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Water NATURE'S PRECIOUS RESOURCE

*An Environmentally
Sustainable Water Resources
Development Strategy for
England and Wales*

SUPPLEMENTARY REPORT



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National Rivers Authority

NATIONAL STRATEGY OVERVIEW
Supplementary Report No 9
August 1994

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**National Rivers Authority
Water Resources Development Strategy
Strategy Overview
Supplementary Report No 9**

August 1994

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WATER RESOURCES DEVELOPMENT STRATEGY
SUPPLEMENTARY REPORT No 9
NATIONAL STRATEGY OVERVIEW**

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SUMMARY

This report is the last in a series of nine supplementary reports which provide supporting information for the NRA's strategy document.

The other reports in the series are as follows:

- 1 Methodology and Assumptions for Demand Scenarios;
- 2 Review of Public Water Supply Yields;
- 3 Marginal Demands;
- 4 'Other' Options;
- 5 Hydrological Modelling;
- 6 Resource Scheme Costings;
- 7 RESPLAN Modelling;
- 8 Comparative Environmental Appraisal of Strategic Options.

This report describes:

- the management structure of the project in terms of its organisation, coordination and programme;
- the component studies;
- the study conclusions, including limitations, lessons learned and outstanding issues.

This report includes a description of each of the studies or study areas undertaken as part of the project. Each study's objectives, methods and limitations are described briefly together with how they fit into the overall strategy. Details of the results of each study have specifically not been included but a full reference list of all the studies is given in Appendix A.

The conclusions in this report refer to the Water Resources Management Project rather than the strategy itself, although reference is made to the key findings of the strategy and the outstanding issues.

1 INTRODUCTION

1.1 Background

The National Rivers Authority (NRA) has a general duty to ensure the proper use of water resources, helping to define the correct balance between the demands of water supply, and those of the environment. Under Section 188 of the Water Resources Act 1991, the NRA also has a duty to "collate and publish information from which assessments can be made of actual and prospective demands for water and actual and prospective water resources in England and Wales". In fulfilment of these duties the NRA was committed to publishing a strategic framework for the development of new water resources in England and Wales to meet demands up to the year 2021.

The production of the strategy was a multi-disciplinary venture, involving demand forecasting, yield assessment, resource engineering and costing, hydrological modelling, environmental assessment and resource allocation studies. The work was carried out by the NRA or by external consultants commissioned by the NRA. Initial problem definition studies, demand forecasting and yield assessment, were carried out, the findings of which were combined and analysed to identify the objectives for later option comparison studies including systems modelling and environmental appraisal. A description of how the key activities were arranged within the programme of work and the inter-relationships between the studies is given in Section 1.2.

The project had an eighteen month programme to completion. Project direction and impetus were the responsibility of the Water Resources Department of NRA Head Office, assisted by external consultants Sir William Halcrow & Partners Ltd, who were retained as Project Managers. The project was completed successfully, fulfilling its objectives within the specified time.

1.2 Scope of Work

Figure 1.1 illustrates schematically the key activities involved in the production of the strategy and the project programme.

The work was divided into three phases:

Phase 1 - Deficit forecasts and options studies

Phase 2 - Option Appraisal and Comparison

Phase 3 - Strategy Development and Reporting

Phase 1 included demand forecasting, yield assessment and deficit forecasting studies - referred to as Problem Definition Studies. Preliminary option feasibility studies were also undertaken in Phase 1 together with development research for hydrological and system modelling studies.

During Phase 2 of the project yields and average transfer volumes for the various resource options and transfer schemes proposed were investigated through the hydrological modelling studies. This was a complex exercise which entailed the cooperation of four NRA regional modelling teams. The option feasibility studies were reviewed, and capital and operating costs were appraised. The various options were compared on the basis of financial criteria using a resource allocation model known as RESPLAN (originally developed by the former Anglian Water Authority), and environmental criteria examined during a comparative environmental appraisal study undertaken by Howard Humphreys in association with Cobham Resource Consultants.

The results of these individual studies, together with comments received through consultation with the water service companies and other interested organisations, were then collated in Phase 3 during which the strategy was developed and the final strategy, "An Environmentally Sustainable Water Resources Development Strategy for England and Wales" was produced. This was published, on schedule, in March 1994.

1.3 Purpose of this Report

This report is the last in a series of nine supplementary reports which provide supporting information for the NRA's strategy document.

The other reports in the series are as follows:

- 1 Methodology and Assumptions for Demand Scenarios;
- 2 Review of Public Water Supply Yields;
- 3 Marginal Demands;
- 4 'Other' Options;
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- the management structure of the project in terms of its organisation, coordination and programme;
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The conclusions in this report refer to the Water Resources Management Project rather than the strategy itself, although reference is made to the key findings of the strategy and the outstanding issues.

2 PROJECT MANAGEMENT

2.1 Organisation

The team responsible for production of the National Water Resources Development Strategy, the manner in which it was organised and the key accountabilities are shown in Figure 2.1.

The NRA Project Director was Jerry Sherriff, Head of Water Resources, based at the Head Office in Bristol. He was assisted on a day to day basis by Richard Streeter and Mark Sitton from Head Office with system modelling support provided by Chris Page of NRA Anglian Region. Jerry Sheriff was also responsible for chairing the Project Steering Group (PSG) which provided advice on the project. The PSG comprised Jerry Sherriff, Richard Streeter, Chris Page and senior NRA water resources staff from those regions most closely involved in the strategy development, namely:

- Andrew Skinner - NRA Severn Trent Region;
- Steve Morley - NRA Severn Trent Region;
- Giles Phillips - NRA Thames Region;
- Graham Wilson - NRA Anglian Region; and
- Peter Herbertson - NRA Southern Region;

plus John Lawson, Project Manager from the Halcrow consultancy team - appointed to assist the NRA in the development of the strategy.

Halcrow was appointed by the NRA in September 1992 to provide a Project Management Team, to provide effective project management, technical co-ordination, directional advice and support to ensure that key milestones were achieved and that the project outputs were published on time and to an assured quality. The Halcrow team consisted of three core members supported by technical experts as appropriate.

The Halcrow team was led by John Lawson, Project Manager, assisted by two project coordinators. The Technical Coordinator, Patrick Hawker, was responsible for the day-to-day coordination and direction of the technical investigations whilst the Management Coordinator, Jill Rankin, provided support in the day-to-day management of the project, monitoring and reporting of progress, quality assurance and financial monitoring and projection etc.

2.2 Programme and Coordination

The Water Resources Strategy was a complex project, made up of a large number of component studies. It was recognised from the start of the project, that strong and effective project management would be central to the successful and timely completion of the work and to ensure that the NRA's Water Resources Strategy report was published on time. It was important, therefore, to prepare a detailed project plan and critical path analysis, coupled with implementation of an effective monitoring and reporting system.

Preparation of the project plan involved the identification of the required key activities to production of a strategy and the relationships between the various activities. These relationships defined the logic of the project, for example, some activities could be carried out in parallel whereas others were inter-related. Critical activities were those which would lead to a delay to a successor activity, or to the overall project, if they were not completed on time. The objectives of developing the project plan were:

- to ensure that the final deadline was met;
- to ensure that critical activities were completed on time and hence did not delay successor activities;
- to provide an agreed work programme against which progress could be monitored.

The programme was developed by Halcrow, using OPENPLAN project management software in close consultation with the PSG, NRA regional contacts and individual project leaders. OPENPLAN is a versatile, open-ended planning tool which can be mounted on a micro-computer. It automatically carries out critical path analysis and accommodates fully the interdependencies between activities.

Figure 2.2 shows an example of the programme barchart produced using this system - the example shown relates to progress achieved to 30 June 1993. The programme was updated monthly with information obtained by means of a simple proforma (see Appendix B), which was sent to the organisations responsible for carrying out each of the activities listed in the programme.

Meetings of the PSG were held on a monthly basis at which overall project progress was discussed, together with specific technical and policy issues as appropriate. Regular Progress Meetings between the NRA Head Office staff and the Halcrow core team members were also held.

2.3 Quality Control

Quality assurance and the provision of a data audit trail, describing data sources, limitations, accuracy and assumptions was one of the key tasks assigned to the Halcrow team as part of this project. Such activities are integral to all projects undertaken by Halcrow, which is registered with BSI as a company whose QA procedures meet the requirements of BS5750 Part 1/ISO 9001. These procedures govern all aspects of Halcrow's work, both managerial and technical, assuring clients of the highest standards of quality.

As far as practicable, the Halcrow quality procedures (for example, for report and calculation production and checking) were applied to this project and audit trail information provided as appropriate. With respect to the marginal demands data, which were central to the development of the

strategy, a specific quality audit exercise was carried out by Halcrow as reported in **Supplementary Report No 3**.

2.4 Consultation

The NRA recognise that the support and cooperation of the water undertakers and other groups interested in the water resources of England and Wales, is essential in the success of any water resources strategy developed by the NRA. The process had already begun with the publication of the NRA's Water Resources Development Strategy Discussion Document (NRA, 1992), in March 1992, which stimulated widespread comment from many organisations. These included the water supply companies, environmental groups, research groups, manufacturers and representatives of abstractors etc.

In developing the strategy, therefore, it was the NRA's policy to continue the involvement of such organisations, keeping them informed of what actions were being taken and providing an opportunity for comment or query. This was achieved through the production of two Consultation Papers in June and October 1993 respectively, plus on-going informal liaison.

The June paper was circulated to the water service companies, Water Services Association, Water Companies Association, Office of Water Services and Department of the Environment. It provided a general background to the NRA's activities in developing the strategy and encouraged comment on the approach being taken by the NRA in the review of public water supply source yields and future demand forecasting.

The second consultation paper, produced in October 1993, when the NRA had begun to identify the options available to meet forecast demands, was circulated to a wider group of selected organisations for comments. The additional organisations consulted at this stage included English Nature, National Farmers Union, Royal Society for the Protection of Birds, Confederation of British Industry, National Power Plc, PowerGen Plc, British Waterways, Inland Waterways Association, Countryside Commission, Countryside Council for Wales and Council for the Protection of Rural England etc.

The responses received to the consultation papers provided a valuable insight into the concerns of those organisations who demand protection for the water environment and of those who use water in their business activities.

As such, the views expressed were gratefully acknowledged by the NRA and had a significant role in shaping the strategy.

3 COMPONENT STUDIES

3.1 Overview

A multitude of component studies were undertaken during the course of this project and can be divided into three groupings:

- problem definition studies - demand forecasting, yield assessment and deficit forecasting
- option appraisal studies - option feasibility and costing studies, including hydrological modelling
- option comparison studies - RESPLAN and Environmental Assessment.

The studies were undertaken by the NRA's staff in the head and regional offices, by NRA employed external consultants and in one case by an independent organisation. Work was coordinated by the NRA head office who also produced the final strategy document. The regional offices participated in all aspects of the study through membership of the project steering group and were particularly involved in the problem definition studies and the hydrological modelling studies. The main consultants to the project who were commissioned to undertake specific studies were Sir William Halcrow & Partners (Project Managers), W S Atkins and Howard Humphreys. The following sections 3.2, 3.3 and 3.4 describe the work undertaken in the above groupings.

3.2 Problem Definition Studies

3.2.1 Demand Forecasting

Studies were undertaken to estimate the levels of public water supply and private demand throughout England and Wales. The public water supply studies were undertaken by the NRA in-house with the assistance of their project managers Halcrow. Private demand studies were carried out by external consultants with specialist knowledge of the key areas of private use.

The NRA's objective was to produce a set of nationally consistent demand forecasts for each Water Service and Water Supply company in England and Wales. For strategic planning studies in the past, the NRA had relied on forecasts prepared by the water companies. The different methods used made results from NRA regional and national studies difficult to interpret. From the outset, a standard methodology for demand forecasting was seen as essential to the success of the National strategy study.

Forecasts were assembled using a multi-component technique; growth rates in the major demand components (domestic, industrial, commercial and supply losses) are predicted independently. Demand was forecast at five yearly intervals up to the year 2021. For each, a set of three demand

forecast scenarios were produced (high, medium and low) to form a prediction envelope. The size of the prediction envelope reflected the range in domestic, commercial and industrial growth rates and different assumed levels of demand management control. The various assumptions made are described in detail in **Supplementary Report No 1**.

An important decision, made at the start of the study, was to incorporate minimum, maximum and intermediate levels of demand management into the high, low and medium forecasts respectively. Demand management options included:

- reduction in total losses with an increase in leakage control
- reduction in domestic usage and customer losses with an increase in the number of metered properties.

In the final strategy an emphasis was placed upon the need for water companies to reduce to a economic minimum through leakage control and metering before considering the development of new resources. In setting the levels for demand management the NRA took into account the regional aspects of water resource availability and potential demand growth. Thus higher demand management requirements were asked of water companies situated in the south and east of the country than those in the west and the north.

Existing distribution inputs, populations and population forecasts, metered demand data and estimates of per capita consumption were sourced from the water companies. These data were used to infer unmeasured demand components and total water company losses.

A great deal of effort was given to ensuring the demand forecasting methodology and assumptions were robust and were generally acceptable to the water industry. As part of the exercise, a consultation document, containing the proposed methodology and resulting forecasts, was sent to the water service companies, Water Services Association, Water Companies Association and OFWAT for comment; account was taken of the responses received when producing the final methodology.

The NRA did not undertake a distorted study of private demand growth as part of the strategy. The growth of private demand is influenced by a great number of political, economic and social factors, with each private demand usage being affected by varying degrees. The decision was therefore made to investigate the two private demand usages most likely to grow in the future, these being:

- spray irrigation
- industrial/commercial

Silsoe college was appointed by NRA to forecast demand for spray irrigation water in England and Wales. The college investigated the potential growth in the ten NRA regions under three different agriculture growth

scenarios. International trade policies were seen as key factors determining spray irrigation demand growth, in particular the extent of Common Agricultural Policy and the liberalisation of world trade through GATT. Using data derived from Manchester University's Agricultural Policy Computer Model, Silsoe College forecast high, low and likely irrigation demands for irrigated crop areas in the ten NRA regions for scenarios. These results were referred to in the final strategy document.

The confederation of British Industry (CBI) were asked by the NRA to conduct a survey of members to discover whether in the next ten years an increase or decrease in industrial demand was anticipated. Questionnaires were sent to 450 companies of varying types, spread throughout the country. In summary, the results suggested there would be no overall growth in demand; increases in water consumption being nullified by decreases due to recycling and improved efficiency.

3.2.2 Existing Resource Yield Assessments

The NRA regions undertook to review, with the water companies, the drought reliable yield of all PWS sources in England and Wales. The objective was to produce for each company an estimate of the average annual supply which can be maintained during a design drought (1 in 50 year or 1976) from existing resources, against which forecasts of annual average PWS demand could be compared. Summaries of company public water supply source yields are given in **Supplementary Report No 2**.

As yet there are no standard accepted methods of defining resource yield and like demand forecasting, the water companies have various methods of defining and assessing yield. These range from operational experience to complex hydrological modelling. In the study specification the NRA set out definitions of groundwater, river and reservoir source yields and the water companies were asked to provide resource estimates based upon these definitions. Yield assessment is a complex subject, hence exact compliance with the NRA yield definitions for all water company sources was not anticipated and a pragmatic approach was adopted. However, where there was an intractable disagreement between the water company and the NRA this was indicated in the yield summaries.

Supplementary Report No 2 - Review of Public Water Supply Yields presents yield summaries for all the water supply and service companies, including licence number, source name, yield and source type. The report also contains for each NRA region, listings of inter-regional transfers, imports and exports resource cut-backs, and potential future regional developments. The future regional developments identified were those which have a potential to be developed to help meet local or regional needs prior to any strategic options.

Most of the regional developments were promoted by the water companies with a few exceptions such as Itchen groundwater, these being promoted by the NRA. The Thames, Anglian, South-West, Anglian, Southern and Yorkshire the potential regional developments identified had been included

as elements of a regional water resource strategy. During production of these regional strategies the NRA had the opportunity to assess the promotability estimated yields and commissioning dates of the schemes and satisfy themselves of the schemes potential for development, with the provision that all major schemes would be subject to an environmental impact assessment.

Possible future cut-backs in resources due to environmental and other reasons were recorded in the ten NRA regions. Many of the environmental cut-backs were identified as a result of the alleviation of low flow studies by the NRA. At a number of sites particularly in the south and east of England, it has been recognised that a cut-back in abstraction in the future may be needed to prevent damage to the environment. Other cut-backs recorded include the reduction in industrial bulk supplies predicted by a number of water companies.

Summary tables in **Supplementary Report No 2** combine existing yields, inter-regional transfers, future schemes and yield cut-backs to give the estimated future total resources in the region. This information was used to develop marginal demand forecasts.

3.2.3 Marginal Demands Forecasts

The marginal demand in a company supply area or NRA region is the public water supply deficit. Forecast marginal demands were calculated at five yearly intervals from 1991 to 2021 by comparison of the forecast demands and existing and planned resource yields at a demand centre. A demand centre depending on the quality the data available, could be either:

- an entire company supply area
- a company supply zone
- a combination of supply areas or zones from more than one company

In most cases demand centres correspond to the water company supply areas, but for the larger companies, such as Thames Water, Welsh Water and North West Water, the areas have been split into demand zones.

The forecast marginal demands are the annual average demands calculated using the NRA national demand forecasting methodology minus the available source yield and presented in **NRA Supplementary Report No 3 - Marginal Demands**. The available source yields at each demand centre are the existing source yield plus the expected yield from planned developments with the total reduced by 2½% to account for operational outages, minus the environmental and other cut-backs. The allowance for operational outages is an acknowledgement that at any time some sources will not be available due to operational failure or maintenance requirements.

Existing company source yields were subdivided into demand centres by the NRA regions, using information supplied by the water companies.

The marginal demand summary tables indicate the size of demands arising in the demand centres and when they are first likely to appear. Resource surpluses are signified by a zero and no indication of size is given.

3.3 Option Appraisal Studies

3.3.1 Option Feasibility Studies

A number of engineering feasibility studies were undertaken into specific future source development options by the NRA, their consultants and independent bodies. A list of development options reports is given in Appendix A.

The development options studied are split into three types:

- | | | |
|-----------------|---|---|
| Source elements | - | these are reservoirs, groundwater schemes or any other water resource development which will increase the available yield. |
| Link elements | - | these are means of transferring water from the source elements to the centres of demand, and include river and canal transfers and pipelines. |
| 'Other' options | - | these include conventional and unconventional water resource options which in the past have been discounted but may in the future prove to be worthwhile; for example groundwater recharge, desalination, effluent re-use, Kielder transfer scheme and a national water grid. |

The objective of these engineering studies, was to define the yield or transfer capacity, and capital and operating costs of the schemes.

Source Elements

The source elements studied include:

- Craig Goch reservoir enlargement;
- Vrynwy redeployment;
- Great Bradley reservoir;
- Birmingham rising groundwater;
- Shropshire groundwater;
- Abingdon reservoir;
- River Thames Effluent Reuse Schemes;
- Broad Oak reservoir.

With the exception of the Abingdon reservoir and Broad Oak reservoir studies, the source studies are either at an early feasibility stage or need to be revised and brought up to date.

A major study was carried out by the Wye River Authority in the seventies into enlargement of the existing Craig Goch reservoir and its use to regulate the River Severn. This work has been updated by the NRA taking into account the current concern for environmental issues, to produce revised scheme cost estimates. It should be noted that no new studies on hydrological aspects of the scheme have been undertaken by the NRA.

Vrynwy redeployment is a scheme which is being promoted by the NRA, the engineering feasibility of which has yet to be addressed. The increased yield from the reservoir, if it were to be converted from direct supply to river regulation, was assessed by the NRA as part of their hydrological modelling studies (see Section 3.3.2).

Great Bradley reservoir is another scheme which has been studied in the past. The Essex River Authority investigated the potential of developing an impoundment reservoir in the headwaters of the Stour in the early seventies. The consultants W S Atkins reviewed this work and the most appropriate reservoir sizes for inclusion in the strategy; taking into account environmental considerations. The yield of the reservoir, when operated in conjunction with the East Anglian transfer system was assessed by the NRA by model simulation (see Section 3.3.2).

Halcrow were commissioned by NRA Severn-Trent region to investigate the potential for supplementing water supplies in the Rivers Trent and Thames by augmented flows with groundwater abstracted from beneath the City of Birmingham. Halcrow used a groundwater model, developed for CIRIA by Birmingham University to determine the maximum yield available and most suitable borehole locations. This led to investigations of development options, engineering feasibility and costs for various schemes.

Shropshire groundwater is an existing groundwater augmentation scheme which is operated by the NRA on the River Severn. The scheme has been developed in phases, with phases 1 & 2 complete and phases 3 to 6 scheduled for development between 1994 and 2007. The NRA have carried out a detailed appraisal of the yields and the capital and operational costs associated with further development.

Thames Water Utilities Ltd (TWUL) have carried out an extensive investigation into a proposed fully bunded, pumped storage reservoir near Abingdon. The findings are confidential, however a limited amount of data were released to the NRA. These included estimates of the proposed reservoir's storage resource value and capital and operational costs. The latter were calculated by TWUL using the standard NRA costing methodology, which is described in Supplementary Report No 6.

TWUL have considered two River Thames effluent reuse schemes:

- Deephams STW; and
- Mogden STW

The Company's plans are described in Supplementary Report No 4 'Other Options'. The Deephams scheme involves the tertiary treatment of a proportion of effluent arising at Deephams and pumped transfer of the effluent to a water storage reservoir. The proposal for Mogden STW includes a pumped transfer of tertiary treated effluent upstream of Teddington Weir to a point just below the abstraction for the London reservoirs. In this way additional abstraction for the reservoirs would take place at Teddington with the water abstracted being replaced by treated effluent. Effluent reuse schemes can be engineered at moderate costs, however, their promotability and public health implications have still to be adjudged.

Broad Oak reservoir is a proposal for a fully bunded, pumped storage reservoir in the River Stour catchment in Kent. Several variations of the Broad Oak scheme have been studied by Mid Kent Water and Folkestone and District Water Company. The NRA have selected a 40 MI/d scheme for inclusion in the strategy and were provided with costing data by the water companies.

In addition to the above, studies were undertaken by local water companies on a number of smaller source elements including Derwent Valley conjunctive use, Chelmsford effluent reuse and Denver MRF. Scheme yields and costs were provided by the companies and costs were adjusted where appropriate.

Link Elements

The key link elements or transfers studied were:

- Severn to Thames transfer;
- Severn to Trent transfer;
- the East Anglian transfer, incorporating;
 - Transfers from River Witham to Ely Ouse;
 - Transfers from the River Trent and Great Bradley reservoir;
 - Transfers from the River Trent to Rutland Water;
- Water transfer by canal.

The engineering feasibility of the first three transfers were investigated for the NRA by the external consultants W S Atkins. British Waterways commissioned the consultants Binnie & Partners to investigate the potential for water transfer by canal; a copy of the Binnie report was issued to the NRA for evaluation.

The objectives of the W S Atkins feasibility studies into river transfers were:

- to identify suitable locations to abstract and discharge transfer water from the donor and recipient rivers;
- to identify potential pipeline routes;

- to develop the key engineering concepts, for example transfer rates, transfer losses and balancing storage and comment on the operational aspects of transfer;
- to produce preliminary estimates of capital and operating costs.

Atkin also produced preliminary environmental assessments of the transfer schemes, these were later superseded by the comparative environmental appraisal of strategic options undertaken by the external consultants Howard Humphreys (see Section 3.4.2).

Scheme costs were produced for a range of transfer capacities and river flow constraints specified by the NRA. The consultants were not asked to determine (with the exception of the Severn to Trent transfer), the frequency with which transfers would be required. These data and the potential resource value of the various transfer options (supported and unsupported) were determined by the NRA using hydrological modelling techniques (see Section 3.3.3).

The consultants were also to estimate for different River Trent flow criteria, the number of days transfer of River Severn water required to support abstractions from the Trent during various design droughts. The storage required to support the River Severn transfer was evaluated by the NRA, again by hydrological modelling techniques. Transfers from the River Severn to the Midland canal system were also investigated to tie in with the work carried out by Binnies on behalf of British Waterways.

The British Waterways study looked at the engineering feasibility of transferring water from the River Severn to the Rivers Trent, Thames, Nene and Great Ouse via the canal system. The preferred canal routes included the Trent and Mersey canal and the Coventry, Oxford and Grand Union canals. The engineering aspects investigated included canal hydraulics, dredging, bank raising and dock bypass and pumping requirements. The capital and operating costs were calculated taking into account modifications to existing structures. The water quality, planning and environmental aspects of transfers were also considered.

Other Options

Halcrow were asked to review a number of 'other' options which, due to their lesser strategic importance, expense or previous studies, have not attracted large scale investigation at this time. The options reviewed were:

- Tidal barrages;
- Groundwater recharge;
- Effluent Reuse;
- Desalination;
- Underseas pipelines;
- Tankers and Water Sacs;
- Kielder Transfer scheme;
- National Water grid;

- Craig Goch enlargement (see source elements)
- Vrynwy Redeployment (see source elements)

Halcrows findings are presented in Other Options, Supplementary Report No 4. In general the report addresses:

- the principles and general advantages and disadvantages of the option under consideration;
- the engineering feasibility of the option;
- the potential yield of the option;
- environmental considerations; and
- estimated capital and operating costs.

The main recommendations of the report include:

- whether the enlargement of Craig Goch and Vrynwy redeployment should be investigated further to determine their resource value if linked to a Severn to Thames or Severn to Trent transfer;
- studies to identify potential groundwater recharge sites and associated sources of recharge water in the forecast deficit NRA regions; and
- further desk studies into the deployment of a national water grid.

3.3.3 Hydrological Modelling

The hydrological modelling studies undertaken by the NRA as part of the national strategy study are described in Supplementary Report No 5. The objectives of these studies were to determine:

- the resource value of proposed river transfers supported by proposed future resource developments, (eg Vrynwy, Great Bradley and Abingdon);
- the resource value of unsupported river transfers; and
- the number of transfer days required in an average year.

The studies were carried out on a regional basis, with the effect of transfers on the donor and recipient rivers being investigated independently. For example, the study of the Severn to Thames transfer supported by a redeployed Lake Vrynwy was divided into three parts:

- (1) NRA North West region investigated the storage available from Vrynwy to support abstractions from the River Severn and the cost of developing replacement sources in the North West.
- (2) NRA Severn-Trent region investigated the maximum transfer available from the Severn using different Vrynwy storages volumes.
- (3) NRA Thames region determined the resource value to London of different transfer volumes and a transfer demand sequence at the Severn abstraction point.

Each region used their own resource model to undertake the work. Direct communication between models was not possible because of the incompatibility of the various modelling systems. Instead, data was transferred by hand and entered manually. A hydrological modelling study group was set up comprising NRA staff from the participating regions and chaired by Halcrow. The group meet once every six weeks with the purpose of exchanging data and reviewing progress.

The results of the modelling studies were inputted into the NRA System model RESPLAN (see Section 3.4.1) in the form of resource values, load factors and yield factors and were used in the form of hydrographs, by Howard Humphreys to evaluate the environmental impacts of the transfer schemes.

3.3.3 Costings

The strategic options studies were undertaken by a number of different agencies; including the NRA and water companies external consultants. A common objective of these studies was to produce an estimate of the capital and operating cost of the scheme, however, the methods used to determine costs by agencies were not consistent and could not be compared directly. To overcome this problem Halcrow were asked to review all costings, and produce a methodology to which all costs could, with adjustment, be made to comply. The cost methodology devised by Halcrow is presented in **Supplementary Report No 6**.

Previous cost estimates were adjusted to standardise the following cost characteristics:

- civil and M&E engineering cost functions;
- base date;
- discount rate;
- feasibility study allowance;
- design and supervision allowance;
- contingency;
- electricity tariff charges; and
- annual maintenance costs.

In carrying out the above exercise, Halcrow reviewed the relative extent and detail of the feasibility studies and made adjustments to the level of contingency accordingly.

Capital and operating costs for the resource-development options are summarised in the supplementary report in the forms which they were included into RESPLAN. Capital costs were expressed as £M/MI/d of source yield or transfer capacities and operating costs were expressed as £M/MI/year transferred, assuming all year round operation. The costs were combined to give a unit net present cost over a thirty year period for each source and link element.

3.4 Option Comparison Studies

3.4.1 System Modelling

The comparison of strategic water resource options in terms of economic criteria was undertaken using the RESPLAN modelling system. The system enables different resource development and allocation scenarios to be tested, with the objective of identifying the optimum choice and timing of strategic capital investments needed to meet forecast demands. RESPLAN does not address hydrological or water quality aspects of resource development. Details are given in **Report No. 7**.

The RESPLAN model idealises a water resources system as a network comprising demand centres, source elements and link elements. Demand in England and Wales was reduced to marginal demand centres; locations where demand deficits which could not be met by local developments were forecast. Link elements connect the source elements to the marginal demand centres as illustrated in the RESPLAN network shown in Figure 3.1. (The source and link elements are as described previously in Section 3.3).

The input data required to run the RESPLAN model include:

- existing and forecast marginal demands;
- the direct supply yield of strategic development and transfer capacities of link elements;
- the resource value of strategic developments expressed in terms of yield and load factors;
- capital and average annual operating costs expressed as a net present cost over a thirty year period.

The model was run for both high and medium demand forecasts. Results were used in conjunction with the findings of the 'Comparative Environmental Appraisal of Strategic Options (Section 3.4.2) to help define the NRA strategy.

3.4.2 Comparative Environmental Appraisal

Preliminary environmental appraisals were carried out on a number of the strategic options included in the RESPLAN model. The work involved:

- a literature review of the environmental issues and known impacts associated with existing water resource development schemes, with particular attention being given to UK schemes;
- the development of a framework for the assessment of individual schemes and objective comparisons of strategic development options;
- the assessment and comparison of the strategic options with the "worst case" for each option being considered.

Details are given in **Supplementary Report No 8**.

The scheme assessments were, by virtue of a lack of baseline data, only preliminary. However, the amount of baseline data available varied considerably. Different options have therefore been assessed to different levels of detail.

The findings of these studies were carefully considered in the production of the national strategy. Reservations were expressed regarding river transfers, indicating that more detailed study is required before whole hearted support for their development can be given.

4 CONCLUSIONS

4.1 Outcome of Studies

The principal outcome of the individual studies has been the creation of a strategic framework against which new proposals for water resources development can be compared. The strategy formulated is the NRA's vision of how, given particular circumstances, they would like to see water resources develop in England and Wales to meet demands to the year 2021. The strategy may be seen as a guide to developers rather than a development plan in which a number of NRA policies are reflected. Foremost amongst these are:

- the NRA's concern to ensure water resources are developed and maintained on an environmentally sustainable basis. This implies that there should be no long-term systematic deterioration in the water environment due to water resource development and water use;
- the requirement of water companies to achieve economic levels of metering and leakage before new resources are developed;
- promotion of water efficiency by industry, commerce and agriculture and use in the home;
- where possible and economically practical, redistribution of existing water resources, rather than development of new sources; and is to be pursued
- for caution to govern discussions on water resource development where the full environmental impacts of schemes are unknown.

In producing their strategy, the NRA have faced a number of technical hurdles and in overcoming them they have been seen able to advance water resource studies in this country.

The NRA produced a consistent set of demand forecasts for all the water companies in England and Wales. This task required the development of an intricate demand forecasting methodology, based upon a multiple component structure constructed around measured components. The use of this methodology helped provide, possibly for the first time, a consistent picture of forecast demands throughout England & Wales.

The system model, RESPLAN, was central to the analysis of the various water resource options and helped focus effort quickly onto the more economically attractive proposals. Without RESPLAN the identification and validation of an economic strategy would have been an onerous task, involving many hours of hand calculations and analysis. In the future, as the information about the options improves, the RESPLAN model can be

adjusted and results reappraised. Thus the model is a tool with which the NRA can monitor the direction of the strategy as time passes.

However, there were also a number of limitations to the studies, some of which are described in Section 4.2 below.

4.2 Limitations of Studies

Development of the National Water Resources Strategy, was a complex and wide ranging project which, as well as its successes, also had a number of limitations.

These included:

- different methodologies used in assessing source yields;
- limited assessment of local resource options and no comparison with strategic resource options;
- absence of a single hydrological model to simulate river transfers; and
- lack of consistency with which the economic costs and environmental impacts of the strategic options have been studied.

Definitions of yield for groundwater and surface water resources were specified in the project definition study. Source yields were collected by the NRA regional offices from the water companies on the understanding that the companies had complied with these specifications. However, when Halcrow carried out a sample audit they discovered a number of examples where definitions had not been applied uniformly. There was a marked difference in the manner in which yields had been assessed depending upon source size and importance. The yields of large, important sources had been assessed in detail by most companies, often with the aid of hydrological modelling techniques which took into account annual demand variations and the imposition of demand restrictions (eg hose pipe bans, drought orders etc). In contrast, the yields of many of the medium and most small sources had been appraised based solely upon operational performance which may or may not include aspects of demand variation and restrictions. These source yield anomalies can only be corrected in the future by the development and application of a standard yield assessment methodology; for the present, however, any inaccuracies have to be accepted.

The local resource options are schemes currently being considered by the water companies and the NRA to meet local demand growth. They differ from strategic resource options in that they are not believed to have the potential to meet demand outside their immediate local zone of influence. However, this does not imply that local schemes are necessarily small or unimportant in terms of the strategy development.

On the contrary, it was agreed at the outset that local schemes forwarded by the NRA regions would be included in the water resource strategy and would have priority over strategic schemes. In making this presumption the assumption is that, on average, the economic and environmental costs of local schemes are lower than those of strategic schemes. This is not always the case. However, it was impractical in terms of cost and time to analyse all of the local schemes using RESPLAN, or evaluate their comparative environmental impact.

A third limitation to the strategy studies was the absence of an integrated hydrological model to simulate the inter-catchment transfers. Three different model formats were used to model the Rivers Severn, Thames and the East Anglian Transfer systems. No hydrological model exists for the River Trent and therefore manual techniques were adopted to determine transfer characteristics. Ideally, the NRA would have liked to have developed a single model which could simulate transfers from any of the four river systems; however, time and economic constraints did not allow.

In developing their strategy the NRA reviewed the costs and the environmental impacts of the strategic schemes to help judge all options on an equal basis. However, the level of detail at which scheme costings had been produced varied greatly and, although adjustments were made, there were inevitably some inconsistencies which could not be eliminated. Also in undertaking the comparative environmental appraisals, no fieldwork or examination of primary data was carried out and the amount of reliable baseline data varied considerably; different options have, in some cases therefore, been assessed to different levels of detail.

4.3 Key Project Management Observations

In undertaking these complex, multidisciplinary studies, a number of key project management observations have been made. These are:

- The importance of a clear, strong project management structure. The project was guided and impetus maintained by NRA headquarters, assisted by the project managers Sir William Halcrow and Partners. Key tasks were managed through management groups made up of key personnel from the regions. This management structure was preferred over a weaker system which might have involved the devolution of individual projects.
- The use of up to date project management planning tools, in particular OPENPLAN, helped identify key tasks critical to the progress of the project and where necessary allowed the programme to be adjusted with minimum effort.
- The benefit of consultation with the water companies and other interested bodies. Consideration of the responses to the Consultation Papers was critical if any type of consensus was to be reached concerning the demand and deficit forecasts.

Such consensus between the NRA and the water service companies is central to the success of the strategy.

4.4 Outstanding Issues

There are still a number of issues concerning the strategy which have to be addressed. Principal amongst these are:

- continued promotion of demand management techniques to minimise the need for new resource development;
- to review the feasibility, cost and environmental impact of local schemes and to compare them with the strategic options;
- to address the environmental issues relating to new source developments, should demand management measures prove insufficient.

KEY ACTIVITIES AND PROGRAMME FOR STRATEGY DEVELOPMENT

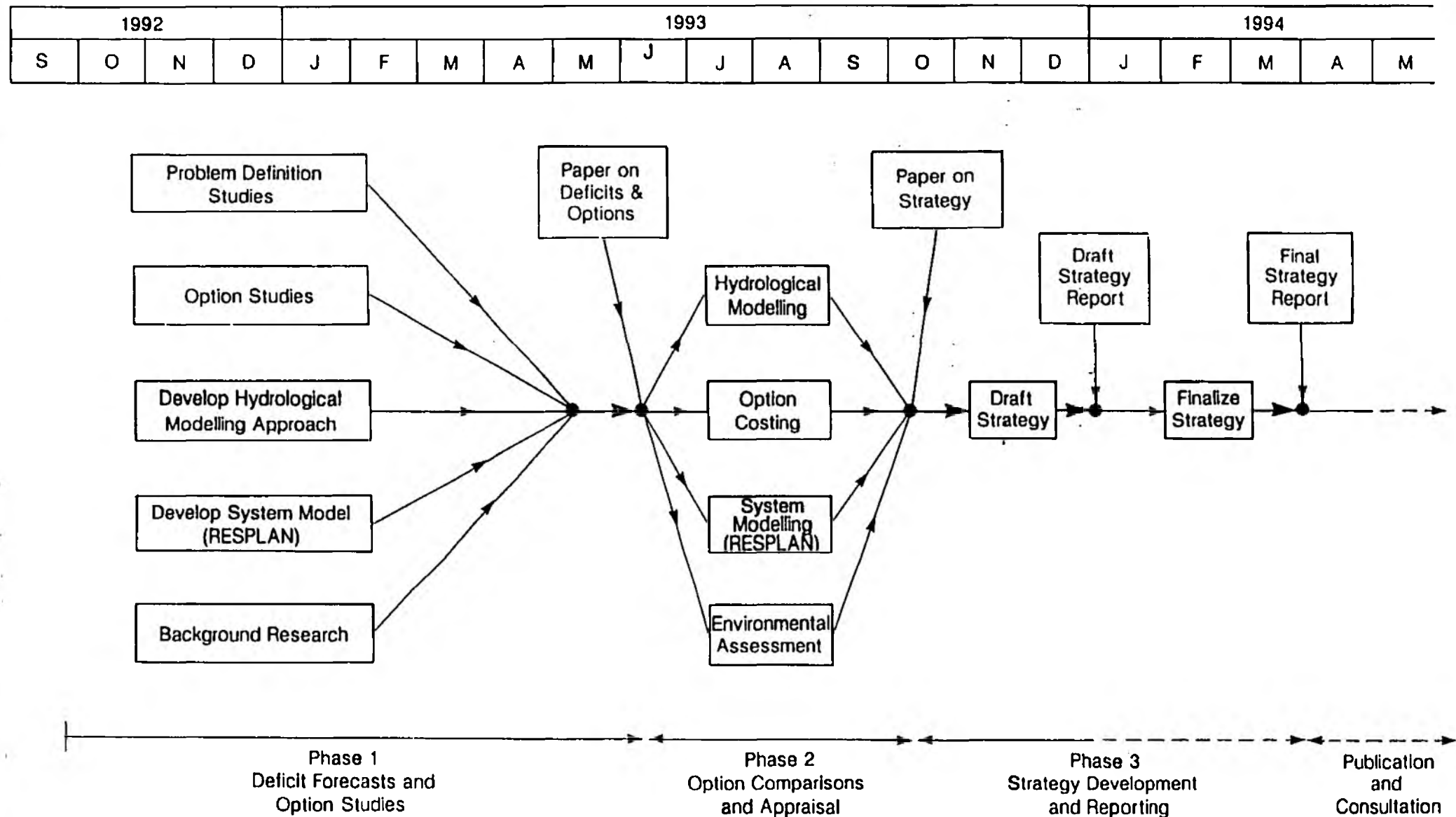


Figure 1.1

NATIONAL WATER RESOURCES DEVELOPMENT STRATEGY - PROJECT ORGANISATION

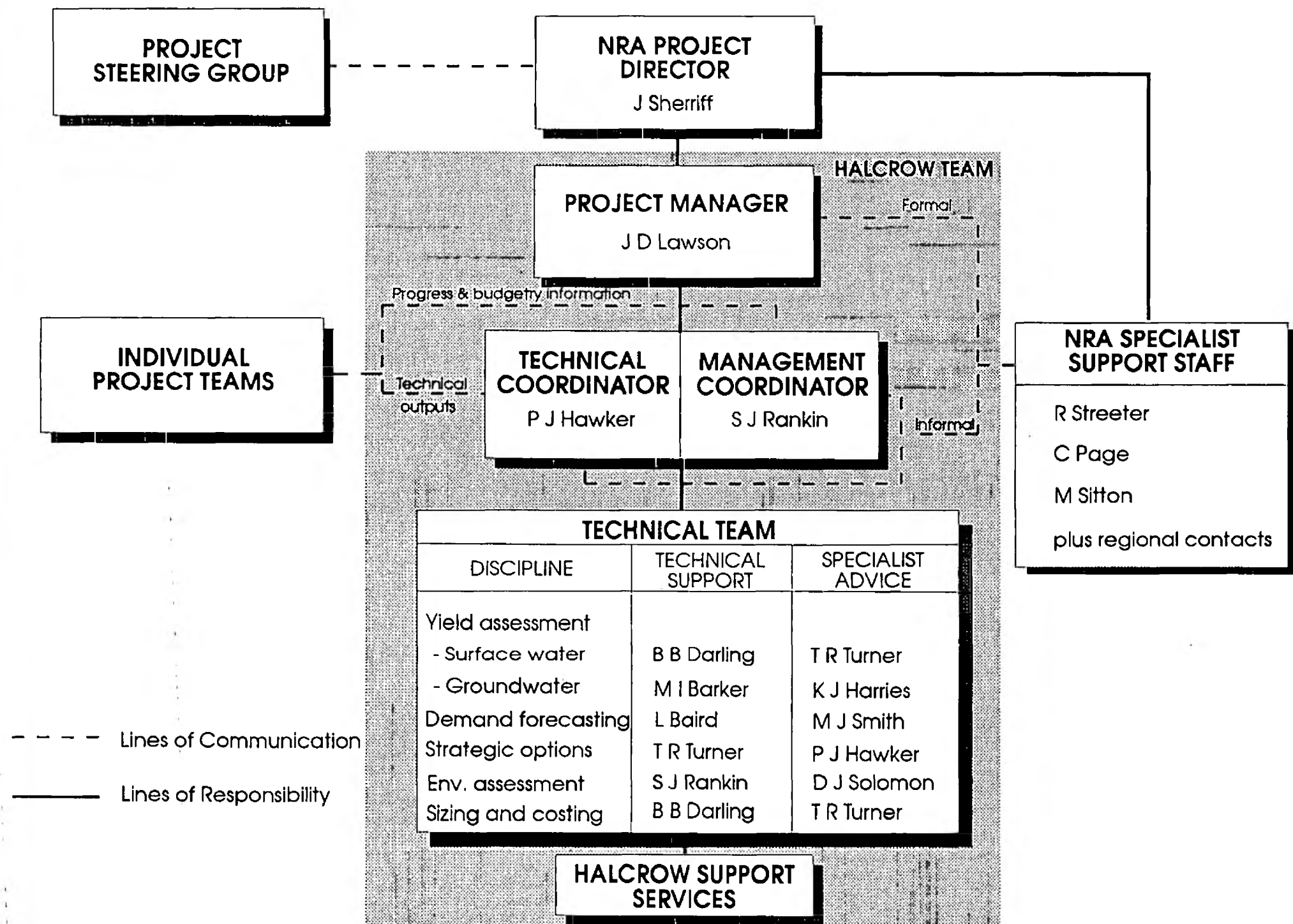


Figure 2.1

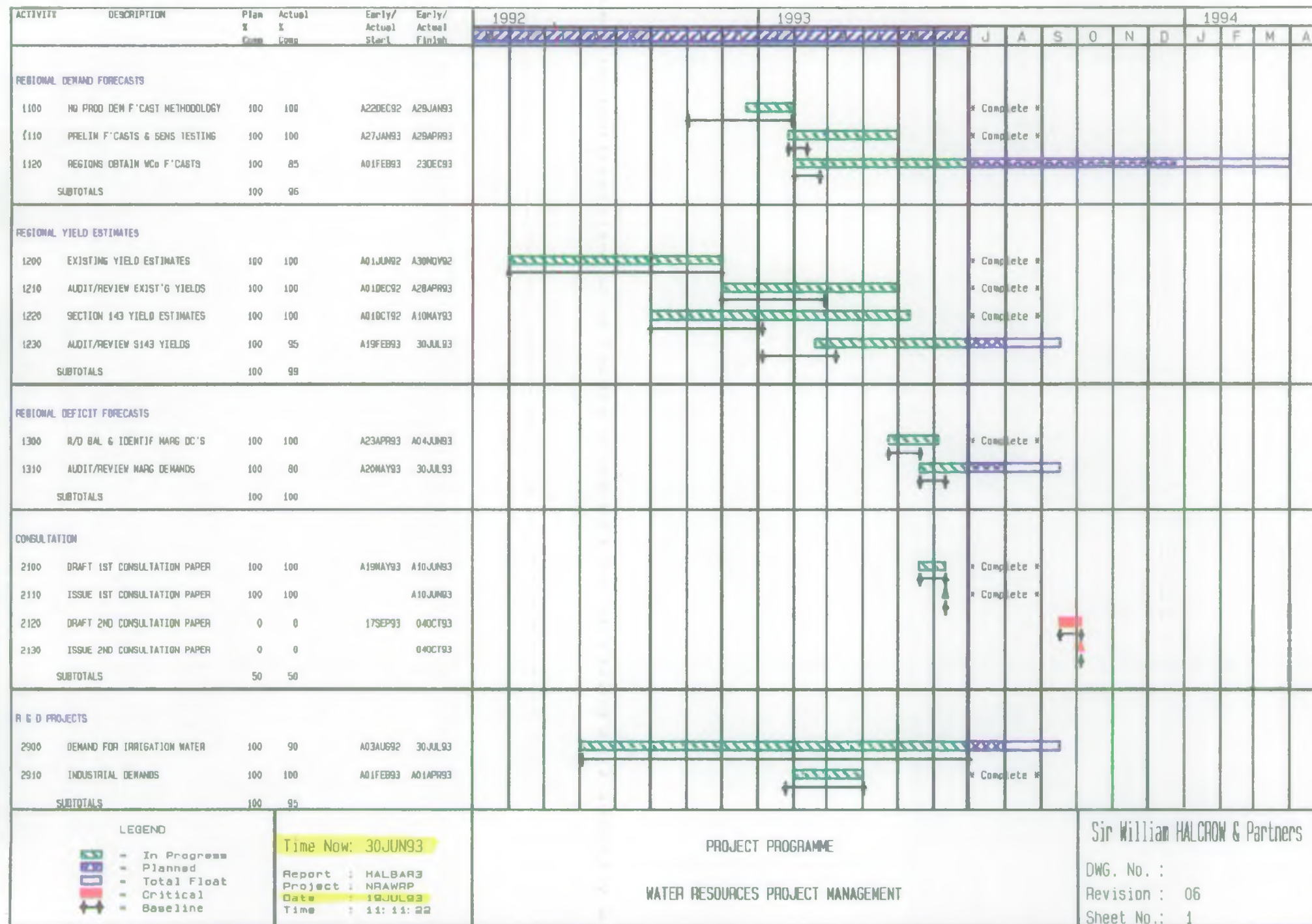


Figure 2.2

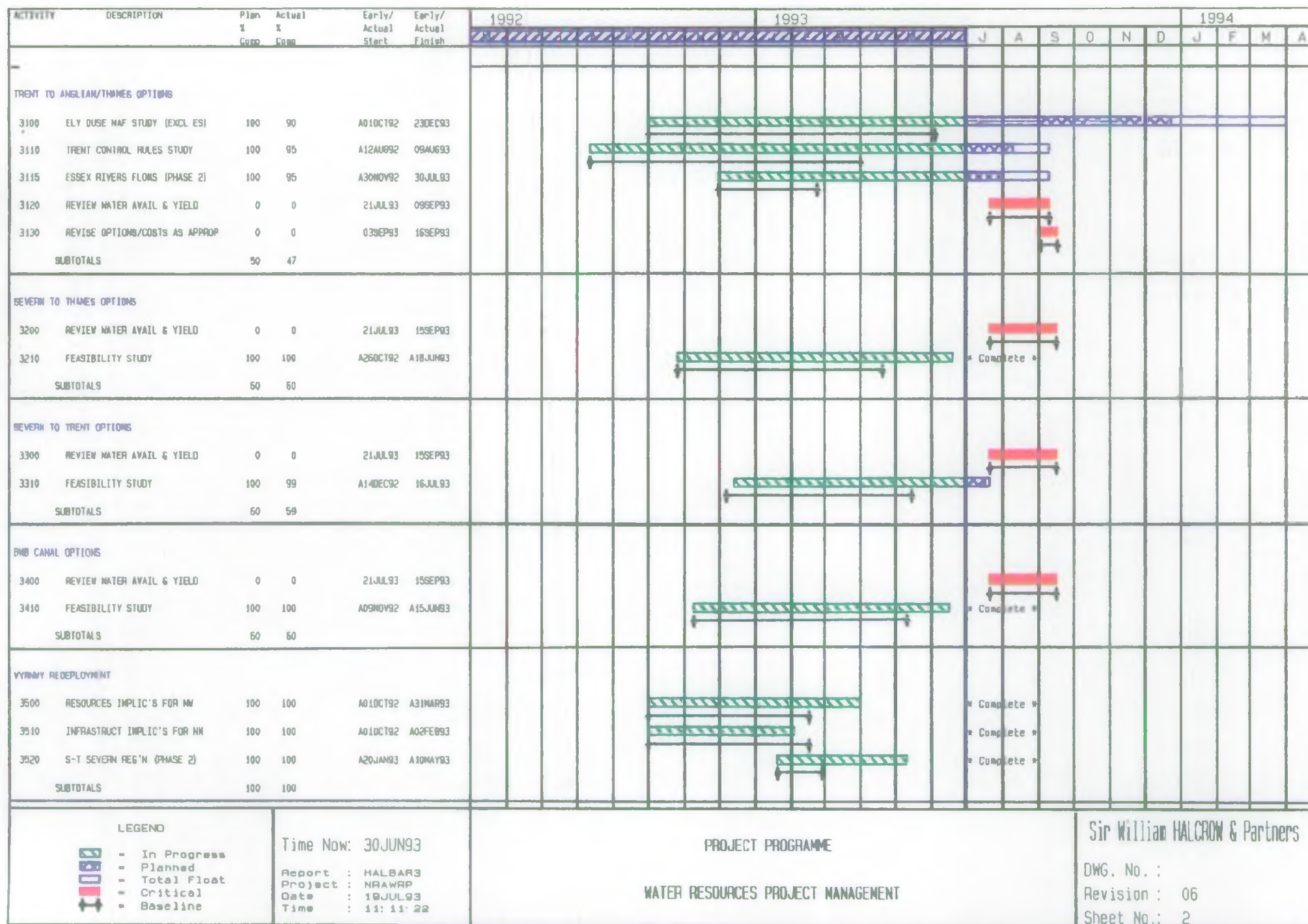
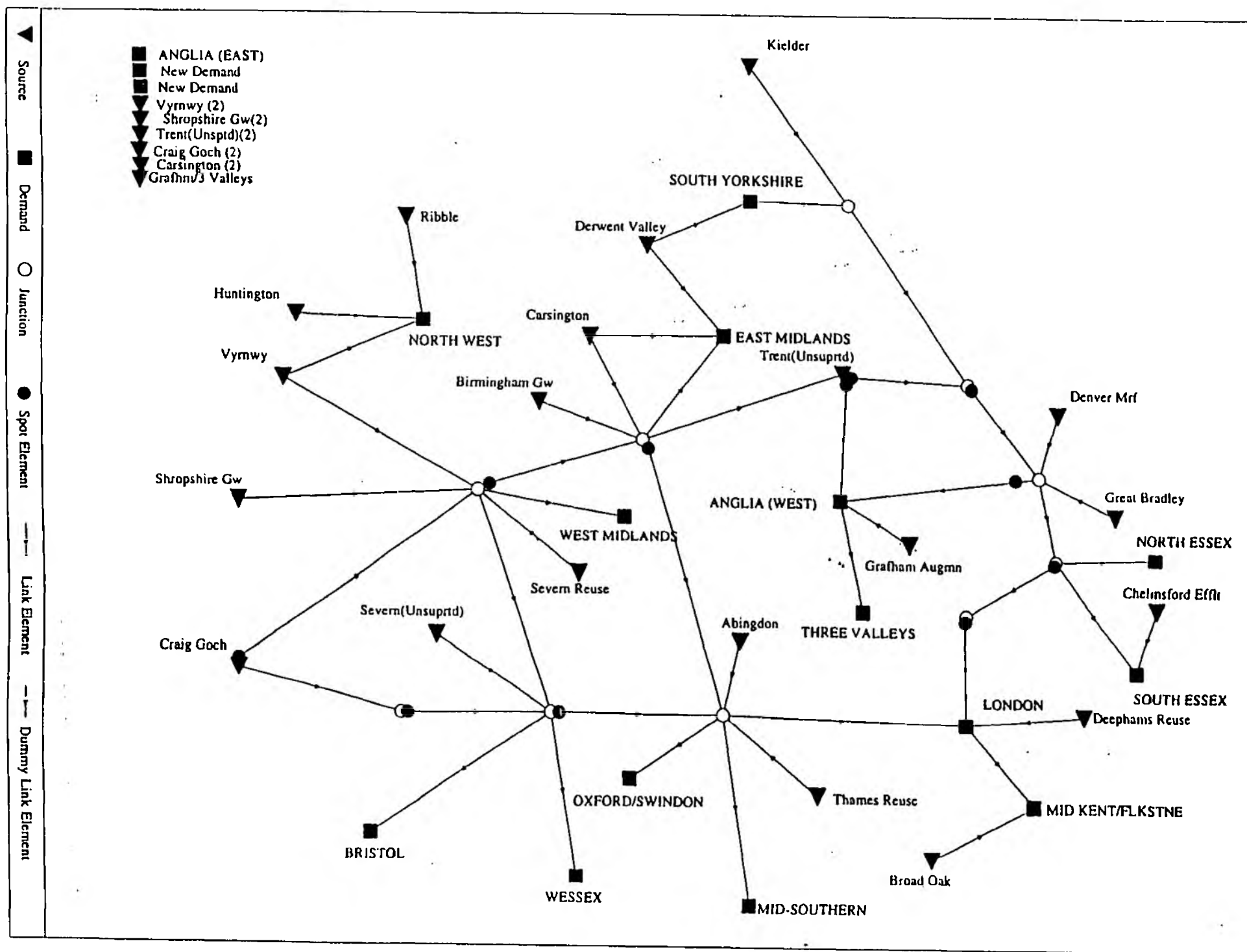


Figure 2.2 cont.

RESPLAN network diagram

Figure 3.1



Appendix A

LIST OF REPORTS

APPENDIX A

Sustainable Water Resources Development Strategy Supporting Studies

Report	Author
Problem Definition Studies	
1 Methodology and Assumptions for Demand Scenarios. Supplementary Report No 1, March 1994.	NRA
2 Demand for Irrigation Water, May 1994.	Silsoe College
3 Water Demand Strategy, May 1993.	Confederation of British Industry
4 Review of Public Water Supply Yields. Supplementary Report No 2, April 1994.	NRA/Halcrow
5 Marginal Demands. Supplementary Report No 3, March 1994.	NRA
Option Appraisal Studies	
6 'Other' Options. Supplementary Report No 4, May 1994.	Halcrow
7 Severn to Thames Transfer Feasibility Study, June 1993 Volumes I and II.	W S Atkins
8 Severn to Trent Transfer Options, June 1993.	W S Atkins
9 Regional Strategic Options Study. Witham to Denver Transfer Option, May 1992.	W S Atkins
10 Options for Transfers of Water from the River Trent and Reservoir Storage at Great Bradley. Volume I - Transfer System, January 1993.	W S Atkins
11 Options for Transfers of Water from the River Trent and Reservoir Storage at Great Bradley. Volume II - Great Bradley Reservoir, January 1993.	W S Atkins
12 Regional Strategic Options Study, Anglian Region. Volumes I and II, May 1992.	W S Atkins
13 Regional Strategic Options Study, Anglian Region. Component 7 River Trent to Rutland Water Transfer, September 1992.	W S Atkins
Option Comparison Studies	
14 Water Transfer: Feasibility Study, June 1993.	Binnie & Partners
15 Hydrological Modelling. Supplementary Report No 5, June 1994.	NRA
16 Resource Scheme Costings. Supplementary Report No 6, May 1994.	Halcrow
17 RESPLAN Modelling. Supplementary Report No 7, March 1994.	NRA
18 Comparative Environmental Appraisal of Strategic Options. Supplementary Report No 8, January 1994.	Howard Humphreys

Appendix B

**MONTHLY PROGRESS
REPORTING PROFORMA**

WATER RESOURCES PROJECT MANAGEMENT
Monthly Progress Report

RESPONSIBLE REGION:						
ACTIVITY	TARGET START	TARGET FINISH	ACTUAL START	% COMPLETION to:	EXPECTED FINISH	ACTUAL FINISH

COMMENTS:

Report Completed by: Date:

Please insert date(s) and % completion as appropriate. Also add any comments including reasons for delays or anticipated future problems where relevant.

Please return completed form to: Mrs S J Rankin, Sir William Halcrow & Partners Ltd, Burderop Park, Swindon, Wilts SN4 0QD.