CHAPTER EIGHT

AMENITY FEATURES

Chapter 8:

Amenity Features

8.1 *Introduction*

8.1.1 The responsibilities of the BWB in relation to amenity features appear to arise from two sections of the Transport Act, 1968. Section 104(1)(b) provides that the Cruising Waterways are to be principally available for cruising, fishing and other recreational purposes and section 107(2)(a) provides that in dealing with Remainder Waterways that are retained their treatment ("in the most economical manner possible") is to be consistent with the requirements of public health and preservation of amenity and safety. There are no corresponding stipulations with respect to Commercial Waterways.

8.1.2 Further, BWB as a public body is charged, under Section 11 of the Countryside Act 1968, to ensure that in the exercise of its functions it shall have regard to the desirability of conserving the natural beauty and amenity of the country-side.

8.1.3 The Waterways forming, as they do, an integral part of the landscape in Britain might be thought, for this reason alone, to justify being kept in good condition. However, as standards for this aspect of amenity value are subjective and defy quantification we have restricted our consideration of the amenity features to those activities that are carried out on the canal system.

8.1.4 The amenity uses of the BWB waterways system, including the reservoirs under their control, can conveniently be divided into two categories, those that are land based and those that are water based. Each of these categories comprises activities that may be either formal that is practised through some establishment organisation or club, or informal. The activities that call for consideration in this Chapter are as follows:—

Land based recreation:	8.2	Angling
	8.3	Environmental and Naturalist Studies
	8.4	Industrial Archaeology
Water based recreation:	8.5	Sailing
	8.6	Canoeing
	8.7	Rowing
	8.8	Power Boating and Water Skiing
	8.9	Sub Aqua

8.1.5 The objects of this Chapter are to explain briefly the conditions affecting the present amenity uses of BWB's water-ways and reservoirs, to consider the extent to which they may interact, and to identify the most likely trends; bearing in mind that there is relatively little reliable information on which to base predictions and the whole field of recreational demand predictions is a young science which is itself the object of several studies. All detailed information regarding the extent of use, as observed by BWB, is shown in Chapter 5. Consideration of the interaction of the activities and their likely trends will be found under headings 8.10 and 8.11.

8.2 *Angling*

8.2.1 By far the most popular land based recreational activity on the canal system is angling. The total number of anglers counted during the BWB's one-day count on 14th July 1974 is seen from Tables 5.8 and 5.9 in Chapter 5 to be 25,126 on canals and 1,010 on the reservoirs.

8.2.2 Of some 3100 km of canal within the system riparian owners own the fishing rights on 25% and the Board lease out the fishing rights to clubs or associations over a further 50%. They reserve the balance of 25%, some of which may be polluted, for use by individual anglers who are not associated with any organisation.

8.2.3 Day and season permits can be obtained from BWB and their authorised agents for use on the waterways reserved for individual anglers, which include stretches of the following waterways:—

- a) Birmingham Canal Navigations — Rushall Canal and Daw End Branch
- b) Gloucester, Sharpness and Stroudwater Canals
- c) Monmouthshire and Brecon Canal
- d) Middlewich Branch (Shropshire Union Canal)
- e) Llangollen Branch (Shropshire Union Canal)
- f) Trent & Mersey Canal
- g) Caledonian Canal
- h) Crinan Canal
- i) Monkland Canal
- j) Forth & Clyde Canal
- k) Union Canal

8.2.4 There are 97 reservoirs owned by BWB, which cover a total area of 1340 ha, of which the fishing rights are owned on 42 only. Again BWB tend to lease the rights to clubs or associations, although there are eight reservoirs where individuals can obtain day or season tickets directly from BWB or their authorised agents. The Board cater mainly for the requirements of coarse fishermen. However several reservoirs have been stocked with rainbow and brown trout to provide for game fishing from which greater revenue can be obtained.

8.2.5 The position relating to fishing rights in some river navigations may be complex. Fishing rights normally relate to the bed of the river and do not embody any rights of access. Since the banks of rivers, ownership of which often extends along the bed to mid stream, are frequently in multi ownership, independently of the navigation rights, the provision of access for anglers can sometimes prove awkward.

8.2.6 Angling, being essentially a solitary recreation, is not club orientated in the accepted sense; however, many anglers join clubs, which themselves may be members of larger associations, in order to gain access to waters to which they would not otherwise be permitted. The London Anglers Association has some 840 affiliated clubs and more than 42,000 individual anglers. The clubs and associations also arrange matches between themselves although these form a small proportion of the total fishing done.

8.2.7 The Board's canal system is one of the main sources of water for coarse fishing in Britain. The species of fish it contains are bream, carp, chub, dace, perch, pike, and tench. These fish spawn in spring and early autumn and are protected by a closed season from 15th March to 15th June.

8.2.8 The statutory responsibility for the conservation of fisheries rests with the Regional Water Authorities although BWB are investigating the possibility of restocking some canals and fish farming on others. Access to the bank is generally along the towpath. However, as will be noted in Chapter 12, there are places where the towpath has disappeared, or is impassable, which causes much inconvenience to those who use the canals for recreation. It should also be noted however that there are some instances where damage to the fabric of the canal has been caused by the thoughtless actions of those who would most benefit from any reappraisal of the system. For example the treading down of the reeds, or the driving of stakes, at the edge of the canal can cause an increase in the rate of erosion of the bank.

8.2.9 Conflict between the boating and angling fraternities has been known to occur (not always too seriously), especially in those areas that have directly felt the impact of the recent expansion of pleasure cruising activities. The major complaint of the anglers is that the disturbance caused by the passage of craft, even though not directly affecting their lines, spoils the fishing in that locality. However, anglers are very often able to fish in waters that are too small to be of value to other activities and a limited passage of craft can be beneficial to angling as the bed of the canal is stirred up, the water aerated and the assorted organisms on which the fish feed disturbed.

8.3 *Environmental and Naturalist Studies*

8.3.1 There are several areas of BWB's system on which Nature Reserves and Sites of Special Scientific Interest (S.S.S.I.) have been established. The Board enter into agreements with the Nature Conservancy Council, set up under the Nature Conservancy Council Act 1973, in whom are vested the powers to establish Nature Reserves and to notify the local authorities of Sites of Special Scientific Interest (and to enter into agreements imposing restrictions on the exercise of rights over these sites) according to the National Parks and Access to the Countryside Act 1949, and the Countryside Act 1968. The Board receive no grant-in-aid for the establishment of these Reserves and S.S.S.I's, although no special maintenance costs are incurred because of their status. The areas of the Board's system that have been designated Nature Reserves or S.S.S.I.'s are listed in Table 8.1.

Table 8.1

Nature Reserves and Sites of Special Scientific Interest at Waterways

Site	Canal Ref. No.	Canal	County
Rye Meads	1a	Lee Navigation	Hertfordshire
Perivale Wood	2c	Grand Union (Paddington Arm)	Greater London
Horsenden Hill	2c	Grand Union (Paddington Arm)	Greater London
Syon Park	3	Grand Union	Greater London
Osterley Park	3	Grand Union	Greater London
Denham Wood	3	Grand Union	Hertfordshire
Harefield Moor	3	Grand Union	Hertfordshire
Colne Valley between Rickmansworth & Uxbridge	3	Grand Union	Hertfordshire
Jacotts Hill & Lees Wood	3	Grand Union	Hertfordshire
Tring Reservoirs	3	Grand Union	Hertfordshire
Port Meadow (Wolvercote)	11	Oxford	Oxfordshire
Somerton Meadow	11	Oxford	Oxfordshire
Pixey and Yarnton Meads	11	Oxford	Oxfordshire
Wilton Water	12	Kennet & Avon	Wiltshire
Bradford (docks) Clay Pit	12	Kennet & Avon	Wiltshire
Coed Y Person	14a	Monmouth & Brecon	Gwent
North Cannock Chase	21a	Shropshire Union	Staffordshire
	18	Staffordshire & Worcestershire	Staffordshire
	23a	Trent & Mersey	Staffordshire
Gailey Pools	18	Staffordshire & Worcestershire	Staffordshire
Brewin's Canal, Dudley	20a	BCN Dudley	West Midlands
Belvide Reservoir	21a	Shropshire Union	Staffordshire
Marston Water Meadows	21a	Shropshire Union	Staffordshire
Whixall & Fenn's Moss	21d	Llangollen	Salop
Black Blake Mere, Cole Mere	21d	Llangollen	Salop
Redwith Bridge to Maesbury Marsh	21c	Shropshire Union (Montgomery Branch)	Powys
One mile of Montgomery Branch	21c	Shropshire Union (Montgomery Branch)	Powys
Leicester to Foxton	5	Grand Union (Leicester Section)	Leicestershire
Long Clawson Brdige to Plungar Bridge	29	Grantham	Leicestershire
Old Norbridge cutting to Hague Bridge	31	Chesterfield	Derbyshire
Coombs Reservoir	40	Peak Forest	Derbyshire
Toddbrook Reservoir	40	Peak Forest	Derbyshire

8.3.2 Although these Nature Reserves provide a safe retreat for many species of animals and birds present in the British Isles, the canal system as a whole can itself provide, for the observant naturalist, an abundance of life in its natural habitat. The results of the one day count, carried out on the 13th August 1974, of the number of people walking around reservoirs and along towpaths is shown in Chapter 5 Tables 5.9 and 5.8 giving totals of 411 and 9793 respectively.

8.3.3 Many schools take advantage of the benefits offered for nature studies and there has also been a movement on some canals for local authorities to take an interest in the establishment of nature trails. A few of the more attractive towpath walks are those on the Brecon and Abergavenny Canal from Pontymoile to Brecon, and on the Ellesmere Canal from Hampton Bank to Ellesmere and from Chirk to Llantisilio.

8.3.4 Some of the many aspects of nature to be observed include insects and their larvae, butterflies and moths, amphibians and aquatic mammals (of which the latter are a source of concern to BWB because of their insistence on burrowing holes in the banks which are often the cause of leakage or even breaches), also much bird life, for example mallard and other ducks, swans, moorhens, coots, herons and kingfishers, not to mention nearly every other species of bird either migratory or resident in the British Isles. All these forms of life interrelate in a complex ecological pattern which is sensitive to disruption, e.g. pollution.

8.3.5 There is also prolific vegetation growth both in and around the canals; a botanist in mid-April and August 1972 catalogued 190 different species of plants associated with the Kennet and Avon Canal near Melksham. Although much of the vegetation on the water's edge, especially the reeds, provides protection to the banks from the wash waves it is often necessary to tame its growth and BWB have a difficult task providing only the degree of agricultural maintenance necessary to preserve a combination of the picturesque and the tolerable.

8.3.6 The reservoirs owned by BWB are of especial importance as they form, with other independent reservoirs about the country, refuges for the many wildfowl that migrate from their breeding grounds in Northern Europe and use the British Isles as a wintering area between October and March. It has been estimated that the reservoirs of Britain support some 15% of this migratory population. There are some species of wildfowl, however, for which the reservoirs are equally important during the summer months. The black tern and great crested grebe, found at the Tring reservoirs, are of particular interest to ornithologists.

8.4 *Industrial Archaeology*

8.4.1 The canal system contains structures of outstanding architectural and engineering interest some of which, like the Pontcysyllte aqueduct, are still functioning elements of the system. A study of these can serve to map out the development in the methods and approach of the great canal pioneers to the challenging tasks presented to them and the solution of engineering problems not previously encountered.

8.4.2 The canal "boom" started in the early 1760's mainly as a result of the economic forces brought about through the industrial revolution and the realisation of the need for an integrated transport system extending to the heart of the developing industrial centres. A complex infra-structure grew up around the canals as they were constructed, to provide the means of loading and unloading barges, and storage space in the warehouses. Many industries had their factories backing directly on to the canals to facilitate the transport of their finished products, and the furnishing of raw materials.

8.4.3 Some of the more interesting and best preserved examples of this infra-structure can be found at the Sheffield Basin on the Sheffield and South Yorkshire Navigation, at Sowerby Bridge Basin on the Calder and Hebble, at Shardlow on the Trent and Mersey Canal, at Stourport on the Staffordshire and Worcestershire Canal and along the Gloucester and Sharpness Canal, as well as the complex system of the Birmingham Canal Navigations which has numerous old arms leading to factory premises.

8.4.4 Quite apart from the structures of engineering, architectural, or industrial interest there are also many that have a broad historical background on or adjacent to the canals. BWB do not always own these properties, like the "Glory Hole" (a medieval arch over the Witham Navigation dated 1540) in Lincoln, although the canals may have played an important part in their history.

8.4.5 The historical aspect of the canal system outlined in the preceding paragraphs was discussed in more detail in Chapter 6 where also comprehensive lists of those structures owned by BWB that have been scheduled as Ancient Monuments, or listed as structures of architectural or historical interest, may be found.

8.5 *Sailing*

8.5.1 Apart from cruising on the canal system, for which reference should be made to Chapter 5, sailing is still the most predominant waterborne activity. Shown in Chapter 5 Table 5.9.are the results of the one day count of the number of craft using the reservoirs on 13th August 1974 – totalling 1,963. (These craft include the powered rescue boats that are present on most reservoirs used for recreation). It has been assessed that 84% of the craft counted were sailing dinghies.

8.5.2 There is no count of the number of craft other than cruisers using the reservoirs in Scotland. However, all the following lochs or reservoirs have sailing clubs attached: Hillend and Lilly Loch on the Crinan Canal, Townhead on the Forth and Clyde, as well as the Union Canal having two sailing clubs, and the Crinan Canal being extensively used, at least once a year, by the yachts involved in the Tobermory race.

8.5.3 As well as those reservoirs listed in Table 5.9, Chapter 5, sailing is also carried out on the Chesterfield Canal, Staffordshire and Worcestershire Canal, the Rivers Severn and Trent, and the Witham Navigation.

8.5.4 The governing body for sailing is the Royal Yachting Association to which most clubs are affiliated and which has more than 31,000 individual members. The British Waterways Board make agreements with individual sailing clubs and associations of clubs for the right to use the water. The form of these agreements varies considerably but they generally set out in detail the rights and duties of the particular clubs so that careful control can be maintained over the numbers involved and the way in which the activity is practised. Also the agreements are generally of short duration so as to provide flexibility should the recreational demands on the water alter. BWB allow recreational use on their reservoirs only to the extent that it does not interfere with operational efficiency.

8.5.5 The recent growth of sailing for recreation can be partially attributed to the emergence of smaller, lighter, glass fibre dinghies which make the sailing fraternity more mobile. However sailing is characterised by a very strong club movement. All clubs have a clubhouse and generally such facilities as slipways, hards, hoists, car and dinghy parks, as well as changing rooms, lockers, bars, washing accommodation and catering facilities within the clubhouse itself.

8.5.6 One of the best known sailing centres is that at the Welsh Harp (Brent) reservoir managed by the Welsh Harp Sailing Association, comprising many individual sailing clubs. There are approximately 250 sailing dinghies present here on 58ha of water. Reservoirs are not the only areas of water used for sailing; there are many thriving centres on some of the broader river navigations, notably the Trent.

8.6 *Canoeing*

8.6.1 Canoeing has been practised in Britain for over one hundred years. The governing body for canoeing is the British Canoe Union which was founded in 1934 and in 1971 had 370 affiliated clubs and over 5,230 individual members.

8.6.2 As happened with sailing the introduction of new materials, enabling the construction of light-weight, easy-to-transport craft, has made the canoeing fraternity extremely mobile. Unlike sailing, however, they are not characterised by any strong club movement. In fact quite the reverse, canoeing being a very individual activity.

8.6.3 The canal system provides a safe and interesting water area on which all the very necessary techniques associated with canoeing may be taught so that devotees may competently graduate to more demanding water areas if they so wish. Many schools and youth clubs, as well as independent canoeing clubs, use the canal system in this manner. There are three canoeing clubs on the Forth & Clyde in Scotland and also clubs on the Kennet and Avon Canal and the Witham Navigation.

8.7 *Rowing*

8.7.1 The Amateur Rowing Association was founded in 1882. In 1969 there were 460 clubs affiliated to it. Club rowing tends to require, like sailing, extensive land based facilities so that work may be carried out on the boats, invariably club owned, and storage space provided. The clubhouse also contains provision for washing, and changing, and catering facilities.

8.7.2 Most of the canals on the Board's system are too narrow for club rowing to be carried out. Many reservoirs however are suitable so long as they are not too exposed, and also some of the broader canals and river navigations, for example the Gloucester and Sharpness Canal and the River Trent. There are also three rowing clubs on the Union Canal in Scotland and on the River Severn Navigation.

8.7.3 Much casual boating and rowing in small dinghies, often rubber inflatables, is carried out on the canal system; both on broad and narrow canals. The number of these casual craft, like the numbers of club rowing boats present on the waterways on 13th August 1974, is included in the figures of craft present on the waterways in Table 5.7 of Chapter 5.

8.8 *Power Boats and Water Skiing*

8.8.1 Power boating and water skiing are two other recreational activities that have recently become popular. Due to the increased risk of pollution associated with these activities, and their need for the exclusive use of large water areas, devotees often have difficulty obtaining access to suitable water. Stretches of the River Trent are used under the supervision of the Trent Power Boat and Ski Club, Aqua Bat Ski Club, and the Wharf Ski Club. Also the Black Loch, on the Monkland Canal in Scotland, is used in this way.

8.9 *Sub Aqua*

8.9.1 Many people have become interested, for either career or recreational purposes, in acquiring unusual skills such as those that are required for aqua-lung diving. As a result the British Sub-Aqua Club has experienced a marked increase in its number of affiliated participants.

8.9.2 Most enthusiasts find that the sea-bed topography of coastal waters is more appealing to their taste than anything that can be offered within the Board's system. Naturally the canal system itself, being generally not deeper than 2-3m, does not offer much scope for aqua-lung diving. However the many reservoirs under the Board's control offer ideal waters for the essential training of young divers, and use is being made of the Redbrook reservoir on the Huddersfield Narrow Canal in this respect. It is generally through specific diving clubs that this training is carried out, although youth organisations are now showing more interest in this activity.

8.10 *Interaction*

8.10.1 It is apparent that the many recreational activities possible on the waterways under the Board's control cannot be carried out simultaneously, on the same water area, without considerable conflict being generated.

8.10.2 It is also apparent that it is the following factors that influence the recreational capacity of any particular water area:

- (i) The question of access and rights over the use of water
- (ii) The compatibility of the activities
- (iii) The non-recreational use of water
- (iv) The physical deterioration of the waterway structure from recreational use.

8.10.3 The question of access to the water and the compatibility of various recreations are very often closely linked. For example, should a sailing club have arrangements with the Board it is likely that much resistance would be offered to any movement to get the use of the water extended for, say, water ski or sub aqua use.

8.10.4 The Board deal with this demand for exclusive possession of the water by providing in general only short term agreements, so that account can be taken of any shift in the recreational demands of a particular area. One result of the short term agreement is, however, the reduction in financial viability of a club. This is because there is not time enough to recoup the financial investment in club-houses and associated facilities from the club members except by subscription fees that are prohibitively high. One way of overcoming this problem is for the Board to pay for the clubhouse facilities and rent them to whatever club, or clubs, they decide most fully cater for the recreational demand at that time.

8.10.5 Compatibility of activities has many facets. Any form of recreational activity, as well as the necessary dictates of the Board's own operational requirements (e.g. draw-down of reservoirs) is bound to have a disturbing effect on the wildlife. although in many cases this disturbance is natural. Many of the previously mentioned activities conflict with each other, for example cruising with angling, and sailing with power boating and water skiing. Also pollution, both industrial and domestic (e.g. from the tipping of the contents of chemical toilets in the canals) has the effect of both detracting from the visual appeal of the locality and causing the loss of life of plants and aquatic animals which alters the finely balanced ecology.

8.10.6 The Board's officers are empowered to enforce the general canal bye-laws (clause No: 40 of which deals with the deposition of rubbish in the canals) although as there are over 3000 km of canal they are obviously not able to police every stretch effectively.

8.10.7 Much water is picked up by the canal system from land drains and it is this source that has provided evidence of nitrate pollution from the dissolving, in the surface water, of excess fertilizer that has been placed on the adjacent land. Responsibility for the prevention of pollution of rivers and water courses generally lies with the Regional Water Authority and the Board is called upon to co-operate in this task as necessary in relation to all these different modes of pollution.

8.11 *Trends*

8.11.1 Shown below, in Tables, 8.2, 8.3 and 8.4 are the results of one-day counts, carried out during each of the years 1967 to 1974, of the number of people occupied in boating (synonymous with cruising on the waterways), angling, or walking by the waterways and reservoirs under the Board's control in England, Wales and Scotland.

Table 8.2

Summary of count of users on the Waterways of England and Wales

Activity	1967	1968	1969	1970	1971	1972	1973	1974
Pleasure Boating	10929	11573	12321	14724	16119	17398	19018	20821
Angling	22093	23724	23867	32995	28781	27823	25274	24870
Towpath Using	–	–	–	9042	13867	9143	10992	9206

Table 8.3

Summary of count of users on the Waterways of Scotland

Activity	1967	1968	1969	1970	1971	1972	1973	1974
Pleasure Boating	–	–	–	–	300	310	320	379
Angling	–	–	–	–	227	198	182	256
Towpath Using	–	–	–	–	749	580	598	587

Note: Scotland was not included in the count until 1971

Table 8.4

Summary of count of users on the reservoirs of England and Wales

Activity	1967	1968	1969	1970	1971	1972	1973	1974
Boating (Sailing etc.)	1974	1732	1865	1824	1928	1892	2098	1963
Angling	1391	1501	1235	1254	1108	952	926	1010
Other users	–	–	–	182	649	510	642	411

8.11.2 The pleasure cruising figures shown in Tables 8.2 and 8.3 were given in detail in Chapter 5 and further consideration will not be given to them here. The count of the number of towpath walkers was not included until 1970. Some of these walkers may be anglers going to, or from their "Swim". Also no figures are available for the reservoirs of Scotland as these have never been included in the count.

8.11.3 When considering the above figures it should be realised that they represent only the number of people present on a particular day, with no account taken of the frequency of their visits. These figures are also subject to the influence of such factors as the weather (it was a rainy day in 1972) and whether or not an angling match or regatta had been organised on that day. They cannot therefore be used as they stand to interpret the demand for any activity. Even if these figures truly represented the demand, an extrapolation of them would not necessarily represent the demand in five years time because there may be a considerable "hidden" demand for an activity for which the provision of new facilities may provide an outlet.

8.11.4 The possible growth of participation in an activity on the waterways managed by the British Waterways Board cannot be looked at in isolation, as it will be a function of the growth of the particular activity countrywide.

8.11.5 As has been apparent from the figures given in Chapter 5 for cruising on the Board's canals, the last five years have witnessed a marked growth in the number of people using the canals for leisure. This is in part a manifestation of a more general increase in both the amount of leisure time of the general public and their increased affluence and mobility with which to take advantage of it. Information available at present suggests that the other activities, i.e., angling, sailing, canoeing, aqua-lung diving, rowing and water skiing are all experiencing periods of growth, with those of sailing, canoeing, and aqua-lung diving being the most marked.

8.11.6 Although it is not possible to predict exact figures for the future demand, because of the inability to assess the hidden demand, there is no indication at present that interest in the above activities is going to do anything other than increase.

8.11.7 Should this increase occur then BWB may have to consider methods of managing their recreational facilities, especially those at reservoirs, according to time sharing or zoning arrangements, either formally through their agreements or informally through voluntary inter-club co-operation.

8.11.8 Although there is plenty of capacity for amenity uses over the Board's entire system it must be remembered that the demand on the resources is not evenly spread. There tend to be specific areas that are more popular, either because of their own intrinsic attractiveness or because of their proximity to centres of population, or the confluence of several distinct canal routes. It is such areas that tend to limit the capacity of the system, especially during weekends in the summer months, and it becomes apparent that for greater use to be made of the system consideration would need to be given to planning utilisation of facilities in more detail. This is of course a function of the Amenities Division.

8.11.9 Finally it is worth noting that an increase in the number of people involved in active recreational activities can have the effect, for many of them, of reducing the amenity value of the canal system as a whole as it may cease to be a quiet restful haven from the hustle and bustle of urban life.

CHAPTER NINE

WATER SUPPLIES

Chapter 9:

Water Supplies

9.1 *Requirements*

9.1.1 It may be self-evident that waterways depend upon water and that they demand the assured provision of considerable quantities at all times. It may also be understood that while a river navigation or a canalised river can, to a very large extent, depend upon the water naturally flowing in the river, it is quite another matter to find enough water to maintain adequate supplies to a wholly artificial canal making its way over a high watershed. Waterways of all kinds require supplies of water for maintaining navigable depths in the channels and for bringing vessels through locks, but there are demands of other kinds which this chapter will describe and also indicate what is involved in meeting them.

9.1.2 *Lock Operations*

9.1.2.1 The Lock commonly found on all types of inland waterway is used for raising and lowering craft from one level to another by alternately filling the lock chamber from the upper level and emptying it into the lower level. For this purpose the lock gates and sluices are operated in sequence. (In some cases the gates themselves may be designed to act also as sluices but this does not affect the amount of water needed to operate the lock). In a complete cycle of filling and emptying the chamber a definite volume of water is clearly drawn from the upper and discharged into the lower level During the cycle craft may have passed through the lock in either or both directions, so that, depending on the state of preparedness of the lock, up to one "lock" of water may be used at each passage. If a train of boats is travelling in one direction each boat will use one lock of water; if boats in opposite directions alternate they will each require, on average, only half a lock.

9.1.2.2 A lock of water is not a fixed quantity. For a narrow lock taking the traditional 22m x 2.15m canal boat it will vary between about 0.09 and 0.15 Ml depending on the "rise"; it is usual to take a figure of 0.115 Ml as an average. For a wide canal taking 4.3m beam boats of the same length the volume would be rather more than double (because of the greater clearance required for the swing of the wider lower gates) and a figure of 0.25 Ml would be a fair average. The larger locks found on river navigations and ship canals would take much larger quantities; about 1.0 Ml at Gloucester and 9.0 Ml at Sharpness locks of the Gloucester and Sharpness Canal.

9.1.2.3 When a boat enters a lock chamber, it displaces water to the extent of its own immersed volume; when going uphill the amount of water taken from the higher level will be more, and when going downhill will be less, than a standard lock by this amount. Elaborate calculations are sometimes made on this theme but they are quite unnecessary as what matters is not the actual volume of water contained in either pound but the maintenance of the water levels. Unless therefore, there is any change of buoyancy due to loading or unloading of the craft the actual displacement is immaterial. In the case of craft passing over a summit, the theoretical effects of displacement would in any event cancel out at the two ends.

9.1.2.4 Occasionally locks are constructed in "staircase" formation and whenever there is a reversal of traffic direction the volume of water taken from the upper level is equal to the total volume of all the chambers. If all the traffic moves in one direction then the consumption is only one lock for each boat, but this is the minimum and the arrangement is inherently more extravagant than a series of single locks separated by pounds. The consumption of water in staircase locks can be reduced by the use of side ponds; by such means it is possible to avoid using much more than one lock of water for each boat passage, irrespective of random reversals of direction.

9.1.2.5 Side ponds can also be used to reduce the amount of water required in the operation of a single lock, in practice a 50% saving can be achieved by the careful operation of three ponds at each lock. A somewhat less effective economy is obtainable where locks occur in pairs, side by side; an interconnecting sluice then enables one lock to be used as a side pond for the other, traffic movements permitting.

9.1.2.6 Very large locks which may be used by craft of various sizes are sometimes equipped with intermediate gates so as to divide the chamber into two compartments, usually of unequal length. Judicious use of the shorter, longer or full length chamber will then enable a saving of water consumption to be made according to traffic conditions.

9.1.3 *Other Lifting Devices*

9.1.3.1 As all locks involve the consumption of water other lifting devices have occasionally been employed which obviate this demand. The only device of this kind now extant on the BWB system is the Anderton lift, described in Chapter 6, by which craft up to about 22m x 4.4m are raised or lowered 15.25m vertically between the Trent and Mersey Canal and the Weaver Navigation. Practically no water is taken from the Canal for its operation, but as the twin tanks now work independently by electric power the effect of counterbalancing, which formerly provided economy of effort, has to be given by a system of counterweights through ropes and pulleys. Saving of water is thus obtained at the expense of greater mechanical complexity and maintenance effort.

9.1.3.2 Other forms of lifting device have been proposed as replacements of lock flights where there is insufficient water for their operation. In general they make no demands on the water supply system, but in the recent French invention of the "water slope" the craft is kept afloat on a wedge of water which is carried up and down an inclined trough by the propelling/retracting action of a watertight diaphragm. The prime mover is a tractor travelling on the trough sides and suitable means are provided for opening a gate at the top of the trough and withdrawing the diaphragm at the bottom to allow onward passage of the craft. Although, assuming a satisfactory degree of water tightness, the consumption of water would be negligible the device carries the handicap of wasteful power consumption in the repeated raising of a large wedge of water, the potential energy of which could not easily be recovered.

9.1.4 *Evaporation and Leakage*

9.1.4.1 The requirements of lock operation are by no means the only, or indeed the major, element of demand upon water supplies. In total the largely invisible effects of evaporation, transpiration, seepage, percolation and leakage are often much greater than the quantities seen to be used at locks. Some kinds of leakage and percolation can be minimised by carrying out suitable protective works. Leakage through lock gates is at least readily detectable and can be checked almost completely by a proper degree of attention to routine maintenance and a normal programme of gate renewals.

9.1.4.2 The distinction between leakage on the one hand and percolation and seepage on the other hand is that the former takes place through definite channels whereas the others are a general diffusion of water through the bed and banks of the waterway. The banks of a waterway should always be water-tight and traditionally this was ensured by the construction where necessary of puddled clay barriers ("boxes" or "gutters") on one or both sides. Seepage can be almost entirely stopped by this means but in its absence other types of barrier (e.g. sheet piling) may be required if the loss of water reaches significant proportions. Relatively few waterways require the provision of artificial water-proofing of the bed, but if percolation develops, for example through porous sub-strata, the loss of water could become intolerable and could also be dangerous in leading to a blow out or a major breach.

9.1.4.3 Serious losses of water, whether on account of percolation or through leakage, can usually be detected and measured by observing the fall in water level in a suspected section after isolating it at locks or by temporary dams. On the reasonable assumption that losses so detected would be checked by carrying out remedial works, it should not be necessary to make allowances for them in assessing normal water demands. If the natural water table in the adjacent ground is fairly high, as would be the case generally with river navigations and canalised river, the loss of water from this cause will not be significant, but with artificial canals it may be quite an appreciable portion of the total demand and is likely to continue unabated unless bank protection work is put in hand over the affected length.

9.1.4.4 Evaporation takes place from all free water surfaces, increasing with the atmospheric temperature but decreasing with its humidity. In a hot dry summer it will be a maximum whereas in cold wet weather it may even be negative, the direct precipitation in some periods being more than is lost by surface evaporation. In many places waterways receive rainfall running off the surface of adjacent land areas, so that during wet periods there could be a net gain over all losses, even to the extent of requiring provision to be made for the quick disposal of surplus water. Such a surplus is not normally recoverable (i.e. unless reservoir capacity is available for temporary storage) and as the storage capacity of the waterway itself is small no credit allowance can effectively be made. Transpiration refers to water absorbed by vegetation and subsequently lost to the atmosphere. So long as there is no undue growth in the water margins the consequent loss is not great and can be reckoned as part of general evaporation losses. Where traffic does not keep weed growth in check, as in unnavigable feeders, serious loss of water may occur when the weeds are not cleared.

9.1.4.5 Various estimates have been made of the loss by evaporation to be expected from waterways in this country. For reasons already given it can vary very widely; another factor is that in hot weather the water in narrow shallow canals will warm up more than in the larger river navigations and thus result in proportionately greater losses in regions where natural water supplies are sparse. Over a full normal year total evaporation to a depth of about 0.45 – 0.60m can be expected, as deduced from experiments in the field, but the maximum rate may well reach 25mm per week for a typical upland length of narrow artificial canal.

9.1.4.6 Although this may seem to be a considerable figure it is small in comparison with the amounts of loss to be expected by leakage, seepage and percolation. Many measurements of total loss (i.e. including evaporation) on lengths of waterway in this country and abroad have been made at different times and the BWB have in recent years carried out a close examination of losses on their northern waterways. The results indicate that in the winter half of the year an average net daily loss of between 8mm and 25mm may be experienced; in the summer half it may increase to between 12mm and 50mm. (By net loss is meant the actual loss, as offset by rain falling on the canal surface and by any general run off directly into the canal from adjacent lands, after taking account of the inflow from all gauged feeders).

9.1.5 *Abstractions, Water Sales*

9.1.5.1 After meeting requirements under statute for compensation water or supplies of a similar character it has always been the practice of the Board and their predecessors to allow neighbouring undertakings to abstract surplus water for their own use by agreement. Such arrangements provide a substantial source of income to the Board and are not prejudicial to their own needs.

9.1.5.2 Typical purposes of these supplies range from cooling water for medium sized power stations of the CEGB down to industrial supplies for various factories' and works' purposes and to small individual users such as farmers for agricultural operations. The larger users in most cases return the water, less any evaporation losses and at perhaps a slightly higher temperature, although not necessarily near the point at which the supply is taken. The smaller users may consume the whole of their intake.

9.1.5.3 Particulars of abstractions and water sales from the various waterways are given in Chapter 5. The very numerous small supplies (i.e. individually up to about 500Mlpa) do not in total make up a very significant part of the system demand. The large users including a total of 15 electric power stations, rely heavily on continuous availability of the water and, despite the lack of a positive obligation in the agreement to maintain supplies at all times, would be seriously embarrassed if they were to be interrupted.

9.1.6 *Total Demand*

9.1.6.1 It will be apparent that the assessment of water requirements for a waterway is not a simple process. Part of the demand will depend on lock operations for traffic and will vary with changes in traffic patterns. Other parts will be less controllable; on the assumption that leakage and similar losses are kept in check by appropriate maintenance measures they will still be liable to variation according to weather conditions. In any event the character of demand of a typical upland narrow artificial canal will be entirely different from that of a wide canalised river subject to mill rights and used for supplying industrial needs on a major scale.

9.1.6.2 There is little point therefore, in quoting figures at this point; they will be meaningful only in relation to the resources from which the particular requirements can be met. At many points on the system water is transferred from one waterway to another, so that what is a demand in one case becomes a source in the other. The demands which are most difficult to meet are those arising on the upland canals; this is, of course, because resources there are naturally more limited.

9.1.6.3 The Board are not, so far as we can ascertain, under any legal compulsion to meet these various demands at all times, although a serious and persistent failure to do so might be a cause for an application to the High Court under Section 106 (1) of the Transport Act 1968. It would appear, however, that in all circumstances every endeavour is made by the Board to meet demands from the resources available to them.

9.2 *Resources*

9.2.1 For reasons already outlined a review of the various sources of water supply is more necessary in connection with artificial canals than with river navigations. Canalised rivers usually depend directly on the flow in natural streams which are led into and out of the canal at suitable intervals. Wholly artificial canals may derive their supplies directly or indirectly from overground sources such as springs, streams, and general land drainage or from underground sources such as wells, boreholes and mine workings.

9.2.2 The way in which a particular canal obtains its water supply depends to a large extent on local geological conditions, which also influence the pattern of run off in relation to fluctuations of rainfall. In view of the seasonal nature of the demands and the frequent variations in rainfall the provision of reservoirs is usually necessary in order to conserve the yield of the catchment areas.

9.2.3 Ideally a reservoir should be of such a size and design as to balance out these variable factors, so that the needs of the waterways and other users can be met at all times, even over a long period of drought. In general water engineering practice a series of three consecutive dry years, with an aggregate of 75% of the long term average rainfall, is regarded as a measure of the worst conditions likely to be encountered. Modern design rules (e.g. Lapworth) enable reservoir sizes and reliable yields from particular catchments to be estimated and it is clear that some of the Board's reservoirs are not large enough to take full advantage of the catchment yield.

9.2.4 Furthermore, experience has shown that in some areas the available reservoir capacity is insufficient to tide over a shorter drought period, for example a dry winter intervening between two dry summers. The consequences are examined in more detail in section 9.6 below. Other considerations affecting reservoirs are mentioned in section 9.7.

9.2.5 Many of the BWB waterways obtain or supplement their supplies by pumping from wells, boreholes, mine-workings and the like. There are a few cases where boreholes have been taken to considerable depths, but unless artesian conditions are favourable the cost of pumping is likely to be very heavy. In the south of England artesian bores into the greensand have been found to yield only small supplies and, unless provided with efficient screens, are liable to choking.

9.2.6 In the particular case of the Tring Summit of the Grand Union Canal water is obtained from springs supplemented by the yield of wells and headings in the chalk of the Chiltern escarpment. It would appear that over the years the water table has tended to fall, no doubt as a result of other abstractions, although we can find no evidence that the rainfall/yield correlation has deteriorated in the last 30 years. It might be possible, with the approval of the Thames Water Authority, to improve the yield of these underground supplies by the installation of pumps or an extension of the collecting passages into the chalk.

9.2.7 Pumping from mine shafts enables large quantities of water to be drawn from worked-out coal mines and where the water level is not too far below canal level this is a reasonably economic way of utilising what is virtually a thoroughly dependable supply. With deep pumping the cost naturally rises, and it would not be satisfactory to base pumping policy on this method. Certainly it would be inadvisable for the BWB to take over old coal workings for the sake of their water potential but at the risk of becoming liable for all maintenance costs and for an unknown contingent liability in the event of disturbance of established water levels causing subsidence in some remote part of the workings.

9.2.8 Another source of water which it has been possible to exploit more fully in recent years derives from the effluent of sewage treatment works. Care must be taken to see that any risk of pollution is avoided, by careful attention to maintaining the purification processes. Surface water from newly developing housing estates is also a possible acquisition in some cases, but this is of little benefit unless it can be discharged into a reservoir – otherwise the supply is likely to come mainly when existing sources are yielding plentifully. Even with reservoir storage the inflow characteristics will be altered by reason of the more efficient collection and run off, which may necessitate a lowering of the relief weir level and consequent loss of storage capacity.

9.2.9 Reservoirs not having a natural catchment may be used for storing surplus water drawn off from strategic pounds with a view either to returning it at times when supplies are low or to smoothing out inequalities of demand in lock flights or pounds at a lower level. Variations also occur in which reception of surplus water is supplemented by flows from natural catchments, and/or pumps may be installed to return the stored water to the parent pound when necessary.

9.3 *Constraints on Use of Water*

9.3.1 Under their respective Acts of Parliament most waterways constructed in the 18th and 19th centuries were empowered to take for their general use any water to be found within a specified distance from the line of waterway. There might be certain safeguards for influential landowners and similar vested interests, and compensation would be payable to parties showing that they would be or had been affected adversely. The general result was that these early canals were comparatively free, within the limits of their own financial resources, to make whatever provision they considered appropriate in respect of meeting their water supply requirements.

9.3.2 Beginning with the Water Act, 1945, however, Parliament has imposed successive statutory controls on the abstraction of water, overriding the earlier legislation and culminating in the Water Act 1973, under which Regional

Water Authorities with wide powers were set up. The overall effect of controls imposed in the last 30 years is that while BWB are in most respects free to utilise resources hitherto available to them they can no longer exercise their general powers, under the various enabling Acts, to extend existing abstractions or to establish new ones.

9.3.3 Without going into detail, the present position is broadly that all abstractions of water in England, whether from overground or from underground sources, require to be licensed by the appropriate Regional Water Authority under the Water Resources Act 1963. Records must be kept, meters, weirs or other gauging devices being maintained for the purpose as necessary, and comprehensive returns must be made to the Regional Water Authority concerned. Abstractions of water by, and the sale of water to, other persons and undertakings by the Board, are subject to the special provisions of Section 131 of the 1963 Act.

9.3.4 The effect of these constraints is that the BWB, whatever their original enabling Acts might allow, cannot now do any of the following things without the approval of the appropriate Regional Water Authority:–

- Construct a new reservoir.
- Enlarge an existing reservoir.
- Bring new feeders into an existing reservoir.
- Make new abstractions from a river or stream by gravity or by pumping.
- Construct headings or adits in water-bearing strata for new gravity supplies.
- Construct boreholes for new pumped supplies.
- Increase the yield of existing headings, adits, boreholes, etc., either by works or by extending the periods of pumping (i.e. beyond licensed limits).
- Reduce, or alter conditions of supply of, compensation water.
- Transfer supplies of abstracted water from one Region to another.

9.3.5 It does appear, however, that the Board would be able to construct, enlarge or alter the use of reservoirs serving only for the reception of waters surplus to immediate requirements in the waterways. They would also be entitled to recirculate any water contained within the system, for example by pumping back from a lower to an upper pound water brought down by the operation of locks. (This is referred to later in this Report as back lockage pumping). In addition, there would always be the possibility of the Board's entering into arrangements with Local Authorities and others for the use of surface water and sewage effluents, as a matter of mutual benefit, subject to the approval of the RWA.

9.4 *Utilisation*

9.4.1 In seeking to match water requirements with resources there are certain preliminary considerations:–

(a) Evaporation and losses through seepage, percolation and leakage are to some extent inevitable and are virtually independent of the number, size and arrangement of any locks in the waterway. (This assumes, of course, that all detectable leaks, whether through lock gates or elsewhere, are stopped and that seepage and percolation losses are kept to a minimum).

(b) Supplies of water to make good such losses will be needed in all parts of the system, whatever their elevation, subject to the qualification that losses tend to be proportionately less in the lower parts of river valleys.

(c) For the operation of locks supplies need be given only at summits, as water used at the top lock of a flight may be used in turn at each of the lower locks. This assumes that all the locks are of equal capacity (of the same "rise") and that all traffic navigates the full flight of locks. If these assumptions are incorrect then additional supplies will need to be fed in below, or run down from the summit.

(d) As water is less readily obtained at the higher levels it is good policy to use the summit supplies primarily for lockage requirements and for losses on the waterway generally to be met from other supplies, which would be brought in at lower levels as soon as practicable.

(e) Where a considerable volume of reservoir storage is available it is prudent to keep a good reserve of water in hand against the onset of a dry period, even at the expense of using pumping plant to draw on other sources of supply for more immediate needs. Pumps would not be used for this purpose if the reservoirs were full or running to waste.

9.4.2 Application of these principles is in general the accepted practice of the Board's engineers. It is not practicable in a report of this kind to describe all the different ways in which resources are used to meet requirements but Table 9.1 summarises the arrangements found on the principal summits of the system.

9.4.3 Other steps can be taken in certain circumstances to optimise the utilisation of resources. For example, the summit pounds of canals were sometimes built to hold a greater depth of water than normal, with the purpose of providing a margin of storage that could be drawn down in dry weather. In a typical short summit on a narrow canal the marginal capacity would be small; so that while assistance could be given for a short period, say in smoothing out supply and demand over the peak of a holiday season, it could not add materially to essential basic resources. While we do not consider that the cost of making new provision of this kind at the present day would be justifiable it would be right, where such capacity was previously available, to maintain bank levels and undertake dredging so as to ensure that benefit is not lost in time of need.

9.4.4 Another possibility is to take advantage of the changes that modern conditions have made in respect of compensation water. Obligations imposed for the protection of millowners and others when canals were built nearly 200 years ago may no longer be meaningful and, with the approval of the Regional Water Authority, it may be beneficial to all concerned to make fresh arrangements for the use of water not previously available.

9.4.5 A case in point concerns the water of the river Colne used in the Grand Union Canal between Watford and Uxbridge. Under the enabling Acts not only was it necessary to return to the river below Uxbridge all water that had not been supplied by the canal from Tring summit, but additional water had to be run to the river in compensation for losses incurred by the canal in operation. A reservoir was built at Aldenham to provide the compensation water and later the Brent reservoir was built to supply the needs of the long level below Cowley lock. At the present time it has been possible to use Aldenham reservoir for public water supply purposes and Brent reservoir serves partly as a flood regulator in the Brent valley. Water may now be taken into the long level through Cowley lock to make up for any consequent deficiency of the Brent supply. The whole arrangement appears to be a very satisfactory way of utilising total resources for mutual benefit, and indicates the value of cooperation between the Board and a Regional Water Authority in such a situation.

9.4.6 It will be evident that there is a great variety of resources within the BWB system and that no simple guide lines for their utilisation can be laid down. Each summit has its own kind of resources and pattern of demands, the possible ways in which they can be matched are necessarily matters of judgement based equally on a proper appreciation of hydrological principles and on considerable experience of the area's peculiarities. Both factors are needed in deciding, for example, how far reservoirs may safely be drawn down in the Spring, or when it will become expedient to start pumping from boreholes having regard to cost of electricity and the effect of maximum demand tariffs.

9.4.7 What is vitally important in all cases is that accurate gaugings should be made of reservoir contents, feeder flows, pump outputs, etc., and that full records should be kept in relation to rainfall, traffic use and known abstractions. Only by constant monitoring is it possible to compare situations one year with another and to form a proper judgement as to how resources should be utilised from week to week. This is generally being done by the BWB and we endorse their aim to extend it as soon as possible to all relevant parts of the system.

9.4.8 A considerable amount of work has been done by the Board's water engineers in constructing a mathematical model of the water resources and requirements for the Stoke summit of the Trent and Mersey Canal. This was developed (in cooperation with a specialised research team from the National Coal Board) in the first place for the Caldon Canal with its reservoirs, but was later extended to take into account the effect of the Macclesfield Canal also. It is expected that with its aid the engineers concerned will be able to make more efficient use of the various sources of supply without the need to rely solely on personal judgement.

9.4.9 Until the consequences of using this means of guidance have been proved by experience over several years it is not possible to say how useful a tool it will be. It does appear, however, to offer the possibility of taking into account not only physical parameters such as rainfall, reservoir storage, traffic demands, etc., but also — if required — the costs of labour, electricity, and other incidental items. If satisfactory results emerge it is intended to adapt the model for use on other summits and we are sure that this is a proper objective. At the lowest it would ensure that the fullest possible exploitation of existing resources is made before it becomes necessary to consider the question of seeking to enlarge them or to provide additional resources.

9.4.10 We have paid particular attention to the water supply problems of the BWB system as we are convinced that the effective use of existing resources is a most important aspect of the Board's operational function. We comment further in Section 9.8 on the organisation of special expertise within the Chief Engineer's department in this connection and would say here only that it is clearly right to give the Area Engineers responsibility for day to day control as well as for minimising losses due to leakage, etc. In this they have, of course, the assistance and advice of the specialist water engineers as required.

9.5 *Conservation*

9.5.1 Whether personal judgement or mathematical models are relied upon to determine how available resources may most effectively be used to meet demands it is important, in the interests of economy, that the demands are as far as possible kept to a minimum. It is obviously better that there may be a surplus of water on occasion than that reserves (which could be invaluable in time of need) should have to be drawn on to make good losses that might easily have been checked.

9.5.2 Tracing and stopping all leaks through the bed and banks is very important as they result in continuous loss, independent of traffic movements, and all the water so lost is lost completely from the system. Leakage through lock gates, although spectacular, is not so damaging if the water would in any event have to be passed down the locks as a supply for the lower pounds.

9.5.3 Less easily remedied, because less easily detected, is the loss to the system due to general percolation and seepage. Where there is reason to believe that such loss is a major item in a particular length of waterway consideration should be given to minimising it by carrying out remedial works. According to site conditions these may comprise making good or renewing clay puddle gutters, or driving sheet piling as a cut off.

9.5.4 Further saving of water can be secured by careful attention to the operation of lock gates and sluices. While experienced users will give due heed to this it is very easy for severe losses to arise from the ignorance or carelessness of amateurs and novices. Where side ponds are provided they will be effective only if they are worked properly, which takes time and trouble. In practice it is doubtful if the retention of side ponds is justifiable unless a measure of supervisory control can be given.

9.5.5 If, however, the need for conservation of water should become so pressing that consideration is given to control of lock operations then there are further possibilities:—

(a) limitations may be placed on the hours during which locks are open. By itself this may not reduce the number of operations required but it could ensure that all operations are carried out within normal working hours and are therefore subject to supervision.

(b) Enforcing a system of "waiting turns", in which craft arriving at a lock may not proceed unless it is already at the appropriate level, or until a boat from the opposite direction has worked through and so brought it to that level.

9.5.6 These measures necessarily impose restraints on users, who may in some circumstances incur appreciable delays as a result. They are not new to waterway operation, however, and if the water supply position makes them necessary there is ample precedent for making suitable arrangements at key points. The additional labour costs involved will be enhanced if, as is sure to be the case with cruising traffic, week end working is necessary. A decision as to the number of staff required, and the hours to be worked, will depend on the number of locks to be controlled. Costs might be kept down if it were found possible to employ part time supervisors, perhaps for the week end duties.

9.5.7 With the development of cruising activities a relatively new factor affecting water conservation has emerged. Although the effects differ in some respects, the siting of both marinas – largely for private owners' craft – and centres for hire-out cruisers must be looked at carefully in relation to the proximity of lock flights. It has been found, for example, that many craft do not make regular trips exceeding perhaps six or eight km from their home moorings, and that if locks are first met at a greater distance there is a pronounced tendency not to pass through them, but to return. (This does not, of course, apply to craft users intent on making a cruise of any length, but it does cover a surprisingly large proportion of the total boat population). This means that, from a water conservation point of view, craft centres should preferably be located several kilometres from flights of locks. If they are too near then users will be practically compelled to use lockage water, both out and home, when wishing to travel in one direction at least.

9.5.8 Conservation of water supplies might also be assisted if codes of practice were drawn up in respect of craft construction and lock operation. The main purpose of the first would be to encourage boats not to exceed such lengths, according to class, as would permit three or two craft to enter a typical narrow lock at a time, thus tending to economy in lockage water in dry seasons. (A Construction Code of Practice could, of course, have other purposes, such as encouraging the best hull shapes for reduction of wave formation and wash). The Operation Code of Practice would make clear what constitutes good practice in passing craft through locks, and in cooperating with other users in so doing. Any question of enforcing the observation of such codes would need to be considered in the light of existing bye-laws or the feasibility of framing new ones, but it would seem that with a combination of licensing conditions and adequate supervision no difficulty need be feared in practice.

9.6 *Drought Conditions*

9.6.1 Prolonged periods of dry weather produce the following effects on the waterways system:–

(a) The main impact is felt in the upland areas, where lack of rainfall quickly reduces the run off from impermeable formations to practically nothing and the water table in permeable strata drops progressively so that springs and streams dry up. The falling water table also results in a reduction in the yield of wells and boreholes; any extension of pumping periods with the object of maintaining supplies will tend to hasten the rate at which the pumping level drops. Similarly the reduced inflow to reservoirs ceases to match the demand and the storage becomes depleted at an ever increasing rate.

(b) This progressive falling away of resources usually coincides with a rise in demand. Losses from percolation and leakage tend to increase as the natural water table drops and the gorund dries out; evaporation also will be significant if the weather is hot. Lack of direct inflow to the waterway from rainfall on the surface and immediate catchment, combined with the increased losses, gives rise to a constantly increasing demand upon the indirect supplies. The cumulative effect is to make the supply and demand balance very sensitive to deficiencies of rainfall and although the first and most pronounced effects are felt in the upland areas, a prolongation of drought conditions will progressively affect the availability of supplies in the lower levels also.

(c) The sequence of events outlined above is experienced to a smaller degree in most years as a normal seasonal occurrence. The Board's engineers are usually able to arrange the utilisation of their resources so that, for example, by March/April in a normal year the reservoirs are up to weir level, so providing the maximum possible storage for use in the summer and autumn. It is when this standard of reserves cannot be achieved that consideration must be given to the ability of the system to deal with deficiences of supply over a longer period than one year.

9.6.2 Engineering practice for public water supply seeks to make provision for a continuance of demand over a drought of such severity as is likely to occur only once in say fifty years, either as a single year of extreme drought or a sequence of two or three years less severe individually but cumulatively of equivalent effect. It can be said at once that the BWB system is not geared up to meet anything like a one year in fifty standard; many sections are embarrassed by shortage of supplies arising from such a not unknown sequence as that of two successive dry summers with an intervening dry winter. On the other hand the obligations of the Board to meet demands at all times cannot be said to equal those of a public supply authority. As neither forecasts of future conditions nor precise calculations of supply and demand are feasible we consider that only empirical guide lines can be relied upon. Our investigations confirm that the Board's engineers possess full knowledge and experience of the factors involved and that they are taking steps to perfect their records of essential data. In our view they are in the best position to judge what can and should be done in any given situation.

9.6.3 The sections of the Cruising waterways that are reported as suffering most quickly from drought conditions are set out in Table 9.2. together with an indication of the main causes of shortage and some possible remedies.

9.6.4 In certain cases the remedial measures suggested should result in a material improvement of the supply for a comparatively small expenditure, e.g. conserving the flow in the Wendover Arm feeder to Tring summit and making use of the back lockage pumps at Napton. The allocation of reservoir supplies on the Peak Forest and Macclesfield Canals is a question of utilisation rather than resources, and one that would properly be dealt with by the mathematical model technique referred to in paragraph 9.4.8.

9.6.5 Heavier expense would be involved in undertaking works of bed sealing on the Leeds and Liverpool Canal and in piping sections of the Lancaster Canal now acting as a feeder above Tewitfield locks. Without detailed surveys and putting in hand pilot schemes it is not possible to judge how far such works could justifiably be taken, but it would certainly be necessary to assess their probable effects before going on to consider the case for any enlargement of reservoir storage capacity. We therefore recommend that provision be made in the programmes of maintenance works to the extent indicated in Chapter 12 under this heading.

9.6.6 The cost of any scheme for a significant increase of storage capacity is likely to be large, whether by the construction of new or the enlargement of existing reservoirs. To give a measure of the problem, the present total storage capacity of the Tring reservoirs is about 2000 Ml; the inflow varies, being about 3000 Mlpa in an average year down to half that figure in a 3 year dry period. To increase the reliable yield of the reservoirs by 500 Mlpa would require the storage capacity to be enlarged by about 750 Ml; an extra yield of 1000 Mlpa could be obtained only if the capacity were enlarged by 3000 Ml.

9.6.7 The Tring Reservoirs are not typical as they are fed partly from underground sources. Boddington reservoir on the Oxford Canal is more typical, being fed solely from the run-off from its catchment area of 2000 ha and having a capacity of 935 Ml. The average yield is about 1400 Mlpa but to increase it to the full reliable yield of the catchment -- some 4000 Mlpa -- would require an additional storage of nearly 3000 Ml. It would be physically possible, by constructing a new head bank some 600 m below the present one, to provide about 1000 Ml of extra capacity but, in addition to the cost of the head bank, land would have to be purchased and extensive road diversion works carried out.

9.6.8 With regard to Winterburn reservoir on the Leeds and Liverpool Canal we are informed that an enlargement scheme is being considered by BWB. An initial desk study is being undertaken by the inspecting engineers appointed under the Reservoirs (Safety Provisions) Act 1930 and their report is awaited. Preliminary indications are that it would be feasible to raise the existing head bank and spillway by about 5½m so as to increase the storage capacity from the present 1240 Ml to 2340 Ml.

9.6.9 It must be emphasized that any proposal to increase reservoir storage capacity must receive consideration by the appropriate engineer under the 1930 Act, as discussed in section 9.7, before any assessment of design criteria and probable cost could be made. We have therefore made no provision in the estimates set out in Chapter 12 for any reservoir enlargement schemes in relation to water supply requirements for present levels of traffic. In Chapter 13, however, dealing with the consequences of increased levels of traffic, we have given an indication of where such schemes may need to be given consideration.

9.6.10 It therefore remains to consider what further steps might be taken to assist needy areas short of incurring the expense of additional reservoir capacity. The problem is of special importance where existing storage capacity is small, giving little scope for hoarding the bounty of the rainy day against the needs of a dry spell. A dry spell in this context may be taken to mean a period of not less than 18 months in which the total rainfall is no more than 90% of the long term average; such spells have occurred in the past at intervals averaging 10-15 years, but their incidence is erratic and unpredictable.

9.6.11 We consider that after taking all precautions to conserve existing resources, for example by stopping leaks and keeping feeder channels clear, the use of back lockage pumps affords the most practicable means of assistance. Where such pumps are already in existence an extension of their operating periods would in many cases enable reservoir storage to be conserved to a greater degree, as mentioned in paragraph 9.4.1 (e). In other cases their installation could go some way towards making up for a present deficiency of reservoir capacity.

9.6.12 The actual locations for these installations, and the specification of pumping units, rising mains, etc., would need to be determined by the Board's engineers after closer investigation of need and justification; some would be justified only at higher levels of traffic than exist at present. We have, however, set out in Table 9.3 a list of the sites where we consider that back-lockage pumps could be advantageous and in presenting the alternative programmes considered in Chapters 12 and 13 we have made appropriate allowances for items selected from this Table.

9.6.13 As an example of the kind of installation we have in mind we would mention the pumps recently put in at Napton, on the Oxford Canal (South) by means of which water will be raised from the important Braunston pound of the Grand Union Canal to the Marston -- Claydon summit of the Oxford Canal. While it has features similar to schemes developed several decades earlier on the Grand Union Canal and elsewhere it has taken full advantage of modern techniques and in our view is an excellent scheme eminently suited to the work it is designed to do.

9.6.14 At other sites which may be developed in the future it is not possible at this stage to determine just how far the chain of pumps would need to extend below the summit level; it would depend on where additional water supplies become available. In some cases it might be feasible, subject to approval by the Regional Water Authority, to terminate the chain at a river or stream (perhaps below the level of the waterway) capable of affording a supply of the order of 5–25 Mld without distress.

9.6.15 As regards the expense of using pumps of this kind, operating costs will be little more than the charges incurred for electricity. (Maintenance costs are very small on these units and will not vary greatly whether the plant is in use or not.) For the size of unit appropriate to wide or narrow canal locks grouped in threes or fours (somewhere in the region of 30 or 15 kw respectively) a block tariff would probably be applied. For larger pumping installations, used for example in pumping from boreholes and mineshafts, a maximum demand tariff would be appropriate. The MD charge is lowest from April -- October, but is increased in the winter months and may rise to a high value in say January. On this account the larger pumping installations would normally not be used before April, when the probable need for the summer can often be foreseen, and would be shut down after October unless the need at that time was deemed sufficient to continue pumping into the more expensive months. This is seldom likely to be the case with a cruising waterway.

9.6.16 The additional cost of such pumping is likely to be appreciable and there is always the possibility that, having embarked on the exercise, the onset of a wet period may result in reservoirs coming up to weir level and even running to waste. The capital cost of back pumping installations is, however, small compared with that of a new or enlarged reservoir and the operating cost would be regarded as an insurance premium against the losses to be expected if the system were closed down during a severe drought. Even when idle, the standing capital charges (plus a small amount of caretaking maintenance) could be regarded as another element of insurance provision.

9.7 *Reservoirs Acts*

9.7.1 As already mentioned, the BWB is obliged to comply with all requirements of the Reservoirs (Safety Provisions) Act, 1930, insofar as their reservoirs come within its scope. The Act applies to all reservoirs having a capacity above natural ground level exceeding 22.8Ml (5mg) and requires that they shall be inspected at regular intervals, by an engineer on a panel appointed by the Government, and that any works of repair or alteration that he may recommend must be carried out.

9.7.2 The reservoirs affected by this requirement are listed in Table 9.4, and we have verified that the statutory inspections have been carried out and that the relative engineer's reports are on record. While we have not made detailed inspections in all cases we believe that the items of work recommended have been carried out. There are one or two exceptions where an inspection, called for to confirm completion of certain recommended works, is not yet due; in such cases we have made allowance for the cost of the works in question.

9.7.3 The Reservoirs Act 1975 is now law and will in due course increase the Board's liabilities in respect of reservoir maintenance and supervision. Up to a late stage in the preparation of this Report the Bill had not received Royal Assent and we were instructed not to take account of the consequences of its provisions. It has not yet been implemented but when it is it should be a straightforward matter for the Board themselves to make an appropriate estimate of costs.

9.8 *Water Engineering Organisation*

9.8.1 The length and ramifications of this chapter at least provide an indication of the complexity of its subject matter. It is not surprising, therefore, that, under the Chief Engineer, the BWB have established a group of specialist water engineers to investigate the numerous problems, to formulate policy recommendations and to advise the Principal and Area Engineers on operating procedures.

9.8.2 The organisation of this section is shown in Fig. 11.1, there being a Principal Water Engineer located at Wembley covering all aspects and advising the Chief Engineer at Headquarters. The Assistant Water Engineers, located at Northwich, Leeds, Gloucester and Wembley, each advise their neighbouring line engineers on water questions generally but they are also now to have responsibility throughout the whole system for a particular class of water-related matters. At Northwich questions of strategy for utilisation of resources will be dealt with; at Leeds matters relating to reservoirs; at Gloucester quality and control of pollution and at Wembley land drainage and more general matters.

9.8.3 With the aid and advice of these specialists the line (Principal and Area) engineers undertake the day to day tasks of maintaining the component parts of the system and of regulating and conserving their various resources to meet the fluctuating demands. As part of the total responsibilities there is also need to comply with the requirements of the independent engineers appointed under the Reservoirs (Safety Provisions) Act, 1930, to confer with and satisfy the proper requirements of such bodies as the Regional Water Authorities, local authorities, etc., and to ensure as far as possible that the interests of adjoining land owners, amenity societies and others are not adversely affected.

9.8.4 Quite clearly all these responsibilities call for a very wide range of expertise, some of which is peculiar to waterway navigation but other parts involve knowledge and experience of general hydrological and land drainage engineering. In our view the BWB have very properly built up a specialist section covering all these fields and have deployed the personnel concerned in a way well suited to their needs. We have heard comments to the effect that the division of what is in effect a H.Q. function over five centres generates a considerable amount of travelling; we do not see, however, that the total amount of travel would be significantly reduced by a concentration on one centre. Any possible saving of costs would be negligible in the context of the present remit and as examination of the point would be concerned essentially with matters of managerial judgement we have not considered it necessary to go further for the purposes of this Report.

Table 9.1

Principal Summit Levels, with related Reservoirs and Lock Terminals

Waterway Ref. No.	Waterway	Extent of Summit Level	Length Km.	Level above OD m.	Lock Dimensions m.	Reservoirs feeding summit	Back lockage pumps at	Remarks
2c 2a	Grand Union Canal, Paddington Arm and part Regents Canal	Bulls Bridge to Paddington and Camden Town	24.5	30	23x4.4x2.4	Brent	None	This is the London "Long Level", not a true summit, as water is fed into it at Cowley Lock (2.0 m. rise)
3 4a	Grand Union Canal, Main Line(S) and Slough Arm	Norwood Top lock to Cowley lock; Cowley Peachey Junction to Slough	19.5	30	23x4.4x2.4			
3	Grand Union Canal, Main Line (South)	Tring (Cowroast to Marsworth)	6.4	119	23x4.4x1.8	Tringford Marsworth Startopsend Wilstone (all pumped) Weston Turville (pumped into Wendover Arm)	Cowroast (into summit) Marsworth (into reservoirs)	Water supplies from Wendover via the former Wendover Arm can be pumped into the summit or gravitate into the reservoirs
3 5	Grand Union Canal, Main Line(S) and Leicester Section	Buckby to Braunston and Norton Junction to Watford locks	8.1	103	23x4.4x2.7 (Buckby) and x1.8 (Braunston)	Daventry Drayton	Buckby Braunston	Water is also supplied from the Leicester Section Watford – Foxton summit (see below) via Watford locks
5	Grand Union Canal, Leicester Section	Watford to Foxton	33.8	119	22x2.2x2.3	Naseby Sulby Welford	None	
6	Grand Union Canal, Main Line (North)	Knowle to Birmingham	16.4	102	25x4.6x2.5 (Knowle) 22x2.2x1.8 (Birmingham)	Olton	Temporary pump formerly in use at Knowle	Salford Bridge and Bowyer St. Pump lift water from the R. Tame to supply the summit
7	Stratford-on-Avon Canal	Kings Norton to Lapworth	17.2	138	22x2.2x2.6	Earlswood Lakes (pumped)	None	These pounds, having a junction at Kings Norton, are at the same level as the Birmingham level of the BCN which is joined at Worcester Bar and from which water may be drawn.
17	Worcester and Birmingham Canal	Birmingham (Worcester Bar) to Tardebigge	22.4	138	22x2.2x2.1	Upper Bittell Cofton		
11	Oxford Canal (South)	Marston Doles to Claydon	17.5	107	22x2.2x1.8	Boddington (including Byfield) Wormleighton Clattercote	Napton – Marston Doles	

(Continued on next page)

Table 9.1 Continued

Waterway Ref. No.	Waterway	Extent of Summit Level	Length Km.	Level above OD m.	Lock Dimensions m.	Reservoirs feeding summit	Back lockage pumps at	Remarks
12	Kennet and Avon Canal	Crofton to Wootton Rivers	4.0	144	22.5x4.3x 2.4	Crofton (pumped)	None	Reservoir capacity very small; pumps capable of dealing only with dry weather yield.
18	Staffordshire and Worcestershire Canal	Compton to Gailey	16.5	104	22x2.2x2.8	Calf Heath Gailey Upper Gailey Lower	None	
20	Birmingham Canal Navigations	Wolverhampton Level (Main Line and branches)	62.0	144	22x2.2x2.0	Rotten Park Cannock	Several, but not all in working order	Summit also fed from Titford Canal via Oldbury Locks and pumping plant at Bradley etc.
23	Trent and Mersey Canal	Etruria to Kidsgrove	9.5	130	22x2.2x3.0	Knypersley Rudyard Stanley	None	From Caldon Canal via locks at Hanley
41	Macclesfield Canal	Hardingswood to Hall Green	2.2			Bosley Sutton	None	From Macclesfield Canal via Hall Green Lock
41	Macclesfield Canal	Bosley to Marple	26.2	158	22x2.2x2.8	Bosley Sutton	None	
40	Peak Forest Canal	Whaley Bridge to Marple	11.3			Coombes Toddbrook	None	
45	Leeds and Liverpool Canal	Barrowford to Greenberfield	9.7	149	19x4.4x3.0	Upper Foulridge Lower Foulridge Whitemoor Slipper Hill Winterburn	None	
46	Lancaster Canal	Preston to Tewitfield	64.5	19	22x4.3x2.6	Killington	None	Reservoir supplies use unnavigable canal north of Tewitfield as Feeder Channel
47	Caledonian Canal	Laggan to Aberchelder (Loch Oich)	9.7	32	50x11x2.3	None	None	
48	Crinan Canal	Cairnbaan to Dunardry	1.0	20	29x7.3x2.8	Lochs:- Duin na Bric na Feoline an Add Daill Cam Clachaig Glen	None	

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Table 9.1 Continued

Waterway Ref. No.	Waterway	Extent of Summit Level	Length Km.	Level above OD m.	Lock Dimensions m.	Reservoirs feeding summit	Back lockage pumps at	Remarks
49	Forth and Clyde Canal	Maryhill to Wyndford Bridge	32	48	Not serviceable	Birkenburn Townhead Kilmannon	None	
						Hill End Lilly Loch Black Loch		Via Monkland Canal and Glasgow branch
50	Union Canal	Falkirk to Edinburgh	47.5	74	None	Cobbinshaw	None	Also fed from river Almond

Table 9.2

Principal Areas of Water Shortage in Drought Conditions

Ref. No.	Waterway	Section Affected	Cause of Shortage	Possible Remedies
3	Grand Union Canal (Main line)	Tring Summit	Deficient yield from chalk aquifier; losses in feeder arm	Improve yield from aquifer; conserve flow in feeder arm.
3	Grand Union Canal (Main line)	Buckby – Braunston Summit	Insufficient reservoir storage capacity	Provide additional storage capacity or arrange for compensating supply from drainage effluent
5	Grand Union Canal (Leicester Section)	Watford – Foxton Summit	Insufficient reservoir storage capacity	Back lockage pumps at Watford and Foxton
11	Oxford Canal (South)	Marston Doles – Claydon Summit	Insufficient reservoir storage capacity	Use of new back-lockage pumps at Napton. Enlargement of Boddington Reservoir.
23a	Trent and Mersey Canal (W)	Stoke-on-Trent Summit	Relies on supplies from Caldon and Macclesfield Canals	Optimisation of supplies from feeder canals.
40 41	Peak Forest and Macclesfield Canals	Whaley Bridge – Marple and Bosley Summit	Limited reservoir. storage capacity	Restrict use of reserves to these canals rather than for transfer elsewhere.
45	Leeds and Liverpool Canal	Foulridge Summit	Leakage from bed into porous strata. Insufficient reservoir storage capacity.	Reduce leakage by bed sealing. Increase capacity of Winterburn Reservoir
46	Lancaster Canal	Tewitfield – Preston	Leakage from feeder bed into porous strata north of Tewitfield locks.	Pipe or channel defective sections of feeder.

Table 9.3

Pumping Installations

Part I — Existing

Waterway Ref. No.	Waterway	Location	Supply	Back Pumping	Notes	Duty
3	Grand Union Canal, Main Line (South)	Northchurch	√			Borehole above LK. 49
		Dudswell		√		at LK. 48
		Dudswell		√		at LK. 47
		Cowroast		√		at LK. 46
		Cowroast Well	√			Well and borehole to Tring summit above LK. 46
		Weston Turville	√		A	From reservoir into Wendover Arm
		Tringford (6 pumps)	√			From Wendover Arm and Tring reservoirs into Tring summit
		Marsworth		√	A	at LKs. 37 and 38
		Seabrook		√	A	at LKs. 34 to 36
		Ivinghoe		√	A	at LKs. 32 and 33
		Slapton		√	A	at LKs. 30 and 31
		Church		√	A	at LKs. 28 and 29
		Leighton Buzzard		√	A	at LK. 27
		Soulbury		√	A	at LKs. 24 to 26
		Stoke Hammond		√	A	at LK. 23
		Fenny Stratford		√	A	at LK. 22
		Ouse Aqueduct	√		C	From R. Ouse
		Cosgrove		√	C	at LK. 21
		Stoke Pound	√		C	From R. Tove
		Stoke Bruerne		√	A	at LKs. 14 to 20
		Buckby		√	C	at LK. 13
		Buckby		√	C	at LKs. 10 to 12
		Buckby		√	C	at LK. 9
		Buckby		√	C	at LK. 8
		Buckby		√	C	at LK. 7
		Buckby	√			Effluent from Whilton Sewage Works into Braunston Summit.
		Braunston		√	A	at LKs. 1 to 6
6	Grand Union Canal, Main Line (North)	Welsh Road		√	A	at LK. 18
		Wood Lock		√	A	at LK. 19
		Fosse (top)		√	A	at LK. 20
		Fosse (middle)		√	A	at LK. 21
		Fosse (bottom)		√	A	at LK. 22
		Radford		√	A	at LK. 23
		Knowle		√	B	at LKs. 47 to 51
		Bowyer Street (2 pumps)	√		C	From Saltley level to Knowle Summit above LK. 52
		Salford Bridge (2 pumps)	√		C	From R. Tame to Saltley level.
7	Stratford-on Avon Canal	Earlswood	√		C	From Earlswood Lakes into Birmingham level.
8	Coventry Canal	Hartshill	√		C	Effluent from Sewage works
10	Oxford Canal (North)	Hillmorton (2 pumps)		√	A	at LKs. 1 to 3
		Newbold	√		C	From reservoir into Longford pound

(Continued on next page)

Table 9.3

Part I Continued

Waterway Ref. No.	Waterway	Location	Supply	Back Pumping	Notes	Duty
11	Oxford Canal (South)	Napton Marston Doles		√ √		at LKs. 8 to 14 at LKs. 15 and 16
12	Kennet and Avon Canal	Crofton	√		C	From reservoir into summit level
15	Gloucester and Sharpness Canal	Gloucester (2 pumps)	√			From R. Severn into Gloucester Docks
17	Worcester and Birmingham Canal	Worcester Blockhouse Sidbury	√	 √ √		From R. Severn into Diglis Basin at LKs. in Worcester at LKs. in Worcester
18	Staffordshire and Worcestershire Canal	Hatherton	√		C	From former Hatherton Branch into Gailey and Calf Heath reservoirs
20a	Birmingham Canal Navigations (Main line)	Bradley (3 pumps)	√			From disused coal mine shaft into Wolverhampton level
20c	Birmingham Canal Navigations (other)	Titford		√		From Wolverhampton level to Titford Canal
26	Erewash Canal	Trent Lock		√		at Trent Lock
31	Chesterfield Canal	Retford West Stock with	√ √		 A	from R. Idle from R. Trent to W. Stockwith Basin
34a	Sheffield and South Yorkshire Navigation	Tinsley (2 pumps) Swinton (2 pumps)	√	 √	B	from R. Don to Dearne and Dove branch
45	Leeds and Liverpool Canal	Liverpool		√		from Stanley Dock to head of Locks

Table 9.3

Pumping Installations

Part II – Potential Installations

Waterway Ref. No.	Waterway	Location	Supply	Back Pumping	Notes	Duty
5	Grand Union (Canal) Leicester Section (S)	Watford		√	D	at 7 Watford Locks
		Foxton		√	D	at 10 Foxton Locks
6	Grand Union (Canal) Main Line (N)	Calcutt		√	D	at LKs. 1 to 3
		Stockton		√	D	at LKs. 4 to 13
		Bascote		√	D	at LKs. 14 to 17
11	Oxford Canal (S)	Claydon		√	D	at LKs. 17 to 21
		Broadmoor		√	D	at LKs. 27 to 24
		Cropredy		√	D	at LK. 25
12	Kennet and Avon Canal	Wootton Rivers		√	D	at LKs. 51 to 54
		Bedwyn		√	D	at LKs. 61 to 70
27a	Grand Union Canal Leicester Section (N)	Kibworth		√	D	at LKs. 18 to 22
		Newton Harcourt	√		D	from R. Sence
45	Leeds and Liverpool Canal	Barrowford		√	D	at LKs. 45 to 51
		Greenberfield		√	D	at LKs. 42 to 44
		Gargrave		√	D	at LKs. 30 to 41
		Bingley		√	D	at LKs. 25 to 29

NOTES:

A. Arrears (Control gear, culverts, etc.) allowed for in Chapter 12.

B. Replacement of former or existing pumping units allowed for in Chapter 12.

C. Replacement of former or existing pumping units referred to in Chapter 13.

D. New installation referred to in Chapter 13.

Table 9.4

BWB Reservoirs

Part I – Subject to Reservoirs (Safety Provisions) Act 1930

Waterway Ref. No.	Waterway	Reservoir	Capacity Ml Present	Capacity Ml Original	Catchment Area	Lapworth Yield Ml/annum	Remarks
3	**Grand Union Canal** Main Line (S)	Aldenham	668	757	513	–	Leased to Herts CC who have maintenance responsibility. BWB maintain supply arrangement with Colne Valley Water Co.
		Brent	1600	2161	7742	12900	Storage maintained at 1168 M1 to allow for flood regulation.
		Marsworth	255	255			
		Startopsend	482	575	336	680	
		Tringford	192	254			
		Wilstone	1105	1390	1879	1910	
		Weston Turville	178	463	81	142	
		Daventry	913	1613	866	1072	Drainage area extends beyond catchment. Storage to be further reduced to 744 M1
		Drayton	316	316	207	304	
5	Leicester Section	Naseby	1118	1118	879	1180	
		Saddington	517	517	622	681	
		Sulby	392	392	921	935	
		Welford	267	365			
		Upper Napton)					
		Lower Napton)	160	227	–	–	Filled from canal, no gathering ground.
		Olton	312	388	282	358	
7	Stratford on Avon Canal	Earlswood Lakes (3 No)	818	818	931	–	
8	Coventry Canal	Oldbury	107	120	73	106	
11	Oxford Canal S(S)	Boddington	882	1016	2011	1685	Dividing head bank now breached to form one reservoir
		Byfield	53	85			
		Wormleighton	76	89	395	634	
		Clattercote	245	245	168	236	
17	Worcester & Birmingham Canal	Cofton	74	74	147	909	Freehold sold. BWB reserve the right to control water and are responsible for maintenance
		Upper Bittel	380	792	–	–	
		Lower Bittel	150	150	480	–	Pump required for canal supply.
		Tardebigge	116	166	Surface only	–	Takes water from summit pound and feeds canal lower down
18	Staffordshire & Worcester Canal	Calf Heath	162	162	5		
		Gailey Upper	362	362	Surface only		Balancing reservoirs fed from Hatherton Branch; at present by-passed
		Gailey Lower	323	323	Surface only		
19	Stourbridge Canal	Fens Pools (3 No)	325	325	154	68	
20a	Birmingham Canal Navigations	Rotten Park	1464	1464	113	1363	All but head-bank conveyed to Local Authority. BWB reserve right to use, and dredge area in water

(Continued on next page)

Table 9.4

Part I Continued

Waterway Ref. No.	Waterway	Reservoir	Capacity Ml Present	Capacity Ml Original	Catchment Area ha	Lapworth Yield Ml/annum	Remarks
	Shropshire Union Canal						
21a	Main Line(S)	Belvide	2241	2241	554	2259	Yield includes imported water
21d	Llangollen Branch	Hurleston	389	389	–	–	Fed from Llangollen Canal to supply North West Water Authority
21f	Newport Branch	Trench	100	100	13	–	Large artesian element, reasonably constant annual yield: 1615 Ml in 1974
24	Cromford Canal	Butterley	309	401	350	745	
		Codnor Park	141	141	93	173	
25	Nottingham Canal	Moorgreen	592	682	834	1573	Further reduction of capacity expected
29	Grantham Canal	Denton	225	276	964	591	
31	Chesterfield Canal	Pebley	220	220	303		
		Harthill (Top)	133	133	170	682	Cascade of three reservoirs
		Harthill (Bottom)	250	250	36		
35a	Aire & Calder Navigation	Southfield	555	555	Surface only		Balancing reservoir for Goole Docks
38	Huddersfield Narrow Canal	Diggle	55	81	13	83	Additional feed from Diggle Brook
		Black Moss	58	85	27	45	
		Brunclough	39	39	9		Compensation reservoir, can be fed to canal
		Swellands	182	182	19		
		March Haigh	240	240	25		Run off to public water supply; 1273 Ml pa received in return
		Tunnel End	27	103	1307		
		Slaithwaite	310	310	390	1346	Part catchment diverted to public water supply.
		Sparth	37	37	53	179	Part catchment diverted to public water supply.
40	Peak Forest Canal	Coombes	1539	1539	1208	4641	
		Toddbrook	1366	1345	1631	5137	
41	Macclesfield Canal	Bosley	1116	1827	1107	2868	Present capacity temporarily reduced from 1688 Ml.
		Sutton	322	427	741	468	
42	Caldon Canal	Knypersley	1154	1154	769	2091	
		Rudyard	3455	3455	1319	4892	
		Stanley	611	611	834	1736	
43	Manchester Bolton Bury Canal	Elton	1000	1000	234	1420	Additional feed from R. Irwell
44	St. Helens Canal	Carr Mill	737	837	1518	2695	
45	Leeds & Liverpool Canal	Barrowford	454	461	7	–	Balancing reservoir fed from Summit pound; supply to Burnley pound.
		Upper Foulridge	492	509	292	3173	
		Lower Foulridge	1488	1538	112		
		Rishton	554	614	130	695	
		Slipper Hill	163	163	87	486	
		Whitemoor	637	627	210	1186	Includes adjacent catchment runoff
		Winterburn	1243	1314	2327	6796	

(Continued on next page)

Table 9.4

Part I Continued

Waterway Ref. No.	Waterway	Reservoir	Capacity Ml		Catchment Area ha	Lapworth Yield Ml/annum	Remarks
			Present	Original			
46	Lancaster Canal	Killington	3482	3482	872	6459	
48	Crinan Canal	Loch Duin	41	41	15	117	Feeds direct into the Crinan pound
		Loch na Bric	136	136	15	171	Feeds into Loch an Add
		Loch na Faoline	396	396	62	641	Feeds into Loch an Add
		Loch an Add	1023	1023	123	1371	Feeds into Daill Loch
		Daill Loch	496	496	60	673	Feeds to summit
		Camloch	580	580	117	1261	Feeds into Loch Clachaig
		Loch Clachaig	768	768	154	1462	Feeds into Glen Loch
		Glen Loch	509	509	131	1146	Direct feed to summit with overflow to Loch na Faoline
49a	Forth & Clyde Canal	Birkenburn	696	696	144	4953	Birkenburn feeds into Townhead. Effective catchment Area 1859 ha
		Townhead	709	709	1148		
		Kilmannon	955	955	423	2451	
49b	Monkland Canal	Hillend	3409	3409	1471	5349	
		Lilly Loch	591	591	140	634	
		Black Loch	796	796	189	857	
50	Union Canal	Cobbinshaw	2955	2955	797	2473	

Table 9.4

Part II — Other Reservoirs Serving the System

Waterway Ref. No.	Waterway	Reservoir	Remarks
12	Kennet & Avon Canal	Crofton Reservoir (Wilton Water)	Artesian well source having normal storage of 11 Ml and a dry weather yield of 4.5 Mld.
20a	Birmingham Canal Navigations	Lodge Farm	Conveyed to L.A. - BWB retain right to discharge into reservoir and to extract the top 1·5 metres, approximately 80 Ml.
		Cannock	Conveyed to L.A. - BWB reserve right to control water and approve all maintenance
48	Crinan Canal	Loch na Bharaine	Balancing reservoir to summit pound
49a	Forth & Clyde Canal		(Natural Lochs with no artificial embankments or works)
		Possil Loch	Overflow spills into canal
		Bishop Loch	Feed into Bothlin Burn and thence into the canal summit at Kirkintilloch via the Lenzie Feeder
		Johnstone Loch	
		Lochend Loch	
		Woodend Loch	

Table 9.4

Part III – Disused Reservoirs

Waterway Ref. No.	Waterway	Reservoir	Remarks
12	Worcester & Birmingham Canal	Wychall	Failed 1965 inspection and abandoned, feeder now turned into canal.
	Shropshire & Union Canal		
21a	Main Line (S)	Knighton	Failed inspection and abandoned in 1955, now acts as part of feeder.
38	Huddersfield Narrow Canal	Little Black Moss	Adjacent to Black Moss, abandoned
48	Crinan Canal	Loch Breac Buidhe	Failed 1965 inspection and abandoned