## CHAPTER TWELVE

## DEFICIENCIES OF MAINTENANCE, FUTURE COSTS AND ALTERNATIVE PROGRAMMES FOR COMMERCIAL AND CRUISING WATERWAYS

Chapter 12

# Deficiencies of Maintenance, Future Costs and Alternative Programmes for Commercial and Cruising Waterways

## 12.1 *Introduction*

12.1.1 Paragraphs 12 to 15 of the Terms of Reference (Appendix 1A) define the requirements of the Department with regard to the identification of arrears of maintenance where they exist on the Board's Commercial and Cruising waterways, the assessment of the necessary works and associated costs of overtaking these arrears on an annual basis under several different programmes, and the relative merits and any additional benefits of each of these. We are further required under paragraph 9 to give estimates of cost for the strategy and timing of continuing maintenance which would, in our opinion, be most economical. This chapter deals with these aspects of the Study, and contains details of our field inspections, the application of the standards defined in Chapter 10, the analysis of the results, the methods of costing and further discussion of the degree of comparability with the Board's 1970 Survey. The various programmes of works outlined in paragraph 13 of the Terms of Reference include for all maintenance and operating costs during the 15-year period, and in deriving these the guidelines of Chapter 11 have been followed as regards methods and strategy of maintenance.

12.1.2 The general approach adopted in carrying out this study has been outlined in Chapter 1, where the reasons for adopting a sampling basis for inspections were given. Because our detailed inspections of the Commercial and Cruising waterways on this basis covered only 12.5% of their total mileage, our final figures are necessarily estimates. Many intermediate partial surveys were also carried out however, and our discussions with the Board's officers and staff were conducted with a view to relating our experience on each sampled length to the waterway as a whole.

12.1.3 Our field inspections have confirmed the existence of substantial arrears of maintenance relative to the standards of Chapter 10, and overall these are of the same order of magnitude as the works identified in the BWB 1970 Survey. Most of the kinds of works required to overcome these present arrears of maintenance occur generally throughout the waterways, and for these we have arrived at estimates for the whole system by extrapolating our findings in proportion to the percentage inspected. In the case of bank protection this method was checked by comparison with an analysis on statistical principles of a survey comprising a series of randomly chosen inspection lengths, as mentioned in Chapter 1. We had expected from the Board's 1970 Survey that the largest single item would be bank protection, and that the cost of this would be several times that for structures and dredging. Our survey effort was to some extent tailored to this expectation (which was in the event justified) and this is the reason for the extra checks mentioned above which are related specifically to bank protection.

12.1.4 It was necessary to cover a larger percentage of non-typical structures, known public safety hazards and other less common items in our field inspections in order to assess their overall effect on the cost of overtaking arrears. In some cases complete lists and estimates have been compiled by our own researches and with the aid of the BWB, while in others the extent of work required over the next few years is not quantifiable; here we have made contingency allowances based on past experience. If for example the thorough and specialised investigations exemplified in Section 12.5 were to indicate major remedial works in many cases then this cost could add up to a significant proportion of the total due to arrears of maintenance.

12.1.5 In our fieldwork throughout the country and in the analysis of the survey reports we have been at pains to ensure uniform standards of assessment. The original briefing for the field teams included combined site visits, and the Project Manager and his Deputy held series of meetings with the team leaders and their assistants, singly and in groups, throughout the survey period. The teams themselves met near the boundaries of adjacent Areas whenever possible, and they were reorganised by interchanging team leaders sometimes when moving to new Areas. The team leader for the special bank protection survey mentioned above joined two of the other teams for several days each beforehand. Comparison of standards of assessment for bank protection by analysis of simultaneous but independent surveys of some 20km of banks carried out by three key members of the field teams, including the leader of the special bank protection survey team, was also carried out. The analysis of all of the survey reports was carried out in the London office, members of each field team being available for questioning if necessary. Considerable use was made of the many photographs taken by the field teams to accompany their field reports, some of which are reproduced in this chapter as illustrations of typical arrears of maintenance.

## 12.2 *The Field Surveys*

12.2.1 Our principal inspections in the field were carried out by three-man teams, mainly between August and November 1974 and in February and March 1975, but with some lengths close to London covered from the office during the winter months. Each team was equipped with an inflatable boat and outboard motor, and a motor-caravan type of road vehicle which served to transport themselves and the boat, and as a mobile office. The programme of inspections for each Area consisted of two distinct kinds, the main survey lengths on which all aspects of the waterway were thoroughly assessed and recorded, and 'spot checks' intended either to cover some non-typical structure or problem or to check that conditions were sensibly constant between the main lengths.

12.2.2 The programmes of lengths to be surveyed in each Area were drawn up in the London office. The division of the BWB maintenance organisation into eight Areas each with a number of Sections was first ascertained. For BWB accounting purposes the waterways are further divided into "Activity Code" lengths and this was the breakdown used in costing the 1970 Programme. In most cases Section boundaries are also Activity Code boundaries, so that each Section contains a whole number of Activity Code lengths. Parts of the BWB 1970 Survey results were examined in the Board's offices at the beginning of July 1974, as soon as we had received instructions to proceed, and it was found that apart from some specific high-cost items the works identified were in general evenly spread throughout the Activity Code lengths. In view of the confirmation we had received that we were to carry out a fresh and independent investigation it was not considered appropriate to study the 1970 Survey records in greater detail at this stage. It was in any case likely that the works which were critical in 1970 would have been put in hand in the meantime, so that it was decided not to refer to these earlier results in planning our main survey lengths, but to cover

specific trouble-spots and extensive work identified therein by separate 'spot check' inspections.

12.2.3 The main survey lengths were therefore chosen on an essentially geographical basis so that:—

a) they covered about 10% of each canal or waterway

b) as many of the Activity Code lengths as possible were represented, since these were convenient to use as the basis for extrapolation of our results, and

c) as a further consideration, the length containing the numbers of bridges, locks etc., most typical of the particular waterway was taken.

12.2.4 In addition to these thorough inspections we covered a further 5% of the Board's waterways in 'spot checks'. The considerations governing the locations chosen for these were:—

a) to investigate specific high-cost items identified in the Board's 1970 Programme,

b) to inspect items which we ascertained were causing concern to the BWB, or which were likely to have changed materially since 1970,

c) by random inspections to form an assessment of any change in conditions between the main survey lengths and hence to help us to form truly representative judgements,

d) to enable us to cover the necessarily higher proportion of certain works, for example special structures, without their dictating the location of full survey lengths.

12.2.5 It was important for our field teams to meet the local BWB officers to discuss the survey lengths in detail, and to collect information on all the waterways for which those officers were responsible. We allowed sufficient flexibility in the field teams' programmes to enable them to carry out spot checks at any place where BWB personnel felt particular concern, where works had a history of giving trouble, or where more than normal maintenance is needed. Our inspections in each Area took between six and ten weeks, and during that time formal meetings were arranged with the Area Engineer and his Assistant, the Area Inspector and each of the Section Inspectors. These normally consisted of introductory sessions on moving into a new Area or Section, and detailed discussion of the relevant aspects of our survey lengths on completion of the fieldwork.

12.2.6 In addition to this the team leader made supplementary visits to the Area Offices, among other things to refer to the large-scale maps marked up with locations of such features as bridges, culverts, fences, feeders, ditches etc, and indicating where their maintenance responsibility is with the BWB and where with others. Also, within the Section complement, the teams' frequent casual meetings with foremen, tradesmen and labourers were always fruitful, and in general we found these men to be of considerable experience and invaluable sources of information on local history and problems. Throughout the fieldwork we were impressed and our task lightened by the accommodating attitudes of all the BWB staff we came in contact with and the friendly and patient way in which they helped us with all kinds of information and any services we lacked.

12.2.7 In addition to the principal inspections outlined above, one further set of inspections was undertaken in February and March 1975. Preliminary results of analysis of our field reports showed that our assessment of bank protection needs in 1974 was not consistent in detail with that from the BWB 1970 Survey. This was disturbing, as our intention to estimate total arrears and maintenance costs from an inspected sample had been based partly on the expectation that our findings would confirm the general pattern and tenor of the BWB 1970 Programme, though not necessarily in the same degree. It seemed probable therefore that the survey could not be used as the general check on our results that we had looked for. It was agreed that the special bank protection survey mentioned in paragraph 12.1.3 should be undertaken, covering a further nominal 5% of the waterway banks maintained by BWB. Twenty-three waterway lengths of five kilometres each were chosen on random sampling principles to allow for assessment of total costs using recognised statistical techniques.

12.2.8 In the result the total cost of bank protection works for the six Areas (excludinn Gloucester Area and Scotland) calculated from this special survey was within 3.5% of the equivalent total calculated from our principal survey. Statistical analysis of the results of the special survey showed that, at the 95% confidence level, the actual total cost would be within 11% of the calculated figure. No such analysis was carried out on the results of the principal survey as it was not on a strictly random sample basis, but it is considered that the close agreement of the extrapolated totals can be taken as confirmation of our initial findings.

12.2.9 The Gloucester Area and Scotland differ from the other six Areas in that they comprise, apart from three major Commercial waterways, only remainder lengths and the short cruising sections of the Kennet & Avon Canal. It was decided to adopt a different approach in surveying these, involving a greater number of inspections of shorter lengths. The locations of the main survey lengths in the other six Areas, and of the twenty-three special bank protection survey sites, are shown in Figure 12.1. We have not indicated where the numerous spot-checks were carried out — there were on average three or four of these for each of the programmed lengths. Our field survey work was completed during the first week in April 1975, and at the end the teams had between them carried out full inspections of 12.5% of the BWB waterways plus a further 6.5% of the banks of the waterways in six Areas only.

12.2.10 The information collected by the field teams was recorded on a series of proformas, each covering the description, condition and maintenance requirements of several related aspects of each programmed length. These included:—

a) use by types of craft, commercial enterprise, related private investment, angling and other amenity pursuits, land drainage, discharges, water supply, pollution etc.

b) details of banks, bank protection, revetments, and ground formation.

c) existing waterway cross-sections, towpaths, hedges fences and boundary walls, ditches etc.,

d) structures such as aqueducts, culverts, weirs, sluices, feeders, tunnels, footbridges etc.

e) the elements of each kind of bridge,

f) each element of locks.

In addition the team leader kept a daily diary, and notes were written of meetings held, people interviewed, etc.

12.2.11 The proportions of the Commercial and Cruising waterways system covered in all our surveys, including spot checks, for the principal types of works and structures are as follows:–

| | |
|---|---|
| Bank protection | 19% |
| dredging | 13% |
| public road bridges | 24% |
| accommodation bridges | 20% |
| aqueducts | 23% |
| tunnels | 45% |
| locks | 22% |
| culverts | 8% (Note – the number |

of culverts inspected has been expressed as a percentage of the total number recorded by BWB in a comprehensive survey carried out in 1965. A significant proportion of these are now disused, and many of them are no longer readily visible). For some items it was decided to use the BWB Activity Code lengths as the basis for grossing up our results, and it was for this reason that we covered a part of as many of these as possible in our full surveys. In the event 86% of the Activity Code lengths were represented.

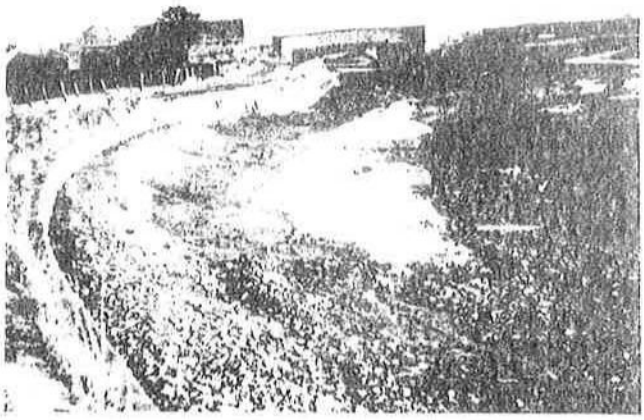


*Plate 12.1 A dewatered length of the Leeds and Liverpool Canal at Huncoat (PFP)*

12.2.12 It has of course not been possible to carry out complete engineering surveys of every aspect of the waterways encountered. Apart from information obtained from BWB staff, our judgements are necessarily based on what was actually accessible and visible at the time of the survey. Where, for example, an accommodation bridge showed obvious signs of distress we have not carried out an engineering analysis to confirm its load-bearing capacity, nor have we disturbed any of its fabric to investigate the extent of damage beneath the surface, nor investigated its foundation. It may be, therefore, that where we have advocated pointing or renewing an area of brickwork it will be found in carrying out the work that the whole thickness of the arch spandrel is affected and a reinforced concrete saddle over the arch is required. Sometimes internal structural damage can be inferred from external observation and there it has been duly recorded and appropriate allowance made, but the field teams were instructed to adopt a tolerant attitude in order to avoid over-estimating the cost of treatment. Also in bank protection we have allowed for the longer lengths of steel sheet piling only where we have seen that it is structurally necessary.

12.2.13 Another major obstacle has been that, except in a few cases when we have been able to visit dewatered lengths, we have been unable to carry out general inspections below water level, though the teams were able to examine particular parts of structures by feel to arm's length under water, and by using a probe. Again, many troublesome situations only show up under certain circumstances, so that although we took pains to question the Section Inspectors as to the existence and histories of doubtful conditions on their lengths of waterway we cannot be certain to have assessed them all completely. From this point of view it was more satisfactory when the Section Inspector could meet us on site and walk the survey length with us.

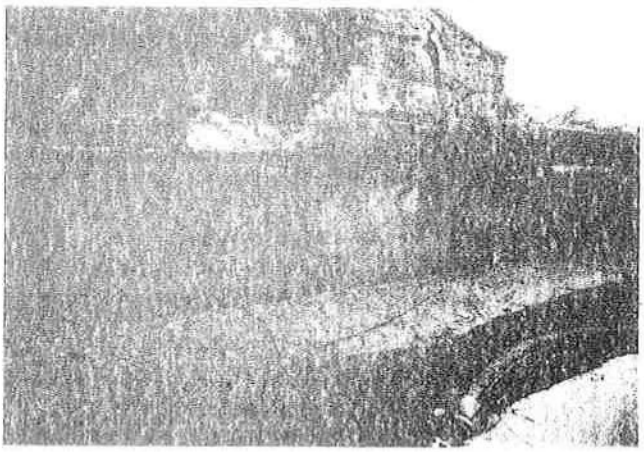


*Plate 12.2 Deterioration of brickwork below water level seen at Hampton bridge (Llangollen Branch of the Shropshire Union Canal) while dewatered for repair of a nearby breach. (PFP)*

12.2.14 Our fieldwork in total covered only eight months of the year, and was suspended for the worst of the winter weather. The survey of each length was done at a single point in time – and although we cross-examined the Board's staff as to the variation in conditions throughout the year and in successive years, our ability to assess the suitability of the waterways to withstand and carry flood water and other extreme conditions, (and indeed their performance throughout the seasons of usage by the commercial or cruising craft, for amenity and so on) was necessarily limited by our relative lack of this detailed experience at first hand.

12.2.15 The foregoing examples serve to make the point that within the time available and the use of resources authorised for the study there were bound to be limitations in some respects. We are, however, confident that in all the circumstances we have made a thorough and reasonable overall assessment of the present situation.

## 12.3 *Application of Standards and Unit Costs*

12.3.1 The maintenance standards outlined in Chapter 10 fall into two main categories – dimensional and loading standards inferred directly from the Transport Act 1968, and relevant qualitative limits on materials, workmanship, operational ability and the acceptable condition of an element as assessed from engineering considerations. In the main the

quantitative standards were defined in our office and compared with dimensions recorded in the field, while engineering assessments of suitability and condition were made in the field and noted down together with details of appropriate forms of attention. This practice of noting condition and appropriate attention, together with quite comprehensive photographic records, was adopted partly to facilitate the achievement of uniformity in application of standards while processing the field data in the office.

12.3.2 The quantities of work calculated from the field reports after applying our standards were priced using unit costs compiled for the purpose and to this end a list of descriptions of the significant types of work required to overcome the arrears of maintenance was produced. Because most of these are in some respect peculiar to the maintenance of inland waterways we approached the BWB with a view to confirming our assessment of the cost elements affecting each. Members of the project team visited each Area Office to discuss the elements of each job on the list relevant to that locality and by taking account of all these variations we were able to compile a schedule of rates generally applicable to the system as a whole. Where possible prices were confirmed independently, and outside contractors' prices checked. We also carried out pricing exercises with the help of the Board's accounts department to extract actual direct labour costs for work done during the last few years, in particular for bank protection and dredging. These were analysed and updated to March 1974 levels (this being the common basis stipulated in the Terms of Reference), and served as further checks on our assessed unit costs. We have followed the established practice of the BWB in allocating administration costs and overheads under a separate heading rather than including them in the unit rates for the various types of work associated with arrears of maintenance.

12.3.3 With regard to dredging, waterway cross-section profiles were taken by lines of soundings from the boat at about 200m intervals, unless these showed sufficient variation to justify closer spacing. These profiles were plotted in the office and compared with the profiles derived as outlined in Section 10.4 to give the volume of material which should be removed by dredging. The profile in each case was taken as that which would exist half-way between consecutive dredging operations. Since there would be no arrears of maintenance on the system as a whole if, on average, half the siltation allowance were taken up, the figures we have obtained are assumed to represent the quantity of arrears directly. Dredging costs vary considerably depending on which of the methods described in Chapter 10 can be adopted, and the particular site details. When, however, we analysed the many individual records of costs and quantities removed over the last five years we found it reasonable, considering average conditions across the country, to price under three headings — through or continuous dredging, local high spot removal and land-based operation where feasible.

12.3.4 The application of standards to bank protection is a more complex matter, and the exact identification of arrears as distinct from annual maintenance is a matter calling for careful consideration. One might consider that if protection had been installed in all places where it is now required, and if on average throughout the system all the protection were halfway through its useful life, there would overall be no arrears of maintenance. It is of course not possible to project accurately the remaining useful life of any of the great number of varieties of protection extant -- any more than it would be to establish complete records of installation. In the case of steel trench sheeting two recent tests have indicated that all protection installed to date will require capping or replacing within the 15-year period, but there is as yet no direct information on the performance of the modified forms envisaged for the future (see paragraph 10.4.20). The definition of arrears of maintenance is, then, somewhat arbitrary.

12.3.5 With these considerations in mind we made a two-tier assessment of bank protection requirements. Our objective was to obtain separate totals for (a) the work which should be done within 5 years (whether because it would thereafter change character from, say, repair to renewal or because public safety might be endangered or because erosion was already severe) and (b) for all other work which will need to be done within the 15-year period we have been asked to consider, assuming traffic at present levels. As mentioned earlier, a series of controlled checks was undertaken throughout the survey period to ensure that our field teams were consistent in their assessments of condition of and appropriate attention to bank protection, including simultaneous but independent surveys of a total of 20km of banks by three of the field engineers. The analysed results of these showed close agreement on the total work which will be required over the 15-year period, but a certain amount of variation in estimating the point in future time when the more serious situations will become critical. To estimate the continuing annual maintenance workload once arrears have been overtaken it is not sufficient merely to divide the total length of banks by the average useful life of common forms of protection; a percentage of the banks can always remain unprotected and, as mentioned in paragraph 10.8.11, a significant proportion of the original towpath dry stone walling is still sound after nearly 200 years! We have therefore used the difference between the 5-year and 15-year totals to estimate the continuing future annual bank protection requirement, on the assumption that for this purpose the 5-year total can be said to equal the present arrears of maintenance. There seems to have been no central guidance on this issue for the BWB 1970 Survey, and there was considerable variation in the local assumptions as to the exact definition of these arrears.

*Plate 12.3 The Grand Union Canal near Long Itchington, showing a towpath virtually impassable due to erosion and damage by stock on the offside. (PFP)*

12.3.6 The field teams inspected the banks of the waterways (where BWB are responsible for them), throughout the main survey lengths and made on-site assessments of the present condition and nature of the work required, on a metre-by-metre basis if conditions were so changeable. Where repairs or replacement, or installation of protection for the first time, were urgent or overdue this was noted and the work has subsequently been incorporated in the "arrears" total as defined

in paragraph 12.3.5. The main considerations in their assessments are summarised below, reference being made to the standards discussed in Section 10.4 where appropriate:—

a) In general the banks or revetments should provide freeboard against overtopping at all times, should prevent leakage and seepage, should act as retaining walls where a depth of water is required alongside, and should support the towing path where necessary (paragraphs 10.4.1 & 24).

b) The banks should resist erosion and disintegration, particularly at the approaches to structures (10.4.2).

c) Ground formation and type of canal construction is to be taken into account (10.4.3).

d) Consideration should be given to the relationship between long-term erosion and dredging. (10.4.4).

e) When reinstating eroded land, a revetment may be required to contain the fill material (10.4.6).

f) One bank at least should be a guide to the line of the channel (10.4.8).

g) Erosion beyond BWB territorial limits should not continue unchecked (10.4.9).

h) Penetration of piling into the canal bed should be sufficient to prevent undercutting (10.4.11 & 24).

j) Treatment of vulnerable banks and places where failure would have serious consequences should be given high priority (10.4.13 & 14).

12.3.7 As far as the waterwall itself is concerned, whether of brick or stone, timber planking, steel or concrete piling etc., we looked for signs of:—

i) settlement or other movement,

ii) extensive local or general damage by impact or wear and tear,

iii) signs of undermining of the foundation on the water face,

iv) the condition of tie-rods, anchors and walings,

v) any reduction in the strength or effective thickness of the structural material, and

vi) any other engineering consideration affecting its structural integrity and capacity.

12.3.8 The field teams were instructed to examine critically each unprotected length, and each protected length where the water-wall was in poor condition, to satisfy themselves that the situation was still deteriorating and that bank protection works carried out in the near future would be appropriate to economic long-term maintenance, before recommending any treatment. Most offside banks were originally unprotected, and it was not until the advent of powered craft that piling became necessary to an appreciable extent. There are still some lengths where, even under the damaging influence of wash waves and other elements discussed in Section 10.4, the status quo is maintained, on account of the presence of dense tree-roots and vegetation, and this can be expected to continue into the foreseeable future.

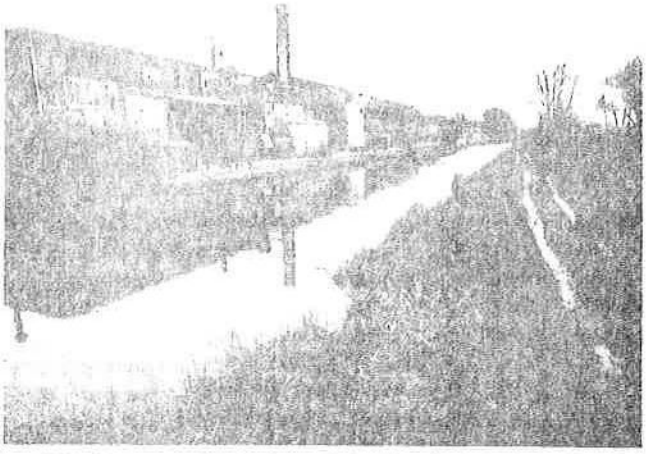


*Plate 12.4. Reed growth providing natural protection to the towpath bank – Oxford Canal (South) (PFP)*

12.3.9 The main forms of bank protection in current use are discussed in Section 10.4. It seems that the part-galvanised trench sheeting will be the most economical modification of the present short lived form, so that we have allowed for this type to be used wherever it is applicable. As there were no reliable contract prices available we made enquiries with a view to building up an informed estimate of the likely increase in cost over untreated sheeting – at March 1974 rates. Purchase of the basic steel itself accounts for over half the installed cost and in this connection it is to be observed that steel prices were increased by just over 20% with effect from the beginning of April 1974, and we must make it clear that this rise is not included in our estimates. We have also derived a unit cost for casting a concrete cap over the existing (non-galvanised) sheeting, and made allowance for this work to be carried out.

*Plate 12.5 Re-protecting an eroded bank on the towpath side of the Oxford Canal (North) (PFP)*

12.3.10 One aspect of bank protection requirements – that of the effect of application of the waterway dimensional standards – was necessarily a desk study. In some cases dredging to the waterway profiles required from Chapter 10 involves a significant increase in the depth of water immediately along side the bank, and then it is considered that the existing protection will not be capable of supporting the bank under this increased loading and will need replacing.

12.3.11 Although, as stated in paragraph 12.2.12, our inspections of the structural elements of the waterways system such as bridges, locks, aqueducts, tunnels, culverts etc. were necessarily more comprehensive as regards visible defects than for internal structural integrity, a number of the instances where the field teams noted a need to commission further investigations of distress symptoms are dealt with in Section 12.5 as special problems. That section also includes details of special works in hand and programmed by the BWB for the near future, and we have considered these problems as a continuing liability rather than as arrears of maintenance since this level of expenditure is likely to continue or increase in the future as the structures grow older and the need for civil engineering works becomes more pressing. Where we have found that major structural work is required on an element of the system, we have assessed the cost using general civil engineering rates (for March 1974) rather than the unit costs assessed for the waterways system, since this kind of work would probably be let to outside contractors by competitive tender.

12.3.12 So far as vegetation is concerned, in general we have regarded anything over two years' growth as arrears, while anything less than this can be dealt with under normal maintenance. Certain operations, like layering of the hedges where this is still done, are normally carried out less frequently, and this has been taken into account. Hardcore surfacing to towpaths is only justified in certain circumstances such as at some locations in towns (where the local authority can often be persuaded to contribute towards the cost), or perhaps at amenity and some mooring sites – we have not found the need to recommend it in any new locations.

12.3.13 We had hoped that unit costs of the Tring Scheme (see Chapter 10) might be available to us before going to print since those prices would relate directly to the work of overtaking arrears of maintenance and provide a further yardstick to check our costs against. In the event the analysis and associated management study were not complete and the Board were not able to release firm details.

## 12.4 *Arrears of Maintenance and Continuing Annual Costs*

12.4.1 Before embarking on discussion of the tables at the end of this chapter covering the costs of operating and maintaining the Board's Commercial and Cruising waterways, and the costs of overtaking arrears of maintenance during the next 15 years, we must again emphasize that a number of factors have to be considered before any attempt is made to compare the results of our investigations and those of the BWB 1970 Programme. The degree of comparability between the two surveys is discussed in Section 10.9 and below in Section 12.7.

12.4.2 The works which we have identified as arrears of maintenance reflect the extent to which the average condition of the system as a whole is at present below the standards of Chapter 10. When these arrears have been overtaken the system will be in a state from which it can be serviced by a normal continuing cycle of programmed annual maintenance. It has been put to us that works carried out in the later years will be relatively new at the end of the programme and that some credit should be allowed for this in our accounting calculations. We consider that this could only apply if the condition of the system as a whole were above average at that time – and we are designing to avoid such a situation.

12.4.3 The costs of overtaking the arrears of maintenance which we have identified are summarised in Table 12.1, while continuing annual maintenance and operating costs are given in Table 12.2 and illustrated, in comparison with equivalent costs in recent years, in Fig. 12.2. The totals for the various types of structure and for the 'other items' are also listed individually in Tables 12.3 and 12.4, while future administration costs, budget allowances for specialist services and major outside contracts, together with estimates to cover specific obligations, are repeated in Table 12.5. Items which must be given high priority, mainly from public safety considerations, are mentioned in paragraph 12.4.45.

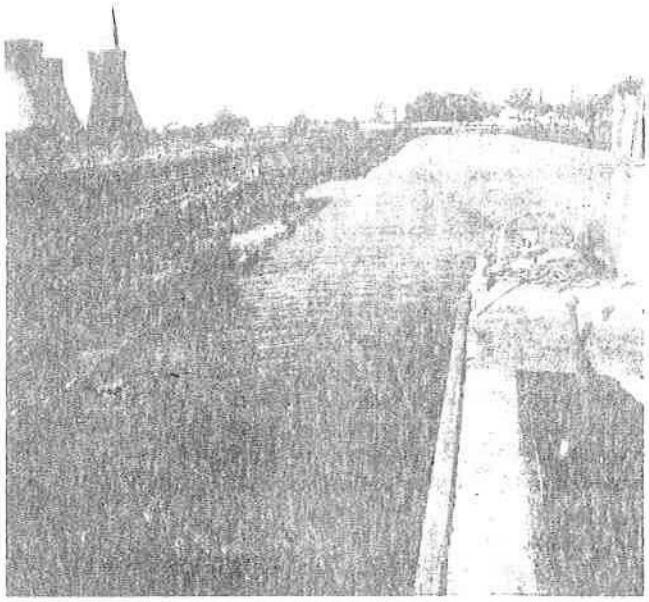
*Bank Protection*

12.4.4 We deal first with arrears and continuing maintenance of bank protection. The combined length of Commercial and Cruising waterways in the system is some 2,290km and we estimate that the net length of banks for which the Board are responsible is 3,600km, or 78% of the total. In arriving at this figure we have subtracted from the overall bank length (4,580km) the stretches, mainly on river navigations, where bank maintenance is not the Board's responsibility as well as the aggregate waterline lengths of structures such as locks, bridges, aqueducts, and tunnels – we have considered these waterwalls as parts of the structures for the purpose of our calculations. Our survey sample indicates that out of this total (3,600km) of banks which could require treatment, approximately 60% are retained by original walling or later protection (i.e 75% of the towpath side and 40% of the offside). At the time of our survey, therefore, the total length of protected banks on Commercial and Cruising waterways was in the order of 2,100km.

12.4.5 From the result of our field surveys and analysis we conclude that, throughout the Commercial and Cruising waterways, some 581km of the existing protected banks contain substantial arrears of maintenance which can be corrected by repair works at an average cost of £3.73 per metre. A further 477km of existing bank protection has deteriorated to such an extent that it should be replaced and 365km of presently unprotected banks are in urgent need of treatment, at a combined average cost of £24.04 per metre. The total cost of carrying out the work recommended under these headings is £M22.403 (included in Table 12.1), and this represents the estimated arrears of maintenance for bank protection (see paragraph 12.3.5).

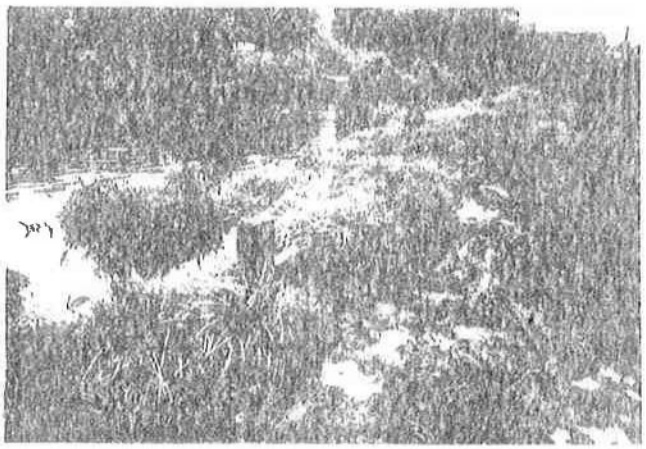
12.4.6 The continuing annual cost of bank protection can be considered broadly under the same three headings. As explained in paragraph 12.3.5, our field assessments were recorded in such a way that we were able to separate present arrears from the workload foreseen over the next 15 years, and after analysing and extrapolating the survey reports in the office we calculated the annual costs under these headings to be (i) regular minor maintenance and repairs to existing protection, including repair of occasional damage due to floodwater, accidental impact etc., £100,000 (ii) replacement of existing protection which is no longer serviceable £315,000: (iii) provision of new piling to unprotected banks when this

*Plate 12.6 Some examples of arrears of maintenance in bank protection*



*a) Failed piling and extensive erosion into an embankment – Sheffield and South Yorkshire Navigation (PFP)*

*(b) A towpath embankment with virtually no freeboard now being re-protected and back filled – Grand Union Canal. (PFP)*



*c) Temporary repair to an offside embankment, only the plank prevents overtopping – Staffordshire and Worcestershire Canal (PFP)*

*d) Advanced erosion of a towpath threatening the foundations of a boundary wall – Sheffield and South Yorkshire Navigation. (PFP)*

*e) An offside embankment with low freeboard, vulnerable to stock damage – Macclesfield Canal. (PFP)*

*f) Support to the toe of this piling on the Aire and Calder Navigation has been undermined, leading to failure. (PFP)*

becomes a necessity, £470,000. These figures, derived in accordance with the assumptions of paragraph 12.3.5, are consistent with an average useful life of the traditional forms of brick and stone walling and concrete piling of 80-100 years, and a notional life of part-galvanised trench sheeting of about 40 years.

12.4.7 If the works we recommend are carried out, then after over-taking arrears the protected banks will increase from the present 60% to 68% of the total. At the end of the 15-year period some 82% or 2,950km of banks will be protected: that is, nearly all of the towpath-side and two-thirds of the offside banks for which the BWB are responsible. After that time the annual expenditure on protection to virgin banks will decrease, but the probable shorter life of piling to be installed from now on will result in a gradual increase in the length of bank to be re-protected each year. We would therefore not expect any substantial reduction in the annual maintenance costs of bank protection at the end of the 15-year programme under consideration.

12.4.8 It will be observed that greater proportions of towpath-side banks than offside banks have been protected and are in need of protection. This is not primarily on account of a need to give support to the towing path itself, but because in many cases the bank on that side is more vulnerable than the offside. Artificial canals do not often follow natural stream courses in the bottoms of valleys but, particularly when climbing to cross a watershed, are located on hillsides or sloping ground. It was the general practice, in constructing a canal on sidelong ground, to form the towing path on the downhill side; not only was the need for a wider bank an advantage in providing more effectively for a waterproof seal, but access was made easier for inspection and maintenance. In these circumstances it is important to maintain the soundness of the towing path side bank, whereas some erosion of the offside bank into the higher ground can usually be tolerated.

12.4.9 It is to be expected that existing works will need regular attention, repair and eventual replacement. Some comments on the necessity to install new piling where there has been none before are, however, relevant. We have noted elsewhere in this report that nearly all of the artificial canals were built for horse-drawn traffic, and it is greatly to the credit of the pioneer engineers responsible that so high a proportion of their originally untreated banks is still in service, particularly since self-powered craft began to appear in numbers as early as the mid-19th century subjecting these banks to turbulence and wash waves for which they were not designed. Viewed in this context it is to some extent surprising that only 75% of the towpath side and 40% of the offside banks are at present protected. These proportions will be 85% and 50%, respectively, when the estimated arrears of maintenance are overtaken.

12.4.10 Quite apart from the banks which should now be, or should already have been, protected, there remain 1135km of untreated bank for which the Board are responsible, much of it eroding or disintegrating to some degree. The great majority of this is on Cruising waterways, where traffic has almost doubled in the last five years. Our field teams recorded signs of recent erosion on many of these banks, and it was confirmed to us in discussions with the Board's officers that the increasing rate at which this is taking place reflects this recent increase in usage by pleasure craft. We have borne this in mind in making our assessments of the work-load for the next 15 years, for which purpose we have also assumed that traffic will remain constant at present levels. We estimate that some 470km of the remaining untreated banks will reach the point of deterioration where an artificial revetment will be required at some time during that period. The effects of increased and decreased traffic levels are discussed separately, in Chapters 13 and 14 respectively.

12.4.11 There are a number of significant differences between the work, and cost, involved in maintaining Commercial as opposed to Cruising waterways springing from the increased size of craft for which the Commercial waterways were constructed or have been enlarged and the fact that these are mostly, and include all of, the major river navigations. The discussion of bank protection arrears and future maintenance costs in the preceding paragraphs has centred on aspects of the system as a whole, and we shall now consider the two categories further in some detail with general descriptions of the work required. The total maintenance and operating costs for bank protection are shown divided between Commercial and Cruising waterways in Table 12.1.

12.4.12 For Commercial waterways we estimate that out of the total net length of banks (525km) some 38% must be treated in order to overcome the arrears of maintenance, of which 21% (110km) require piling or other suitable form of artificial revetment, and 17% (90km) are at present capable of being repaired. Compared with Cruising waterways there is relatively little trench sheeting installed, so that the cost of capping with concrete when corrosion becomes advanced is not a significant part of the total. Including this,the overall average cost of repair work is £5.29 per metre, varying between £2 and £8 per metre for different canals depending on the form and extent of deterioration. The largest single item in the repair category is the renewal of most of the toe-boarding at channel bed level which supports the stone pitched banks of the Caledonian Canal generally between Laggan and Fort Augustus. We also found that as much as a fifth of the Aire and Calder and of the Calder and Hebble Navigations' net bank length was protected with waterwalls which are in need of repair, mainly attention to brickwork, masonry and dry-stone constructions.

12.4.13 The total cost of new or replacement protection to Commercial waterways is calculated as £3,891,000. Of this total 61% relates to waterways in the Castleford Area, which make up 43% of the net Commercial bank length. The Aire and Calder and Sheffield and South Yorkshire Navigations each account for just over a million pounds, and the average unit cost for these is around £34 per metre, which reflects the need for a significant percentage of piling longer than 2.5m: furthermore this is the case throughout the Commercial waterways. The results from our survey lengths on the Weaver Navigation indicate that piling costs there will amount to over £600,000, mainly on the busy Northwich-Weston Point section where siltation and natural changes in the river bed profile necessitate regular dredging of the order of 255,000 tonnes per year. On the Severn and Trent Navigations the Board are only responsible for banks on approaches to locks and in short lengths of artificial cut, where high flood water levels and relatively deep dredging contribute to the need for deep piling – priced at £110 per metre in some cases. Our calculations show that the cost of overtaking all arrears of bank protection on Commercial waterways (excepting the Severn and Trent Navigations) varies between £2,500 per net kilometre of bank for the New Junction Canal and £13,150 on the Sheffield and South Yorkshire Navigation, where 48% of the banks on our survey lengths require attention. The highest proportion of banks we found in need of treatment on any one Commercial Waterway was 65%, on the lower reaches of the Calder and Hebble Navigation.

12.4.14 The Cruising waterways contain 85% of the net length of banks of both Commercial and Cruising categories. Our calculations show that arrears of maintenance on these 3,070km of banks are such that 40% require attention, of which 24% (732km) should have new protection installed, while 16% (491km) have waterwalls which are in urgent need of repair. Details of the requirements under these headings for each Area are given in Table 12.6. The total cost of this work is £18,034,000 of which new protection accounts for just over 90%. The average cost per kilometre of net bank length for the Cruising waterways is £5,870, (compared with £8,320 for the Commercial), average costs per metre of repair work being £3.44 (compared with £5.29), and of new protection £22.34 (as against £35.35). These figures reflect two general differences between the two categories, firstly that the Commercial waterways have been marginally better maintained in recent years – this is to be expected since traffic on Cruising waterways had dwindled until pleasure boating began to multiply in the late 1960's – and secondly that the scale of protection works is larger for Commercial waterways, due to greater depths of water at the channel sides in many places. There are no major variations in the pattern of works involved or the costs of overtaking the arrears across the several Areas, though a number of instances of particularly high or low cost are noted in the following paragraphs where we discuss the work under the separate headings of repair and new protection.

12.4.15 We consider first the bank protection which we have recommended for repair works – which we expect to prolong its working life for at least fifteen years before major treatment is required. The total expense of this work is small beside that of new piling – two fifths of the arrears bank length being treated for one tenth of the total cost for the Cruising network – but it must be carried out relatively soon or the accelerating rate of decay will increase the work of restoration to the point where replacement piling will be required instead. We have mentioned (in paragraph 10.4.19) that the trench sheeting installed by the BWB to date is not expected to remain serviceable until the end of the 15-year programme, and we have included for casting a concrete cap on this estimated 210km of piling, the cost of this work being £850,000.

12.4.16 In four Areas the lengths of bank needing repair came to 19% or more of the net totals. We found substantial lengths of protection on the Coventry and the Trent and Mersey Canals in the Northwich Area, and on the Rivers Soar and Trent and the Fossdyke Navigations in the Nottingham Area to be capable of restoration at average rates between £3 and £4 per metre. In the Castleford Area the cruising part of the Calder and Hebble Navigation and the Huddersfield Broad Canal have been noticeably less thoroughly maintained than the Commercial Navigations, though much of the damage can still be repaired. It is however the canals of the Birmingham Area which are the most consistently troublesome in this respect. On our survey samples of six canals, representing half of the net bank length in this Area, over 25% of the banks were protected with brick, masonry or dry-stone walls which were in poor condition but at present capable of repair.

12.4.17 The cost of installation of the recommended new protection to Cruising waterways under the heading of arrears is £16,345,000. The Birmingham and Northwich Areas account for 63% of this, the average cost per metre being £26.12 in the Birmingham Area – relatively high because deep piling is called for in several places on the Grand Union Canal and the Oxford Canal (North), and £21.08 in the Northwich Area, where the Macclesfield Canal and parts of the Staffordshire and Worcestershire Canal are more expensive than the others in this respect. On five canals in the Birmingham Areas, namely the Grand Union Canal Main Line, Stratford-on-Avon, Ashby, Oxford (North) and Staffordshire & Worcestershire Canals, we found that an average of 37% of the net bank length required new piling, accounting for 65% of the Area cost under this heading while comprising only 46% of the Area net bank length. It is also worthy of note that we recommend virtually no new protection to the 61km of banks on the BCN Main Lines, though four fifths of our surveyed lengths need some repair work carrying out. The £1,940,000 to be spent on new protection in the Wigan Area is almost entirely made up of 1.5m and 1.8m part-galvanised trench sheeting, with some timber post-and-planking in less vulnerable situations. Our surveys indicated that nearly two fifths (50km) of the Lancaster Canal banks and one sixth (65km) of the Leeds and Liverpool Canal banks need new piling. In the Nottingham Area piling works on the Trent and Mersey Canal and the River Soar Navigation account for 70% of the expenditure on piling, while in the London Area the Oxford Canal (South) is high in this cost at almost £5,000 per kilometre of net bank length. The highest average unit cost for new protection obtains in the Castleford Area, which also shows the highest proportions of both repair and replacement requirements. It is possible that our survey lengths were not fairly representative of the short net length of banks on Cruising waterways in this Area, particularly as they contain two of the 'high priority arrears' lengths quoted in paragraph 12.4.42. With a sampling survey it is to be expected that individual typical results will assume undue prominence within the length, or to a lessor extent the Area, in which they occur – it is only in overall results that a reliable balance can be reached.

*Plate 12.7 Extensive erosion following failure of dry-stone walling on the towpath side – Shropshire Union Canal (PFP)*

12.4.18 The kinds of jobs involved in redressing ghe arrears situation are similar throughout the system, and it is because of this that our discussion above has been of the extent, rather than the description, of the work. The *new protection* allowed for in our estimates is made up largely of part-galvanised trench sheeting (described in Section 10.4), with some lengths of longer steel sheet piling in special circumstances and occasional lengths of stone pitching, timber post and planks etc, where appropriate to local custom and conditions. The *repair* work naturally depends on the form of the existing construction, and consists typically of:–

a) pointing and renewing patches of brick and masonry walling, particularly at water level

b) rebuilding parts of dry-stone walls, or filling gaps with concrete bagwork, in-situ mass concrete etc.

c) casting a concrete cope to counteract settlement or renew dilapidated top courses and restore continuity of the structure

d) casting a concrete cap on existing trench sheeting (see paragraph 10.4.20)

e) providing or renewing walings and anchors with tie bars where necessary.

Although we have not given specific examples of the bank protection work required to overtake arrears of maintenance, the several photographs accompanying this section of the chapter have been chosen as typical of present conditions and it is hoped that they will aid comprehension of the written descriptions.

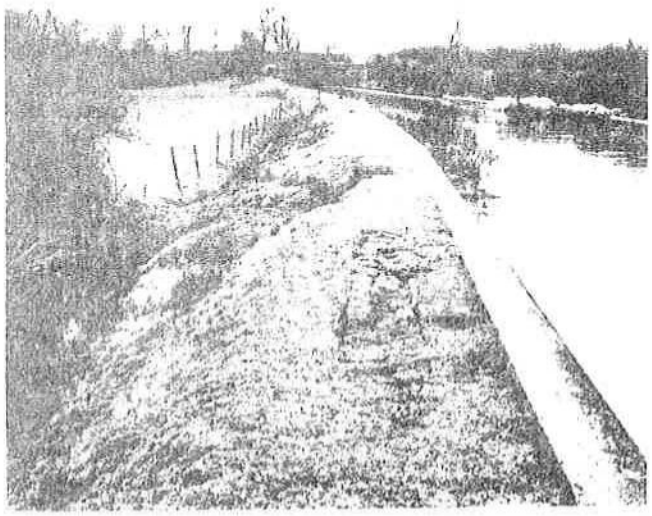


*Plate 12.8 This embankment on the Grand Union Canal has a history of persistent leakage problems (PFP)*

*Dredging*

12.4.19 In the case of dredging, the arrears of maintenance were obtained directly from our survey results and extrapolated by simple proportion for the whole system. The future annual costs of dredging on a regular basis were assessed with the help of estimates prepared by the Board for this purpose in 1970. At present over half of the total annual cost relates to the major Commercial river navigations, and regular clearance of silt and debris carried by storm water throughout the system accounts for a further considerable part. Even if the required extra dredging to accommodate the statutory craft dimensional standards is not carried out until later in the programme the removal of local accumulations of silt to afford passage to the majority of cruising craft must continue in the meantime.

12.4.20 The practice which the Board have necessarily had to adopt in recent years is inefficient in that it involves an abnormally high proportion of local 'high spot' dredging and the average cost per tonne for this is of the order of twice that for continuous 'through' dredging of a reasonable length of waterway. In the future, when regular restitution of the full waterway profile is on a programmed basis, dredging productivity will be higher and we estimate that with appropriate plant the increased annual quantity will be handled at approximately the same cost, in real terms, as in 1974. We also expect the use of land-based plant to increase considerably within the limited lengths where it is applicable, and have made an appropriate allowance for this in our calculations.

12.4.21 The estimated present arrears of dredging on Commercial and Cruising waterways total some 3,735,000 tonnes, and the removal and disposal of these will cost £3,520,000. The Commercial waterways account for £1,175,000 of this at an average cost of £2,200 per km, while the average cost per km of Cruising waterways is £1,350. Where we found that the quantity to be removed was sensibly constant throughout our survey lengths we have applied the unit cost for "through" dredging to the extrapolated total tonnage. When there was significant variation between successive measured profiles, however, we have applied the higher "spot" dredging rate (see paragraph 12.3.3) for removing local accumulations of silt. We found that dredging operations at this higher rate accounted for 41% and 59% of the total costs for Commercial and Cruising waterways respectively. We have borne in mind the possibility of using land-based dredging plant in some places on Cruising waterways (see paragraph 10.4.6) but the overall effect on the cost of overtaking the present arrears is marginal because of the additional cost of making access for the machine the first time this method is used. The main benefit of extending this practice to more of the suitable locations has been allowed in our calculations for the cost of continuing future maintenance.

12.4.22 For Commercial waterways nearly 90% of the total cost of overtaking dredging arrears arises from the Gloucester, Northwich and Castleford Areas. The relatively large quantities of material that we find need to be removed from the Weaver Navigation and at the Rotherham end of the Sheffield and South Yorkshire Navigation each lead to costs exceeding £7,000 per km, while the Doncaster to Bramwith length of the latter, together with the Wakefield to Castleford and the Knottingley to Selby lengths of the Aire and Calder Navigation were costed at over £3,000 per km. A similar cost liability was found to exist also on the Gloucester and Sharpness Canal where it is known that pumping from the River Severn at Gloucester has in the past brought in large quantities of silt. Pumping operations have in recent years, however, been monitored and controlled with a view to minimising siltation problems. Dredging requirements were particularly low, on the other hand, in Scotland and the Nottingham Area.

12.4.23 The arrears of dredging on Cruising waterways were found to be more evenly distributed than for the Commercial waterways. The average cost per km is within 20% of the overall figure (£1.350) in four Areas, the exceptions to this being the Wigan Area (£2,200) and the Gloucester and Northwich Areas (less than £700). Within the Areas also the costs are appreciably uniform. It was only on three of our survey lengths that the cost exceeded £3,000 per km, these being on the eastern, broad gauge, length of the Trent and Mersey Canal, the River Soar Navigation and the northern part of the Birmingham and Fazeley Canal. Relatively low results were obtained on several canals throughout the system, but mostly in the Northwich Area where the individual canal costs were all around £600 per km except for the Llangollen Branch of the Shropshire Union Canal. In spite of the recommended dredged depth of only 1050mm on this latter waterway (see paragraph 10.3.15), our calculations showed that some £110,000 will need to be spent on dredging work.

12.4.24 The average cost of overtaking dredging arrears on broad-gauge Cruising waterways is just over £1,700 per km, while on narrow-gauge canals it is only £1,100 per km. This difference is due in part to the greater width of dredged channel in the first case, but it also reflects the relatively small number of 'broad' craft using these waterways, whether for cruising or commercial purposes. Silt has been allowed to accumulate at the sides of 'broad' channel beds in recent years because this has not inconvenienced many users and the Board's limited resources have been diverted to other, higher priority, works.

*Structures*

12.4.25 Maintenance liabilities for the various types of structures are summarised individually in Table 12.3. These costs include normal maintenance and the structural repairs noted to be necessary by our field teams in their survey reports: in some cases we have made additional provision to cover work which could not be predicted directly from visual inspections -- these are also given mention in the following paragraphs.

12.4.26 The main unpredictable cost for lock chambers is that of grouting cavities behind the walls when lack of pointing has allowed the water to wash out material, causing leaks and in some cases instability of the wall. It is usually possible to see when this problem exists by observing water runs on filling and then emptying the lock, but the cost of treatment depends largely on the volume of the hidden cavities to be filled. The amount of money involved is relatively small, and we have included an allowance which we consider appropriate.

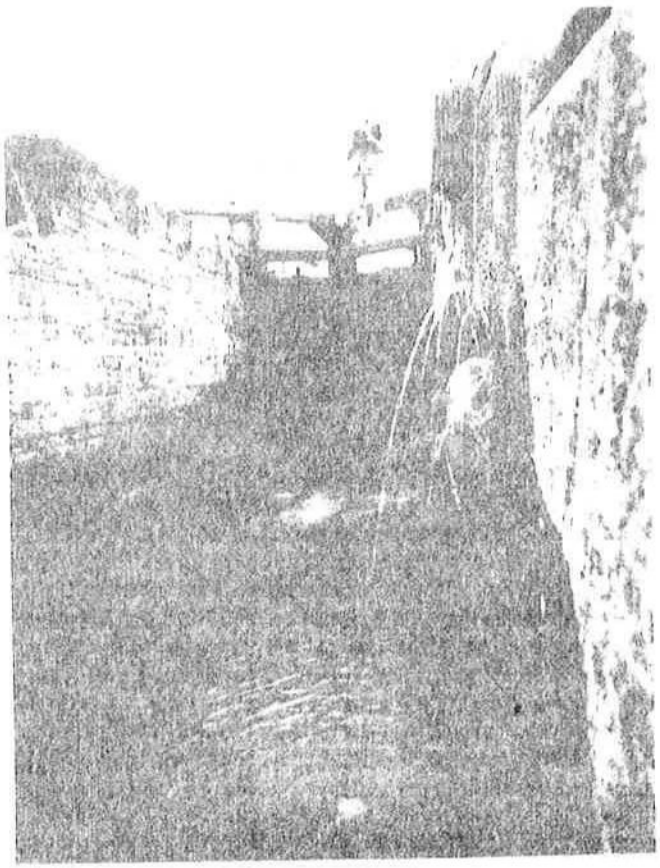


*Plate 12.9 Water pouring out from cavities behind a lock chamber wall -- Llangollen Branch of the Shropshire Union Canal (PFP)*

12.4.27 Arrears of work on lock gates have been costed by linear extrapolation of work noted on our survey reports. Future maintenance and gate renewal programmes were assessed with operational life expectancy and previous experience in mind. We have included for replacement of around 60 pairs of lock gates a year, as well as on-site repairs and renewals of fendering, this last being a significant item only on the more active Commercial waterways. We do not consider that an accelerated programme of installation of hydraulic or other easily operated paddle gearing is called for, but have allowed for its cost in conjunction with renewals and replacement following high wear and tear in use elsewhere.

12.4.28 The results of our analysis show that for *Commercial waterways* the total cost of arrears on locks is £700,000. The most expensive in this respect is the Caledonian Canal (£255,000) where the major problems are cavities behind chamber walls leading to instability, and poor condition of the gates throughout. On the Weaver Navigation, the 100 year old water-powered lock operating machinery is in need of modernisation and attention, and this contributes the major part of the total £95,000 against the waterway. For *Cruising waterways* the equivalent total cost is £1.87M. Here the locks are generally less massive structures, and this is reflected in the average of £2,000 per lock as compared with £4,900 for the Commercial locks. The only outstandingly large figure in this total is £80,000 -- the BWB estimate for reconstructing Ham Mills lock on the Kennet and Avon Canal. Otherwise the costs arise more or less evenly throughout the system, though it is worth noting that Area totals exceed £200,000 for work on chambers in the Birmingham Area, and on gates in the Northwich, Birmingham and London Areas.

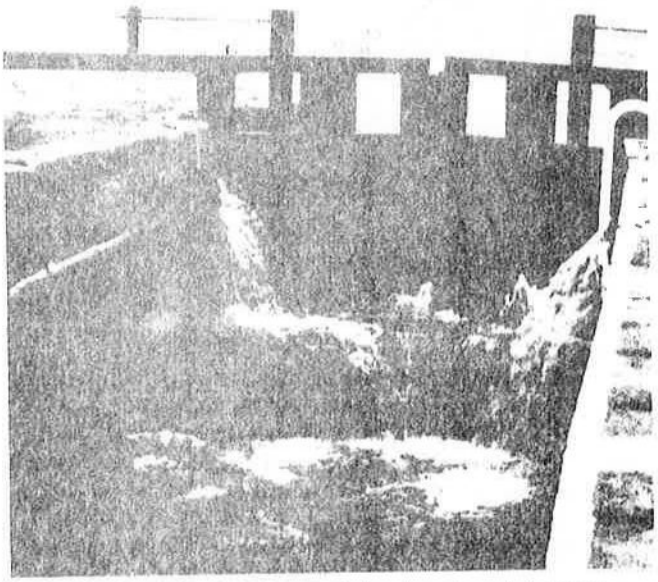


*Plate 12.10 Leakage between gate heel posts and chamber quoins, etc, -- Leeds and Liverpool Canal (PFP)*

12.4.29 We have said in Chapter 10 that stop-planks should be kept on site in critical locations -- where the ground formation, local development and length of pound make it important to minimise the escape of water (typically from public liability or water supply considerations) in the event of a breach. Increased vandalism in recent years has prompted the BWB to remove many sets of planks to section yards. We consider that in a number of these instances secure shelters should be constructed on site instead -- and have priced for them accordingly.

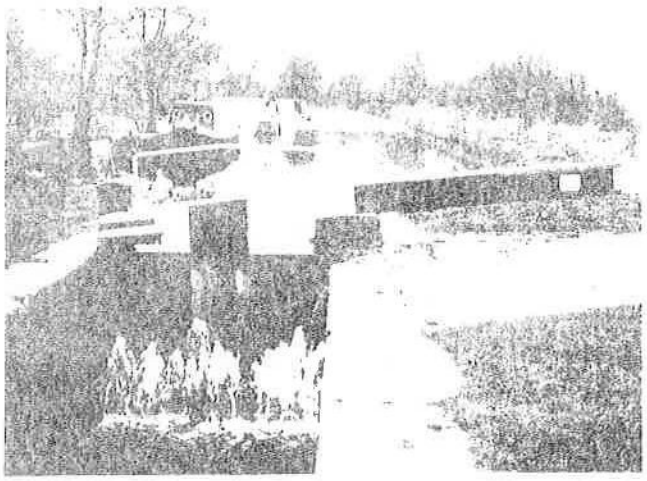


*Plate 12.11 Leakage at a top gate sill -- Trent and Mersey Canal (PFP)*

12.4.30 Storm sluices in the beds of artificial canals could not be inspected by the field teams though the Section Inspectors usually know if they are in working order as a number of them are vital to water control after heavy rain. An estimate of the work required on these has been calculated from experience with similar structures elsewhere. Leakage at canal overflow weirs would likewise not have been visible when water was passing over the crests but no extra has been included for work on these as the cost would not be of much overall consequence.

12.4.31 The condition of river weirs and dams is particularly difficult to assess without comprehensive individual surveys. In most cases remedial works must be carried out when flow conditions will allow, and if attention to the by-pass sluice or the toe of the weir is required the cost of dewatering without undue interruption of the river regime can be a significant part of the whole. The totals in Table 12.3 include for repairs to dam and weir crests and some structural works such as local stone-pitching to counteract a tendency to scour or replacement of seized sluice gear etc., but major repairs are discussed in Section 12.5 with other 'special problems', and their costs included in the budget estimates of Table 12.5.

12.4.32 During the past five years, over 30% of the major breaches and emergencies within the BWB system have been attributed in some measure to failures in culverts. Some of the special problems and difficulties relating to culverts have been mentioned in Section 10.6, and in some areas it is known that many of them need replacing. There are, for example, a number of timber culverts in the Wigan Area, and much of the lime mortar with which the masonry ones were built has disintegrated; a programme of replacement is under way here, and we agree its necessity and have included for the cost. It is largely because of this special item that the Wigan Area arrears total for culverts is £370,000 – over half of the total for the system. The statistics do not show how many breaches have been averted by timely works on culverts following on routine inspections, but the actual failures are relatively few and we consider that when the manpower and organisation called for in Chapter 11 are available the improved regular inspections will ensure that these contingencies are minimised. We have not, therefore, recommended a major programme of assessment of culverts – though if the incidence of unsuspected problems were to increase this might become advisable.

12.4.33 The Bridgeguard programme of checking, strengthening and replacing public road bridges has been discussed in Section 10.6. There was no 'Bridges Section' as such before operation Bridgeguard commenced in 1970, but the Board have recently decided, in view of their continuing responsibility under Section 117 of the Transport Act 1968, to extend the remit of the Principal Bridge Engineer beyond the present re-assessment programme. Our costs in Table 12.3 do not include any allowance for this, but it is to be found in Table 12.5 where we suggest that special provision is made within the Board's income on a regular basis, as is now done to cover statutory responsibility under the Reservoirs Acts. On the basis that 12 bridges might require major work per year the Board have estimated annual continuing maintenance costs at up to £750,000, and we have adopted this figure for present purposes.

12.4.34 The cost of overtaking arrears of maintenance on accommodation bridges, as discussed in Section 10.6, cannot be estimated with confidence until the tasks of defining loading and checking capacity have been carried out. We have, with past experience and relevant aspects of the Bridgeguard programme in mind, made broad estimates of the cost of bringing the bridges to their required strength (included in the Table 12.3 total) and of future maintenance costs to the standards which are to be clarified (included in Table 12.5). The remaining £595,000 of the Table 12.3 arrears total covers the deficiencies noted by our field teams. Some two thirds of the bridges we inspected required at least superficial attention, a considerable number betrayed signs of structural movement, and several were clearly not in a suitable condition to bear any substantial traffic. The level of maintenance was naturally higher in urban environments, but even here there was a clear need for assessment by qualified engineering staff on a regular basis. Among the problems associated with the Board's responsibility for these bridges is the difficulty of apprehending those who overload them – it seems that the offending vehicle must be caught in the act of crossing the bridge to be sure of a successful prosecution. The same difficulty is experienced with restricted public road bridges.

*Plate 12.12 Derelict accommodation bridge -- Oxford Canal (South) (PFP)*

12.4.35 Several of the Board's major aqueducts have been the subject of recent investigation by independent Consultants, and costs of remedial works have been estimated in some cases. Examples of these are quoted in Section 12.5, and provision for future works of this magnitude is made in Table 12.5. In a number of other instances we considered, after discussion with BWB staff, that a full maintenance survey

including dewatering was overdue as the cause of leakage was not evident, making it difficult to estimate the extent of work required; we have made an allowance to cover such contingencies within the totals of Table 12.3. The more superficial defects, such as a need for pointing or patchwork repairs of masonry, ineffective protective fendering, growth of vegetation, damaged approach walls, etc. amounted to £75,000 in the Northwich Area, and over £100,000 in the Wigan Area (average costs of £1,100 and £1,300 per aqueduct respectively). In contrast it would appear from our sample of the aqueducts in the Birmingham Area that these are in somewhat better condition, the average cost of arrears works being only £300. The cost of overtaking such superficial arrears on the Commercial waterway aqueducts inspected amounted to only a few thousand pounds – but these structures are relatively few in number because the waterways are mostly natural river navigations, or artificial cuts close to the valley floor.

12.4.36 There are 36 tunnels in the Cruising system (none on Commercial waterways), varying in length from only a few metres to more than 2.5km in three cases (Netherton, Harecastle and Blisworth). The Harecastle tunnel on the Trent and Mersey Canal has been closed for repairs since late 1973, and the work is not yet complete (see Table 12.9). The Foulridge tunnel on the Leeds and Liverpool Canal is in need of major attention, and this is also discussed among the special items of section 12.5. The sum of £190,000 for arrears of maintenance in Table 12.3 is calculated from our field observations of visual defects, typically pointing to brickwork and masonry in the 'splash zone', and replacing single bricks or localised patches which have disintegrated. Half this cost arises in the Birmingham Area which contains a total of 21 tunnels including Netherton which, at 2.77km, is the longest on any Cruising canal.

12.4.37 It is generally true with all of these types of structure that ordinary maintenance works are relatively cheap, but if deterioration is allowed to continue until a significant degree of reconstruction becomes necessary the cost of this is quite out of proportion. It would take only one percent of the locks, perhaps five or six aqueducts and about 200m of lined tunnel needing rebuilding to make up the total arrears under these headings in Table 12.3 – and only one or two of each to absorb the whole of the projected future annual costs. We have of course based these future costs on the assumption that necessary works will be carried out in good time so that such instances of collapse will be rare.

*Other items*

12.4.38 Table 12.4 summarises the arrears and projected future expenditure under the remaining maintenance headings, including administration costs for the arrears programme. Departmental Administration and Area and Section costs for operation and continuing maintenance are shown separately in Table 12.5. Some explanatory observations on the Table 12.4 totals are made in the following paragraphs.

12.4.39 Reservoir enlargement schemes are not considered as maintenance works for the purposes of this chapter (see also paragraph 9.6.9), but will be dealt with in Chapter 13 – Growth of Traffic. We have not included for any dredging of accumulated silt to be carried out in reservoirs as other methods of restoring or increasing storage, such as raising headbanks, are almost invariably more cost-effective. Financial provision for works required by the inspecting engineers appointed under the Reservoirs Acts is made in a special fund, and a notional estimate of the annual allocation which will be required is entered in Table 12.5. The works comprising the arrears total in Table 12.4 are minor attentions to structures such as outfalls and clearance of vegetation to facilitate proper inspection of headbanks, etc.

*Plate 12.13 Heavy weed growth on the Chesterfield (Remainder) Canal which is a feeder to the Cruising length. (PFP)*

12.4.40 Arrears of maintenance on 'agricultural' works, such as ditches, feeders, boundaries, and clearance of vegetation present no problems of definition. These are all elements of the system which should be inspected and repaired piecemeal at frequent intervals, so that blocked ditches, overgrown hedges (more than 2 years' growth), etc. have been costed, extrapolated and included in Table 12.4 as arrears to be overtaken. The cost of dealing with hedges and fences which are no longer stock-proof, broken down boundary walls etc., is seen from Table 12.4 to amount to almost £600,000. The Commercial waterways account for one sixth of this, which is in proportion to their length when the stretches of natural rivers where the Board have no boundary responsibilities are taken into account. For Cruising canals 80% of the total arises in the Birmingham Northwich and Wigan Areas – and in the latter case the average cost is almost £500 per km. Elsewhere our survey indicates much lower costs, indeed in the Gloucester and London Areas there was little that could not be corrected under normal maintenance. The field teams did not record every item that was due for attention as under a programmed maintenance regime it is not necessary to complete an item of work immediately it becomes due as long as there are no appreciable arrears at the end of the maintenance cycle. The costs of future maintenance, after overtaking arrears, were calculated partly with the aid of figures estimated for this purpose in 1970, and from experience of similar works and BWB records.

12.4.41 Towpaths are, for the most part, in reasonable condition and many lengths are adequate for both maintenance access and general purposes. We have, however, found a considerable number of examples of badly eroded and even impassable towpaths, and most of these are instances of arrears of maintenance. When bank protection is installed at an eroded section granular backfilling material used in restoring the towpath level forms an adequate surface for most situations so that no further expenditure is required. In other places continuing attention is necessary to ensure that the standards set out in Chapter 10 are maintained.

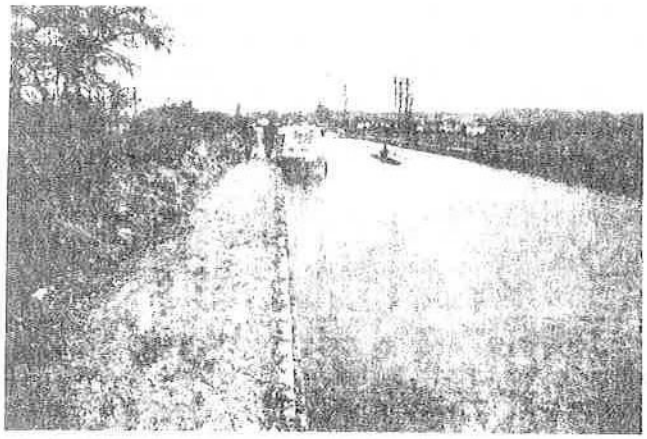


*Plate 12.14 Towpath surface formed by granular back-fill material at a linear mooring site on the Grand Union Canal. (PFP)*

12.4.42 The arrears total under the heading 'operational property equipment' is made up from requirements for repair yards and workshops (30%), and residential property (70%). Inspections of repair yards and plant units showed that there were in general adequate facilities for the anticipated continuing workload – but that a certain number of tools and machines were no longer economical or effective and should be replaced. We have assessed the immediate capital requirements for replacing obsolete operational equipment such as dredgers, pumps etc. in the order of £600,000. No allowance is made for this as a capital sum in the arrears figures, however, as it will be depreciated over the life of the equipment in the normal way. The works detailed for residential property are almost exclusively concerned with the provision of such 'normal' conveniences as inside toilets, septic tanks, hot water and bathrooms, as well as damp proofing and other local building regulation requirements. These amount to some £440,000 across the country, costs being particularly high in Scotland, where the BWB estimate that £170,000 needs to be spent. In Birmingham and most of the other Areas we have, after selected checks and discussions with Area Engineers, adopted the estimates included in the BWB 1970 Survey with corrections to allow for work carried out in the intervening years and with costs indexed to March 1974.

12.4.43 The costs of planning, administering and supervising the work of overtaking arrears of maintenance will depend on several factors which we cannot evaluate accurately as they are for the Board to decide. For example the programme of assessing the actual arrears throughout the whole system at the time when the money needed to overtake them is available, the proportion of works to be carried out by outside contract, the exact numbers and levels of extra staff required for this work, etc. all affect these overheads to some extent. We have made a broad estimate (in Table 12.4) of the cost of servicing the chosen programme of works based on the Board's experience in recent years but with allowances for the different nature of this task and the parallel existence of the Board's continuing maintenance organisation. We cannot see where in Appendix 10B of the Board's outline corporate plan their equivalent allowance is made, though it is mentioned in their Appendix 2. The level of expenditure on Area and Section costs is expected to be somewhat higher, in real terms, after the arrears are overtaken then it has been for the last few years. The figures in Table 12.5 have been calculated to include allowance for the staffing levels recommended in Chapter 11. This general heading of Area and Section Costs also covers certain other overheads, such as transport, telephone systems, etc.

12.4.44 Table 12.5 also lists the budget allowances for special items on a continuing annual cost basis. The figures for specialist services, major works, and breaches and other emergencies are derived in Section 12.5, while the liability due to mining operations stems from Chapter 7. The remaining items have been discussed in the preceding paragraphs.

12.4.45 The Board take particular care to identify works with implications of danger to public safety or serious consequences to the waterway itself, and give them high priority in their annual programmes. Even under a regime so closely approaching breakdown maintenance as has been adopted in recent years, the most serious of these are dealt with before failure occurs; however, our field inspections did reveal a number of situations which had not been rectified, though they were generally in hand. We estimate that, over the system as a whole, the works amount to £2,750,000 in value. Some 80% of this total is comprised of bank protection requirements, and we have arrived at this by summing all the critical works recorded in our survey lengths and multiplying by a factor to allow for the lengths not visited; the following four illustrative examples are representative:–

a) On the Calder and Hebble Navigation above Salterhebble Locks, the offside is in cutting below a public road and housing development; considerable erosion has resulted in a potentially dangerous situation and piling to the toe of this cut with backfilling behind is recommended. The affected length is 750m and estimated cost £23,000.

b) The towpath-side embankment nearly opposite (a) has a history of leakage, and we observed running seepage in several places. The embankment is up to 10m high above light industrial premises and housing. A recent serious leak was cured with deep piling, and we think that a further 200m of 5m piling might be found necessary on full investigation. Cost estimate £13,000.

c) The Llangollen Branch of the Shrophshire Union Canal near Whitehead bridge requires piling where the offside embankment has slipped and in a number of places where slips are probable in the future. Estimated cost £17,600.

d) Existing sheet piling has been undercut by deeper dredging and scour from craft on the Aire & Calder Navigation near Rawcliffe until its toe is clear of the canal bed and erosion of the embankment is taking place at a low level. BWB are investigating the overall extent of this, but some 1000m of one of our survey lengths was affected (where the canal is above agricultural land, commercial premises etc.), and new piling about 4m long will be required. Cost for 1000m say £55,000.

12.4.46 The remaining 20% of the 'high priority arrears' cost falls under two headings:--

(i) Some are taken from recommendations of consulting engineers called in to examine certain structures, e.g. New Junction Canal Aqueducts £70,000, and Pontcysyllte Aqueduct £70,000. Costs of such items have not been extrapolated, though there probably are presently undiscovered problems of this nature elsewhere.

(ii) The remainder is made up by many minor works springing from the safety considerations of paragraph 10.8.9. such as safety chains in deep locks, repairs to walkways across lock gates etc. (examples are Norwood Upper Lock near Brentford; Kingshead No. 3, Blockhouse No. 4 and Worcester and Birmingham Locks 50-58). Works in this category total £65,000.

12.4.47 In addition to this, we consider that full investigations are called for in many instances where distress symptoms are evident, and that these should be carried out as a matter of urgency so that the seriousness of each situation is known. For example a considerable part of the recommended programme of assessment of accommodation bridges (see Section 10.6) is most urgent and there are a number of aqueducts, tunnels, locks and culverts with signs of recent movement which are being watched, but which must each undergo thorough engineering appraisal to establish the exact need and priority for action. The costs of this immediate investigation work, together with those of the major surveys listed and discussed in Section 12.5, are expected to be of the order of £250,000.

12.4.48 Under the Terms of Reference paragraph 13(b) we are required to re-cost, at March 1974 rates, the works needed to overcome the arrears of maintenance identified by the BWB in their 1970 Survey. This exercise has been carried out and a summary of the totals is given in Table 12.7. Our equivalent totals are shown alongside these, though it must be remembered that the BWB arrears figures are not directly comparable with our own results, for reasons discussed in Sections 10.9 and 12.6.

12.4.49 Thus far our review of the arrears of maintenance has been directed to conditions on the BWB system as a whole, with some discussion of particular situations and references to items of special importance by way of illustration. The results are summarised in Table 12.1, where we show the total of £37.6 M broken down under four main headings for each BWB Area, with separate subtotals for the Commercial and Cruising waterways.

12.4.50 As explained in Section 12.2 these figures are derived from the results of our field survey inspections, extrapolated in accordance with the sampling procedure employed, and provide sufficiently reliable estimates of costs for each Area as well as for the totals in the two categories. A further breakdown to individual waterways, using the same four main works headings, may be of value in helping to identify those calling for particularly high or low levels of expenditure.

12.4.51 We have compiled Tables 12.8 and 12.9 for this purpose, covering the Commercial and Cruising waterways respectively, but excluding general administration costs in each case. We have not rounded off the figures (as we have done in Table 12.1) but it will be understood that they must be used with caution; without more detailed checks than were possible with our sampling inspections these results cannot be regarded with the same order of confidence as those of Table 12.1. For example relatively expensive items of arrears of maintenance encountered on a short inspection length produce disproportionately high figures for the particular waterway in isolation, as exemplified in paragraph 12.4.45.

12.4.52 We are confident that the average cost of overtaking the arrears of maintenance identified on all of our detailed survey lengths throughout the system is sufficiently close to the actual average for the whole system. The results from the small number of survey lengths on any individual waterway cannot, however, be expected to reflect the total costs for that waterway with the same accuracy. Nevertheless we put forward these estimates as being reasonably representative of the total costs for the arrears on individual waterways and as providing at least a first indication of the relative apportionment of the totals set out in Table 12.1.

## 12.5 *Special Problems*

12.5.1 We discuss in this section the provision which needs to be made in future annual budgets for non-recurring major maintenance items on the Board's Commercial and Cruising waterways. The works are divided into two distinct categories (i) extensive repairs to or strengthening of particular structures (some of which have been described in Section 6.5), including the cost of specialist services outside the normal capacity of the Board's organisation, and (ii) the incidence of breaches, water losses and other emergencies that can occur virtually anywhere on the canal system. Our assessments under these headings are included in Table 12.5 and carried through into the totals of Table 12.2.

12.5.2 The works under (i), although primarily concerned with specific structures such as tunnels, aqueducts and embankments, take into account two more general problems which have been noted during the course of our field work as being of particular significance, but whose occurrence is not distributed throughout the system. They concern firstly river weirs in general, whose condition is impossible to assess from a superficial survey, and secondly the particular problems associated with the Trent Navigation locks and weirs. The marl on which these are founded becomes friable after continued scour over a number of years and leaches out from under the mass concrete construction undermining the structures; maintenance of these calls for extensive engineering works.

12.5.3 Since the scope of this study does not encompass the detailed investigations required to quantify the major works under this heading, our assessment in these cases is based on one of the following:—

a) An examination of the Board's engineering returns for works carried out during the period January 1971 to March 1975 inclusive.

b) Estimates prepared by consulting engineers when commissioned by the Board to report on the structural condition of specific structures.

c) Budget figures for works programmed in the current year and estimates, prepared by the Board's engineering staff, for work requiring attention within two or three years.

d) Estimates prepared by ourselves following observations in the field and discussions with the Board's engineers.

12.5.4 The costs incurred for major maintenance items during the period from January 1971 to March 1975 have been extracted from BWB work returns and are shown summarised in Table 12.10.

12.5.5 Table12.11 lists cost estimates for presently outstanding urgent major maintenance works, and it is assumed that these will be carried out during the next three years. From this it is clear that the Board's annual expenditure on such works is going to continue at a rate of the order of £500,000 for the time being (at March 1974 prices).

12.5.6 In addition to the items listed in Table 12.11 we find it necessary to make provision for the investigation of certain constructions noted during the course of our survey work as being potential safety risks. Tentative assessments of the remedies and costs (indexed to March 1974) associated with these problems are derived below:—

a) *Foulridge Tunnell* (Leeds & Liverpool Canal) Twenty significant bulges were observed in the crown of the stone-lined semi-circular arched tunnel. It is recommended that a detailed survey, at a cost of approximately £5,000, should be carried out as a matter of some urgency to establish the remedial treatment required. Although dependent on the survey the cost of making safe the affected 74m length of tunnel could be of the order of £50,000 if rock-bolting and pressure grouting will suffice or as much as £150,000 if cutting out and rebuilding is considered necessary.

b) *Burnley Embankment* (Leeds & Liverpool Canal) It was apparent from our survey that the toe of this embankment, which had been excavated to a height of 4.5m over about one third of its length for mill buildings, suffered some loss of restraint when the cross walls providing support to the back of these buildings were removed at the time when many of them were demolished. It was also noted that remedial grouting measures had been undertaken in one small area where local subsidence, probably caused by movement of the subsoil from old shallow mine workings, had occurred. It is recommended that a detailed investigation of the embankment walls and subsoil should be carried out in order to establish the need for remedial works. We estimate that the soils investigation and bank analysis would cost about £15,000 and that the cost of carrying out the necessary works to include improving the water-tightness of the canal bed might be in the region of £150,000.

c) *Leigh Branch Embankments* (Leeds & Liverpool Canal) As a result of mining subsidence the whole length of this canal, which was originally at ground level on a slight side slope, is now almost entirely on embankment. The embankment, nearly 9m high in parts with 1:1 side slopes, has been raised in colliery waste with a clay core, and the channel bed infilled concurrently. The water walling comprises either cribwork or mass concrete in 0.6m lifts or heavy steel piling with concrete coping. We were advised that this Branch had suffered from continuous leakage problems, and our survey also recorded some doubt as to the stability of the embankment and the possible risk of failure of both the 'Aberfan' type fill material and the subsoil. We therefore recommend that a thorough soils survey and stability analysis of the fill and subsoil be carried out as a matter of some urgency; the cost of this would be about £15,000. Our tentative estimate for curing all leakage and overcoming stability problems by building up shallower embankment slopes is £400,000.

d) *Upper Peak Forest Canal, Bench Construction.* This problem is common to both the lower (Remainder) and upper (Cruising) Peak Forest canals. The following appraisal deals only with the latter, however, since all aspects of Remainder waterways are discussed in Chapter 15. The towpath embankment of this canal, which is built on a steep hillside, is retained by dry-stone walling which is sometimes buttressed by dry-stone laid on the slope without, apparently, any foundations. Our survey observed that in a one-kilometre stretch the natural slope in the soft marl was near to its limit of stability and we recommend that a soils investigation and analysis should be carried out to establish what work is needed to obviate this potential breach situation. Our tentative estimates for this investigation and an assessment of remedial treatment to include draining the slopes and replacing soft material with stone are £5,000 and £75,000 respectively.

12.5.7 We have endeavoured within the time available for field survey work to search out as many of these special maintenance problems as possible, but we do not suppose that the above estimates are complete. For the purpose of assessing an annual maintenance cost, however, we have assumed that the estimates of paragraph 12.5.6 represent the average cost of such work over any period of three years. The annual figure thus obtained is approximately £250,000, excluding the £40,000 for site investigation which is regarded as high priority arrears of maintenance (see paragraph 12.4.47).

12.5.8 To summarise, Table 12.10 shows that a dramatic increase in the level of expenditure under this heading since 1973 has been occasioned by the need to carry out extensive remedial works on two major structures, namely the Anderton Lift and the Harecastle Tunnel. Paragraphs 12.5.5 to 12.5.7 show that works of a similar magnitude are required on several other structures. Since the estimates indicate that necessary expenditure over the next three years will be of the order of £750,000 per annum it is quite clear that even the 1974 level (in Table 12.10) is much lower than is necessary to keep pace with current needs. There will, however, be some reduction in the incidence of these major repair projects once the present arrears are overtaken and a programmed cycle of continuing maintenance is under way. We therefore expect that an average continuing rate of expenditure of £600,000 per annum will be sufficient to deal with these consequences of the increasing age and continued usage of the system before serious public safety hazards develop.

12.5.9 We turn now to the second category of works defined in paragraph 12.5.1 – breaches and other emergencies. The costs of carrying out repairs and of settling the claims submitted by third parties arising from the incidence of breaches, near-breaches, major water losses and other emergency situations during recent years are shown in Table 12.12. This shows that the total expenditure over the last 4¼ years, when indexed to March 1974, has been £752,000 giving an average

of some £175,000 per annum. Without the claims arising from the major breach at Disley these figures would be reduced to £322,000 and £76,000 respectively.

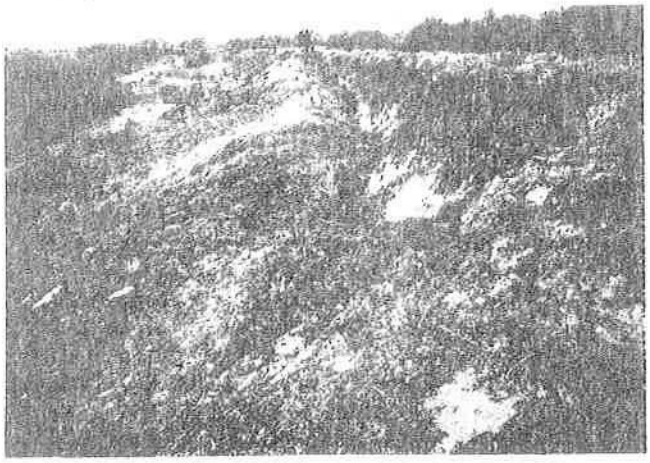


*Plate 12.15 Embankment slip at New Bradwell on the Grand Union Canal, January 1975. (PFP)*

12.5.10 Although the annual costs of dealing with the continuing problems of minor water losses from the canals have been included elsewhere under normal maintenance, the aspect of claims arising from such incidents is considered here. The Board's annual expenditure in settling claims by third parties relating to damage to property or loss of crops because of seepage and minor leakage, can be seen from the following records to average about £12,000 per annum.

| Year | Total paid £ | Total indexed to March 1974 |
|---|---|---|
| 1972 | 12,328 | 16,500 |
| 1973 | 4,498 | 5,300 |
| 1974 | 13,715 | 13,700 |
| | | 35,500 |

12.5.11 To summarise, it is apparent from the paragraphs above that the total average expenditure on breaches and other emergencies exclusive of catastrophic claims is approximately £88,000 per annum. Since some reduction in the number of such incidents would follow implementation of the recommended system of Programmed Maintenance (see Chapter 11) we feel that a corresponding future sum of say £75,000 per annum is appropriate. In addition some contingency allowance should be made for claims arising from catastrophic incidents on the scale of Disley. Assuming this to be of the order of £250,000 every 10 years, a further provision of £25,000 per annum will be required. We therefore consider that a gross total of £100,000 per annum should be allowed as a continuing annual provision to cover eventualities under this heading. This figure is included in Table 12.5.

## 12.6 *Alternative Programmes*

12.6.1 Paragraph 13 of the Terms of Reference requires us to "advise on the necessary works and associated annual costs (over the period up to 1989)" of operating and maintaining the Commercial and Cruising waterways to the standards of Chapter 10 according to the following alternative programmes:—

(a) The arrears of maintenance which we have identified to be made good in the initial years.

(b) overtake the arrears defined by BWB according to their programme (viz as in Appendix 10B of their draft outline corporate plan)

(c) no attempt to be made to make good any arrears (excepting public safety work) in the initial years

(d) any other programme which in our opinion would result in optimum value for expenditure.

We assume that 15-year programmes are required, starting in 1976, for alternatives (a), (c) and (d). The arrears of maintenance in programme (b) are the recosted BWB totals from Table 12.7 distributed over 15 years in proportion as Appendix 10B of the BWB draft outline corporate plan. Our own estimates of the continuing annual expenditure on operation and maintenance have been used in all four of the programmes.

12.6.2 The total cost of each programme is made up of two parts, that due to overtaking arrears and the expenditure on operation and continuing maintenance for the 15 years. The cost of overtaking arrears will vary depending on the timing of the works — this is discussed in the following paragraphs. It is essential that the levels of activity for operation and continuing maintenance, calculated to be necessary after overtaking arrears, are established as soon as is practicable. If this is not done within one or two years then the result will be that new arrears of maintenance will accrue. Until the present arrears are eliminated, a further annual expenditure will be incurred in dealing with minor leaks and potential failures which will temporarily continue, and such variations are all quantified below as far as is possible. Table 12.13 summarises these elements of the cost for each programme, and gives the calculated total cost of each of the four 15-year programmes at March 1974 rates.

12.6.3 *Programme (A)* provides for the earliest practicable start on the work of overtaking the arrears of maintenance and shows the work completed within 5 years. In order to achieve this it will be necessary to let the majority of the work to outside contract, and this is only an economical course of action for certain limited types of work. The Board will also have to take on temporary staff to administer these extra contracts. As mentioned previously the Table 12.1 costs include for appropriate works to be carried out in this way but we consider that an addition should be made to these tables of about 20% of the cost of the extra works let to contract for this particular programme. This will increase the cost of overtaking arrears by approximately £3,000,000. Out of these total costs, the items mentioned in paragraphs 12.4.45 and 47 must be put in hand immediately from public safety considerations — moreover this is the case for any realistic programme. Under programme (A) the arrears are to be overcome relatively quickly, and we have assumed that it will be possible to effect the proper solutions to recurring problems of minor leaks etc. as and when they next occur so that the operating and maintenance costs of Table 12.2 will obtain throughout with no additions.

12.6.4 Considering *programme (B),* the reassessed costs of overtaking the arrears identified by the BWB in 1970 are given in Table 12.7. Apparently no consequential adjustments due to the timing of these works were allowed for in the BWB programme (but see also paragraph 12.7.4). The costs due to arrears in that programme included for Remainder waterways, which we cover separately in Chapter 15. Because of this we have distributed the reassessed costs due to arrears on