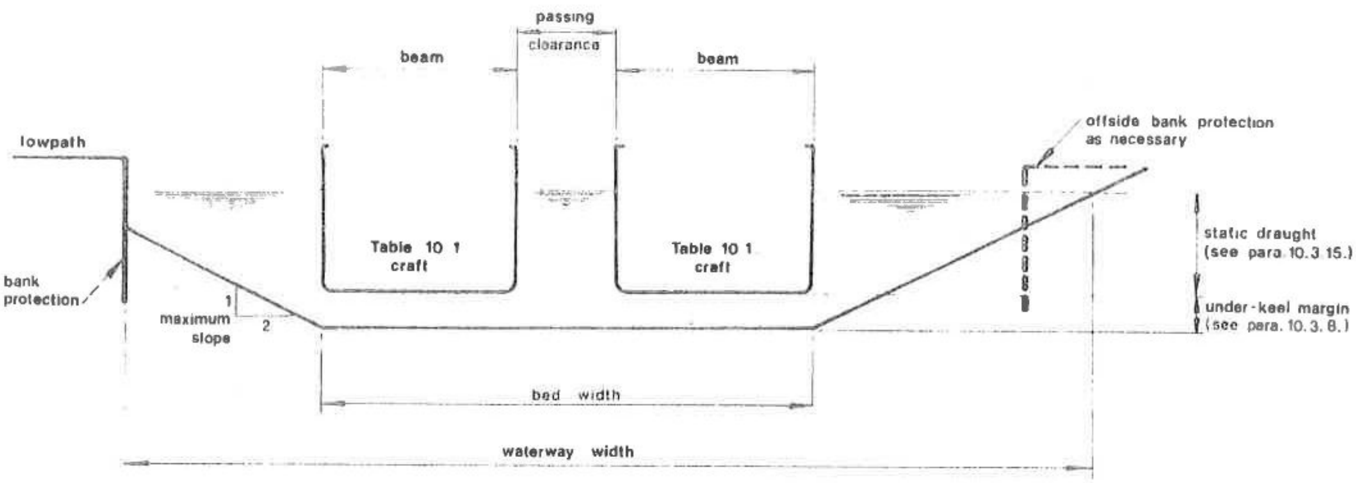
(c) to act as a retaining wall where there must be an appreciable depth of water alongside

(d) where necessary, to provide a firm abutment for a towing path.

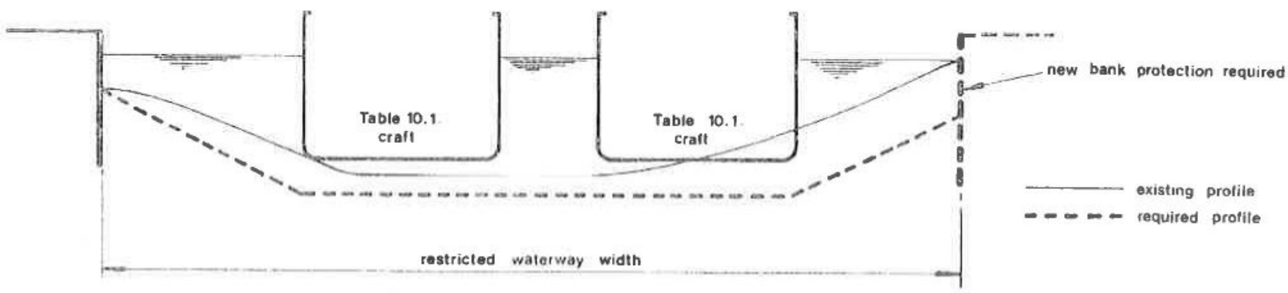
10.4.2 To meet these requirements different forms of construction or revetment will be apporpriate in different circumstances. Particular care must be taken in the case, for example, of a waterway carried on a high embankment where overtopping or leakage could quickly develop into a serious breach; similarly at the approaches to restricting structures such as bridges, locks and aqueducts. In cuttings, erosion at the foot of a slope can cause a slip to develop that may result in a serious blockage. In all cases, however, it is important that the construction of the bank or its revetment should be such as to resist erosion and disintegration, or that it should be given protective treatment if material erosion or disintegration is taking place.

10.4.3 It is essentially unsatisfactory to allow any kind of erosion to continue unchecked indefinitely; unless some criteria of permissible deterioration are established there can be a real risk that a danger line may be passed undetected. Canals which are lined with a clay 'saucer' seal are particularly sensitive to bank erosion. If the upper edge of the clay 'saucer' is trodden down or washed out, then water can easily overtop it and cause leaching of the ground behind. In other cases, where the canal was built on sidelong ground and a clay seal was provided only against the built up bank on the down-hill side, leakage paths into the canal bed and under the clay seal can develop.

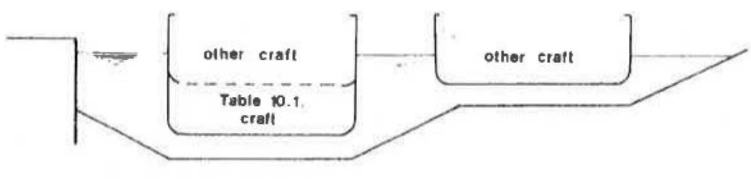
10.4.4 A further consideration in assessing the need for bank protection is the effect it may have in reducing the need for dredging, although these two treatments cannot be regarded as simple alternatives. Where there is no revetment, material is washed out of the banks and most of it is deposited on the canal bed and must eventually be removed. There are occasional situations, for example on the offside in level ground where the BWB own a strip of land, where continued erosion could be allowed and the costs of protection not incurred for an indefinite time. In general, however, bank protection may be required for other reasons and will not entirely avoid, although it will reduce, the need for dredging. Erosion is by no means the only cause of siltation of the waterways. Silt and clay are carried into the canals by ditches and streams supplying the



(a) Typical required profile to accommodate statutory dimensional standards



(b) Application of dimensional standards resulting in extra bank protection



(c) Possible eccentric profile when Table 10.1 draught obtains in one direction only

Fig. 10.1 WATERWAY PROFILES – SCHEMATIC ILLUSTRATIONS

system with water, and the deposits from these usually reach a maximum after winter floods. Where canals pass through cuttings, rain tends to wash soil off the hillside. Material from towpath surfaces is also washed in, and soil blown off fields by high winds.

10.4.5 There are basically two methods of carrying out dredging of waterways; the more usual is by means of a crane or hydraulic grab mounted on a barge which discharges each grab load into an attendant floating hopper. When full, the hopper is towed away to the spoil tip and is replaced by another empty hopper craft. At the spoil tip a land based grabbing crane unloads the hopper into dump trucks for ultimate disposal over the site. The cost of all this work is relatively high and may be increased if disposal sites cannot be obtained cheaply or within a reasonable distance of the dredging work.

10.4.6 A cheaper method, and one that is to be preferred in the limited situations where conditions admit of its use, is to employ a mechanical scoop or a dragline working from the towing path or offside bank and discharging the spoil directly on to the adjacent ground or perhaps into dump trucks for on-site tipping. Suitable conditions are not likely to be found in urban areas; in the country it will generally be necessary to pay the landowner a tipping fee and to undertake all work necessary in obtaining access, levelling of deposits and leaving the site in good order. Also, where eroded private land must be reinstated, or the towpath side backfilled, it is clearly economical to use dredging arisings for the purpose where practicable. In most cases a revetment must be provided to contain the material and to prevent its being washed out before it can consolidate.

10.4.7 Although dredging costs depend very much on local conditions it is probably right to expect a saving of 50-75% if land-based appliances can be used instead of floating craft and double handling, once the necessary access has been provided.

10.4.8 There is one further consequence of unchecked deterioration of bank structures which can be very dangerous to craft navigating the waterways, where masonry, concrete or other fragments of disintegration may fall into the waterway and form unseen obstructions. If, as a further result of such deterioration, the line of the bank loses its definition, this will constitute an additional hazard for navigators. It is true that gradual and more or less uniform erosion of an unprotected bank would not present much risk of damage to craft but it is necessary that one bank at least (conveniently the towpath bank in most cases) should be a reliable guide to the line of the navigable channel within which no invisible obstructions need be feared.

10.4.9 As discussed in Chapter 3, the BWB has obligations to the public, other authorities and neighbouring private landowners. Apart from this, it is in the interests of the BWB to foster good relations with all neighbours as many maintenance tasks would be very difficult and time-consuming without their willing co-operation. It is therefore important that erosion beyond BWB territorial limits is prevented, and where this has occurred the land should be reclaimed by suitable protection and back-filling.

10.4.10 Erosion or disintegration of banks may arise from various causes, the main cause at the present day being the wash-waves of powered craft. Most canals were built before self-powered craft came into common and regular use, and were designed for slow speeds and haulage by horse. Bank protection on the offside was virtually nonexistent, though dry-stone walling or similar support to the towpath was provided in many areas. The characteristics of wash waves vary with the shape and roughness of the channel, weeds or obstructions in the waterway, the form of the hull and complex inter-relationship of speed and 'blockage factor' (the ration of cross section wetted area of hull to area of waterway). A good deal of research has been carried out recently into these phenomena – in particular Report No. 236 of the British Transport Docks Board Research Station dated August 1972, and entitled "Creation of Wash by Pleasure Craft", contains a thorough appreciaton of the problem but stops short of making clear recommendations for the design of hulls for minimum wash.

10.4.11 A comparatively recent innovation on commercial waterways is the fitting of tugs and other craft with swivelling propulsion units. Hitherto underwater bed slopes have been protected (for example by stone pitching) only on the outside of some relatively sharp bends, and this has been necessitated as much by water flow conditions as by turbulence from craft. A tug fitted with twin Schottel units and pushing three Bacat barges, however, produces a very powerful jet of water well below water level; on a sharp curve, or when steering to correct the line, this can be directed straight at the bed slope and the adjacent bank protection. To guard against undermining of the protection it may be necessary to provide piling with a toe level considerably lower than the channel bed. Some maintenance craft are fitted with similar, but less powerful, units.

10.4.12 Wind generated waves can also be a problem on long or wide exposed stretches of waterway, and though they are by nature less destructive to the banks than wash waves, they can combine with the latter and increase their amplitude. Variations in water level aggravate the situation by increasing the height over which the waves act.

10.4.13 Often an appreciable depth of water immediately alongside the bank is necessary, for example where the canal width is such that stable slopes upwards from the dredged channel bed do not reach the surface or for reasons mentioned in paragraph 10.3.7. In such places, unprotected banks are more than usually vulnerable to wave action, to treading in by cattle, damage caused by driving in mooring posts or angler's equipment, impact of craft and so on – and relatively minor damage to the towpath revetment can make it treacherous to walk along.

10.4.14 Water-rats, rabbits and other burrowing animals are a continual hazard. Often a breach or a slip is initiated by water finding an underground passage with an outlet in the bank, and though regular inspection will show up new activity, old disused holes are just as dangerous. Such considerations could justify bank protection at vulnerable points, and may require more frequent attention to pointing of existing and masonry walling, or replacing it with sheet piling if local development has increased the potential consequences of a failure.

10.4.15 When the present condition of the banks of a particular length of waterway has been ascertained by inspection it is then necessary to decide, in the light of the foregoing considerations, whether protective works are required and what form they should take. The appropriate type of construction will depend on design factors (e.g. as to whether a retaining element is involved) and on estimated costs. Both initial costs and those of future maintenance must be examined.

10.4.16 It has not been necessary for us to attempt a detailed study of bank protection methods employed in recent times, as a comprehensive Report on the subject was published as recently as January 1973 by the British National Committee of the Permanent International Association of Navigation Congresses. This report, the "Study of Various Types of Revetments" (for protecting the banks of rivers and canals in inland navigation) reviews all the methods relevant to our present Study and gives comparative costs. We have given consideration to the data presented therein and, in particular, think it appropriate to make some observations on BWB's recent practice.

10.4.17 It is the present practice of the BWB to employ steel sheeting and piling for the great majority of bank protection works undertaken. This has been the situation for some five years now, and the plant, purchasing and productivity schemes are all tailored to it.

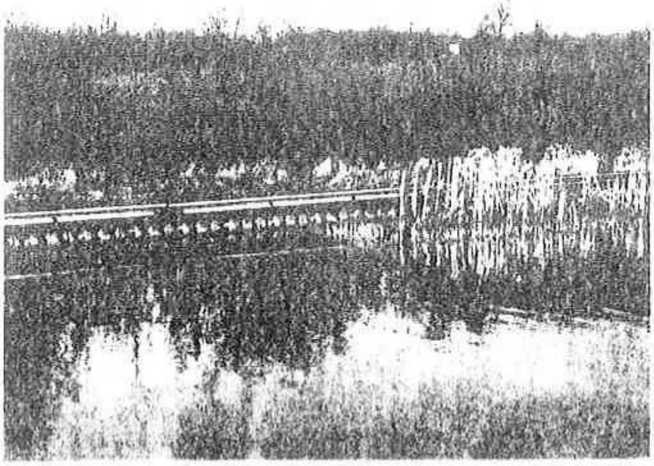


Plate 10.3 Typical use of steel trench sheeting as bank protection. *(PFP)*

10.4.18 Reinforced concrete sheet piling was the method chosen in the large scale Grand Union development scheme of 1932-5 and became the standard type of protection until the 1960's, with two BWB precasting yards kept in operation until 1969. We understand that the main reasons for changing to trench sheeting were a lower first cost, allowing a greater length of critical protection to be carried out within the same limited budget, and easier handling and driving. We have also been told that leaching of fine bank material through gaps between concrete piles was causing leakage and subsidence. This problem was overcome in the 1930's by making the piles with grooved edges and introducing a 'grout sausage' after driving, and there are a number of other solutions, such as waterproof sheets or filter membranes to place behind the piles before backfilling, or adhesive tape or joint fillers, which could be evaluated.

10.4.19 In the course of our survey we found that concrete piling driven 40 years and more ago was generally in good serviceable condition with considerable further expectation of life, especially where an in-situ concrete cope had been provided. The trench sheeting which has been in general use since about 1965 is, however, not likely to last this long; we have seen examples corroded through at the waterline within 10 years of installation. The Board are aware of this, and some investigations into the useful life of trench sheeting have recently been undertaken in conjunction with their main pile suppliers. Analysis carried out in June 1975 of samples from two piles yielded estimates of useful life of 13½ and 11½ years respectively at water level, assuming a linear rate of corrosion and 50% loss of section as the governing criterion. The indications are that above the 'splash zone' sheeting should have a life of more than 50 years, and no corrosion was found on the part which is always immersed.

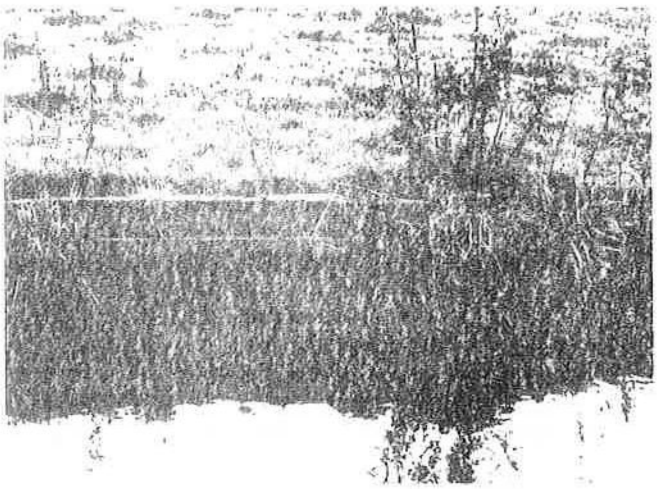


Plate 10.4 Typical precast concrete piling bank protection — Shropshire Union Canal *(PFP)*

10.4.10 There has also been some experimentation with galvanised trench sheeting, but only with the lightweight 'M5A' section, which has been unsatisfactory for other reasons. The Board's suppliers are investigating the possibility of galvanising only the top metre of the heavier section 'M7A' sheeting, but at the time of writing no firm prices were available and some problems remained to be overcome before large scale production could start. When the existing steel sheeting corrodes nearly through at water level it should be possible to cast an in-situ concrete cap to cover this critical area, extending to below water level. The Board expect by adopting one or other of these measures (illustrated in Fig. 10.2) to extend the life of trench sheeting used as bank protection to about 40 years. At present the walings used with trench sheeting are galvanised, but the tie-rods and nuts are quite untreated. We feel this is unsatisfactory, especially if galvanised piles are to be used, and recommend that consideration be given to sherardising the tie-rod ends and nuts, or using some other form of protection, to ensure that all details of the system are consistent.

10.4.21 There are also a number of local types of bank protection, some traditional and some recently introduced. In parts of the Wigan Area timber posts and horizontal slabbing have long been used and our investigations have shown that for shallow depths of water at the bank a first cost saving over trench sheeting of up to 35% was possible in March 1974. This method is not suitable where leakage has to be avoided. Timber has also been used on the Crinan Canal, the Llangollen Branch of the Shropshire Union Canal and a number of others. We feel that this is one of the forms which should be kept under review for countrywide application in appropriate situations.

10.4.22 The New Junction Canal was constructed at the turn of this century with banks formed of stone pitching. Where sufficient land is available for the shallow slopes required up to freeboard height this has a numebr of advantages — particularly for Commercial Waterways. It is an inherently stable and permanent revetment which can be designed to withstand strong currents and wave action using suitable stone sizes and filter layers or membranes, and the resulting waterway cross section allows a better area ratio and reduced blockage effect on craft than with the vertical waterwalls of piled bank protection.

10.4.23 We consider it to be important that a qualified engineer should design or at least check the design of every stretch of bank protection installed. It could be, for example, that where a Section Inspector may recommend sheeting piling to stop leakage at the top of an embankment, considerations of permeability and structural stability would demand a longer length of pile. Where abnormal loading conditions are imposed, for example on a Commercial Waterway where craft with swivelling propulsion units operate, extra safeguards are necessary, calling for a full engineering appraisal and design. We have not been able to confirm that the BWB submit all bank protection proposals to a technical design check of this kind.

10.4.24 We have not been able ourselves to undertake fully detailed designs for bank protection required in each case, though we have been careful to allow for special piling where there is evidence that it is needed. For normal conditions we have adopted the following dimensional standards:—

(a) Freeboard above weir level should be made up to at least 200mm, and where new bank protection work is carried out it should not be less than 300mm. Allowance must also be made for the maximum likely rise in water level due to flash flooding and other water control phenomena.

(b) In firm ground the toe-in of sheet piling used as bank protection against undercutting and erosion on cruising waterways should be at least 750mm, and the toe should preferably be at or below the maximum dredged depth at that section of the canal.

(c) For the great majority of cases the foregoing requirements, together with the required waterway profiles, will be met by the provision of sheeting either 1500, 1800 or 2400mm long.

10.4.25 From the qualitative point of view, it is considered that a working life of 40 years without the need for major attention is reasonable for bank protection in present circumstances. Either of the modified forms of trench sheeting mentioned in paragraph 10.4.20 should be suitable for general use, but the relative costs of these and of precast concrete piling as the main form of general protection can only be assessed as a total system, including for precasting yards, distribution and handling arrangements, installation plant and procedures etc. We have not been able to carry out a complete analysis of the overall cost and reorganisation which would be involved in returning to concrete piles, but indications are that at present their first cost would be higher than for the part-galvanised trench sheeting. However, whenever it should be found that concrete piling has become comparable in price then consideration should be given to changing back again to this form of protection. If properly made and installed concrete piling could last upwards of a hundred years.

10.5 *Towing Paths*

10.5.1 It appears to be generally accepted that, in consequence of the Transport Act, 1968, the BWB are no longer under an obligation to maintain the towing paths of their waterways so that, by implication, no one has cause for complaint if a towing path falls into disuse or becomes impassable because of erosion of the surface or growth of vegetation. This view is reflected, for example, in paragraph 74 of the Board's Annual Report for 1974 ("Over the majority of towing paths the public have no right of way and the Board have no statutory duty to maintain them."), although we understand that no explicit statement regarding the legal position has been made.

10.5.2 The clearest expression of this view that we have encountered is perhaps what is said in "It lends itself Naturally", a report on the Leeds and Liverpool Canal issued by the Board in 1973, where on page 53 the following statement appears:—

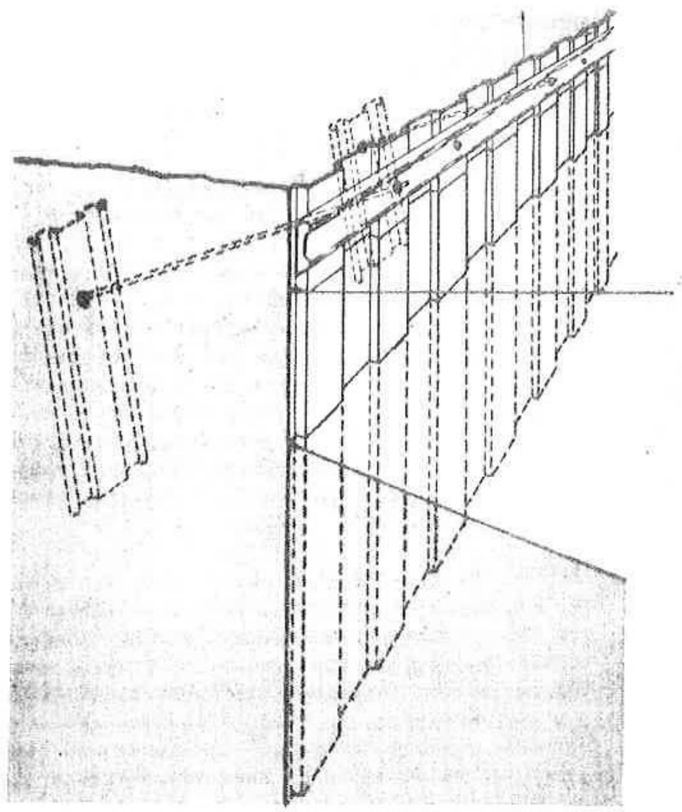
> "Unfortunately the maintenance duties of the British Waterways Board on a "Cruising Waterway" as defined in the 1968 Transport Act, do not extend beyond the main navigable channel and therefore do not include the towing path. Regular maintenance can therefore only be carried out to the towing path where it is required for general maintenance of the canal e.g., to provide access for maintenance vehicles to a lock, or where it provides the only means of access to a recreational facility."

10.5.3 The expression "main navigable channel" is used in the Transport Act 1968 only in Schedule 12 Parts I and II, which list the Commercial and Cruising Waterways respectively, and does not appear to be further defined. The interpretation placed upon this expression as justification for the view given above is evidently that "main navigable channel" refers solely to the structural components delimiting and containing the body of navigable water; if so it is by no means clear what obligations are thought to exist for the maintenance of other more remote components such as bridges, aqueducts, etc.

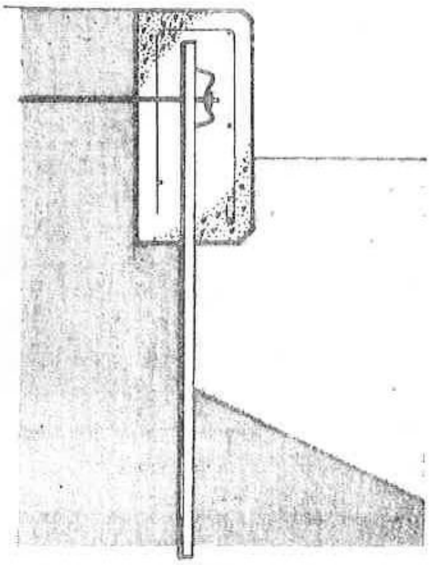
10.5.4 In our view the words "main navigable channel" are used in the Schedules to distinguish the main through routes of the respective Commercial and Cruising Waterways from unnavigable river loops, canal branches and unused sections not essential to through navigation, and are not apt to discriminate between one integral component and another of any one waterway. We have not obtained a legal opinion on this question as an authoritative ruling could only be given by a competent court of law, where the matter has not yet, we understand been brought to the test.

10.5.5 We found in the course of our field inspections a number of cases where bank protection works have been carried out in recent years that appeared to have been designed more to restore the original section of the towpath than to check actual or potential leakage. In our view these works were indeed necessary, but as this practice seemed to be at variance with the Board's officially stated policy we made special enquiry and discussed the matter with the Chief Engineer and Solicitor.

10.5.6 As a result it seems clear that while the Board do not recognise any statutory obligation to maintain towing paths in connection with navigation, they nevertheless regard them as integral parts of the waterways and therefore deserving of maintenance in order that they may function satisfactorily, for which purpose they have statutory powers under the Transport Act 1962. Provision was accordingly made in the BWB 1970 Programme for dealing with arrears of maintenance on towing paths, to such extent as local conditions might require.

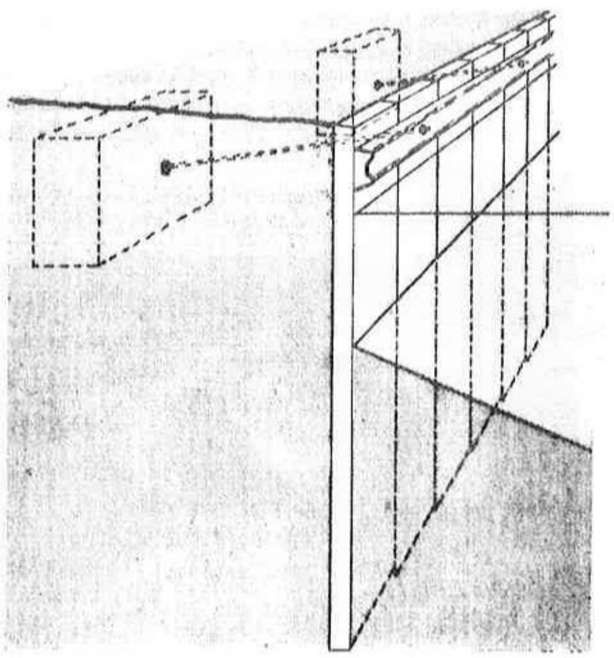


(a) above: Trench Sheeting



(b) above: Reinforced concrete capping to trench sheeting

(c) below: Concrete piling



(d) below: Timber post and planks

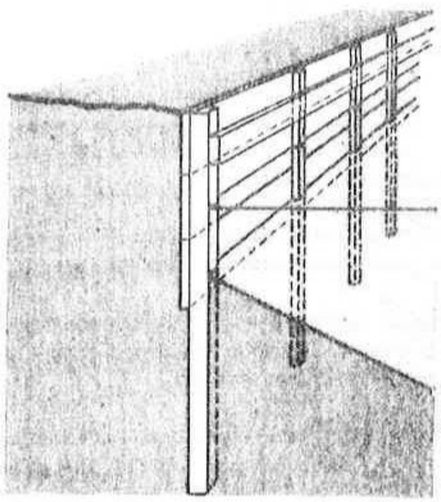


Fig. 10.2 TYPICAL REVETMENT DETAILS

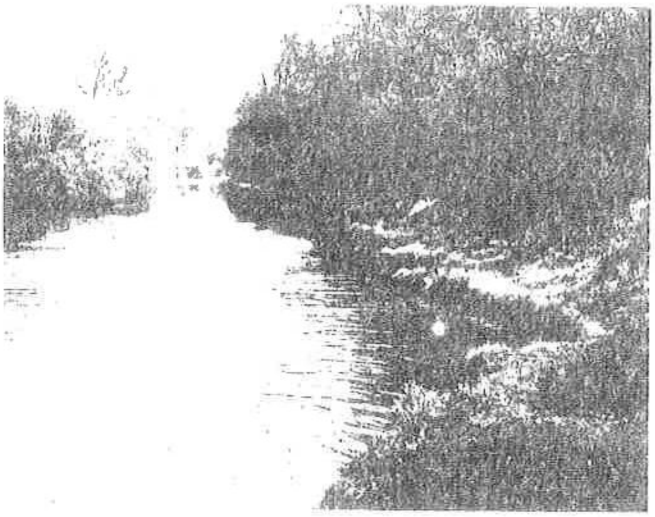


Plate 10.5 Extensive erosion of the towpath-side bank on the Oxford Canal (North) (PFP)

10.5.7 In present circumstances, with a need for economising to the maximum safe degree, every proposal submitted by an Area Engineer for undertaking works of bank protection must be supported by a certificate setting out the grounds of the application. The proposal will not usually be approved unless there is some element of risk other than to the towing path itself, but this is recognised as not necessarily meeting a proper standard of maintenance.

10.5.8 In these circumstances we consider that, whatever the precise legal interpretation of the Board's statutory obligations may be in respect of navigation, their general practice with regard to the maintenance of towing paths is in accordance with our own opinion, ie., that their responsibilities in this respect are on the same footing as for other structural components of the system. Maintenance should therefore be directed to at least the following:—

- securing continuous and ready means of access on foot or bicycle to all parts of the waterway for inspection
- obtaining access for labour and mobile plant engaged on routine maintenance operations such as grass mowing, hedge trimming and ditch clearance; also land-based dredging
- providing for passage on foot or bicycle for preparation of locks, access to moorings, etc.
- where appropriate, for the accommodation of horse or tractor engaged in the towage of dumb cruising and/or maintenance craft.
- angling and other amenity and environmental pursuits.

10.5.9 Where adequate bank protection exists, or the waterside verge is sound, a satisfactory towing path will in general be obtained if the clear width is not less than 2m and the surface is reasonably level, draining either to the waterway or to a lateral ditch. The filling of holes and cutting of vegetation will then be the extent of the regular maintenance requirement, the cost of which will not be a large element in the total maintenance budget. Towing paths that are public rights of way may call for a higher standard of maintenance under agreement with a local authority, who would thereby contribute the extra cost involved.

10.6 *Bridges, Culverts, Aqueducts and Tunnels*

10.6.1 Under Section 117 of the Transport Act 1968, the Board, with other statutory bodies, are obliged to maintain and, if necessary, to improve or strengthen any bridge which belongs to them and carries a highway over one of their inland waterways so that it has the necessary load-bearing capacity. If this is not reasonably practicable the Board must reconstruct or replace the bridge. To be of the required load-bearing capacity, a bridge must either comply with standards prescribed by an Order made by the appropriate Minister, or otherwise be capable of bearing the weight of the traffic which ordinarily used, or might reasonably be expected to have used, the highway carried by the bridge at the time the Section came into force. In the case of a new bridge, the governing criteria relate to the traffic at the time of its opening.

10.6.2 The Department's current Technical Memorandum BE 3/73 gives guidance on the assessment of highway bridges for "Construction and Use" vehicles — and this in practice defines the obligation under Section 117 as regards load-bearing capacity. The assessment of public road carrying bridges and their improvement or strengthening where necessary is known as operation 'Bridgeguard'. The public road bridges owned and maintained by the Board were all assessed for strength under 'Bridgeguard' in 1970, and those which were not passed as 'full strength' or given suitable permanent weight restrictions are included in a strengthening and replacement programme due for completion in 1976. This programme of works is funded separately by the Department, and carried out by the Board's Bridges Section at Leeds.

10.6.3 It will be necessary to continue regular inspection and reassessment of the bridges (numbering 1,133 at the end of 1974) in the future, and there may not be any period of reduced expenditure in this respect after 1976 as the bridges which were passed as 'full strength' in 1970 have not been examined since. The 1970 assessment did not specifically include abutments, parapets, wingwalls or foundations and there have been a number of cases of serious deterioration — even closure — among these 500 or so bridges not included in the Bridgeguard programme or subjected to permanent weight restrictions.

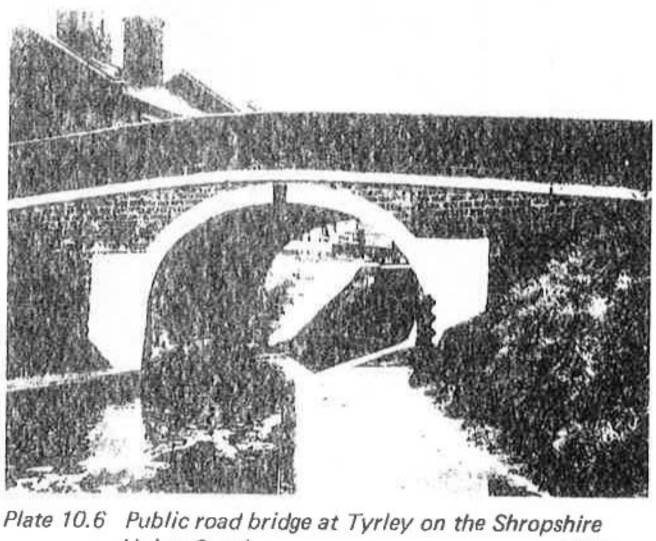


Plate 10.6 Public road bridge at Tyrley on the Shropshire Union Canal. (PFP)

10.6.4 The maintenance of the Board's public road bridges has been until now the responsibility of the Area Engineers, except when works under 'Bridgeguard' have been in progress on a particular bridge. We understand, however, that the Bridges Section is to take over entire responsibility for all the Section 117 obligations, including maintenance, in the near future. No full Memorandum, equivalent to BE 3/73, covering maintenance of bridges has yet been issued by the Department, but Interim Memorandum IM13 dated 6th October 1971 entitled "The Inspection and Maintenance of Bridges', does give guidance as to the minimum level of bridge inspection and maintenance to be observed in bridges for which the Secretary of State is the Highway Authority. This memorandum states:–

> "The Department requires each of its bridges to be inspected at least once a year and culverts (structures of less than 3m span) at intervals appropriate to their structural significance in relation to the highway. Any bridge showing significant deterioration must however be inspected more frequently and positive action must be taken to safeguard the situation or to replace the structure before a dangerous situation arises."

10.6.5 Listed below are a number of recommendations of Interim Memorandum IM13 which are particularly relevant to the structures maintained by the BWB:–

(a) Bridge registers should be instituted

(b) Once thorough assessment has established the condition of a bridge, annual inspections should be concentrated on known points of weakness with a major check overall not less frequently than every three years.

(c) Bridges which are subject to a weight restriction and those which are assessed only slightly above "Construction and Use" limits, should be inspected more frequently.

(d) The level of assessment of each bridge should be reviewed by professional staff in the light of any deterioration in conditions which cannot be rectified.

(e) Where a bridge is subjected to an 'abnormal' load, an engineer should consider which parts of the structure may be critical and specific inspections should be carried out.

(f) Inspections should be carried out by trained staff using a check list of items which must be examined and reported to an experienced professional engineer. Where any significant deterioration is reported, its implications and the bridge condition should be assessed by experienced bridge staff.

(g) Foundations below water level should always be inspected annually with the rest of the bridge. Where probing reveals any doubt regarding foundations, divers should be employed to make a detailed survey.

(h) Vegetation should not be allowed to gain a foothold on bridges. Roots of adjacent trees and shrubs must not be allowed to affect any part of a structure.

(i) Road surfaces on approaches to and over bridges must be adequately maintained to ensure a smooth surface to minimise the effect of impact.

(j) Cast iron bridges should be inspected at least twice a year, wrought iron and steel at least annually. Major structures in these materials should be examined periodically by engineers.

(k) Recommendations for surface preparation and protection of new works are incorporated in the Department's Technical Memorandum BE 3/73. The interval between complete repaints will vary with local conditions, but even with modern paint systems in rural areas is unlikely to exceed 10 years.

(l) It is important to maintain the pointing of brick and masonry arches in good condition but before re-pointing attention should be paid to drainage and the condition of fill to ensure that the pointing is not washed out.

10.6.6 We understand that the Bridges Section will be adopting these and other recommendations of IM13 as maintenance standards for the Board's public road carrying bridges when they assume responsibility for them. We consider that similar standards should also apply to accommodation bridges and, so far as is applicable, to tunnels, culverts and aqueducts as well.

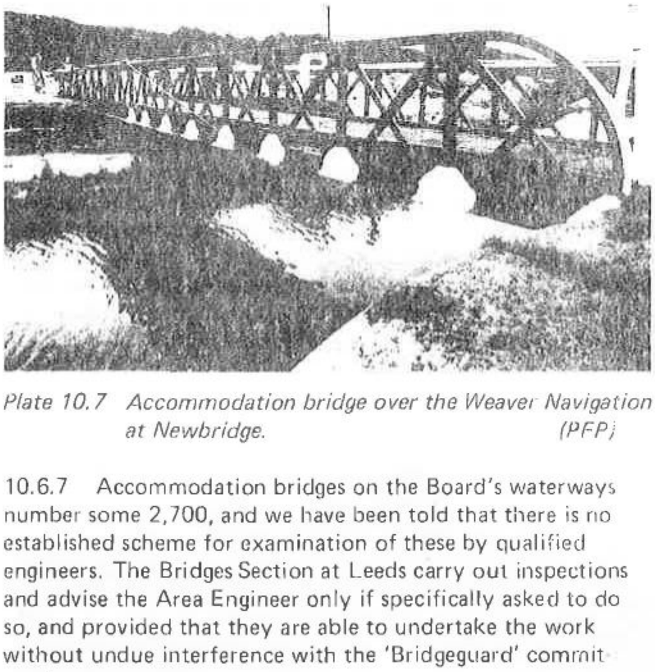


Plate 10.7 Accommodation bridge over the Weaver Navigation at Newbridge. (PFP)

10.6.7 Accommodation bridges on the Board's waterways number some 2,700, and we have been told that there is no established scheme for examination of these by qualified engineers. The Bridges Section at Leeds carry out inspections and advise the Area Engineer only if specifically asked to do so, and provided that they are able to undertake the work without undue interference with the 'Bridgeguard' commitments.

10.6.8 These accommodation bridges were generally constructed more than 100 years ago, for use by the local traffic of the period, and we consider that maximum loadings should be specified for each bridge as the tendency is for ever larger and heavier vehicles to use them, with no check on the extra stresses involved. Collection of milk from farms in bulk milk tankers is now the rule in most parts of the country, and the use of full size container trucks in collecting grain and other produce from farms and delivering fertilisers, feed, etc., is on the increase.

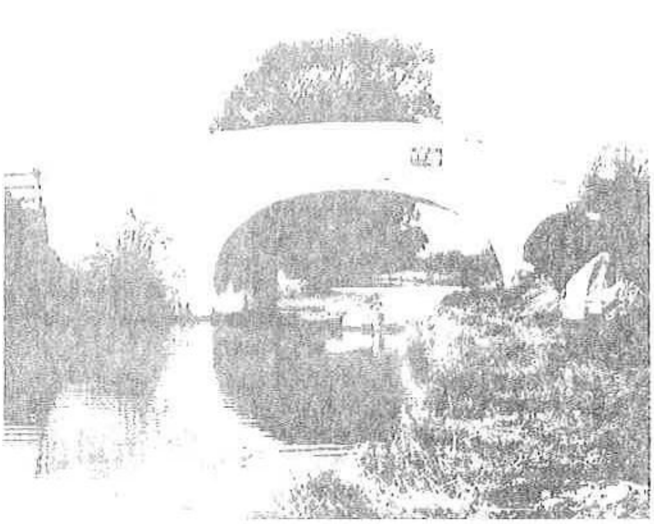


Plate 10.8 Accommodation bridge at Claydon on the Oxford Canal (South) after gunite treatment. *(PFP)*

10.6.9 On certain waterways the original enabling Acts provided that accommodation bridges should be strengthened if necessary from time to time to keep in step with changing requirements of local traffic. This kind of obligation does not appear to have been removed by Section 105(5) of the Transport Act 1968 and is one that may impose unforeseen burdens on the maintenance programme. In such cases there is a need for BWB to define and agree the exact usage, and hence the maintenance obligation, so that a comprehensive programme for overtaking any arrears of maintenance can be put in hand.

10.6.10 Moving bridges, carrying both public and private traffic, are common throughout the system. On commercial waterways they are often manned, but elsewhere are operated by canal users and the general public – and these are particularly prone to misuse and abnormal wear and tear. Inspection of moving bridges needs to be carried out more frequently than for fixed bridges because the assumption of slow structural deterioration made in deciding inspection periods for the latter is not so readily applicable where machinery which is vulnerable to impact and abuse is involved.

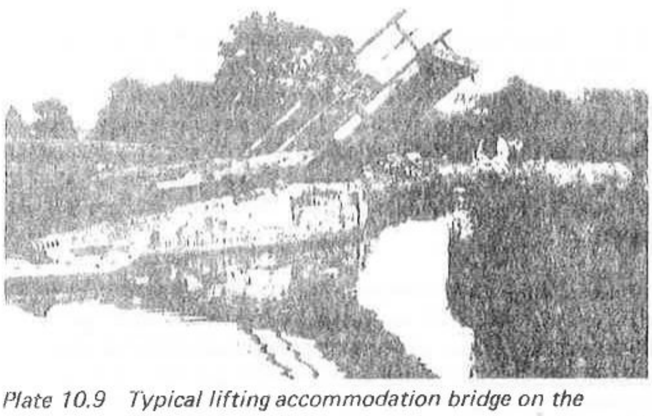


Plate 10.9 Typical lifting accommodation bridge on the Oxford Canal (South). *(PFP)*

10.6.11 Culverts, as distinct from bridges and aqueducts, are defined as such in Interim Memorandum IM13 and elsewhere when their span is less than 3m. In constructing the artificial canal system the engineers had to provide for existing lateral watercourses to continue their flow uninterrupted, and this was generally effected under the canal by means of culverts of either inverted siphon or free-air type. Thus the majority of the culverts in the BWB system are water-carrying and of the same age as the canal itself. The total number must be of the order of three thousand if everything down to the smallest masonry, brick or timber structures is included. Many of the smaller culverts are no longer used and cannot be found – indeed we were unable to locate several which were shown on maps marked up as recently as 1965. These are all potential hazards as their collapse at any time could induce leakage paths from the canal bed and lead to a breach.

10.6.12 It is important to keep all culverts clear of silt and debris, both to preserve their ability to handle occasional storm water and to facilitate inspection. Access into inverted siphons and the smaller free-air types can be very awkward, particularly if the flow of water does not dry up naturally in the summer, so that it can be a time-consuming and expensive business merely carrying out a thorough inspection.

10.6.13 Aqueducts are particularly vulnerable structures – they carry their full working load all the time, their approaches are generally on steep embankments, and the joints between the trough of the aqueduct and the channel on either side are very sensitive to settlement or any structural movement. In many cases the potential consequences of failures at an aqueduct are serious, so that from the point of view of public safety preventive measures should be given a high priority. It is particularly important to keep brickwork and masonry in good repair and well pointed so that leakage is stopped before the water can leach out any mortar or fill. It will probably be necessary to dewater in order to carry out a full inspection.

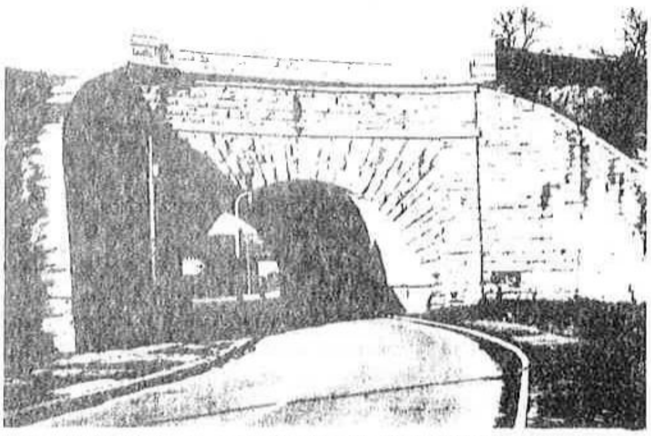


Plate 10.10 Masonry aqueduct on the Leeds and Liverpool Canal at Blackburn *(PFP)*

10.6.14 Where the trough is made up of cast iron sections bolted together the bolts should be examined periodically and any iron or steelwork below water level will need to be stripped back to parent metal and thoroughly reprotected at regular intervals. Continuous fendering on both sides of the waterway is normally required to protect the sides of the trough, especially where these are in a brittle material like cast iron. Also among the special maintenance needs of aqueducts is that of ice-breaking – it may well be necessary to avoid any build-up of ice across the waterway to prevent its expansion from inducing strains in the structure.

Plate 10.11 Cast iron aqueduct at Nantwich on the Shrophsire Union Canal. (PFP)

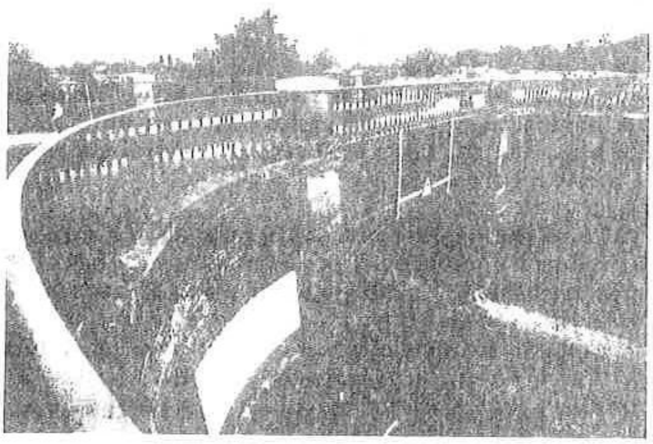


Plate 10.11 Cast iron aqueduct at Nantwich on the Shrophsire Union Canal. *(PFP)*

10.6.15 It is necessary to preserve air-draught (headroom) clearance at bridges, tunnels etc., but the existence of many different structure profiles presents a problem. Dimensions of height and width of superstructure of craft are recorded in the BWB official compendium relating to Section 105 (2) (a) of the Transport Act, 1968, and are reproduced in Table 10.1. A profile giving 300mm clearance from the craft at all points above the waterline is in our view a reasonable requirement for unhindered navigation. Where the margin at any point for a Table 10.1 craft passing any particular structure (with normal water level) is not more than 300mm that margin should not be reduced by maintenance or reconstruction works. If the application of gunite to the arch of such a bridge is contemplated, for example, then the brick or stonework may have to be cut back to allow the addition of the gunited layer. Mining subsidence, discussed in Chapter 7, can cause appreciable settlement of structures relative to the water level, and in some cases major works will be required if the full margin is to be preserved. It is considered that action should be taken to restore the air-draught clearance for Table 10.1 craft as soon as it is reduced to 150mm at any point.

10.6.16 Section 122 of the Transport Act 1968 provides that where an inland waterway passes under a highway by means of a tunnel, or runs in a cutting over which a highway is superimposed, the earlier provisions of the Act (including Section 116) shall have effect as if the structure of that tunnel or cutting were a bridge, so far as applicable and subject to any necessary modifications. The obligation to inspect and maintain such tunnels therefore has statutory force under the Act though, as suggested in paragraph 10.6.6 above, we consider that the same standards should be applied to all tunnels.

10.6.17 All brickwork requires periodical attention to repair the effects of wear and tear and weather, and near or below water level the deleterious effects of the water. Incipient defects can readily be dealt with by pointing the joints but if this is not done in time more extensive repairs are likely to become necessary. The longest brick-lined tunnels on the system have traditionally required almost continuous attention, indeed there were gangs of bricklayers permanently attached to the Harecastle and Standedge tunnels until the 1940's.

10.6.18 Although siltation of aqueducts and tunnels is generally less severe than an open waterway, because of the increased speed of water flow due to the restricted channel dimensions, removal of deposits does eventually become necessary everywhere. One method used is to dewater and wash the accretions out with high pressure hoses, though shovels and barrows have been resorted to on occasion. Sometimes dewatering is not possible, perhaps because of springs or mine water entering the canal within a tunnel, and this can increase the time and cost of the job out of all proportion.

10.7 *Locks*

10.7.1 There are some 1350 locks in the Board's system of waterways, ranging between 2.1m gauge on the inland artificial waterways, and the 18.3m wide sea lock at Sharpness. Before the first world war brickwork and masonry were used almost exclusively in the construction of chambers and approaches, though reinforced and mass concrete, and more recently steel sheet piling, have been employed in the majority of cases since then.

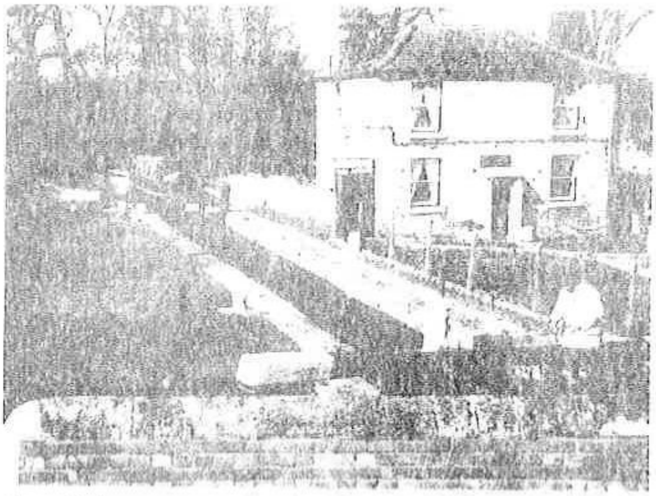


Plate 10.12 Narrow lock on the Chesterfield Canal. *(PFP)*

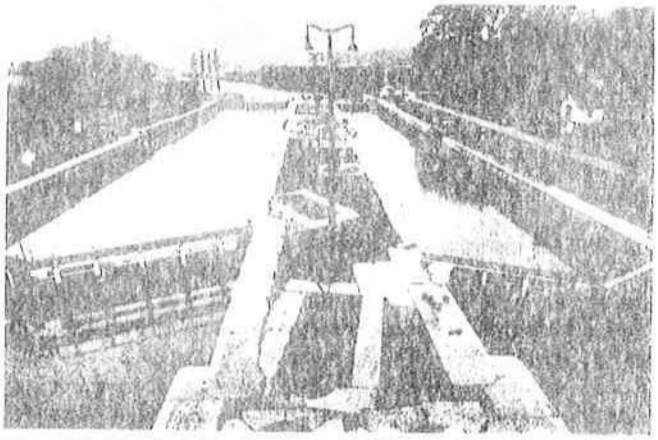


Plate 10.13 Saltersford lock on the Weaver Navigation. *(PFP)*

10.7.2 Defective brickwork allows water to get into and behind the walls and to build up hydrostatic pressure when the locks are alternately filled and emptied. As with other structural elements of the waterways system defects of pointing are relatively simple and cheap to correct, but if they are not attended to in time then bricks begin to work loose and it is necessary to cut out and rebuild an area of the wall. Where masonry is used instead of brickwork similar considerations apply but intervals between attention are likely to be longer and the costs of repair somewhat less – as long as the work is done in time.

10.7.3 Vegetation must not be allowed to gain a foothold in brickwork or masonry or on lock gates as it quickly forces stones, bricks and timbers apart and generally induces leakage and accelerates decay.

10.7.4 Fendering is of greater importance on Commercial canals as any impact from the frequent, heavily laden steel hulled commercial craft could damage the lock approaches, gates or upper sill. On Cruising waterways the replacement of fenders and rubbing strips may not be of first importance as the majority of the craft using them are of fibreglass or other light construction and their owners will be very careful to avoid collisions in which their craft would come off worst. Few helmsmen are expert, however, and hire operatores tend to provide strongly constructed craft for their customers for this reason. It is also the case that broken or part-demolished fenders are a hazard, so that attention is often required to remove remnants of fender supports on masonry lead-in walls or to provide a new sill fender at the upper end.

10.7.5 Where locks have been provided with sideponds to conserve water these must be restored to and kept in good working order if it is intended that they be used. This is especially important on a lock flight or staircase, where the amount of water saved can be considerable. This is discussed at greater length in Chapter 9.

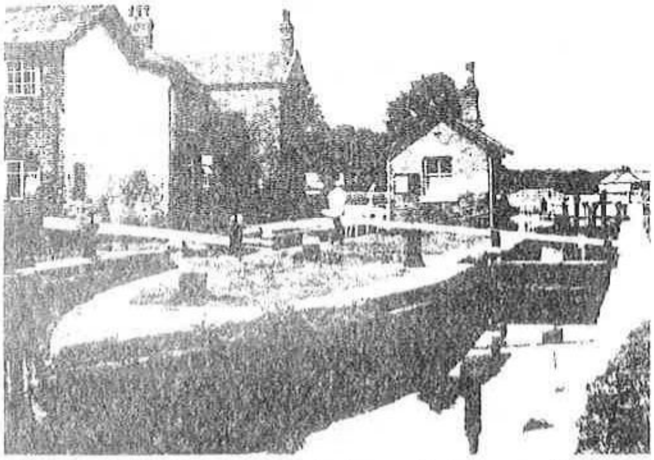


Plate 10.14 Duplicate narrow locks, on the Trent and Mersey Canal. (PFP)

10.7.6 The paddles, sluices or cloughs which are used to control the filling and emptying of the locks are generally of timber running in timber or cast iron guides. They must be free-running within their guides and frames and yet watertight when closed. Regular inspection and periodic attention are required to repair damage from wear and tear, and from objects floating in the canal which are sucked through the opening or occasionally jam across it, and the search for improved designs and materials to increase the life of components with good fit and low friction should be continued.

10.7.7 Gate quoins are mostly of shaped masonry blocks, timber or cast iron and occasionally with inserts to improve the water seal. A damaged quoin can quickly spoil the heel post of the gate, and may also let quantities of water through. Regular attention to pointing of masonry is relatively easy to organise, but repairs are the job of a skilled mason. If BWB find it uneconomic to replace or train such skilled craftsmen they will need to give consideration to substituting concrete for masonry when a structure reaches such a state of deterioration that major repairs become necessary.

10.7.8 The large majority of the gates in the 1,350 or so locks in the Board's system in England and Wales are of timber construction, although a small number of steel framed and cast iron gates exist. Experience has shown that oak is the best timber for framing these though elm or some imported hardwoods are suitable for planking and fendering. The design and manufacture of lock gates, hardly any two of which are the same, is another highly skilled process in which specialised experience is of great value.

10.7.9 The continuing good fit of gates in the lock chamber is important for conservation of the limited water supplies on most canals (see Chapter 9). Regular clearance of debris and minor repairs to the gates in situ are important factors in achieving this and protective fendering needs constant attention, particularly on well used commercial waterways where this is commonly replaced every three or four years. Long before a gate becomes a structural liability the sill and quoins will probably pass significant quantities of water, and this consideration of wastage will often dictate the need for attention before those of operation and safety.

10.8 *Other Aspects*

10.8.1 Devices such as weirs and sluices for flood relief and pound level control must be kept clear of debris and in good working order. It is still the case on a number of Cruising and Commercial waterways that the regulation of water level during times of heavy rain depends on BWB employees operating sluices throughout their Section manually — and at any time of the day or night. The BWB have replaced a number of these, often relatively inaccessible, storm sluices with long crested weirs, and we would recommend that where it is possible this rationalisation be continued to provide automatic storm water regulation and reduce this inefficient use of manpower.

10.8.2 The engineers who designed our artificial waterways were well aware of the possibility and serious consequences of breaches, both to the navigation itself and the surrounding countryside. Provision for the emergency installation of stop planks, and in some places flood gates, was made where necessary so that a length of canal could quickly be isolated and the loss of water minimised. The stop-plank grooves are also used when a structure has to be dewatered for maintenance or repair and so must be kept in good condition. The planks themselves, usually of longleaf pitch pine, need to be kept on site at critical locations. Unfortunately they are a frequent object of vandalism, so that it is becoming necessary to construct secure shelters for them with locks and keys. This complication of emergency safety operations is particularly antisocial, and all attempts to solve the problem should be encouraged.

10.8.3 Underwater weeds are not a serious problem to navigation or the passage of water where there are regular craft movements. If the volume of traffic is small, however, weeds will need to be cleared at intervals; in unnavigable feeders clearance is essential if the flow of water is to be maintained. Weed growth tends to be stronger in shallow depths of water, where the sun's rays penetrate more easily to the channel bed.

10.8.4 As an example of the effect of weed growth in a feeder, measurements of flow in the former Wendover Arm which supplies the Tring summit of the Grand Union Canal may be quoted. In the early spring of a dry year, and after weed clearance in September, net losses were negligible. Between April and July, however, weed growth induced higher water levels and increased percolation through the banks. The effect of this, together with the enhanced evaporation and transpiration, was to reduce the quantity delivered to 50% of the input. It was estimated that, had weed clearance been carried out in good time, some 1100 locks of water would have been saved.

10.8.5 Pollution inludes that of a chemical nature, such as sewage, oil, etc. but often is physical, particularly in urban areas where bulky objects are commonly thrown into the water along with many minor items of miscellaneous character. All this calls for continuous observation and periodical removal to reduce the risk of damage to fragile craft and of restrictions to the flow of water.

10.8.6 Controlling the growth of vegetation on land takes up a significant amount of time in the spring and summer. Grass on the towpath must be cut and path and road surfaces kept clear, hedges must be trimmed and trees removed when their roots threaten a bank or structure. Embankments should be kept free of large shrubs, bushes and trees so that any signs of leakage or slippage are readily visible to the experienced eye of the length foreman on his regular inspections. It should also be remembered that reservoir headbanks require continuous attention of this kind and other normal maintenance, apart from any requirements of the Inspecting Engineers appointed under the Reservoirs (Safety Provisions) Act, 1930.

10.8.7 Desirable maintenance standards for the many buildings owned by the Board should be those of normal good practice, and we do not feel it is incumbent on us to go into detail in this Report. Special requirements when buildings are listed as being of special architectural or historic interest are discussed in Chapter 6 – Special Features.

10.8.8 There are a great number of other maintenance tasks and considerations which it has not been considered necessary to spell out in this chapter and for these, as for points which have had specific mention, the guidelines must be good technical practice related to long term economy and safety, and the extent of the Board's responsibilities. The merits of different strategies of maintenance are discussed in Chapter 11. There are also, however, a number of arguments affecting both strategy and standards which it is appropriate to mention here.

10.8.9 Section 104 of the Transport Act 1968 requires that the Cruising waterways shall be principally available for cruising, fishing and other recreational purposes. This constitutes a change of use from their traditional commercial operation, and in consequence a greater emphasis on safety and ease of operation is in our view unavoidable. It is difficult to quantify the changes involved in general terms, but to give some examples:–

(a) It should be possible for boat users to get on and off their craft in a lock chamber to operate paddle winding gear and gates. In the deeper locks this may necessitate the provision of a ladder either set back into the lock side or fixed to a gate. In case anyone should fall into the water when the gates are closed, particularly when there is no boat in the lock, safety chains or hand-holds should be provided – or at the least a life-belt in evidence on the lock side.

(b) It is necessary to ensure that paddle winding gear is easy to operate, as it is less reasonable to expect the cruising public to have the strength needed to operate worn mechanisms; we note that the Board have been introducing a number of hydraulic and other alternative trial designs of winding gear with this in mind:

(c) Whereas boatmen of old might have been content to walk across the top of closed lock gates to reach the paddles on the other side, some sort of walkway with a handrail is needed for children and the less nimble enthusiasts among today's boat crews.

(d) Some tunnels were built with towpaths and, as they are now available for use by the cruising public who are seldom equipped with better than a hand torch, it is clearly vital that where these still exist the handrails and path surface are well and evenly maintained.

(e) Safety barriers and grilles may be necessary at a greater number of sluices, weirs etc. as it is inevitable that the standards of navigation and craft handling will be lower than in the days of professional boatmen.

These are examples where purely engineering and economic considerations, as normally evaluated for commercial situations, are insufficient arguments in themselves. There are many other problems whose solutions must owe something, however little, to the requirements of amenity and recreation – and it is important to make this point that the BWB must keep their unusually broad obligations in this respect continually in mind, though any resulting extra cost is usually small.

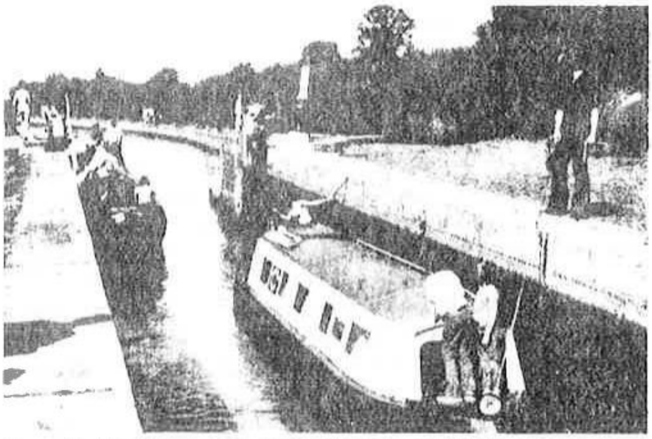


Plate 10.15 Calcutt lock (Grand Union Canal) showing safety chains. (PFP)

10.8.10 It has been shown that an improvement in appearance can have a dramatic effect on the public. A coat of paint has reduced vandalism, with its associated accelerating decay, by as much as 50 percent overnight – and the public are naturally proud of the Waterways System with its place in our industrial national history, as long as it is seen to be well tended in the 'good housekeeping' sense. It is worth mentioning here that such arrangements as lock-keeping competitions which promote and maintain a pride in the appearance of the canals, with associated good housekeeping standards, pay dividends in many ways; the staff are more contented, the users gratified, vandalism discouraged and overall maintenance costs reduced.

10.8.11 There are a number of special skills and methods which, though no longer economical in application to large scale new work, are necessary for the proper repair and maintenance of existing elements of the system. Most of the original towpath water-walling was of the dry-stone type, and a significant amount of it has survived almost 200 years of use – and will continue to give service as long as local repairs are promptly and appropriately carried out. Many of the canal structures are of dressed masonry – and repairs to lock walls, bridges, aqueducts, etc., call for a high quality of workmanship from masons of wide experience. Under many of the enabling acts there is an obligation to provide a stock-proof fence on the towpath-side boundary, and in some cases layering of hedges by hand is still the most economical method; tractor mounted cutting machines do not deal with gaps in the hedge – and in some places access for them is not available. As a last example the maintenance of many mechanical elements, such as bridge operating machinery, sluice gates and locks on inland canals and particularly the larger river navigations, demands continuity of experience and above average versatility in the ground staff and repair yard craftsmen.

10.9 *The BWB 1970 Survey and the Tring Scheme*

10.9.1 Having considered the standards of maintenance which, in our opinion, are implied by the Board's statutory and other obligations, and having defined them in terms that will be used in the following chapters as the basis of our estimates, we think it necessary in concluding this chapter to comment on the standards used by the Board in making their 1970 Survey. The necessity arises from the fact that some kind of comparison will inevitably be made between the results of that Survey and the conclusions that we present in this Report. It will be found that there are differences. Some of these are due merely to quantitative factors, i.e. in the actual extent and estimated cost of work considered to be required to achieve a given standard; others spring from more fundamental considerations involved in defining the basic standards themselves.

10.9.2 The BWB Survey was carried out between the middle of February and the end of June 1970, a period of 4½ months. It was carried out by the Board's existing engineering staff in addition to their normal duties. There was no opportunity to appoint a special team or to call in independent consultants, and the time available was strictly limited. The work was divided among the 8 Area Engineers and their Area and Section Inspectors, the results being collated and the resultant programmes submitted to the Chief Engineer by the then Regional Engineers.

10.9.3 There was obviously insufficient time for a completely fresh survey, although the staff were no doubt familiar with the general condition of the various works and structures, and it is understood that to a large extent reliance was placed on a comprehensive survey that had been carried out some five years earlier.

10.9.4 With a view to ensuring that (as far as practicable) uniform criteria were adopted in assessing arrears of maintenance, the Chief Engineer issued to the Staff concerned a memorandum of instructions dated 13th February 1970. This contained three statements, relative to:

A Commercial Waterways
B Cruising Waterways
C Remainder Waterways

respectively which were intended to provide definitions of standards against which the survey could be made on a broadly comparable basis between the eight areas. As time was short it was emphasised that efforts to obtain marginally improved estimates must not be allowed to delay the survey.

10.9.5 The statements setting out maintenance standards for the three categories were all framed in general terms, giving no specific guidance as to dimensions or structural capacity. Typical phrases used included:–

"sound and tidy standard"
"suitable and economic design" and
"normal requirements"

It is very doubtful, in our view, if such directions could have ensured the desired degree of uniformity.

10.9.6 Only with reference to dredging were more precise criteria laid down. Here it was provided that dredging on Cruising waterways should allow for continued movement of commercial craft where they existed. In other cases "a dredged depth of 4' – 0" (1.22m) or a requirement to pass craft which passed in the relevant period defined by the Transport Act 1968 (whichever is the greater) and over a channel width equal to twice the beam of the craft normally using that waterway should be allowed for to cover movement of pleasure craft". On Remainder canals dredging should be "to water channel or other suitable standards".

10.9.7 The BWB Survey was made about 4½ years before our own and apart from any other considerations it must be expected to be so much out of date. Some items, it is known, have since received attention; others would now, no doubt, require to be added to the list for various reasons. The position with regard to some Remainder canals has certainly altered where assistance has been received from Local Authorities or volunteer parties in doing work not necessarily contemplated at the time.

Plate 10.16 Dry-stone walling reinstated by volunteers under BWB supervision – Tring Summit, Grand Union Canal. (PFP)

10.9.8 Whatever our reservations as to the definition of maintenance standards for the Board's 1970 Survey, we have had an opportunity to examine a recent practical application of them in some detail. A length of 24km of the Grand Union Canal at Tring was selected as the subject of works designed to overcome the arrears of maintenance detailed in the 1970 Survey and raise the waterway to a reasonable engineering state compatible with the 1968 Transport Act. The Board's Chief Engineer emphasised to his Staff at the outset that what was required was sound basic work, though volunteers should not be discouraged from adding finishing touches where they would. The treatment of 15km of this length is now completed, with the exception of dredging, between Northchurch and Marsworth and was shown to the public and the press on 15th May 1975.

10.9.9 We have made a careful examination of this length of the Grand Union, and it was included in a field visit attended by Officers of the Department on 5th May 1975. In our view the completed works on this length of waterway exemplify the effects of bringing its component parts up to the standards outlined in this chapter. This view relates to engineering aspects of the scheme under the main headings of bank protection, structures (so far as they are represented) and agricultural works. We should point out, however, that some minor details such as the provision of lock-side seats, gardens and gravel surfacing to certain lengths of towpath, go beyond a strict interpretation of the Board's statutory obligations. We make no comment on these as they arise from requirements of the Amenities Division, whose activities are excluded from this Report except in so far as they involve actual operations and maintenance work.

10.9.10 It will be appreciated also that this length of waterway is temporarily in above-average condition as one would not normally expect to find so many of the works and structures fully up to standard together at any one moment of time. With a normal application of maintenance methods, as discussed in the next chapter, the average condition of lengths of waterway would fall below the full standard by about half the permissible amount of deterioration. We take this into account in assessing arrears of maintenance in Chapter 12.

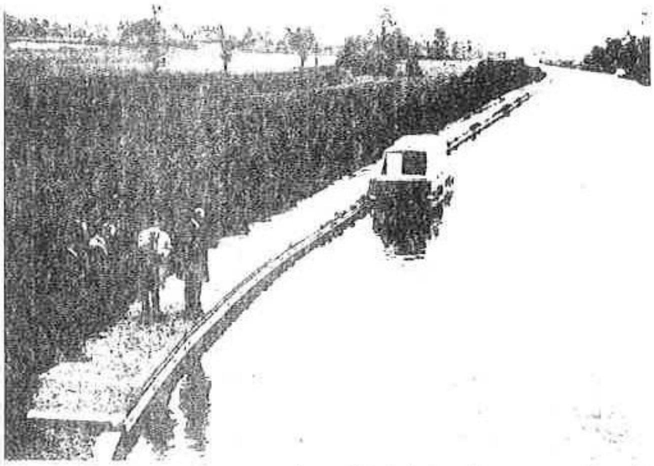


Plate 10.17 Combined DOE/PFP field visit – Cowroast, Grand Union Canal. (PFP)

Table 10.1

Statutory Craft Dimensions and Limiting Lock Dimensions

Part 1 – Commercial Waterways

Waterway and extent	Waterway Ref. No.	Craft Dimensions^{z} (metres)					Lock Dimensions (metres)			Notes
		Length	Beam	Static Draught	Superstructure Width	Superstructure Height	Length	Width	Sill Depth	
Aire & Calder Navigation										
River Lock-Leeds Lock tail	35a	43.59	5.41	2.13	5.41	3.66	67.21	5.52	2.44	z) maximum dimension in each case, may not all refer to the same craft.
Leeds Lock – Goole Docks	35a	59.44^{y}	5.71	2.44^{x}	5.71	3.81	66.14	5.94	2.54	
Fall Ings Lock tail – Castleford Junction Lock	35b	59.44	5.41	2.31	5.41	3.66	65.23	5.79	2.59	y) and 134.61 Cawood Hargreaves Units below Castleford, 122.22 compartment boats above.
Bank Dole Lock-Haddlesey and Selby Canal	35c	23.16	4.42	1.52	4.42	2.44	27.51	5.33	1.99	
Into Selby Basin Only	35c	22.86	5.64	2.13	5.64	–	27.43	5.79	2.24	
Calder and Hebble Navigation										x) 2.51 Astley to Ferrybridge
Broad Cut to Thornhill only	36	17.53	4.32	1.68	4.32	2.97	8.85	4.42	1.83	w) restriction through flood lock
Fall Ings to Fletcher Wharf, Wakefield	36	36.58	5.41	2.13	5.41	3.66	40.49	5.49	2.29	
Fall Ings to Spencer Wire Works, Thornes	36	38.40	4.95	1.98	4.95	3.66	39.47	5.49	2.29	
Thornhill to Greenwood	36	17.53	4.11	1.22	4.11	2.97	21.79^{w}	4.42	1.80	
Caledonian Canal										
Inverness to Corpach Basin	47	48.06	8.31	3.96	–	27.43	51.82	11.58	5.18	
Through sea lock to Corpach Basin only	47	57.91	8.56	3.96	–	–	51.82	11.58	5.18	

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Table 10.1 Part 1 Continued

Waterway and extent	Waterway Ref. No.	Craft Dimensions[z] (metres)					Lock Dimensions (metres)			Notes
		Length	Beam	Static Draught	Superstructure Width	Superstructure Height	Length	Width	Sill Depth	
Crinan Canal										v) walls battered; 6.63 only at full draught.
Crinan to Ardrishaig	48	25.55	6.63	2.97[u]	–	27.43	29.26	7.32[v]	3.05	
Through Sea locks to Crinan and Ardrishaig Basins only	48	29.57	6.50	3.05	–	–	32.92[t]	7.92[t]	3.05	u) in fresh water t) Crinan Basin only
Gloucester and Sharpness Canal	15	59.13	8.99	3.51	–	–	97.54[s]	18.29[s]	7.32[s]	s) through sea lock at Sharpness
River Lee Navigation										
Below Old Ford Locks	1a	25.91	5.79	1.75	3.05	2.13	31.70[r]	5.94[r]	–	r) restriction at Bow Locks tidal below
Old Ford Locks to Enfield Lock tail	1a	25.91	5.49	1.52	3.05	2.11	28.80	5.64	2.19	
Enfield Lock to Hertford	1a	22.86	4.72	1.37	3.81	2.11	28.65	4.88	1.78	
New Junction Canal	34b	59.44[q]	5.36	2.13	5.36	3.53	65.53	6.71	2.82	q) and 122.22 compartment boats.
River Severn										
Gloucester to Worcester	16	42.67	6.65	2.51	4.72	5.03	43.41	9.22	2.87[p]	p) up to 3.10 depending on tide
Worcester to Stourport Basin	16	27.43	5.79	1.75	2.44	4.11	28.50	6.10	1.91	
Sheffield and South Yorkshire Navigation										
Tail of Tinsley bottom lock to tail of Sprotborough lock	34a	18.75	4.72	2.13[o]	4.72	3.05	19.02	4.88	2.08[o]	o) normally 2.08 only available over Rotherham lock sill, otherwise 2.1
Sprotborough lock to tail of Doncaster lock	34a	59.44	5.36	2.13	5.36	3.53	65.53	5.59	3.07	
Doncaster lock to Bramwith	34a	59.44[n]	5.36	2.13	5.36	3.35	65.53	5.38	2.90	n) plus 122.22 compartment boat, splits for locks
Bramwith to Keadby	34a	30.78[m]	6.20	2.36	6.20	3.05[l]	23.67	6.65	3.94[k]	
Trent Navigation										m) also 59.44 Cawood Hargreaves units light only from Dunstons Shipyard (splits into three for Thorne Lock)
Nottingham to Cromwell Lock tail	28	42.67	5.72	1.83	3.51	3.96	57.00	7.32	2.23[j]	
Cromwell lock to Gainsborough	28	45.57	7.06	2.13	3.51	4.27	–	–	–[i]	
Weaver Navigation										l) ballasted 4.06
Weston Point to Winnington	22	53.64	9.14	3.12	–	17.07	69.80	12.95	4.57	k) Thorne Lock 20.12 x 5.36 x 2.74
Winnington to Winsford	22	45.72	9.14	2.67	–	8.84	69.80	12.95	4.57	
										j) Cromwell lock 1.60 to 2.82 depending on tide
										i) no locks.

Table 10.1

Statutory Craft Dimensions and Limiting Lock Dimensions

Part 2 – Cruising Waterways

Waterway and extent	Waterway Ref. No.	Craft Dimensions[z] (metres) Length	Beam	Static Draught	Superstructure Width	Superstructure Height	Group	Lock Dimensions (metres) Length	Width	Sill Depth	Notes
Ashby Canal	9	21.64	2.08	1.07	1.58	1.88	B	32.92[y]	2.51[y]	1.52[y]	z) maximum dimension in each case, may not all refer to the same craft
Birmingham Canal	20a	21.79	3.13	0.94	1.60	1.98	A	22.61	2.21	1.24	
Birmingham and Fazeley Canal											y) through stop lock
Huddlesford Junction to Fradley Junction	20b	21.95	2.16	0.77*	2.16	2.08	A*	–	–	–[x]	x) no locks
Fradley Junction to Farmers Bridge Junction	20b	21.79	2.13	0.94	1.60	1.98	A	23.67	2.19	1.37	
Digbeth Branch	20b	21.79	2.13	0.94	1.60	1.98	A	23.67	2.19	1.37	
Calder and Hebble Navigation											
Greenwood lock to Sowerby Bridge and	36	17.53	4.32	1.07	4.32[w]	2.97	K	18.59	4.37	1.73	w) 2.36 from Mirfield to Sowerby Bridge
Huddersfield Broad Canal	37										
Chesterfield Canal											
West Stockwith to Worksop	31	21.95	2.11	0.76*	1.37	1.75	A*	22.26	2.16	1.32	
Coventry Canal											
Fazeley Junction to Coventry	8	21.95	2.08	1.07	1.37	2.08	B	22.25	2.20	1.52	
Erewash Canal											
Tamworth Road Bridge to its junction with the River Trent	26	21.95	2.74	0.76*	2.59	2.03		25.30	4.62	1.17	
Fossdyke Navigation	30a	22.86	4.67	1.62	3.05	3.66		24.69	5.33	1.52[v]	v) Torksey lock into the Tidal Trent
Grand Union Canal											
Regents Canal	2a	21.95	4.27	1.17	3.35	2.67	L	23.85	4.38	1.17	
Hertford Union Canal	2b	21.95	2.13	0.81*	1.83	2.11	A*	27.48	4.38	1.45	
Paddington Arm	2c	21.95	4.27	1.17	3.35	2.67	L	23.85	4.38	1.17	
Brentford to Berkhamsted	3	21.95	4.27	1.17	3.35	2.67	L	23.85	4.38	1.17	
Berkhamsted to lock 13, Long Buckby	3	21.95	3.81	1.17	2.44	2.67	L	24.23	4.38	1.23	
Aylesbury Arm	4b	21.95	2.13	0.81*	1.83	2.11	A*	22.86	2.32	1.29	* Maximum draught take as 0.90 (see text)
Northampton Arm	4c	21.95	2.13	0.81*	1.83	2.11	A*	22.63	2.18	1.15	
Lock 13, Long Buckby to Camp Hill locks	3 & 6	21.69	3.81	1.17	2.44	2.44	L	24.08	4.41	1.23	

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Table 10.1 Part 2 Continued

Waterway and extent	Waterway Ref. No.	Craft Dimensions[z] (metres) Length	Beam	Static Draught	Superstructure Width	Superstructure Height	Group	Lock Dimensions (metres) Length	Width	Sill Depth	Notes
Camp Hill Locks to Digbeth and Salford	6	21.69	2.13	1.17	2.44	2.44	C	22.63	2.22[u]	1.60	u) 2.20 at Camp Hill Locks
Leicester Branch to Foxton	5	21.79	2.12	0.84*	1.37	2.06	A*	22.56	2.21	1.52	
ditto Foxton to Leicester	27a	21.79	3.05	0.99	1.98	2.06		22.56	4.57	1.52	
Market Harborough Arm	27a	21.79	2.90	0.84*	1.98	2.06	A*	–	–	–[x]	
Kennet & Avon Canal											
Reading to Tyle Mill	12	21.95[t]	1.98	0.91	1.83	1.98	A	21.34	4.47	1.19	t) Lies diagonally in lock
Bull's Lock to Hamstead	12	8.53	2.74	0.76*	1.37	1.98		22.56	4.34	1.30	
Hanham to Bath	12	12.19	3.05	0.76*	2.13	1.83		29.87	5.79	1.78	
Lancaster Canal											
Preston to Tewit – field including Glasson Dock Branch	46	21.95	4.65	0.99	2.34	2.49		22.86	4.72[s]	1.60[s]	s) Locks on Glasson Dock Branch only
Leeds and Liverpool Canal											
Aintree to Wigan	45	18.90	4.42	0.69*	1.83	1.62	J*	23.27	4.65	1.30	
Wigan to Leeds	45	19.51[r]	4.34	1.22	2.44	2.67	L	19.85[q]	4.53[p]	1.37	r) limit through Wigan flight 18.59
Leigh Branch	45	21.95	4.34	0.84*	4.11	2.51	J*	23.32	4.52	1.60	q) Newlay and office locks
Rufford Branch	45	21.95	4.34	0.61	4.11	2.51		20.52	4.57	1.37	p) Bingley 5 – rise
Macclesfield Canal											
Hardingswood Junction to Marple	41	21.34	2.15	0.84* 1.07[o]	1.91	2.13 2.34[o]	A* B	23.01	2.23	1.44	o) bridges 12-21 only
Oxford Canal											
Braunston Junction to Hawksbury Junction	10	21.67	2.13	1.09	1.60	1.83	B	22.56	2.21	1.35	
Napton Junction to Oxford and the Thames	11	21.95	2.13	0.81*	1.83	2.11	A*	22.56	2.21	1.27	
Peak Forest Canal											
From the top of Marple locks to Whaley Bridge	40	21.34	2.16	0.84*	1.91	2.13	A*	–	–	–[x]	
Ripon Canal											* maximum draught take 0.90 (see text)
From its junction with the R. Ure to Littlethorpe lock tail	33a	17.37	4.34	0.76*	4.34	2.59	J*	18.59	4.60	1.55	

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