NRA Wales 172

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Rhanbarth Cymru

NRA

National Rivers Authority
Welsh Region

Welsh Regional Water Resources Planning and Development Strategy

Final Project Report

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BINNIE & PARTNERS
CONSULTING ENGINEERS

NRA Wales

EXECUTIVE SUMMARY

The National Rivers Authority (NRA) has a statutory duty under the Water Resources Act 1991 to conserve, redistribute or otherwise augment water resources and secure the proper use of water resources. This duty does not relieve any water undertaker of the obligation to develop water resources for the purpose of performing any duty imposed on it by virtue of the Water Industry Act 1991. The NRA must have regard to the reasonable needs of all abstractors, particularly those of the water companies. Additionally, the NRA is charged as the guardian of the water environment.

This report provides a policy framework for a Regional Water Resources Strategy for the sustainable development and ongoing management of water resources in the Welsh Region until 2021. It highlights the major issues and makes recommendations concerning the basis for decisions within the Region. Specific consideration has been given to:

* the existing balance of resources and demands;
* future demands for public water supply (PWS), industry, and agriculture;
* the need to improve 'low flow rivers' resulting from overabstraction;
* the selection of water resource options needed to meet justified needs.

By virtue of the Region's relatively abundant water resources several rivers in the Region are already major resource providers to other Regions and this could potentially increase. The proposed strategy has therefore been developed in parallel with the NRA's National Water Resources Strategy, and strategic national resource development proposals affecting the Region are addressed.

The Region's water resources are reviewed in Section 2. The Welsh Region, the third largest of the eight NRA Regions, receives higher rainfall than any of the English Regions and includes a large number of major regulated rivers which represent the principal surface water resource of the Region. Groundwater is also important in the Region, being a source of water for many small private abstractions. However, much of the Region is underlain by impermeable strata and groundwater provides only a limited resource for public water supply resources. The licence exemption status of a large part of Western Wales with respect to groundwater abstractions has resulted in a lack of detailed information on these resources and demands. The Welsh Region is a major net exporter of water. Imports to and exports from the Region are described.

Section 3 identifies and quantifies current and historic demands for water, both human and environmental. Hydroelectric power generation is the largest user of water in the Region, although this is a non-consumptive use. Public water supply is the second largest user of water, with about 40% exported out of the Region. Other abstraction demands include industrial, agriculture and amenity and conservation. In addition to abstraction the Region's rivers are important for several in-river demands. Navigation, angling and effluent dilution all make requirements on rivers. Equally importantly surface water and groundwater resources are required to meet the demands of the environment in the form of water for the soil, wetlands, rivers and estuaries.

This leads on to the forecasting of future demands in Section 4. Future demands for public water supply are forecast under a range of scenarios incorporating assumptions about growth in domestic and commercial consumption, per capita consumption, metering and leakage reduction. A consistent, multiple-component methodology, based on one developed in the NRA's national resources development strategy project, has been employed. This leads to a demand forecast envelope which delimits growth in public water supply demand, ranging from 2% decrease to a 22% increase in demand in the Region. Future demands for private abstraction are also forecast, based on historic trends and consultation with representatives of industry and agriculture. Only spray irrigation and hydroelectric power generation are forecast to increase significantly over the planning horizon.

The forecasts illustrate how sensitive the timing of new resource developments is to the assumptions made in the demand scenarios. Marginal demand for public water supply ranges from about 20 Ml/d to 100 Ml/d in 2021. Under the medium growth scenario demand is forecast to increase by about 6% producing a marginal demand of 28 Ml/d with deficits commencing in 1996.

In Section 5 options for meeting the forecast marginal demands are explored. This includes saving water (demand management), re-allocation of water (reduction in licensed entitlement and incentive charging), and making more water available (resource development). Most of the marginal demands could be met through demand management measures and local source development. Under the high growth scenario one new resource development is identified as being required.

Section 6 details the proposed water resources development strategy in the form of proposed water resources management policies and extensions to the public water supply network. Recommendations for further work by the NRA are also included.

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GLOSSARY OF TERMS

1:50 year Drought	A drought of a severity which is likely to occur on average approximately once every 50 years.
£M	Million Pounds Sterling
£K	Thousands Pounds Sterling
AAF	Actual Abstraction Factor.
Alleviation of Low Flows	(ALF) The strategy for resolving environmental problems caused by over-abstraction in certain catchments.
Abstraction Licence	Authorization granted by the NRA to allow the abstraction of water from a source of supply.
Aquifer	A porous water bearing formation of permeable rock, sand or gravel capable of holding or transmitting significant quantities of water. *Confined aquifer* - where the upper boundary of the aquifer is largely sealed by overlying impermeable strata. Recharge can occur at those parts of the aquifer which are unconfined. *Unconfined aquifer* - the upper boundary of the permeable strata outcrops at the ground surface. Recharge occurs through rainfall or runoff.
(River) Augmentation	To increase, support or regulate river flows by releasing or pumping from stored resources eg. reservoir or groundwater scheme.
Baseflow	When rain falls onto a catchment, some water is absorbed by the soil instead of flowing directly to the river. The water reaches the river by slowly seeping through cracks and pores in the soil and rock. This is termed the 'baseflow' and provides the flow in a river during a long dry spell.
BW	British Waterways
Catchment	The area from which precipitation and groundwater will collect and contribute to the flow of a specific river.
Catchment Management Plan	The planning process being used by the NRA with the aim of sustainable river basin development at a catchment scale.
Conjunctive Use	Combined use of different sources of water (usually surface water and groundwater).
Conjunctive Use Area (CUA)	Term used to refer to an area in which the public water supplies are obtained from a group of sources operated conjunctively.
CWC	Chester Waterworks Company.

Demand	The requirements for water by consumers. *Average demand* - usually refers to the average daily demand (averaged over the year) *Peak demand* - may refer to the seasonal peak consumption, peak week distribution demand, or peak daily demand recorded.
Demand Management	Activities to manage the amount of water required from a source of supply; includes measures to control waste and/or to discourage consumption.
DCC	Dee Consultative Committee.
Discharge Consent	A licence granted by the NRA to discharge effluent of specified quality and volume at a specific point.
Drought	A general term covering prolonged periods of below average rainfall resulting in low river flows and/or low recharge to groundwater, imposing significant strain on water resources.
Dry Weather Flow (DWF)	For sewage works, this is calculated by adding estimates of domestic sewage discharge plus the industrial discharge plus the infiltration into the sewers.
EIA	Environmental Impact Assessment.
Ecology	The relationship between living systems and their environment.
Effluent	Liquid waste from industrial, agricultural or sewage plants.
Effluent Re-use	The use of effluent treated to appropriate (or required) standards for various uses from low grade (grey water) uses to potable supply. The term usually refers to indirect use of treated effluent - effluent mixed to a large degree with other raw water.
Effective Rainfall	That rainfall 'available' for recharge of aquifers or to support river flows after losses due to evaporation and take up by plants.
EU	European Union
Freshet	Seasonal release of water.
GATT	Global Agreement on Trade and Tariffs
Global Warming	The generic term used to describe the climate changes which may occur for example, as a result of depletion of the ozone layer or through the emission of 'greenhouse' gases.
ha	Hectare
HEP	Abbreviation for hydroelectric power.
HMIP	Her Majesty's Inspectorate of Pollution.
Hydrology	The study of water on and below the earth's surface.

Groundwater	Water held in aquifers.
l/hd/day	Litres per head per day.
l/prop/hr	Litres per property per hour.
Ml	Megalitre
Ml/a	Megalitres per annum.
Ml/d	Megalitres per day.
MAFF	Ministry of Agriculture, Fisheries and Food.
Marginal Demand	A forecast demand for public water supply which cannot be met from existing sources.
NFFO	Abbreviation for the government-led Non-Fossil Fuels Obligation scheme.
NFU	National Farmers Union.
NRA	National Rivers Authority.
NWWL	North West Water Limited.
OFWAT	Office of Water Services. OFWAT regulate charges of Water Companies and their service to customers.
PCC	Per Capita Consumption or the quantity of water used for normal household domestic purposes expressed as a volume per person.
PE	Potential Evapotranspiration
Public Water Supply (PWS)	Water treated to potable standards, supplied to domestic and commercial consumers.
Q95	The mean daily flow of a river which is exceeded on average for 95% of the year.
R&D	Abbreviation for research and development.
Regulated River	A river where the flow is augmented through addition of water from another source.
SPL	Supply pipe leakage.
SSSI	Site of Special Scientific Interest.
STWP	Severn-Trent Water Plc.
SWQO	Statutory Water Quality Objective
ToR	Terms of Reference

Water Table	The level in an aquifer below which the ground is wholly saturated with water.
Wetland	An area of low lying land where the water table is at or near the surface for most of the time leading to characteristic habitats.
WEDWC	Wrexham & East Denbighshire Waterworks Company.
Yield	The reliable rate at which water can be drawn from a water source.

1 INTRODUCTION

1.1 BACKGROUND

The National Rivers Authority (NRA) has a statutory duty under the Water Resources Act 1991 (Ref 1) to "take such action as it may from time to time consider.....to be necessary or expedient for the purposes of conserving, redistributing or otherwise augmenting water resources and securing the proper use of water resources. This duty does not relieve any water undertaker of the obligation to develop water resources for the purpose of performing any duty imposed on it by virtue of the Water Industry Act 1991." The NRA must "have regard" to the reasonable needs of all abstractors and "have particular regard" to those of the water service companies and water supply companies. The NRA must also "generally promote" and, so far as is consistent with its other duties, "further the conservation of the water environment."

Increasing - and often conflicting - demands are made of the natural environment. These demands, working in concert with natural phenomena, can result in serious environmental problems. Water quantity, already reduced by abstraction, can be further reduced by drought. Water quality, affected by low river flows, is at greater risk from pollution by industry and agriculture. Polluted water puts aquatic life and abstraction for public supply at risk. Similarly complex interactions exist between river flow, underground water levels, and flooding, channel morphology and navigation, water quality and recreation. These demands and their interactions make the protection and improvement of the water environment, the NRA's core business, an increasingly delicate balancing act.

Under Section 188 of the Water Resources Act 1991 the NRA is required to "...collate and publish information from which assessments can be made of the actual and prospective demand for water, and of actual and prospective water resources, in England and Wales". The overall objective of this project has been to respond to this Statutory requirement for the Welsh Region of the NRA, through the production of a Regional Water Resources Planning and Development Strategy.

1.2 SPECIFIC OBJECTIVES OF THE PROJECT

The Terms of Reference (ToR) for the project are included as Appendix A. The specific objectives are detailed below:

(i) Review the current development of water resources within NRA Welsh Region and their use in meeting existing demands for water;

(ii) Collate and review estimates of future demands for Public Water Supply (PWS) abstraction in the Region up to the year 2021, in 5 year steps, commencing 1981;

(iii) Collate and review estimates of future demand for all other water requirements which impact on the water resources of the Region (including those from outside the Region) up to the year 2021, in 5 year steps, commencing 1981;

(iv) Consider the scope and options available to formulate a sustainable policy. Provide a plan for developing and augmenting water resources, and ensuring their proper use, to meet existing and estimated future demands for water in Welsh Region to 2021;

(v) Compare the various options and proposals considered, take account of environmental impact and other relevant criteria, and give due weight to economic considerations;

(vi) Liaise with the Consultants undertaking the National Water Resources Development Strategy to provide Welsh Region input as necessary and ensure compatible development so far as is possible;

(vii) Take account of progress made on the NRA Welsh Region proposed Abstraction Licensing Policy and other associated National and Regional developments.

These objectives are steps to develop a strategy to ensure the water resources of the Welsh Region are managed in the most environmentally acceptable and sustainable manner.

2 REVIEW OF THE WATER RESOURCES OF THE REGION

2.1 REGIONAL CHARACTERISTICS

The Welsh Region of the NRA, which covers an area of 21,262km^2 (Ref 2), is shown in Figure 2.1 at the end of this Section. Geographically, it is the third largest of the eight NRA Regions. The landscape is very diverse across the Region, from the distinctive mountainous areas of North Wales to the low lying coastal areas of the Gwent and Glamorgan levels. The Region is characterised by a large number of river systems which flow in deeply incised valleys, radiating from the central high ground. Much of the Region has thin soil coverage and limited aquifers. Rainfall therefore finds its way quickly to the sea, with little held back to provide baseflows to sustain river flows in dry periods. The Region's river flows consequently tend to rise and fall quickly in response to rainfall.

The Welsh Region receives more rainfall than any of the English Regions, averaging 1313mm over the period 1961-1990 (Ref 2). Table 2.1 summarises hydrometric data for the principal gauging stations in the Region. After allowing for evaporation losses and water used by plants and vegetation, which amounts to approximately 425mm on average (Ref 3), the effective rainfall available to sustain river flows and recharge aquifers averages about 900mm per year. On average approximately 600m^3 /s, or 52000 Ml/d, of runoff flows to sea. In drought conditions effective rainfall is reduced by about one third because increased losses from evaporation have a disproportionately large effect on the smaller depth of rainfall that is received. It is at such times that pressure is placed upon the environment and abstractors.

About 70% of the Region's population of around 3.1 million people (Ref 4) are located in Wales, with the remainder located in Hereford & Worcester, Shropshire, and Cheshire (Ref 5). After Scotland and Northern Ireland, Wales is the most sparsely populated region of the United Kingdom, although there is a marked contrast between the urban areas of the former mining and heavily industrialised valleys in the South and the largely agricultural communities in Mid and West Wales. Approximately 50% of the Region's population is located in South East Wales (Ref 4), with Cardiff, Swansea and Newport having a combined population of about 0.6 million people. During the 1980s the population of Wales increased by around 70,000 with some of the rural areas growing at a faster rate than the industrialised urban areas (Ref 5).

The Region's population distribution has a major influence on how the Region's water resources are utilised. The majority of PWS abstractions are made from the lower reaches of a number of the Region's larger rivers. These rivers are subject to a high degree of regulation, with river flows carefully managed to support both abstractions and in-river demands. The majority of effluent discharges are made to estuarial and tidal waters and are therefore lost from the Region's water resources.

2.2 SURFACE WATER RESOURCES

The majority of effective rainfall runs to sea as river flow, mainly in winter. This provides no reliable resource unless there is storage for summer use. There are three ways in which major reliable supplies are obtained from surface waters in the Region:

Table 2.1 Hydrometric data for principal gauging stations in the Welsh Region

Hydrometric Area No.	Hydrometric Area Area (km²)	Study Subcatchment	River gauging stations No.	River	Location	Area (km²)	Gauged total		Average annual value Rainfall mm	Runoff mm	Losses mm	MAF m³/s	Q95 m³/s
55	4355	Upper Wye	55007	Wye	Erwood	1282.1			1387	895	492	36.37	4.5
		Upper Wye	55025	Llynfi	Three Cocks	132.0			982	540	442	2.26	0.16
		Lugg	55003*	Lugg	Lugwardine	885.8			839	378	461	10.63	1.43
		Lugg	55018	Frome	Yarkhill	144.0			714	266	448	1.21	0.14
		Monnow	55009*	Monnow	Kentchurch	357.4			1028	521	507	5.90	0.77
		Monnow	55022*	Trothy	Mitchel Troy	142.0			870	352	518	1.58	0.13
		Lower Wye	55023	Wye	Redbrook	4010.0	4010.0	92%	1024	567	457	72.12	11.61
56	1830	Ebbw	56002	Ebbw	Rhiwderyn	216.5			1496	1061	435	7.28	1.43
		Upper Usk	56004*	Usk	Llandetty	543.9			1494	977	517	16.85	2.35
		Upper Usk	56012*	Grwyne	Millbrook	82.2			1251	771	480	2.01	0.34
		Lower Usk	56015*	Olway Brook	Olway Inn	105.1			963	427	536	1.42	0.1
		Lower Usk	56001	Usk	Chain Bridge	911.7			1389	962	427	27.81	4.18
		Lower Usk	56005	Lwyd	Ponthir	98.1			1439	999	440	3.11	0.62
		Lower Usk	56008*	Monks Ditch	Llanwern	15.4	1346.8	74%	891	432	459	0.21	0.05
57	955	Ely	57009	Ely	St.Fagans	145.0			1350	933	417	4.29	0.55
		Taff	57003*	Taff	Tongwynlais	486.9			1863	1365	498	21.08	4.03
		Rhymney	57008	Rhymney	Llanedeyrn	178.7	810.6	85%	1407	955	452	5.41	0.72
58	975	Neath	58002	Neath	Resolven	190.9			2034	1522	512	9.21	0.67
		Neath	58008	Dulais	Cilfrew	43.0			1782	1391	391	1.90	0.24
		Ogmore	58001	Ogmore	Bridgend	158.0			1747	1265	482	6.34	0.91
		Ogmore	58009	Ewenny	Keepers Lodge	62.5			1347	913	434	1.81	0.38
		Thaw	58011	Thaw	Gigman Bridge	49.2	503.6	52%	1170	636	534	0.99	0.14
59	920	Loughor	59002	Loughor	Tir-y-dail	46.4			1534	1351	183	1.99	0.3
		Tawe	59001	Tawe	Ynystanglws	227.7	274.1	30%	1895	1650	245	11.91	1.38
60	2135	Taf	60003	Taf	Clog-y-Fran	217.3			1423	1059	364	7.30	0.77
		Taf	60004*	Dewi Fawr	Glasfryn Ford	40.1			1462	978	484	1.24	0.11
		Upper Tywi	60007*	Tywi	Dolau Hirion	231.8			1694	1319	375	9.69	1.87
		Upper Tywi	60005	Bran	Llandovery	66.8			1499	1047	452	2.22	0.11
		Upper Tywi	60009*	Sawdde	Felin-y-cwm	81.1			1537	1210	327	3.11	0.4
		Cothi	60002	Cothi	Felin Mynachdy	297.8			1638	1202	436	11.35	0.84
		Gwili	60010	Tywi	Nantgaredig	1090.4			1573	1109	464	38.35	3.63
		Gwili	60006*	Gwili	Glangwili	129.5	1477.3	69%	1613	1190	423	4.89	0.41
61	1420	N.Pemb coast	61003*	Gwaun	Cilrhedyn Bridge	31.3			1532	1121	411	1.11	0.15
		Cleddau	61002	E.Cleddau	Canaston Bridge	183.1			1441	1030	411	5.98	0.97
		Cleddau	61004*	W.Cleddau	Redhill	197.6	412.0	29%	1293	859	434	5.38	0.65
62	955	Teifi	62001	Teifi	Glan Teifi	893.6	893.6	94%	1349	999	350	28.30	2.92
63	785	Rheidol	63002*	Rheidol	Llanbadarn Fawr	182.1			1790	1544	246	8.91	1.9
		Ystwyth	63001	Ystwyth	Pont Llolwyn	169.6			1485	1088	397	5.85	0.58
		Wyre	63003*	Wyre	Llanrhystyd	40.6	392.3	50%	1085	760	325	0.98	0.05
64	1380	Dysynni	64002	Dysynni	Pont-y-Garth	75.1			2195	1890	305	4.50	0.49
		Dyfi,Leri	64001	Dyfi	Dyfi Bridge	471.3			1915	1521	394	22.73	2.04
		Dyfi,Leri	64006	Leri	Dolybont	47.2	593.6	43%	1504	743	761	1.11	0.04
65	1300	Gwrfai	65004	Gwrfai	Bontnewydd	47.9			2212	1520	692	2.31	0.29
		Seiont	65006	Seiont	Peblig Mill	74.4			2411	1956	455	4.61	0.59
		Dwyfor	65007	Dwyfor	Garndolbenmaen	52.4			2092	1517	575	2.52	0.23
		Erch	65005	Erch	Pencaenewydd	18.1			1409	1058	351	0.61	0.09
		Glaslyn	65001	Glaslyn	Beddgelert	68.6	261.4	20%	3097	2654	443	5.77	0.52
66	1470	Clwyd	66001	Clwyd	Pont-y-cambwll	404.0			910	473	437	6.06	0.89
		Clwyd	66002*	Elwy	Pant yr Onen	220.0			1119	642	477	4.48	0.45
		Conwy	66011	Conwy	Cwm Llanerch	344.5	968.5	66%	2214	1666	548	18.20	1.24
67	2290	Upper Dee	67001	Dee	Bala	261.6			1844	1530	314	12.69	2.2
		Upper Dee	67006	Alwen	Druid	184.7			1321	844	477	4.94	0.63
		Upper Dee	67029*	Trystion	Pen-y-felin Fawr	12.3				826		0.32	0.02
		Middle Dee	67015	Dee	Manley Hall	1019.3			1402	958	444	30.98	5.16
		Middle Dee	67025*	Clywedog	Bowling Bank	98.6			879	472	407	1.48	0.5
		Lower Dee	67008	Alyn	Pont-y-Capel	227.1	1345.0	59%	919	332	587	2.39	0.47
102	495	Anglesey											
Total	21265						13289	62%					

MAF – Mean annual flow   Q95 – 95%ile flow   * Gauging station no longer operational

Weighted average rainfall	1428 mm	Long term regional average rainfall	1313mm
Weighted average runoff	975 mm	Regional runoff	897mm
% runoff for Region	68.3		

(i) *Abstractions from unregulated rivers* These depend on a steady baseflow component throughout the year and use the natural groundwater and wetlands storage in catchments to maintain flows in the river by natural means. (eg. Afon Teifi);

(ii) *Abstractions from regulated rivers* Several major rivers are regulated from surface storage (eg. Rivers Dee, Tywi, Usk, Wye) or from groundwater (eg. Clwyd);

(iii) *Abstractions from impounding reservoirs* Reservoirs constructed in areas where geography and topography have combined to produce factors favourable to reservoir construction, filled by either natural inflow or from pumped storage (eg. Rivers Elan and Alwen).

Most rivers in the Welsh Region, which are capable of providing worthwhile supplies, are utilised in one of these ways. Many of the major abstractions are made at or not far above the rivers' tidal limits.

Historically, a lack of local resources for PWS in the industrialised Midlands and North West England, as well as South East and North East Wales, led to the development of direct supply reservoirs in the sparsely populated uplands of Wales, such as the Elan and Taf Fawr/Fechan Valley reservoirs. More recently development has continued, but with river regulation schemes replacing direct supply reservoirs as a more efficient way of utilising resources. Industrial and agricultural abstractions are important, although more recently industrial demand has declined with the collapse of "heavy" industry, to be replaced by hydroelectric power generation (HEP) and agricultural spray irrigation.

The Wye catchment, the largest in the Region, is particularly important in resources terms. Approximately 20% of the Region's PWS is obtained from the river (of which around 10% is exported for supplies in England). The Wye is also utilised for a large number of private demands, with about 50% of the Region's abstractions for spray irrigation being made from the Wye.

The Usk catchment, which covers 20% of the Region's area, is also of particular importance, accounting for a further 15% of the Region's PWS resources and supporting nearly 30% of industrial demand in the Region.

The Dee, in the north-east of the Region, is the source of about 30% of all PWS obtained from surface waters in the Region. Much of this water is exported from the Region for supplies in the North-West Region. It is also important for private demands for fish-farming and industry.

The Region's high rainfall and runoff has led to its importance for HEP, which is concentrated in catchments in the north-west of the Region, with most HEP schemes found in the Glaslyn and Gwrfai catchments.

2.2.1 'Section 20' Operating Agreements

Historically, the high population density around the Region's coastline has led to the development of regulation schemes on a number of the Region's major rivers. Section 20 of the Water Resources Act 1991 enables agreements between the NRA and water companies concerning the operation of water resources schemes owned by the water companies. These agreements are commonly referred to as 'Section 20 Agreements'.

Such schemes involve the NRA in defining operational control policies to meet the regulated water supply demands from these schemes. NRA involvement in the operation of water company schemes can enable a proportion of the resource to be licensed to other abstractors and also gives greater control over how releases can best be managed to protect or enhance the environment.

NRA Welsh Region has six such Agreements with Dŵr Cymru, on the Rivers Dee, Tywi, Wye, Dwyfor, Aled and Clwyd. Agreements were originally proposed for the regulation schemes in operation on the Rivers Usk, Eastern Cleddau and Gwyrfai. These were not implemented due to economic considerations and, in the case of the Gwyrfai, the short length of regulated river (Ref 6).

The Section 20 Agreement sets out the management rules for the system and specifies the financial provisions between the NRA and the water company. Each Agreement is supplemented by an Operating Manual which details the procedures to be followed by both the NRA and water company to ensure the intentions of the licences and management rules are implemented by staff with a minimum of supervision. A consultative group, comprising representatives of the NRA and Dŵr Cymru, exists to agree procedures for the release of regulation water and freshets for river management, procedures for emergencies, and to agree any updating and revision to the Operating Manual.

2.2.1.1 The Dee Agreement

The Dee Regulation Scheme is unusual in that the detailed application of matters formalised in Statutory Instruments and Licences is subject to the over-riding framework of the Dee & Clwyd River Authority Act 1973 (subject to minor modifications in parallel with the Water Resources Act 1991). Both detailed and general principles are set out in the Dee General Directions which are modified from time to time through the Statutory Dee Consultative Committee (DCC). The DCC comprises representatives of the NRA, Dŵr Cymru, North West Water Limited (NWWL), Wrexham & East Denbighshire Water Company (WEDWC), Chester Waterworks Co. (CWC), and British Waterways (BW).

The general principles for river regulation relate to the definition of a maintained flow of specified magnitude and location whilst having due regard to mitigating floods, safeguarding fisheries, supplying BW with a specified quantity, and any other purposes which in the opinion of the NRA are appropriate and consistent with the purposes of the Scheme.

The Section 20 Agreement deals with the management rules necessary for the effective day-to-day operation between the NRA and Dŵr Cymru of Llyn Celyn, Llyn Brenig and Alwen Reservoir within the Dee Regulation Scheme.

2.2.1.2 The Wye Agreement

The storage of the Elan Valley reservoirs is used to satisfy three specific requirements: Firstly, to provide a direct supply to Severn-Trent Water Plc (STWP). Secondly, to provide a direct supply to Dŵr Cymru at Elan Valley. Thirdly, to provide river regulation releases to the River Wye during periods of low flow, and which facilitate PWS abstractions by Dŵr Cymru at Monmouth and STWP at Lydbrook. The general principles covering the operation of the Regulation Scheme are dependent on storage in the Elan Valley reservoirs and the flow in the Wye at Redbrook.

2.2.1.3 The Tywi Agreement

Llyn Brianne is used to regulate the River Tywi to support PWS abstractions at Manorafon and downstream at Nantgaredig. There is provision for compensation water and freshet releases from Llyn Brianne for the river system, which is an important salmon and sea trout fishery for both commercial and angling interests.

2.2.1.4 The Aled Agreement

Llyn Aled and Aled Isaf provide storage for river regulation of the Afon Aled to support PWS abstractions by Dŵr Cymru at Bryn Aled, compensation releases from Aled Isaf, a residual flow for part of the year downstream of the Bryn Aled abstraction, and freshet releases in autumn and winter for fisheries.

2.2.1.5 The Clwyd Agreement

Boreholes in the Permo Triassic Sandstone in the Vale of Clwyd are used as the principle source of water for river augmentation of the Afon Clwyd. In addition, a statutory provision allows augmentation discharges of water from the Alwen Aqueduct, which provides a significant import of potable water into the Vale of Clwyd. The augmentation discharges are particularly beneficial in enhancing the very low natural summer flows in the Afon Clwyd between Ruthin and the confluence with the River Wheeler.

2.2.1.6 The Dwyfor Agreement

Llyn Cwmystradlyn is the principal source for the Lleyn Peninsula. The reservoir storage is used conjunctively on a seasonal basis for both direct supply and river regulation which supports abstractions by Dŵr Cymru at Dolbenmaen, diurnally variable abstractions at Brynkir Mill, and compensation water and freshet releases for a river system which is an important salmonid fishery.

2.3 GROUNDWATER RESOURCES

Groundwater is utilised throughout the Region ranging from small private abstractions to major industrial and PWS sources. A detailed map showing the geology of the Region in included as Appendix B. The karstic limestones of the Carboniferous represent one of the major aquifers in the Region (Ref 4). They are highly permeable as a result of well developed joint and fissure systems. Large yields are obtained from major spring resurgences of groundwater, which occur near the base of the sequence or along faults. The groundwater catchments in karstic limestone may bear little relation to surface topography.

The Permo Triassic Sandstone in the north-east of the Region is a major aquifer but is limited in its distribution within the area. Where it does occur it is exploited by industrial and PWS abstractions.

The Old Red Sandstone, which has minor aquifer status on a national level, is regionally important in sustaining a large number of small public and private supplies. Supplies from gravel deposits exist throughout the Region and are heavily exploited by both local industry and private abstractors. In most cases these deposits are in hydraulic continuity with surface water systems.

Other aquifer systems throughout the Region may have too limited storage capacity and geographical extent for them to be exploited for large scale PWS. They do, however, offer an important resource for many rural areas and have become increasingly used for spray irrigation purposes.

2.4 LICENSED ABSTRACTION IN THE REGION

NRA Welsh Region currently controls about 4100 licences for abstraction of water from surface waters and groundwater, with the current total licensed entitlement amounting to just under 30,000 Ml/d (averaged over 365 days). PWS demand accounts for about 10% of the total. Private demands - abstractions made by individuals or organisations for their own use as alternative (for reasons of cost, quality or convenience) to the PWS system - account for the remainder. Typical uses are industrial cooling water, spray irrigation, and HEP generation. Many households take their water from private domestic wells but, because these are very small in size, they are not generally licensable. These abstractions are unlikely to increase in number and are not addressed in this report.

For the purposes of this study abstractions from springs have been considered as groundwater abstractions. However, it should be noted that springs are important to both surface water and groundwater; springs feed the surface water source, but the groundwater is important in the protection of the source. Licences have been classified according to 10 categories of use specified in the ToR. The categories are listed below:-

* Agriculture
* Amenity and Conservation
* Electricity - cooling (non-evaporative cooling)
* Fish farming
* Hydroelectricity
* Industrial (includes process and sand & gravel washing, milling, bottling water, sewage treatment, evaporative cooling)
* Public water supply
* Private water supply
* Spray irrigation
* Others (unspecified uses)
* Transfers

Table 2.2 summarises the licensed average daily abstractions (averaged over 365 days) and peak abstractions (maximum daily quantity) from surface waters and groundwater, in each category of use. About 30% of the licences are for abstractions from surface waters, but these account for 98% of the total licensed quantity. The majority of the large number of licences for groundwater abstractions are for abstractions for agricultural use. About 24350 Ml/d (averaged over 365 days), or 80% of licensed abstraction is from non-tidal waters. These figures are based on information obtained from the NRA's licence database in July 1993.

Licences equal to or greater than 1 Ml/d (averaged over 365days) were audited to avoid double-counting of multiple site licences and linked licences, and to identify and rectify any errors in the database.

In this study the Region has been divided into 40 sub-catchments. The licensed quantities in each sub-catchment are presented in Appendix C.

Table 2.2 *Summary of licensed abstraction in the Welsh Region*

Source	Purpose	No of licences	Licensed quantity (Ml/d)	
			Daily Average	Daily Peak
Surface Water	Agriculture	48	1	1
	Amenity/conservation	82	79	118
	Electricity-cooling	2	4985[1]	5507[1]
	Fish farming	62	447[2]	632[2]
	Hydroelectricity	37	17803[3]	24656[3]
	Industrial	182	1480[4]	2540[4]
	Public water supply	148	2909	3127
	Private water supply	122	< 1	1
	Spray irrigation	520	17	179
	Others	27	89	100
	Transfers	23	1837	7816
	SOURCE TOTAL	1253	29646	44679
Groundwater	Agriculture	2118	15	21
	Amenity/conservation	5	< 1	1
	Electricity-cooling	0	-	-
	Fish farming	5	2	2
	Hydroelectricity	0	-	-
	Industrial	138	72	121
	Public water supply	117	219[5]	260[5]
	Private water supply	386	2	3
	Spray irrigation	81	3	22
	Others	12	1	1
	Transfers	7	10	24
	SOURCE TOTAL	2869	323	452
REGION TOTAL		4122	29969	45131

Legend:

[1] Includes 4979 Ml/d tidal abstraction

[2] Includes 10 Ml/d tidal abstraction

[3] Includes 93 Ml/d tidal abstraction

[4] Includes 523 Ml/d tidal abstraction

[5] Includes notional 15 Ml/d in licence-exempt area

2.4.1 Licence - exempt areas in the Region

Abstractions are exempt from licence controls under the Water Resources Act 1991 in two areas in the Welsh Region: much of the west of the Region including most of Dyfed, Gwynedd and Anglesey is exempt for groundwater abstractions and the Upper Usk sub-catchment upstream of Llangynidr is exempt for minor surface water abstractions.

Figure 2.2, at the end of this Section, shows the licence-exempt areas and the sub-catchment boundaries. These areas were designated by application to the Secretary of State for Wales for an order under the Water Resources Act 1963. Within the groundwater exempt areas, spring water is classed as surface water and its abstraction is controlled by appropriate licensing procedures.

No information is currently available concerning the minor surface water abstractions in the Upper Usk licence-exempt area. However, the NRA believe these abstractions are insignificant in this area.

A large part of the Region's groundwater resources are located within the licence-exempt area of West Wales. Dŵr Cymru are known to operate a number of PWS sources in this area, mainly in the south-west of Wales. Although information about these sources is not available, the NRA has identifed a number of sources with a total yield of 15 Ml/d. A notional licensed quantity of 15 Ml/d (averaged over 365 days) has therfore been included in Table 2.2 to represent these sources. The total volume of abstractions from groundwater in the licence-exempt area is likely to be somewhat larger than this figure. It should therefore be noted that the figures in Table 2.2 and Appendix C underestimate the utilisation of groundwater in the Region.

The current lack of controls on groundwater quantity within the licence-exempt area pose problems for an integrated approach to water resource management throughout the Region. However, the controls exercised by the NRA concerning water quality within these areas are not compromised by the licence exemption status.

2.4.2 Surface water abstraction licensing policy

The Welsh Region of the NRA currently does not have a formal abstraction licensing policy. The Region is now undertaking an R&D project to develop a consistent, simple methodology for the licensing of surface water abstractions. The methodology will provide a straightforward, robust quantitative system for the evaluation and determination of abstraction licence applications. The project will address how much abstraction should be allowed from a catchment (taking account of in-river needs) and the setting of residual flow and other conditions on licences.

2.5 PUBLIC WATER SUPPLY RESOURCES

The NRA currently licenses 265 abstractions for PWS in the Welsh Region, which account for about 13% of the total licensed quantity from non-tidal waters. Dŵr Cymru is the principal provider of water supplies in the Region. CWC and WEDWC provide water supplies in North East Wales, with their boundaries almost entirely within the Welsh Region of the NRA. Additionally STWP and NWWL have supply areas which cross over into Welsh Region's area.

The Welsh Region has a highly developed water resource infrastructure for PWS. This provides considerable flexibility in the management of water resources across the Region through intra-regional transfers. The Region's principal water resources are shown in Figure 2.3 at the end of this Section. The three Welsh companies depend almost entirely on abstractions within the Welsh Region. STWP and NWWL benefit from substantial exports from the Region.

2.5.1 Source yields

The quantity licensed at each source is not necessarily reliably available. The term yield is used to define the quantity an abstractor can rely upon from a source under design drought conditions, that is the uniform rate at which water can be drawn from the source throughout a dry period of specified severity without depleting the contents to such an extent that withdrawal at that rate is no longer feasible. Traditionally, yields are based on 1:50 year or 1:100 year design droughts.

All PWS companies have levels of service proposed by the Office of Water Services (OFWAT), which are:

* a hosepipe ban on average not more than once in 10 years;
* need for voluntary savings of water on average not more than once in 20 years; and
* risk of rota cuts or use of stand-pipes on average less than once in 100 years.

Since 1985, Dŵr Cymru has used 'operational yield' as a measure of the source yield. This takes account of the way sources would actually be operated in severe droughts. It includes the effects hosepipe bans and drought orders would have on reducing demand upon its sources. Operational yield is based on the worst historic drought on record rather than a design drought, although Dŵr Cymru believe that for their sources the worst historic droughts are not dissimilar to a 1:50 year or 1:100 year drought (Ref 7). Another important point is the assumed end date of the drought. Dŵr Cymru assume an end date in mid-October for river-regulating systems and river abstractions, and mid-November for direct supply reservoirs and groundwater sources and springs. The addition of such a dry tail to the drought used in the yield calculation adds to its severity, leading to operational yields being lower than traditional yields.

CWC takes nearly all its water from the regulated River Dee, just upstream of Chester Weir. This regulated river has a reliable yield based on a 1:100 year design drought, and is subject to complex operation rules controlled through the DCC. In drought conditions the DCC can set rules to reduce abstractions. As a result the reliable yield of the Dee is assumed to equal the licensed quantity.

WEDWC takes approximately 70% of its water from the River Dee at Bangor-is-y-Coed. The yield of this source is equal to the licensed quantity. The remainder of its 14 sources, which comprise a mixture of surface water, spring and groundwater abstractions, have yields based on a 1:50 year design drought. Table 2.3 summarises the total yield for PWS sources in the Region. Detailed information is given in Appendix D.

The NRA is currently developing a National Methodology for assessing Surface Water Yield on a consistent basis.

2.5.2 Dŵr Cymru resources

Dŵr Cymru's resources comprise 41 supply zones which have been considered in 5 sub-divisional areas for the purposes of this project. The supply zones show only limited correlation to sub-catchment boundaries. Dŵr Cymru has developed a number of conjunctive use areas (CUAs) in recent years. These schemes in effect provide water grids covering a large proportion of the Company's supply area, and enable Dŵr Cymru to meet demands more efficiently. Dŵr Cymru currently operate six CUAs.

Dŵr Cymru is part way through a programme of phasing out smaller sources for which it is not economically viable to provide water treatment to satisfy EU requirements on water quality: of the 225 licences which the company currently holds for PWS, 86 small licences (flagged in Tables D.1-D.3 in Appendix D) with a total licensed quantity of 64 Ml/d (averaged over 365 days) are disused. Dŵr Cymru's reductions in yield are taken into account in the existing yield figures in Table 2.3 as the Company has already set the yield of these sources to zero. The 22 Ml/d source at Schwyll near Bridgend in South Wales (which poses particular water quality difficulties), and a number of small sources with licensed quantities between 1 Ml/d and 5 Ml/d (averaged over 365 days), are being retained on a standby basis for emergency use. Dŵr Cymru plan to decommission the Schwyll source in the near future.

Table 2.3 *Summary of PWS licensed quantities and yields (excluding water for non-potable supplies)*

Water Company	Licensed quantity (Ml/d)		Yield (Ml/d)	
	Current 1993	Planned 1996	Current 1993	Planned 1996
DC SE Division	1339.0	1339.0	647.1	647.1
DC SW Division	624.0	624.0	431.0	409.0
DC N Division (W)	118.5	118.5	96.5	96.5
DC N Division (E)	148.0	148.0	138.0	138.0
DC TOTAL	2229.5	2229.5	1312.6	1290.6
WEDWC	67.4	55.0	55.9	54.6
CWC	36.4	36.4	34.6	34.6
Region total	2333.3	2320.9	1403.1	1379.8

Dŵr Cymru have strategic plans to make good the reductions in yield by 1996. To a large degree the development of CUAs is making it possible to phase out unsuitable sources without the need to promote new sources. It is important to remember that the yield of revoked PWS licences immediately becomes available for the issue of new abstraction licences for other purposes. In addition to the total yield of 1291 Ml/d for potable supply Dŵr Cymru also has a yield of 196 Ml/d for non-potable supply. The CUAs and their principal sources for potable supply (yield greater than 5 Mld) are discussed below.

2.5.2.1 The Southern CUA

The Southern CUA is the largest of the six CUAs, meeting nearly 50% of the Company's demands. The principal sources supplying the Area are detailed in the table overleaf. Llandegfedd is a pumped storage reservoir, which is supported by regulation releases to the River Usk from Usk impounding reservoir. At times when there is water surplus to regulation requirements in Usk Reservoir this is used to augment the guaranteed direct supply to the SW Division, thereby reducing that Division's demands on the regulated River Tywi. The Monmouth Intake is supported by the Elan Valley reservoir group and

Taf Fechan/Taf Fawr reservoir group. Talybont Reservoir is used for direct supply.

Source	Yield (Ml/d)	Treatment Works
Llandegfedd Reservoir	234	Llandegfedd, Court Farm
River Wye, Monmouth intake	125	Court Farm
Taf Fechan reservoir group	71	Pontsticill
Taf Fawr reservoir group	46	Llwynon
Talybont Reservoir	46	Talybont
Castell Nos & Lluest Wen Reservoirs	11	Maerdy
Llyn Fawr Reservoir	7	Tynywaun
Grwyne Fawr Reservoir	7	Cwmtillery
Carno Reservoirs	5	Carno
Shon Sheffrey Reservoir	5	Nant-y-bwch
Bulk supply from SW Division	22	Felindre
TOTAL	579	

2.5.2.2 Felindre/Schwyll CUA

The Felindre/Schwyll CUA, in the SW Division, which accounts for about 20% of Dŵr Cymru's resources, comprises the principal sources shown overleaf.

The Cray source provides much more than the operational yield for most of the year, and the use of surplus Usk water at Bryngwyn treatment works means that it is rarely necessary to take water from the Manorafon intake. Both these factors help to conserve storage at Brianne Reservoir on the Afon Tywi.

Source	Yield (Ml/d)	Treatment Works
River Tywi, Nantgaredig intake	227	Felindre, Capel Dewi
River Tywi, Manorafon intake	36	Bryngwyn
Cray Reservoir	20	Cray
Usk Reservoir	13	Bryngwyn
Lliw reservoirs	10	Felindre
Headwaters of the River Loughor	7	Bryngwyn
Less bulk supply to SE Division	(22)	
TOTAL	291	

2.5.2.3 Alwen/Bretton CUA

The principal sources supplying water to the Alwen/Bretton CUA are detailed overleaf. The new treatment works at Alwen is designed to treat water in excess of the operational yield of the reservoir. This means that, instead of spilling into the River Dee, surplus water from Alwen Reservoir can be treated locally and delivered by gravity to the CUA, with a consequent reduction in the quantity which needs to be pumped to the more expensive Poulton treatment works.

Source	Yield (Ml/d)	Treatment Works
Alwen Reservoir	35	Alwen
River Dee, Poulton intake	24	Bretton
TOTAL	59	

2.5.2.4 North Eryri/Ynys Môn CUA

A trunk main across the reconstructed Britannia Bridge allows mainland water to be used on Ynys Môn to supplement the yield of Alaw and Cefni impounding reservoirs. The principal sources supplying water to the North Eryri/Ynys Môn CUA are detailed below:-

Source	Yield (Ml/d)	Treatment Works
Alaw Reservoir	26	Alaw
Llyn Cwellyn	12	Cwellyn
Cefni Reservoir	10	Cefni
Ffynnon Llugwy Reservoir	9	Llandegai
TOTAL	57	

2.5.2.5 Hereford CUA

The Hereford CUA primarily relies on an intake on the River Wye which delivers water to Broomy Hill treatment works. The CUA includes the town of Leominster, the city of Hereford and large rural areas to the north and south of the city.

Source	Yield (Ml/d)	Treatment Works
River Wye, Broomy Hill Intake	45	Broomy Hill
TOTAL	45	

2.5.2.6 The Pembrokeshire CUA

The principal sources supplying water to the Pembrokeshire CUA are detailed on the next page:-

Source	Yield (Ml/d)	Treatment Works
River E.Cleddau, Canaston intake	58	Bolton Hill
River W.Cleddau, Crowhill intake	10	Bolton Hill
Prescelly Reservoir	7	Presceli
Allocation to non-potable supply	(37)	
TOTAL	38	

2.5.3 Wrexham & East Denbighshire Water Company resources

The current total available yield from WEDWC's sixteen sources amounts to 56 Ml/d; 40.9 Ml/d from the River Dee at Bangor-is-y-Coed and a total of 15.1 Ml/d from small sources, which include seven small impounding reservoirs and a number of boreholes and springs. The supply from the River Dee is pumped to the Marchweil bunded raw water storage reservoir, which provides a buffer of several days supply against pollution of the River Dee. Water gravitates from Marchweil to Llwynon treatment works which supplies the most densely populated part of the Company's area in and around Wrexham.

The second largest source is the Legacy treatment works which treats water from Ty Mawr and Cae Llwyd reservoirs, which have a yield of 3.4 Ml/d. Arrangements have recently been completed which allow the yield of Penycae reservoirs to be transferred to Legacy, thereby enabling WEDWC to abandon the smaller Penycae treatment works.

WEDWC, similarly to Dŵr Cymru, has developed a conjunctive use scheme. The Company is completing the construction of pumping stations and trunk mains which will enable them to deliver River Dee water to those parts of their area which have previously been dependent on direct supplies from impounding reservoirs and groundwater sources.

The Company has a number of small sources where the introduction of a satisfactory level of treatment is problematic or abstraction is causing low flow problems. Closure of seven of the Company's smaller sources, with a combined yield of around 2 Ml/d is planned. To offset the reduction in the Company's resources associated with the closure of its Minera sources WEDWC are expected to apply to the NRA to increase the Company's abstraction from the Dee at Bangor. This will result in the source yield increasing to 43.4 Ml/d. Overall, the closures and licence changes will result in a total yield of 53.8 Ml/d.

WEDWC's area of supply extends as far north as the recent commercial development located 3km south of the centre of Chester. WEDWC's area lies mostly within the Middle Dee sub-catchment, with the remainder in the Lower Dee sub-catchment. The progressive integration of supplies across the Company's area means that it is no longer meaningful to consider their different pressure zones as discrete supply zones.

All abstraction by WEDWC are used and returned entirely within the Dee Catchment.

2.5.4 Chester Waterworks Company resources

Currently, CWC's total available yield is 35 Ml/d. Plemstall borehole, located within the North West Region, has a yield of 1.6 Ml/d which is used to supply consumers in that Region, although there is a connection to the main part of the Company's supply system within the Welsh Region. CWC's area lies primarily within the Lower Dee sub-catchment, with a small fraction in the lower Mersey catchment.

Except for Plemstall, the whole of CWC's supply is drawn from an intake on the left bank of the River Dee, about 1km upstream of Chester weir. Water is pumped via a syphon under the river to the Company's Broughton treatment works 1.5km east of the city centre. This Works has been progressively enlarged and modernised during the last 100 years. It now includes three raw water storage reservoirs, the latest of which was constructed after a major pollution incident on the River Dee in 1984 and has a capacity of 38 Ml.

The total raw water storage could now maintain supplies for more than 2 days during a pollution incident, but this would necessitate pumping water at a rate in excess of the licensed quantity in order to refill the raw water storage reservoirs after the incident. About 1.5 Ml/d of abstracted water is returned to the river. Because the supply area drains via Chester sewage treatment works into the tidal length of the Dee, below Chester weir, all present and future demand in the Company's area is a net drain on the resources of the Dee catchment.

2.5.5 Efficiency of use and constraints on yield

Dŵr Cymru and WEDWC have developed effective conjunctive use schemes which enable them to meet demands during dry years and to provide benefits to the environment by minimising their consumption of power and treatment chemicals in wet years. Since privatisation, despite the occurrence of successive dry summers, none of the three companies has imposed restrictions on supplies to their consumers, indicating efficient use of available resources.

The relationship between licensed quantity and yield for the principal categories of abstraction licensed to the three Welsh companies is described in more detail in Section 3 below. In general the yield of abstractions supported by river regulation schemes equates to the licensed quantity. For other classes of PWS abstraction - direct supply impounding reservoirs, unsupported river abstractions and groundwater abstractions - the licensed quantity has usually been set at a high enough figure to enable the undertaker to take full advantage of water available in the reservoir, river or aquifer following periods of above average rainfall. The operational yield for these types of source is generated by the quantity of water available at the end of a prolonged dry period, which will clearly be less than the quantity licensed on the foregoing basis.

This method of licensing makes it possible to prevent surplus run-off escaping to the sea from overflowing reservoirs, from not fully exploited unregulated rivers, or in the case of aquifers which become surcharged, from springs which start flowing in these conditions. The maximum use of gravity supplies from sources reduces the consumption of power for pumping and of chemicals for water treatment. This provides benefits to the environment which would not be achieved if licences were restricted to little more than the operational yield of all sources.

Because the operational yield depends on the ability to use all the licensed quantity of water available at the abstraction point at the end of a prolonged dry period it would not be possible to grant new licences to other classes of abstractor if the water companies licensed quantities were to be reduced to figures closer to the operational yield. Examples of cases where the actual quantities abstracted greatly exceed the operational yield are reservoirs in under-reservoired catchments. These include Cray, Taf Fawr, Lliw, Ystradfellte and Alwen.

At Lliw, where the two reservoirs have an operational yield of 10.3 Ml/d, the daily quantity pumped to Felindre via Lliw from Nantgaredig has to be adjusted to take account of the inflow to the reservoirs from their direct catchment. On occasions the quantity abstracted from the Tywi at Nantgaredig is reduced by as much as 100 Ml/d following heavy rainfall. Full utilisation of the available run-off from the Taf Fawr catchment permits a reduction in the daily demand on Llandegfedd Reservoir, as a consequence of the trunk main links throughout the Southern CUA.

2.6 PRIVATE DEMANDS RESOURCES

In addition to PWS the Region's surface waters and groundwater are utilised for agriculture, power generation, and other industry. These abstractions are made directly from rivers and boreholes, although the water companies meet some industrial demands. Private abstractions account for 87% of the total licensed quantity for abstractions from non-tidal waters. The reliable output associated with the 3850 or so licences for direct use, are not readily available. For strategic planning purposes the 'broad-brush' assumption is made that the yield available to private abstractors is 100% of the licensed entitlement.

2.7 IMPORTS AND EXPORTS OF WATER

The Welsh Region is a net exporter of water to England, with about one third of licensed PWS abstraction being used outside the Region. Table 2.4 summarises those licences which account for exports.

NWWL have a single licence for their three abstractions from the River Dee at Chester for transfers to Merseyside. The abstracted quantity in 1992 was 547 Ml/d. NWWL Ltd have a second licence for 47 Ml/d for water taken to Nantwich via the Llangollen canal; the 1992 abstraction was 37 Ml/d.

STWP purchase from Dŵr Cymru all except 5 Ml/d of the direct supply yield of the Elan Valley reservoirs; abstraction in 1992 was 323 Ml/d. When the current refurbishment of the aqueduct to Birmingham has been completed the average demand will probably return to the net available yield of 335 Ml/d. The Company's abstraction from the River Wye at Lydbrook is for transfer to the Forest of Dean/Gloucester area, with actual abstraction around 39 Ml/d. The 9 Ml/d of treated water from this source sold to Dŵr Cymru goes to Ross on Wye.

There are also several small imports to Welsh Region from North-West Region and Severn-Trent Region, detailed in Table 2.5 overleaf.

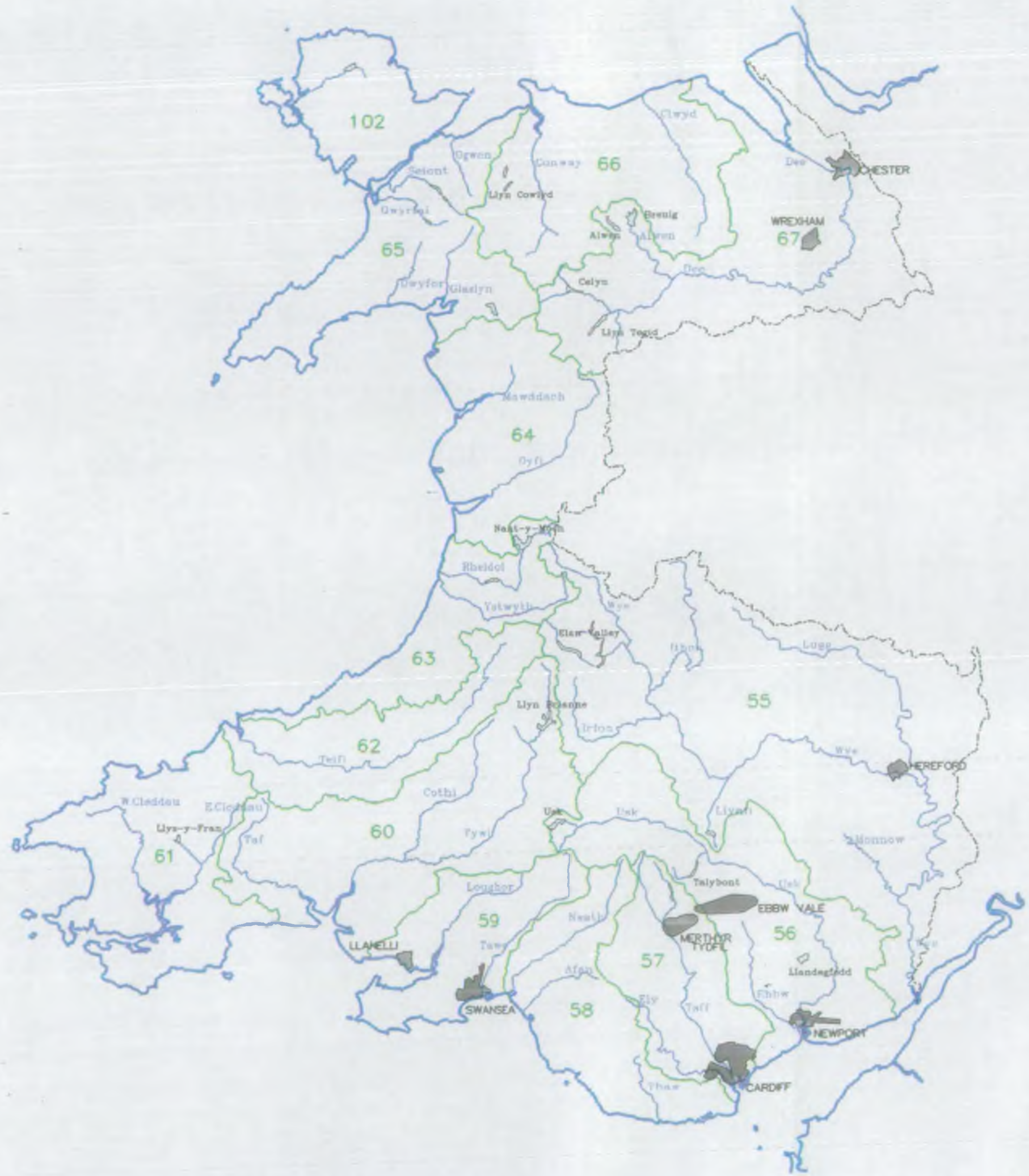
Table 2.4 *Exports from the Welsh Region above 1 Ml/d licensed quantity*

Water Company benefitting	Sub-catchment & Source	Licence number	Licensed quantity (Ml/d)	Present yield (Ml/d)
NWWL	Middle Dee			
	* Llangollen Canal	67-05-057	47.0	47.0
	Lower Dee			
	* Dee at Chester	67-09-147	650.4[1]	650.4
	* Neston boreholes	67-10-064	2.3	2.3
STWP	Upper Wye			
	* Elan Valley reservoirs	55-01-007[4]	359.4[2]	335.5
	Lower Wye			
	* Wye at Lydbrook	55-18-375	36.4[3]	36.4
	* Spring at Lydbrook	55-18-257	4.0	4.0
	* Big Well at Monmouth	55-21-256	4.5	4.5
TOTAL			1103.5	1080.1

1 excluding 36 Ml/d sold to Dŵr Cymru at Heronbridge for non-potable supply
2 excluding 5 Ml/d used at Dŵr Cymru treatment works
3 excluding 9 Ml/d sold to Dŵr Cymru at Mitcheldean
4 licence held by Dŵr Cymru

Table 2.5 *Imports to the Welsh Region above 1 Ml/d licensed quantity*

Water Company benefitting	Region and Source	Licence number	Licensed quantity (Ml/d)	Present yield (Ml/d)	Current demand (Ml/d)
CWC	NW Region				
	* Plemstall b/h	68-06-011	2.3	1.8	1.5
Dŵr Cymru	ST Region				
	* Whitbourne	54-09-008	9.0	8.8	7.7
	* Leintwardine	54-09-367	1.0	1.0	1.1
TOTAL			12.3	11.6	10.3



KEY:

- Coastline
- NRA Welsh Region Boundary
- Main Rivers
- Hydrometric Boundaries
- Reservoirs
- Principal Urban Areas
- 64 Hydrometric Reference No

SCALE 1 : 1,000,000

0 — 100 km

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Note: The limits, including the heights and depths of the works shown in the drawing are not to be taken as limiting the obligations of the contractor under the Contract.	Checked	Date
	Traced	Date
	Checked	Date
	Reviewed	Date

Rev.	Nature of Revision	Drawn	Chkd.	Rvwd.	Appd.	Date

BINNIE & PARTNERS
GROSVENOR HOUSE
REDHILL SURREY
Licence No. 1054

NATIONAL RIVERS AUTHORITY (WELSH REGION)

Regional Water Resources Strategy

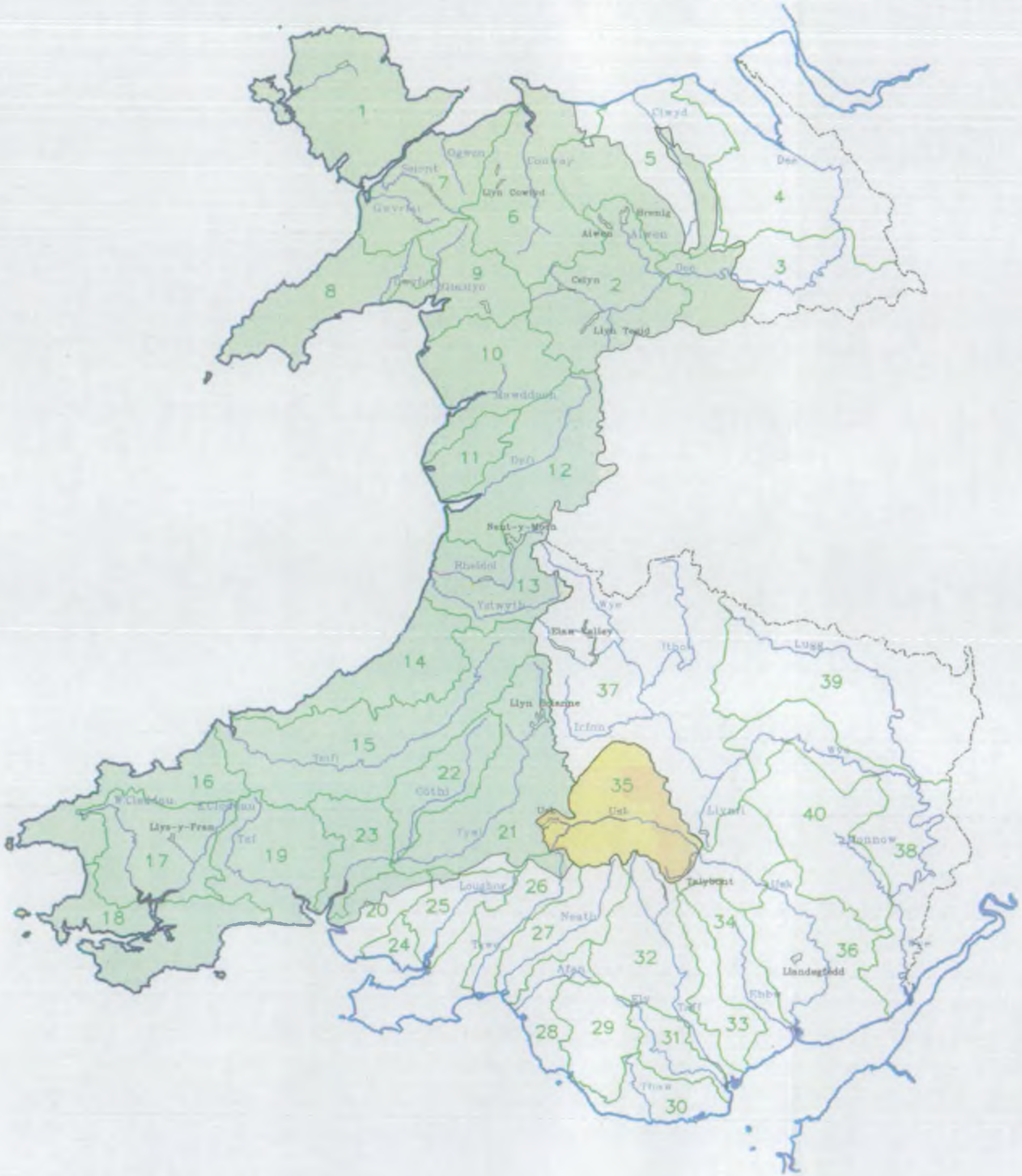
The Welsh Region
FIGURE 2.1

Contract No.	Approved	Date	Contract Drawing No
		APRIL 94	

BINNIE & PARTNERS
CONSULTING ENGINEERS

Scale: 1:1,000,000

Drawing No. 4432/06/04



Note: The limits, including the heights and depths of the works shown in the drawing are not to be taken as limiting the obligations of the contractor under the Contract.

Designed		Date:
Checked		Date:
Traced:		Date:
Checked:		Date:
Reviewed:		Date:

Rev.	Nature of Revision	Drawn.	Chkd.	Rvwd.	Appd.	Date:

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GROSVENOR HOUSE
REDHILL SURREY
Licence No. 1054

1 – ANGLESEY
2 – UPPER DEE
3 – MIDDLE DEE
4 – LOWER DEE
5 – CLWYD
6 – CONWAY
7 – GWRFAI
8 – DWYFOR
9 – GLASLYN
10 – ARTRO
11 – DYSYNNI
12 – DYFI
13 – RHEIDOL
14 – AERON
15 – TEIFI
16 – NORTH PEMBROKESHIRE
17 – CLEDDAU
18 – SOUTH PEMBROKESHIRE
19 – TAF
20 – GWENDRAETH
21 – UPPER TYWI
22 – COTHI
23 – GWILI
24 – GOWER
25 – LOUGHOR
26 – TAWE
27 – NEATH
28 – AFAN
29 – OGMORE
30 – THAW
31 – ELY
32 – TAFF
33 – RHYMNEY
34 – EBBW
35 – UPPER USK
36 – LOWER USK
37 – UPPER WYE
38 – LOWER WYE
39 – LUGG
40 – MONNOW

KEY:

Coastline
NRA Welsh Region Boundary
Main Rivers
Subcatchment Boundaries
Underground Strata Licence Exempt
Minor Inland Waters Licence Exempt
Reservoirs
30 Sub-catchment Ref.

SCALE 1 : 1,000,000

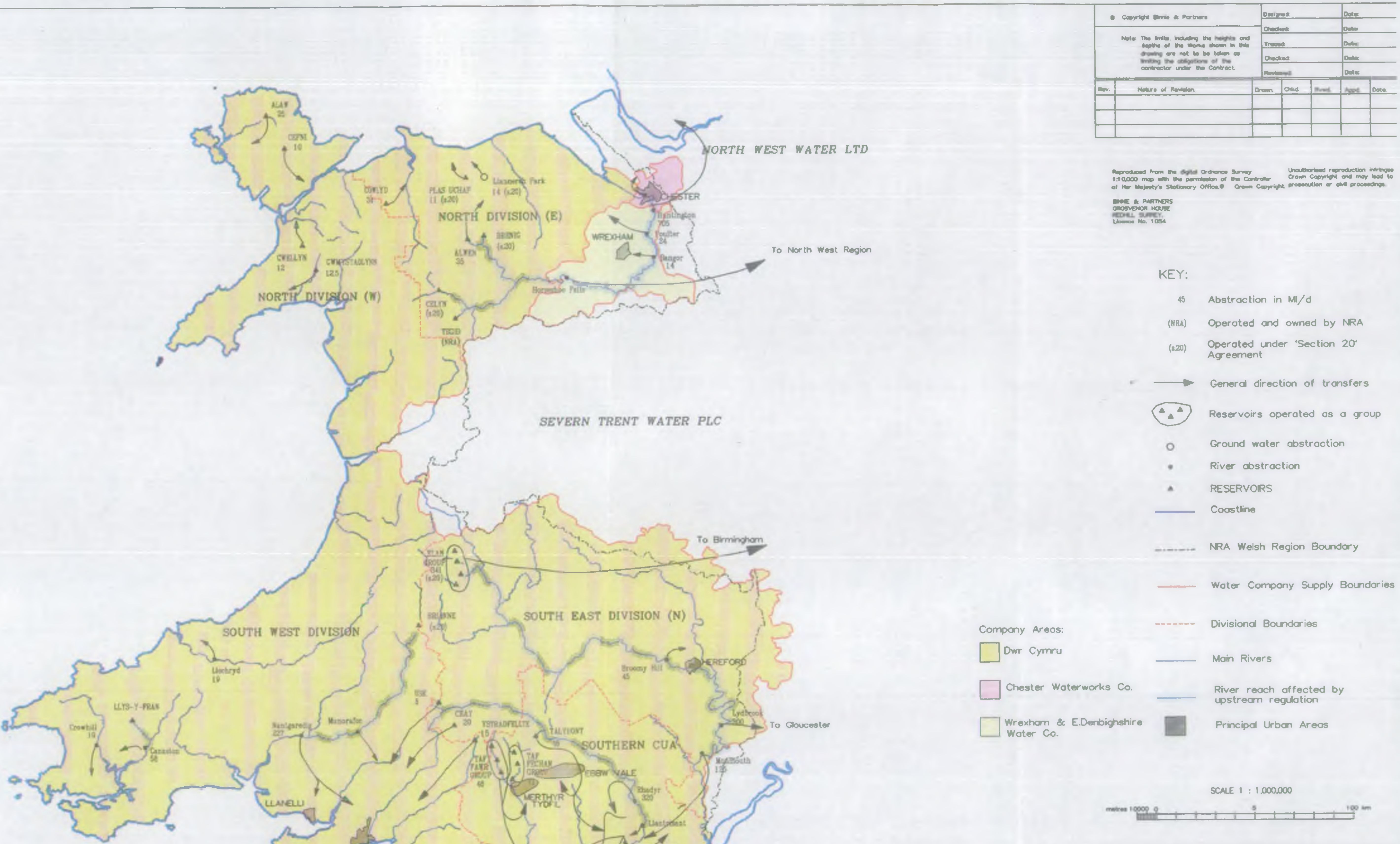
metres 10000 0 50 100 km

NATIONAL RIVERS AUTHORITY (WELSH REGION)

Regional Water Resources Strategy

Subcatchments and Licence Exempt Areas
FIGURE 2.2

Contract No.	Approved	Date: APRIL 94	Contract Drawing No.
BINNIE & PARTNERS CONSULTING ENGINEERS GROSVENOR HOUSE – REDHILL – SURREY		Scale: 1:1,000,000	
		Drawing No. 4432/06/02	



NATIONAL RIVERS AUTHORITY (WELSH REGION)

Regional Water Resources Strategy

Principal Water Resources of the Welsh Region

FIGURE 2.3

Contract no.	Approved	Date	Computer drawing no.
		APRIL 94	
BINNIE & PARTNERS CONSULTING ENGINEERS GROSVENOR HOUSE - REDHILL - SURREY		Scale 1:1,000,000	
		Drawing no. 4432/06/03	

g4432d00/area/dwo KAL GEMS DEPT 15/6/94

3 CURRENT AND HISTORIC DEMANDS FOR WATER

3.1 INTRODUCTION

In order to develop a Regional Water Resources Strategy the demands made on those resources must be identified, and quantified where possible. This Section describes the demands made upon the Region's water resources, both human demands - public and private abstractions, in-river demands (navigation, fisheries and recreation) - and environmental demands (rivers, wetlands, estuaries).

Historic and current abstraction demands are estimated to gain a better picture of how the utilisation of resources has changed in the last decade or so, and to provide useful information for forecasting future demands. Estimates of abstraction demands are based on an analysis of licensed entitlement and abstraction returns in the years of interest, which is detailed in Appendix E.

3.2 GENERAL

Table 3.1 summarises licensed average quantities in 1981, 1986, 1991, 1992 and 1993. These have been estimated from an analysis of licence issue dates for licences greater than 1 Ml/d.

Table 3.1 *Licensed abstractions from non-tidal waters 1981-1993*

Source	Purpose	Licensed quantity (Ml/d)				
		1981	1986	1991	1992	1993
Surface Water	Agriculture	0	0	1	1	1
	Amenity/Conservation	3	7	72	78	79
	Electricity - cooling	6	6	6	6	6
	Fish farming	93	98	421	437	437
	Hydroelectricity	17134	17162	17597	17694	17710
	Industrial	936	951	956	957	957
	Public Water Supply	2890	2890	2909	2909	2909
	Private water supply	0	0	1	1	1
	Spray Irrigation	10	13	17	17	17
	Other	0	1	89	89	89
	Transfers	1825	1836	1836	1837	1837
Groundwater	Agriculture	14	14	15	15	15
	Amenity/Conservation	0	0	0	0	0
	Electricity - cooling	0	0	0	0	0
	Fish farming	1	1	2	2	2
	Hydroelectricity	0	0	0	0	0
	Industrial	61	67	72	72	72
	Public Water Supply	170	196	219	219	219
	Private water supply	1	1	2	2	2
	Spray Irrigation	1	2	3	3	3
	Other	0	0	1	1	1
	Transfers	9	9	10	10	10
REGIONAL TOTAL		23156	23257	24226	24348	24365

The total licensed quantity has remained fairly stable over the last 12 years, with a 5% increase between 1981 and 1993. The majority of this growth has been in fish farming and amenity/conservation, with less than a 1% growth in licences for PWS over the period. As growth in demand is influenced by a large number of factors the reader should be wary of drawing conclusions from this low growth. It may be that, due to the 1970s predictions of massive rises in demand, large increases in licences were granted. As demands did not increase as rapidly no extra licences would have been required.

Demands for water in the Region for the years 1981, 1986, 1991, and 1992 have been estimated from actual abstractions data held on the NRA's licence database. To assess gross demands for the different categories of use for surface water and groundwater sources the returns data and licensed quantity data were compared in the years of interest. This analysis is detailed in Appendix E.

From the results of the comparison analysis % multipliers, to be applied to the licensed quantity to give an estimate of gross demand, have been set for each category of use and source. These multipliers are referred to as Actual Abstraction Factors (AAFs). It should be noted that the returns data used in the analysis was not complete, with only about 50% of licensed abstraction accounted for. Consequently, estimates of actual abstraction should be treated with caution. Table 3.2 sets out the AAFs used to estimate the current and historic demands in the Region.

Table 3.2 *Actual Abstraction Factors*

Source	Purpose	AAF (%)			
		1981	1986	1991	1992
Surface Water	Agriculture	65	65	65	65
	Amenity/Conservation	35	28	40	40
	Electricity - cooling	24	14	10	15
	Fish farming	50	50	50	50
	Hydroelectricity	50	40	69	67
	Industrial	68	60	32	28
	Public Water Supply	68	67	71	69
	Private water supply	60	60	60	60
	Spray Irrigation	26	20	27	36
	Other	5	5	1	1
Groundwater	Agriculture	80	80	80	80
	Amenity/Conservation	40	40	40	40
	Electricity - cooling	-	-	-	-
	Fish farming	50	50	50	50
	Hydroelectricity	-	-	-	-
	Industrial	63	49	49	69
	Public Water Supply	65	59	57	59
	Private water supply	60	60	60	60
	Spray Irrigation	30	43	43	96
	Other	50	50	50	50

3.3 PUBLIC WATER SUPPLY

PWS accounts for about 13% of licensed quantity (excluding tidal abstractions), and is the second largest demand for water after HEP. Average demand in the Region is currently about 2200 Ml/d, of which approximately 40% is exported outside the Region. After rapid growth in the 1960s and 1970s the demand for PWS has increased rather less during the 1980s, with a 3% increase in gross demand between 1981 and 1993. Abstraction has remained at 60% - 70% of licensed quantity throughout the period.

	1981	1986	1991	1992	1993
Licensed quantity (Ml/d)	3060	3087	3128	3128	3128
Estimated gross demand (Ml/d)	2076	2052	2200	2136	2182

3.3.1 Analysis of the licensed quantity/yield/demand balance in 1992

Table 3.3 summarises the results of this analysis. Average daily demand figures for 1992 have been taken from the Companies' October 1993 returns to OFWAT, with maximum week figures taken as 6% higher for Dwr Cymru and 12% higher for WEDWC and CWC based on information received from the three companies. Of the total licensed quantity of 3128 Ml/d for PWS, 54% depends on abstractions from regulated rivers and 46% on abstractions from direct supply reservoirs, unregulated rivers, groundwater and springs.

For Dŵr Cymru abstractions from regulated rivers the yield is just under 100% of the licensed quantity. Exceptionally, the licensed quantities of 136 and 85 Ml/d for the Wye (Monmouth) and Eastern Cleddau (Canaston Bridge) abstractions are taken to have yields of 125 Ml/d and 58 Ml/d respectively, which reduces the yield from the total licensed quantity of 809 Ml/d from regulated rivers by 5%. The corresponding reduction in the yield from the total licensed quantity of 1055 Ml/d from unregulated sources is 36%. Taken together, these figures give for 1992 a yield for all Dŵr Cymru sources which was 81% of the licensed quantity of 1870 Ml/d (excluding the Elan Valley licensed quantity and yield).

CWC and WEDWC are predominantly dependent on licensed abstractions from the regulated River Dee for which the yield is approximately 100% of the licensed quantity. However, about 30% of WEDWC demands are met from other sources for which the yield is quoted as 57% of licensed quantity. For CWC the average daily demand is already 84% of the available yield and has already reached a level where the margin available to meet peak demands and outages is uncomfortably small. For WEDWC the percentages are very similar to those for Dŵr Cymru discussed above.

The average daily demand in 1992/93, for the Welsh Region as a whole, was 70% of the licensed quantity for PWS and 81% of the yield. In the maximum week, demand rose to 85% of the yield. These figures for the whole Region mask the fact that in some supply zones the maximum week demand was very close to the operational yield. The figures are considered to be more meaningful than the suggestion in the NRA Discussion Document (Ref 8) that there was a surplus of 26% of Welsh regional resources above the 1990 average demand (ie. that demand was 74% of resources).

Dŵr Cymru's six CUAs supplied 84% of the total average daily demand for potable water during 1992, as shown in Table 3.4.

Table 3.3 *Analysis of 1992 licensed quantity, yield and demand figures*

	Regulated sources			Unregulated sources			Total sources			Average demand			Peak week demand	
Company	Licensed	Yield	%	Licensed	Yield	%	Licensed	Yield	%	Demand	% of licensed	% of yield	Demand	% of yield
Dŵr Cymru (incl. non-potable)	815	780	96	1055	730	69	1870	1510	81	1176	63	78	1247	83
WEDWC	40.9	40.9	100	26.5	15.0	57	67.4	55.9	83	42.3	63	76	47.4	85
CWC	34.1	32.8	96	2.3	1.8	78	36.4	34.6	95	28.9	79	84	32.4	94
Sub total	890	854	96	1084	747	69	1974	1600	81	1247	63	78	1327	83
SWTP														
Elan Valley				359	335	93	359	335	93	320	89	96	320	96
Lydbrook	45	45	100				45	45	100	36	80	80	39	87
NWWL														
Chester	686	686	100				686	686	100	547	80	80	580	85
Llangollen	47	47	100				47	47	100	37	82	82	37	82
TOTAL	1668	1632	98	1443	1082	75	3111	2713	87	2187	70	81	2303	85

Table 3.4 *Dŵr Cymru CUA 1992 PWS demand breakdown*

Supply Zone	Average daily demand (Ml/d)	% total demand
Southern CUA	480	46.2
Felindre/Schwyll CUA	211	20.3
Alwen/Bretton CUA	52	5.0
North Eyri/Ynys Môn CUA	48	4.6
Hereford CUA	42	4.1
Pembrokeshire CUA	38	3.7
Sub-total	871	83.9
35 smaller zones	167	16.1
DŴr CYMRU TOTAL	1038	100

A further 138 Ml/d of non-potable water was supplied.

3.4 PRIVATE DEMANDS

3.4.1 Private water supply

Private water supply, at about 2 Ml/d, accounts for less than 1% of the total licensed abstraction in the Region. Demand has grown only slightly between 1981 and 1993, with estimated abstraction about 60% of licensed quantity.

	1981	1986	1991	1992	1993
Licensed quantity (Ml/d)	1	2	2	2	2
Estimated gross demand (Ml/d)	< 1	1	1	1	1

The majority of private water demands are met from groundwater sources. As a large part of the Region is licence-exempt for groundwater abstractions the actual demand in this category of use is likely to be greater than the figures above indicate. It should be remembered that there are a large number of small abstractions for domestic supplies which do not require a licence. However, as this category of use is not significant in strategic water resources terms it is not considered further in this report.

3.4.2 Power generation

3.4.2.1 Hydroelectric power

HEP is the largest user of water in the Region, accounting for about 70% of the total licensed quantity (excluding tidal abstractions). Over 90% of this demand is within the Gwrfai and Glaslyn sub-catchments. All types of HEP schemes which include a physical abstraction from the river by pipe or leat require an abstraction licence. In many cases an impoundment licence is also required where upstream water levels are controlled by the scheme. Under special statutory provisions for HEP no annual payment is required for schemes generating less than 5 Megawatts. Nevertheless the duties imposed on the NRA by the issue of a HEP licence are substantial.

HEP comprises recirculation water schemes and conventional HEP schemes. Three major recirculation water schemes in the Region - Dinorwic and Ffestiniog pumped storage schemes, and Trawsfynydd nuclear power station - account for 87% of the licensed quantity. Trawsfynydd power station is currently being decommissioned, and the licensed quantity is to be reduced from 3534 Ml/d to 639 Ml/d. All three schemes depend on impounding reservoirs, constructed by the generating companies, dedicated to power generation. As they have no significant impact upon the water resources of the Region they have been excluded from both the analysis detailed in Appendix E and the forecasts of HEP demand.

There are 34 conventional HEP licences which account for about 26% of the total licensed quantity (excluding the three pumped storage schemes). Scheme sizes vary from less than 10 Ml/d to 1000 Ml/d. Several schemes in the range 25 Ml/d to 125 Ml/d have been licensed during the last 6 years. This has primarily been prompted by the Non-Fossil Fuels Obligation scheme (NFFO). The NFFO is a Government led initiative set up to ensure that regional electricity companies receive a proportion of their demand from non-fossil fuel sources. The NFFO offers incentives for the construction of relatively small HEP schemes in the form of subsidies towards construction costs and a guaranteed price for all power produced, regardless of the minimum quantity or time of day. The NFFO has made many small "run of river" schemes viable for the first time. HEP schemes at Dolwyddelan and Afon Hwch were commissioned in 1992, and at Aberdulais and Swansea Barrage in 1993. Recently licensed schemes at Afon Idwal and Penmancho Mill have yet to be built. The third round of bids to the Non Fossil Purchasing Agency had a deadline of 9th March 1994. Gross demand is estimated to have increased by 75% between 1981 and 1993.

	1981	1986	1991	1992	1993
Licensed quantity (Ml/d)	1894	1922	2357	2361	2377
Estimated gross demand (Ml/d)	947	769	1626	1582	1664

Although water is generally discharged through turbines without loss in quantity, the operation of HEP schemes can create river management problems, causing severe damage to the aquatic environment and its users; a fact which can offset the benefits of the 'clean' energy produced. Associated with such schemes the operation of sluice gates to impound or release water can produce unacceptable variations in river levels and flow which can result in potentially serious consequences for other water users and for fisheries.

The steep, fast-flowing upland rivers of North Wales are particularly attractive for HEP development because of the high heads and relatively high flows. Up to thirty potential sites have been identified by promoters to date, with proposals to abstract up to the average daily flow. There is a clear, unfulfilled demand for small scale high head HEP. There are likely to be two more NFFO rounds in the next two years.

The abstractions can, in some instances, be made with minimal environmental impact, particularly where there is little distance between abstraction and discharge points and there is an adequate residual flow between the two. It is NRA policy to oppose a proposal where long reaches of river are bypassed, with attendant problems for water quality, fisheries, conservation, recreation, amenity, and other abstractors.

3.4.2.2 Electricity - cooling water (non-evaporative cooling)

There is an established network of strategic national power stations located around the coastline using sea-water for cooling purposes. National Power Plc has a licence for 4979 Ml/d for South Pembrokeshire power station, but this is a tidal abstraction. National Power also operates a power station at Aberthaw which takes water for cooling from the sea and is therefore not subject to licensing. The only licence for non-evaporative cooling water from non-tidal waters is in the Gwrfai sub-catchment, and relates to cooling water for cable ducts for Dinorwic power station.

	1981	1986	1991	1992	1993
Licensed quantity (Ml/d)	6	6	6	6	6
Estimated gross demand (Ml/d)	1.5	0.9	0.6	0.9	0.9

Between 1981 and 1993 gross demand for electric-cooling water fell by about 35%. Consumptive use is very small, with most water returned to Llyn Padarn.

3.4.3 Industrial

Industrial demands form a significant component of water resources demand in the Region, accounting for about 5% of total licensed quantity in the Region. There is a wide range of industrial uses of water ranging from almost wholly non-consumptive uses such as mineral washing to almost wholly consumptive such as top-up cooling water.

	1981	1986	1991	1992	1993
Licensed quantity (Ml/d)	997	1018	1027	1029	1029
Estimated gross demand (Ml/d)	675.2	603.4	340.8	317.3	317.3

Whilst licensed abstraction has increased slightly between 1981 and 1993, gross demand has fallen dramatically from about 70% to 30% of licensed abstraction. This is in line with a national downward trend in industrial demand over the past 12 years, with the Welsh Region experiencing a significant decline in heavy industry.

The reasons for this decline are complex, with significant effects attributable to the general fall in industrial production, plant closures, and economic downturns. The NRA's Charging Scheme for Discharges, introduced in 1991, has also probably had an impact on industrial abstractions. Under the scheme charges are made in respect of applications and consents for discharges to controlled waters, with the charge depending upon discharge volume, content and receiving waters. The scheme encourages dischargers to increase water recycling and use water more efficiently, and indirectly acts as an incentive to reduce abstractions. It should also be noted that some industrial demands are met by the water supply companies.

3.4.4 Agriculture

3.4.4.1 Spray irrigation

Unlike many other uses virtually all water used is lost, either by evaporation or crop transpiration.

	1981	1986	1991	1992	1993
Licensed quantity (Ml/d)	11	15	19	20	20
Estimated gross demand (Ml/d)	3.01	4.86	5.66	8.85	8.85

Licensed spray irrigation (averaged over 365 days) has increased from 11 Ml/d in 1981 to about 20 Ml/d in 1993, with peak abstraction rates very much higher (about 200 Ml/d in 1993). Between 1981 and 1993 gross demand has increased from 30% of licensed abstraction to about 45% of licensed abstraction. Spray irrigation currently accounts for less than 1% of total licensed quantity. However, it has a significant impact on the water environment because demands occur over a short period when resources are least and demands are not uniformly distributed regionally but are concentrated in the Lower Wye, Lugg and South Pembrokeshire sub-catchments.

Whilst the Welsh Region did not suffer from severe water shortages as experienced in the south-east of England in the 1990 to 1992 drought, spray irrigation demands in 1992 were significantly higher than in 1991, with a marked increase in abstractions from groundwater. The NRA now lays down conditions in new spray irrigation licences for abstractions from surface waters. These allow the NRA to restrict or prohibit abstraction when river flow measured at a control point falls below a prescribed value.

3.4.4.2 Other agriculture (excluding fish-farming)

The demand for general agricultural use in regional resources terms is small. Abstractions are mostly less than 20 m^3/day and do not therefore need a licence if they are from surface waters.

	1981	1986	1991	1992	1993
Licensed quantity (Ml/d)	14	14	16	16	16
Estimated gross demand (Ml/d)	10.99	11.16	12.79	12.85	12.85

Licensed abstraction, at 16 Ml/d, accounts for less than 1% of total licensed quantity for the Region, with the majority of demand met from groundwater sources. The water is used for general purposes in connection with dairying, food processing and where farmers depend upon springs and wells for domestic and general farm use. Unlike PWS, agriculture has no water infrastructure and individual farmers generally have to obtain water on or adjacent to their farm as best they can. Agricultural demand has remained fairly static between 1981 and 1993 at about 70% of licensed abstraction. However, it should be remembered that there may be a significant demand on groundwater resources in the licence-exempt area of West Wales.

3.4.5 Fish farming

Fish farming has grown significantly over the past 12 years, and now amounts to about 2% of total licensed quantity in the Region. Gross demand is estimated to be 50% of licensed abstraction, with virtually all water returned to the river.

	1981	1986	1991	1992	1993
Licensed quantity (Ml/d)	93	99	423	439	439
Estimated gross demand (Ml/d)	46.63	49.56	211.29	219.36	219.36

3.4.6 Amenity/Conservation

	1981	1986	1991	1992	1993
Licensed quantity (Ml/d)	3	7	72	78	79
Estimated gross demand (Ml/d)	1.20	1.91	28.71	31.27	31.67

Amenity/Conservation is also a small demand on resources, accounting for under 1% of licensed abstraction in the Region. There has been a large increase in demand between 1981 and 1993, accounted for by a single licence in the Ebbw sub-catchment for the National Garden Festival of Wales.

3.4.7 Other uses

	1981	1986	1991	1992	1993
Licensed quantity (Ml/d)	1	1	89	89	90
Estimated gross demand (Ml/d)	0.26	0.28	1.15	1.15	1.15

Other uses includes all minor unspecified abstractions, and amounts to less than 1% of licensed abstraction in the Region.

3.5 IN-RIVER DEMANDS

In addition to the abstraction demands made upon the Region's surface waters and groundwater navigation, angling and recreation, conservation and the general aquatic environment, and effluent dilution all make demands for water.

3.5.1 Navigation

Navigation requires level as well as flow. There are several canals in the Region, constructed between 1760 and 1840 under the Canal Enabling Legislation. Canals are used primarily for amenity and navigation purposes, but some are also utilised for transfer of water across watersheds for PWS. BW operates two canals in the Region: Llangollen Canal and Brecon & Monmouth Canal. BW do not require a licence for abstractions from surface waters to its canals under current legislation for the purpose of navigation. Additionally, BW hold licences for abstractions from the Brecon & Monmouth Canal and Swansea Canal for water which they sell on to third parties under their own charging scheme.

The Llangollen Canal is the longest running transfer scheme in the UK, and feeds the Shropshire Union Canal system in Severn-Trent Region. BW abstracts its water from the River Dee; about 20 Ml/d for operational purposes, and about 40 Ml/d for transfer to Hurleston for NWWL as detailed in Section 2.7.

The Brecon & Monmouth Canal runs along the Usk valley. An unlicensed canal feeder at Brecon is the primary source of water for the canal, with minor tributaries of the Usk and the Lwyd used to a lesser extent. The canal is believed to be used only for amenity purposes. The canal has a dramatic effect on the River Usk, particularly at times of low flow. Also, as the Usk is regulated on a put and take basis with a release from Usk Reservoir and subsequent abstraction downstream at Prioress Mill for Llandegfedd Reservoir, this canal feeder can intercept this release.

3.5.2 Angling and recreation

Angling and recreation are important human uses of water, but with a demand that cannot be measured in the same way as abstractive uses. It is assumed that the needs of angling and recreation will be met if rivers are sustained in a healthy state, ecologically and aesthetically.

Regulation has had a significant impact on fisheries and recreation in certain rivers in the Region, due to changes in the flow regime, water temperature, water quality and sedimentation.

Alterations to the flow regime - steady higher summer flows and dampening of flood events - has resulted in a loss of spawning habitats and a reduction in the number of adult fish returning to spawn. Studies on the River Dee (Ref 9) have shown a reduction in salmon activity because of this phenomenon.

Regulation can lead to a reduction in water temperature, which is likely to have a damaging effect on coarse fish populations, although some species may benefit from this change. Changes in water quality can also lead to reduced juvenile salmonid recruitment as seen on the Dee. Increased sedimentation due to organic enrichment of impounded waters may impact on salmonid egg survival downstream.

Controlled releases can benefit recreational activities, such as on the River Tryweryn where regulation releases are utilised for canoeing. However, fisheries and recreation can make conflicting demands on regulation releases. The Section 20 Agreements between the NRA and Dŵr Cymru contain provisions for freshet releases to safeguard fisheries, at such times and for such durations as requested by the NRA, subject to exceptional over-riding operational constraints. In addition, NRA and Dŵr Cymru may arrange opportunistic river management releases when reservoir storage conditions make it possible. Smolt stocking schemes have been introduced to mitigate the loss of spawning and juvenile habitat.

3.5.3 Aquatic ecology

Research (Ref 9) indicates that regulation schemes in the Region have led to a reduction in the diversity of Benthic Macroinvertebrate fauna immediately downstream of reservoirs such as Llyn Brianne and Llys-y-fran Reservoir.

3.5.4 Effluent dilution

River flows are used not only as sources of water but also as diluters of effluent. There can be a conflict between abstractors and dischargers, who in effect compete to use the same water for incompatible purposes. It is necessary to try to maintain a balance between abstractors, dischargers, and the environment. Recent research (Ref 10) indicates that it is far more economic to achieve a given river quality by improving effluent treatment rather than increasing dilution flows.

The NRA issues consents for discharges to rivers and tidal waters. A small number of discharges, those to tidal waters from power stations now fall under the jurisdiction of HMIP. Information on consents was retrieved from the NRA database and HMIP in October 1993. The database does not hold consented Dry Weather Flow (DWF) data for all consents, with only the Maximum Daily Volume (MDV) or 'Flow in l/s' given for over 50% of consents.

Analysis of those consents for which values of DWF and MDV/'Flow' were available indicated that the consented DWF is a factor of 3.7 less than MDV/'Flow'. DWFs were estimated for consents by application of this divisor to MDV/'Flow'. Table 3.4 summarises the estimated total DWFs for all consents ≥ 1 Ml/d MDV in the Region. Of the 14590 Ml/d total DWF only about 5% is discharged to non-tidal waters, with the majority of this from sewage treatment works.

3.6 ENVIRONMENTAL NEEDS FOR WATER

There are four elements to the fresh water environment:

* Soil water which sustains plants and trees
* Wetlands/lakes
* River flows
* Estuary flows

3.6.1 Water for the soil

Soil water is generally independent of the deeper water table from which abstractions are made, and is usually only in contact with groundwater along valley bottoms. It is affected by farm practices but is not generally in conflict with other water uses, and so is not considered further.

3.6.2 Water for wetlands

Wetlands are areas where the water table is close to or at the surface. They can be important in maintaining baseflows, as evidenced by Tregaron Bog on the Upper Teifi, and are also seen as important buffers for water quality purposes. Developments of all kinds have greatly diminished natural wetlands, and those remaining are rightly seen as valuable heritage.

Table 3.5 *Summary of discharge consents in Welsh Region*

Subcatchment	Non-tidal consents				Tidal consents				Combined Total	
	Sewage		Trade/Other		Sewage		Trade/Other			
	No.	DWF (Ml/d)	No.	DWF (Ml/d)	No.	DWF (Ml/d)	No.	DWF (Ml/d)	No.	DWF (Ml/d)
Monnow	0		3	14.15	0	-	0	-	3	14.15
Lugg	9	9.37	4	11.42	0	-	0	-	13	20.79
Lower Wye	8	38.76	2	0.74	3	2.42	1	9.73	14	51.65
Upper Wye	5	3.46	2	2.27	0	-	0	-	7	5.73
Lower Usk	9	68.82	7	23.18	17	227.98	4	31.99	37	351.97
Upper Usk	4	5.40	3	2.85	0	-	0	-	7	8.25
Ebbw	0	-	6	9.58	3	80.22	0	-	9	89.80
Rhymney	0	-	1	1.17	0	-	0	-	1	1.17
Taff	5	57.94	17	44.58	4	283.66	0	-	26	386.17
Ely	11	32.17	2	4.69	1	1.35	1	2.16	15	40.38
Thaw	6	12.26	4	9.14	9	119.30	4	6103.64	23	6244.34
Ogmore	1	6.02	2	5.87	1	23.00	0	-	4	34.89
Afan, Kenfig	1	3.13	0	-	1	38.88	3	142.76	5	184.76
Neath	6	10.64	8	11.48	2	7.68	0	-	16	29.81
Tawe	5	20.90	7	13.05	0	-	2	5.93	14	39.89
Loughor	5	13.15	3	11.70	2	11.57	0	-	10	36.42
Gower	6	29.51	2	7.15	12	61.89	2	3.69	22	102.24
Gwili	2	1.32	1	0.37	3	5.96	0	-	6	7.65
Cothi	1	0.28	0	-	0	-	0	-	1	0.28
Upper Tywi	3	6.72	1	0.86	0	-	0	-	4	7.58
Gwendraeth	4	8.45	3	2.02	4	22.77	0	-	11	33.24
Taf	3	0.95	3	1.57	4	3.23	0	-	10	5.75
South Pembs	7	2.71	2	6.22	9	13.69	5	5626.03	23	5648.64
Cleddau	4	8.12	2	4.84	2	7.10	0	-	8	20.06
North Pembs	2	0.84	0	-	3	2.85	0	-	5	3.69
Teifi	7	5.35	2	1.51	1	2.68	0	-	10	9.54
Aeron, Arth	1	0.29	0	-	3	5.88	0	-	4	6.17
Rheidol	2	1.33	0	-	0	-	0	-	2	1.33
Dyfi, Leri	3	1.88	1	0.28	1	1.19	0	-	5	3.35
Dysynni	0	-	1	0.29	0	-	0	-	1	0.29
Artro, Mawddach	2	2.32	1	2.28	4	3.66	0	-	7	8.26
Glaslyn	2	1.36	1	0.93	5	5.40	0	-	8	7.70
Dwyfor	0	-	0	-	5	5.88	0	-	5	5.88
Gwrfai	9	5.81	3	4.90	11	28.69	2	91.33	25	130.73
Conwy	2	1.29	0	-	15	36.71	3	25.27	20	63.27
Clwyd	14	49.70	8	14.24	6	55.41	0	-	28	119.35
Lower Dee	18	36.93	10	5.40	9	41.68	6	13.50	43	97.51
Middle Dee	7	51.09	11	29.09	0	-	2	1.56	20	81.75
Upper Dee	0	-	6	28.34	0	-	0	-	6	28.34
Anglesey	2	5.43	2	2.78	21	13.41	2	635.14	27	656.76
TOTAL	176	503.71	131	278.95	161	1114.14	37	12692.72	505	14589.52

Number of tidal consents ≥ 1 Ml/d	198
Number of non tidal consents ≥ 1 Ml/d	307
Volume of tidal consents ≥ 1 Ml/d	13807 Ml/d
Volume of non tidal consents ≥ 1 Ml/d	783 Ml/d
Total consented volume	14740 Ml/d
Percentage of consents ≥ 1 Ml/d	99 %

3.6.3 Water for rivers

Rivers are naturally changing systems. They have been greatly changed by man over the centuries. Today a large number of the Region's major rivers are thoroughly unnatural, subject to a high degree of flow regulation. The character of a river depends on its flow, its quality, and the physical characteristics of its bed and banks. Flows are changed by abstractions, effluent discharges, water transfers, drainage improvements and regulation. The net effect is often to reduce middle range flows but increase low flows. Quality is changed by effluent discharges, land use, and transfers.

Research has shown that moderate reductions in average flows are not generally ecologically significant. However there is a need to sustain acceptable minimum flow regimes. No objective criteria are yet established, although the NRA is currently undertaking research to define ecologically-acceptable flows (Ref 11). The Surface Water Abstraction Licensing Policy R&D project (See Section 2.4.2) will address this issue as part of the development of a consistent methodology for licensing.

A provisional estimate that has been used in the interim is the natural Q95 flow - the flow that would naturally be equalled or exceeded for 95% of the time. In some catchments, where there is little or no artificial influence on river flows (abstractions and discharges), the 'natural' flow can be assumed to be equal to the gauged flow. Otherwise the 'natural' flow has to be estimated from gauged flow records and knowledge of artifical influences. In the Welsh Region many of the major rivers are subject to a great degree of artifical influence by way of the regulation schemes. Unfortunately, very few of these rivers have had their flow records 'naturalised'.

The Water Resources Act 1963 provided for the setting of minimum acceptable flows (MAFs). The Water Resources Act 1991 restates this provision, with minor changes. However, no MAFs have been set in this (or any other) Region. A few minimum residual flows (MRFs) have been set instead, mostly as control flows, below which specific abstractions must cease. They have a similar effect to MAFs but without such legal connotations. Table 3.5 details the minimum residual flows to rivers in the Welsh Region.

Table 3.6 *Residual flows to rivers in the Welsh Region*

River	Location	MRF (Ml/d)	Comments
Tywi	Nantgaredig	136.4	PWS Intake
Usk	Rhyadyr	228.0	PWS Intake to
Wye	Redbrook	1210.0	Llandegfedd
E. Cleddau	Pont Hywel	4.5	
E. Cleddau	Canaston weir	68.2 (variable)	PWS Intake
Afon Aled	Bryn Aled	29.5 (variable)	Natural flow at PWS
		11.4	Intake
Dwyfor	Dolbenmaen	29.5	Jun-Jan
		59.1	Feb-May
Afon Clwyd	Pont y Cwmbwll	147.0	Sep-May
			Jun-Aug

3.6.4 Water for estuaries

The criteria for setting minimum flows to estuaries are different to those for inland waters. There are major abstractions at or near to the tidal limits of many the Region's rivers. Most of these are subject to minimum residual flows for protection of the estuary. Table 3.6 lists the minimum residual flows to estuaries in the Region identified in recent research undertaken by the NRA (Ref 12).

Table 3.7 *Residual flows to tide in Welsh Region*

River	Location	MRF(Ml/d)	Comments
Tywi	Nantgaredig	136.4	PWS Intake
Wye	Redbrook	1210.0	
Dee	Chester weir	363.0	

3.7 REGIONAL WATER BALANCE

In some categories of use some, if not all, water is returned to the river after use. In order to assess the overall water balance for the Region the net demands of abstractors have been estimated. There is little information available to assess the amount of water returned to river, principally due to a lack of information on actual discharges. In order to estimate the net demand for water in the Region Net Use Factors (NUFs) have been set to estimate net demand, based on NRA R&D Note 35 Vol.2 (Ref 13) and recent work carried out on three rivers in Essex (Ref 14). The NUFs are shown in Table 3.7.

In the case of PWS net demands are less than 100% reflecting the fact that it is assumed that 70% of these abstractions are returned to either non-tidal or tidal waters and 30% of sewage treatment works discharge to inland waters.

Table 3.6 summarises the current licensed quantity, and estimated total and net abstractions in the Region, using the AAFs for 1992 with licensed quantities for 1993 and the NUFs shown above. Tidal abstractions are excluded as these do not draw upon the water resources of the Region. A breakdown of current demands at a sub-catchment level is given in Appendix F.

The water balance for the Region can be expressed as follows:

Balance = Gross regional resource - Net abstractions - Exports from Region

- Minimum river flow

It was explained in Section 2.1 that the effective rainfall under drought conditions is 600mm/yr. This equates to a gross regional resource of approximately 34700 Ml/d. The minimum river flow is used as a simplistic estimate of the resources which must be protected to meet environmental and in-river demands on rivers. Research is ongoing to establish ecologically-acceptable flows (See Section 3.6.3). In the absence of a readily applicable measure of this river flow it is conservatively estimated as being 50% of the gross regional resource (Ref 15). The NRA has recently undertaken research into ecologically-acceptable river flows and is currently looking into a methodology for application to rivers.

Table 3.8 *Net Use Factors*

Purpose of abstraction	NUF(%)
Agriculture	20
Amenity/Conservation	0
Electricity - cooling	0
Fish fanning	0
Hydroelectricity	0
Industrial	30
Public water supply (excluding exports)	80
Private water supply	80
Spray irrigation	90
Other	0

The regional water balance therefore becomes,

Balance = 34,700 - 1067 - 934 - (0.5 x 34,700) = + 15350 Ml/d

The positive water balance indicates that the Welsh Region is in a generally healthy state. This position will need to be reviewed once a methodology has been developed to assess minimum river flows.

Table 3.9 *Summary of current abstractions in the Region (excluding transfers)*

Source	Purpose	Licensed quantity (Ml/d)	Estimated gross abstraction (Ml/d)	Estimated net abstraction (Ml/d)
Surface water	Agriculture	1	1	<1
	Amenity/Conservation	79	31	0
	Electricity-cooling	6	1	0
	Fish fanning	437	218	0
	Hydroelectricity	17710	11865	0
	Industrial	957	268	80
	Public Water Supply	2909	2007	858[1]
	Private water supply	1	<1	<1
	Spray irrigation	17	6	5
	Other	89	1	0
Groundwater	Agriculture	15	12	2
	Amenity/Conservation	<1	<1	0
	Electricity-cooling	-	-	0
	Fish fanning	2	1	0
	Hydroelectricity	-	-	0
	Industrial	72	49	15
	Public Water Supply	219	129	103
	Private water supply	2	1	<1
	Spray irrigation	3	3	3
	Other	1	<1	0
REGION TOTAL		22518	14595	1067

1 excluding exports from the Region of 940 Ml/d

4 FUTURE DEMANDS FOR WATER SUPPLY

4.1 INTRODUCTION

This Section describes the predicted future demands for water that arise both within the Region and those at a national level. The potential changes in demand are identified, and shortfalls in existing available resources are estimated for a range of scenarios. The work the NRA is currently undertaking on the Alleviation of Low Flows (ALF) in the Region is also described.

Forecasts of future demand for PWS are calculated using a multiple component methodology, developed for the NRA's National Water Resources Strategy. A range of scenarios is considered, incorporating various assumptions about demand management, growth in domestic supply, and metering. Forecasts of future private demands are based on historic trends, available published information and consultation with representatives of industry and agriculture.

4.2 GENERAL

Forecasts of demands for water have been made for the period 1996 to 2021 at five yearly intervals. Forecasts are based on trends in historic demands between 1981 and 1991, available information from the NRA, water companies, and County Structure Plans, and discussions with representatives of industry and agriculture.

In the case of PWS, forecasts have been made at a supply zone level for Dŵr Cymru, the principal water service company in the Region, and at a Company level for the two other water supply companies. Forecasts of private demands, for agriculture and industry, have been made on either a sub-catchment or regional basis as appropriate.

4.3 REGIONAL PUBLIC WATER SUPPLY DEMANDS

4.3.1 Methodology for PWS demand scenarios

A multiple component methodology, based on that utilised in the NRA's National Water Resources Strategy (Ref 16), has been used to forecast current and future PWS demand. Demand scenarios are described by a suite of broad based assumptions about future demand. The forecasts delimit the range of forecast between high and low and therefore indicate the predictive demand envelope. The base year has been taken as 1992, with the forecast horizon set at 2021. Calculation intervals are 5 years (with the exception of the first time step of 4 years) ie. 1996, 2001, 2006, 2011, 2016, 2021.

The following data sources have been used for calculation of the forecast components:-

* OFWAT October Returns to the Director General 1993;
* OFWAT Cost of Water Delivered & Sewage Collected 1992-93 (Ref 17); and
* Per capita consumption data from Binnie and Herrington (Ref 18).

The various demand assumptions, combined to produce forecast scenarios which reflect a prediction envelope, are summarised in Table 4.1.

Table 4.1 *Assumptions and combinations within demand scenarios*

		Assumptions for each scenario			
No.	**Assumptions**	**High**	**Medium**	**Low**	**Broad area of effect**
1	Growth of PCC by compound annual rate of 1%. Upper limit of 189 l/hd/day.	■			PCC growth
2	Growth of PCC by compound annual rate derived from Ref 18. Upper limit of 180 l/hd/day.		■	■	
3	Growth in metered and unmetered non-household consumption by compound annual rate of 0.75%.	■			Commercial growth
4	Growth in metered and unmetered non-household consumption by compound annual rate of 0.5%.		■		
5	No growth in metered and unmetered non-household consumption above 1992 level.			■	
6	Dŵr Cymru - Metering of new properties only if requested by the customer (Company policy) WEDWC - No metering of new properties from 1996 CWC - No metering of new properties from 1996.	■			Metering
7	Dŵr Cymru - Metering of new properties from 2006 WEDWC - No metering of new properties from 2006 CWC - No metering of new properties from 2006.		■		
8	Dŵr Cymru - As high forecast plus all new properties metered WEDWC - All new properties metered (Company policy) CWC - All new properties metered (Company policy).			■	
9	Leakage levels held at 1992 levels to simulate effect of no improvements to reduce leakage levels. If existing leakage above 14.5 l/prop/hr constrained to this figure at reduction rate of 0.5 l/prop/hr.	■			Leakage
10	Leakage targets achieved affecting a reduction in total treated water losses to 11 l/prop/hr. Rate of reduction 0.5 l/prop/hr.		■		
11	Leakage targets achieved affecting a reduction in total treated water losses to 10 l/prop/hr. Rate of reduction 1.0 l/prop/hr.			■	

The scenarios which can be built up using these assumptions are as follows:-

* *Low demand scenario* This can be defined as the line describing the set of assumptions which indicate the minimum increase (or even decrease) in demand in 2021. It forms the lower boundary of the demand envelope.

* *Medium demand scenario* The medium scenario can be defined as the line which shows a modest set of assumptions on per capita consumption growth, metering and leakage. It is important to note that this line is not regarded as a preferred or most likely line relative to the other two scenarios.

* *High demand scenario* This scenario is defined as the line which describes the maximum feasible increase in demand. This line forms the upper boundary to the demand envelope

4.3.2 Assumptions underlying demand scenarios

4.3.2.1 Population data

Population figures to 2021 are based on the 1993 Returns to OFWAT for Dwr Cymru and WEDWC. CWC data is taken from the NRA's National Water Resources Strategy. Figures for 1996 to 2011 are linearly interpolated from Returns and figures for 2016 to 2021 are linearly extrapolated from the Returns. Any population forecast data from whatever source can only represent a view of the most likely way forward at the time of preparation. It is not possible to make exact predictions of population growth and how this will affect future demography. Nevertheless, the use of company and NRA data, which is based on the 1991 census, is believed to represent the best available data extending to 2021.

4.3.2.2 Occupancy rates

Occupancy rates have been derived from population and household numbers data in OFWAT Returns.

4.3.2.3 Per capita consumption (PCC)

Figures for 1992 are taken from OFWAT Cost of Water Delivered 1992-93 (Ref 17). Metered household consumption is assumed to be 10% less than in unmetered households in existing metered properties.

Preliminary information from metering trials in the Isle of Wight have indicated that the installation of meters in domestic properties results in an average reduction in household consumption of 20%, of which 10% can be attributed to lower customer demand, and the remainder to reduced supply pipe leakage which is identified upon installation of meters. However, as a result of consultation and in recognition of the need to consider that this 10% reduction may not be a sustained effect, a 10% reduction in PCC upon metering is not invoked under the high forecast.

For the base year total treated water losses is derived as the residual of distribution input after the other components have been accounted for. In subsequent years total treated water losses is directly calculated on the basis of total treated water losses per property ('night flows'). A saving on the night flow figure is therefore assumed for existing and new metered properties. The level of this saving is 1.5 l/prop/hr.

The growth factors used are derived from Binnie and Herrington (Ref 18) in all but the high demand scenario. The data given for 1991, 2011, and 2021 given are described by a straight line, the equation of which has been used to calculate annual compound percentage growth factors. In the case of the high demand scenario a growth rate of 1% compound has been used to indicate the upper limit of PCC growth suggested by Binnie and Herrington.

Under the low and medium demand scenarios the rate of growth in PCC is constrained to a maximum of 180 l/hd/day. This figure reflects a proposed upper limit fro consumption at 2021 based on a component of use analysis of households in the south and south east of England. It is recognised that this limit may be artificial, but given the uncertainty in initial PCC figures at the start of the planning period, this limit is believed to be appropriate. For similar reasons, under the high demand scenario PCC growth is constrained to an upper limit of 189 l/hd/day.

4.3.2.4 Domestic metering

Within the three demand scenarios a number of assumptions have been made about future household numbers and levels of domestic metering. These are detailed in Tables 4.2-4.4. County Structure Plans (CSPs) contain information about future housing development. Unfortunately, the CSPs covering the Welsh Region have planning horizons ending around 2001 and are due for renewal in the near future. Therefore, future household numbers have been taken from the October 1993 OFWAT returns.

4.3.2.5 Growth of non-household demand

Under the high and medium demand scenarios unmetered non-household demand are considered to grow at an annual rate of 0.75% and 0.5% respectively. This is intended to indicate the upper extent of any growth in these components as well as the effect of modest growth. Zero growth under the low demand scenario is intended to show the effect of increased charges for discharges.

4.3.2.6 Leakage

Leakage targets incorporated in the demand scenarios have been based on those used in the national strategy, and are as follows:

* Low demand	Dŵr Cymru	Target of 10 l/prop/hr (reduced at 1 l/prop/hr/yr);
	CWC/WEDWC	Reduction of 0.05l/prop/hr/yr;
* Medium demand	Dŵr Cymru	Target of 11 l/prop/hr (reduced at 0.5 l/prop/hr/yr);
	CWC/WEDWC	Reduction of 0.025 l/prop/hr/yr;
* High demand	Dŵr Cymru	Target of 14.5 l/prop/hr (reduced at 1.0 l/prop/hr/yr);
	CWC/WEDWC	1992 leakage levels.

Both CWC and WEDWC both already have leakage levels below the target levels used in the national strategy. Under all demand scenarios any metered properties have their leakage target reduced by 1.5 l/prop/hr.

Table 4.2 Dwr Cymru PWS demand forecast household numbers assumptions

CORE DATA		Source	1992	1996	2001	2006	2011	2016	2021
Population	[A]	OFWAT return	2758000	2781200	2817000	2849000	2867000	2877000	2887000
Occupancy rate	[B]	A/E	2.65	2.61	2.56	2.51	2.45	2.39	2.33
No. of metered households	[C]	OFWAT return	26200	31000	33500	36000	38500	41000	43500
No. of unmetered households	[D]	OFWAT return	1014000	1033000	1065500	1098000	1130500	1163000	1195500
Total No. households	[E]	C+D	1040200	1064000	1099000	1134000	1169000	1204000	1239000
No. old prop's connected to meters	[F]	C{96}−C{92} ETC		4800	2500	2500	2500	2500	2500
New prop's in 5 yr period	[G]	E{96}−E{92} ETC		23800	35000	35000	35000	35000	35000
LOW FORECAST			1992	1996	2001	2006	2011	2016	2021
No. metered households	[H]	C+SUM(G)	26200	54800	92300	129800	167300	204800	242300
No. unmetered households	[I]	E−H	1014000	1009200	1006700	1004200	1001700	999200	996700
MEDIUM FORECAST			1992	1996	2001	2006	2011	2016	2021
No. metered households	[J]	C+SUM(G) from 2006	26200	31000	33500	36000	73500	111000	148500
No. unmetered households	[K]	E−J	1014000	1033000	1065500	1098000	1095500	1093000	1090500
HIGH FORECAST			1992	1996	2001	2006	2011	2016	2021
No. metered households	[L]	C	26200	31000	33500	36000	38500	41000	43500
No. unmetered households	[M]	D	1014000	1033000	1065500	1098000	1130500	1163000	1195500

Table 4.3 WEDWC PWS demand forecast household numbers assumptions

CORE DATA		Source	1992	1996	2001	2006	2011	2016	2021
Population	[A]	OFWAT return	148020	149440	151310	152870	154040	154300	154560
Occupancy rate	[B]	A/E	2.67	2.64	2.59	2.55	2.51	2.47	2.43
No. of metered households	[C]	OFWAT return	2770	4044	5974	7724	9300	10500	11700
No. of unmetered households	[D]	OFWAT return	52610	52534	52404	52274	52144	52014	51884
Total No. households	[E]	C+D	55380	56578	58378	59998	61444	62514	63584
No. old prop's connected to meters	[F]	C{96}−C{92} ETC		1274	1930	1750	1576	1200	1200
New prop's in 5 yr period	[G]	E{96}−E{92} ETC		1198	1800	1620	1446	1070	1070
LOW FORECAST			1992	1996	2001	2006	2011	2016	2021
No. metered households	[H]	C	2770	4044	5974	7724	9300	10500	11700
No. unmetered households	[I]	D	52610	52534	52404	52274	52144	52014	51884
MEDIUM FORECAST			1992	1996	2001	2006	2011	2016	2021
No. metered households	[J]	H−SUM(G) FROM 2006	2770	4044	5974	7724	7854	7984	8114
No. unmetered households	[K]	E−J	52610	52534	52404	52274	53590	54530	55470
HIGH FORECAST			1992	1996	2001	2006	2011	2016	2021
No. metered households	[L]	H−SUM(G) FROM 1996	2770	4044	4174	4304	4434	4564	4694
No. unmetered households	[M]	E−L	52610	52534	54204	55694	57010	57950	58890

Table 4.4 CWC PWS demand forecast household numbers assumptions

CORE DATA		Source	1992	1996	2001	2006	2011	2016	2021
Population	[A]	NRA National Strategy	116760	119790	124740	131270	137790	142595	147400
Occupancy rate	[B]	A/E	2.88	2.91	2.93	2.99	3.05	3.06	3.08
No. of metered households	[C]	OFWAT return	1330	2270	4120	5970	7820	9670	11520
No. of unmetered households	[D]	OFWAT return	39160	38900	38400	37900	37400	36900	36400
Total No. households	[E]	C+D	40490	41170	42520	43870	45220	46570	47920
No. old prop's connected to meters	[F]	C{96}−C{92} ETC		940	1850	1850	1850	1850	1850
New prop's in 5 yr period	[G]	E{96}−E{92} ETC		680	1350	1350	1350	1350	1350
LOW FORECAST			1992	1996	2001	2006	2011	2016	2021
No. metered households	[H]	C	1330	2270	4120	5970	7820	9670	11520
No. unmetered households	[I]	D	39160	38900	38400	37900	37400	36900	36400
MEDIUM FORECAST			1992	1996	2001	2006	2011	2016	2021
No. metered households	[J]	H−SUM(G) FROM 2006	1330	2270	4120	5970	6470	6970	7470
No. unmetered households	[K]	E−J	39160	38900	38400	37900	38750	39600	40450
HIGH FORECAST			1992	1996	2001	2006	2011	2016	2021
No. metered households	[L]	H−SUM(G) FROM 1996	1330	2270	2770	3270	3770	4270	4770
No. unmetered households	[M]	E−L	39160	38900	39750	40600	41450	42300	43150

4.3.3 Demand forecasts

The PWS demand forecasts for the three water companies, calculated in accordance with the methodology described above, are presented in Tables 4.5-4.7 and Figures 4.1-4.3.

The Dŵr Cymru forecast ranges from a 4% decrease in demand for potable water under the low scenario to a 19% increase under the high scenario. Non-potable demands increase to 70% of 1992 allocation under the low forecast to 100% of 1992 allocation under the high forecast.

The WEDWC forecast ranges from a 12% increase in demand for potable water under the high scenario to a 31% increase under the high scenario. The CWC forecast ranges from a 30% increase in demand for potable water under the high scenario to a 47% increase under the high scenario.

Table 4.8 summarises the Region-wide forecast (including exports). Growth in total demand within the Region range from a 2% decrease by 2021 for the low scenario to a 22% increase for the high scenario. The medium growth scenario indicates a regional increase in demands of 6% by 2021 from 1247 Ml/d to 1328 Ml/d. The planning forecasts of the three water companies agree to within 7% of the medium growth scenario forecast.

A significant proportion of PWS demand is to meet losses through leakage and therefore estimates of these losses are a key component of the demand forecasts. There is some debate at present on how to assess leakage with differences in approach by the local companies. It is the policy of the NRA to ensure that water companies are doing all they can to reduce leakage down to an economic level before a new resource development is authorised. This appraisal should take into account the environmental costs as well as the purely financial cost of any new scheme. Substantial expenditure would be required to reduce leakage down to the targets assumed in the low demand scenario forecast. However, there would be other considerable benefits arising in terms of improved drinking water quality and overall standard of service to the consumer.

4.3.3.1 Peak week demands

The OFWAT indicator for raw water availability compares the average daily demand during the peak week with the yield of the sources for each supply zone or company area. This criterion has been used to assess the adequacy of existing raw water sources to meet the low, medium and high growth forecasts for each company during the period 1996 to 2021.

Factors of 1.06 and 1.12 have been applied to the calculated average daily demands to estimate peak week demands for Dŵr Cymru and CWC & WEDWC respectively, based on information obtained from the water companies. Peak week demand forecasts for the three companies are presented in Table 4.9.

Information obtained from Dŵr Cymru relating to their own demand forecasts indicates that the Company expects demand growth to be non-uniformly distributed with population growth forecast to be greater in the Northern Division and leakage reduction forecast to be greater in the South-East Division. However, to maintain consistency with the NRA National Water Resoureces Strategy approach, the total peak demand is distributed between supply zones using 1992 supply zone population distribution figures provided by the Company. This assumes direct correlation between supply zone peak demand and population, and no change in the distribution over the planning horizon. Detailed peak week demands for PWS at a supply zone level are provided in Appendix G.

Dŵr Cymru non-potable demands are included at the same levels as used in the annual average daily demand forecasts. The NWWL abstraction at Chester is assumed to increase from 547 Ml/d to 580 Ml/d in the peak week, but other exports are included as in the average daily demand forecasts.

4.3.4 Projected resources shortfall for PWS

For planning purposes there should be a margin between projected average daily demands and available resources to allow for outages and higher than average demand years. In order to identify resources shortfalls the forecast peak week demands have been compared with available resources for each company. Table 4.10 summarises the marginal peak week potable water demands in the Region.

Detailed figures at a supply zone level are given in Appendix G. Figures 4.5 - 4.7 show these marginal demands over the period 1996 to 2021. In the case of Dŵr Cymru the identified marginal demands are the summed deficits at a supply zone level, and ignore surpluses in supply areas throughout the planning horizon.

For Dŵr Cymru there is a resource deficit for all forecast scenarios for the entire planning period ranging from 10 Mld under the low growth scenario to nearly 80 Ml/d for the high growth scenario. Development of resources will be required to improve the reliability of the resource system.

In the case of WEDWC under the low growth scenario there are no marginal demands. Under the medium scenario there are marginal demands by 2016 and by 2006 under the high scenario indicating the possible full utilisation of the Company's abstractions from the River Dee.

For CWC there are marginal demands under all forecast scenarios, ranging from 7 Ml/d in 2021 under the low growth scenario to 13 Ml/d under the high growth scenario.

The projections illustrate how sensitive the timing of new resource development is to the assumptions made in the demand scenarios. For example, if the assumptions for demand management under the low growth scenario prove accurate, only limited resource development would be required to meet peak demands. Only broad indications of the relative degree of resource shortfall and likely timing of developments can be drawn from this analysis. However, it does emphasise the importance of reviewing demand forecasts regularly and the adoption of a consistent methodology for assessment of resource needs between the NRA and water companies. The yield deficiencies will clearly become more significant if the actual long-term increase in demand is closer to the medium or high forecast than to the low forecast.

Table 4.5 Dwr Cymru PWS average demand forecasts

CORE DATA		SOURCE							
Distribution input 1992 (Ml/d)	[a]	Input	1038.5						
Total metered (Ml/d)	[b]	Input	231.6						
Unm. non-household (Ml/d)	[c]	Input	42.6						
Weighted av. PCC	[d]	Input	140						
LINKED DATA			**1992**	**1996**	**2001**	**2006**	**2011**	**2016**	**2021**
Population	[e]	Input	2758000	2781200	2817000	2849000	2867000	2877000	2887000
PCC suppression	[f]	Input	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Occupancy rate	[g]	Input	2.65	2.61	2.56	2.51	2.45	2.39	2.33
PCC unm. growth (%) – Low	[p1]	Input	0.64	0.64	0.64	0.64	0.64	0.75	0.75
PCC unm. growth (%) – Med	[p2]	Input	0.64	0.64	0.64	0.64	0.64	0.75	0.75
PCC unm. growth (%) – High	[p3]	Input	1	1	1	1	1	1	1
Unm. non hh growth (%) – Low	[q1]	Input	0	0	0	0	0	0	0
Unm. non hh growth (%) – Med	[q2]	Input	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Unm. non hh growth (%) – High	[q3]	Input	0.75	0.75	0.75	0.75	0.75	0.75	0.75
No. metered prop. – Low	[r1]	Input	26200	54800	92300	129800	167300	204800	242300
No. metered prop. – Med	[r2]	Input	26200	31000	33500	36000	73500	111000	148500
No. metered prop. – High	[r3]	Input	26200	31000	33500	36000	38500	41000	43500
No. unmetered prop. – Low	[s1]	Input	1014000	1009200	1006700	1004200	1001700	999200	996700
No. unmetered prop. – Med	[s2]	Input	1014000	1033000	1065500	1098000	1095500	1093000	1090500
No. unmetered prop. – High	[s3]	Input	1014000	1033000	1065500	1098000	1130500	1163000	1195500
Unm. night flow (l/pr/hr) – Low	[t1]	Input	18.7	14.7	10.7	10.0	10.0	10.0	10.0
Unm. night flow (l/pr/hr) – Med	[t2]	Input	18.7	14.5	12.5	11.0	11.0	11.0	11.0
Unm. night flow (l/pr/hr) – High	[t3]	Input	18.7	16.7	14.7	14.5	14.5	14.5	14.5
BASELINE 1992		**SOURCE**	**1992**						
Metered households (Ml/d)	[h]	(d x f x g x r1)/10 ^ 6	8.7						
Metered non-households (Ml/d)	[j]	b – h	222.9						
Unmetered households (Ml/d)	[k]	(d x g x s1)/10 ^ 6	376.2						
Distn less UFW (Ml/d)	[l]	b + c + k	650.4						
UFW (Ml/d)	[m]	a – l	388.1						
Night flow (l/pr/hr)	[n]	((m x 10 ^ 6)/(r1 + s1))/20	18.7						
Non-potable demand (Ml/d)			137.6						
LOW FORECAST		**SOURCE**		**1996**	**2001**	**2006**	**2011**	**2016**	**2021**
Unmetered PCC (l/hd/day)	[aa]	(aa" x (1+(p1/100)) ^ 5)	Note 1	143.6	148.3	153.1	158.0	164.1	170.3
Metered PCC (l/hd/day)	[ab]	aa x 0.9		129.3	133.4	137.8	142.2	147.7	153.3
Unmetered household (Ml/d)	[ac]	(g x s1 x aa)/10 ^ 6		378.3	382.1	385.8	387.9	391.8	395.5
Metered household (Ml/d)	[ad]	(g x r1 x ab)/10 ^ 6		18.5	31.5	44.9	58.3	72.3	86.5
Unmetered non-household (Ml/d)	[ae]	(ac x (1+(q1/100)) ^ 5)		42.6	42.6	42.6	42.6	42.6	42.6
Metered non-household (Ml/d)	[af]	(af" x (1+(q1/100)) ^ 5)	Note 2	231.6	231.6	231.6	231.6	231.6	231.6
Distn. less UFW (Ml/d)	[ag]	ac + ad + ae + af		671.0	687.9	704.9	720.4	738.3	756.2
Metered losses (Ml/d)	[ah]	(20 x r1 x (t1 – 1.5)/10 ^ 6)		14.4	16.9	22.1	28.4	34.8	41.2
Unmetered losses (Ml/d)	[aj]	(20 x s1 x t1)/10 ^ 6		295.8	214.5	200.8	200.3	199.8	199.3
UFW (Ml/d)	[ak]	ah + aj		310.2	231.4	222.9	228.8	234.7	240.5
TOTAL DISTRIBUTION INPUT (Ml/d)	[al]	ag + ak		981.2	919.3	927.8	949.1	972.9	996.8
Non-potable demand (Ml/d)				137.6	137.6	137.6	137.6	137.6	137.6
MEDIUM FORECAST		**SOURCE**		**1996**	**2001**	**2006**	**2011**	**2016**	**2021**
Unmetered PCC (l/hd/day)	[ba]	(ba" x (1+(p2/100)) ^ 5)	Note 1	143.6	148.3	153.1	158.0	164.1	170.3
Metered PCC (l/hd/day)	[bb]	ba x 0.9		129.3	133.4	137.8	142.2	147.7	153.3
Unmetered household (Ml/d)	[bc]	(g x s2 x ba)/10 ^ 6		387.2	404.4	421.9	424.2	428.6	432.7
Metered household (Ml/d)	[bd]	(g x r2 x bb)/10 ^ 6		10.5	11.4	12.4	25.6	39.2	53.0
Unmetered non-household (Ml/d)	[be]	(bc x (1+(q2/100)) ^ 5)		43.5	44.6	45.7	46.8	48.0	49.2
Metered non-household (Ml/d)	[bf]	(bf" x (1+(q2/100)) ^ 5)	Note 2	236.3	242.2	248.3	254.6	261.1	267.6
Distn. less losses (Ml/d)	[bg]	bc + bd + be + bf		677.4	702.7	728.4	751.2	776.8	802.6
Metered losses (Ml/d)	[bh]	(20 x r2 x (t2 – 1.5)/10 ^ 6)		8.1	7.4	6.8	14.0	21.1	28.2
Unmetered losses (Ml/d)	[bj]	(20 x s2 x t2)/10 ^ 6		299.6	266.4	241.6	241.0	240.5	239.9
Total losses (Ml/d)	[bk]	bh + bj		307.6	273.7	248.4	255.0	261.6	268.1
TOTAL DISTRIBUTION INPUT (Ml/d)	[bl]	bg + bk		985.0	976.4	976.8	1006.2	1038.3	1070.7
Non-potable demand (Ml/d)				141.2	146.3	151.4	156.6	161.7	166.8
HIGH FORECAST		**SOURCE**		**1996**	**2001**	**2006**	**2011**	**2016**	**2021**
Unmetered PCC (l/hd/day)	[ca]	(ca" x (1+(p3/100)) ^ 5)	Note 1	145.7	153.1	160.9	169.1	177.8	186.8
Metered PCC (l/hd/day)	[cb]	ca x 0.9		131.1	137.8	144.8	152.2	160.0	168.1
Unmetered household (Ml/d)	[cc]	(g x s3 x ca)/10 ^ 6		392.8	417.7	443.5	468.5	494.1	520.4
Metered household (Ml/d)	[cd]	(g x r3 x cb)/10 ^ 6		10.6	11.8	13.1	14.4	15.7	17.0
Unmetered non-household (Ml/d)	[ce]	(cc x (1+(q3/100)) ^ 5)		43.9	45.6	47.3	49.1	51.0	52.9
Metered non-household (Ml/d)	[cf]	(cf" x (1+(q3/100)) ^ 5)	Note 2	238.6	247.7	257.1	266.9	277.1	287.6
Distn. less losses (Ml/d)	[cg]	cc + cd + ce + cf		685.9	722.7	761.0	798.8	837.8	878.0
Metered losses (Ml/d)	[ch]	(20 x r3 x (t3 – 1.5)/10 ^ 6)		9.4	8.8	9.4	10.0	10.7	11.3
Unmetered losses (Ml/d)	[cj]	(20 x s3 x t3)/10 ^ 6		344.1	312.3	318.4	327.8	337.3	346.7
Total losses (Ml/d)	[ck]	ch + cj		353.5	321.1	327.8	337.9	347.9	358.0
TOTAL DISTRIBUTION INPUT (Ml/d)	[cl]	cg + ck		1039.4	1043.9	1088.8	1136.7	1185.8	1236.0
Non-potable demand (Ml/d)				144.8	155.0	165.3	175.5	185.8	196.0

Notes:

1 For 1996 use [d x (1+(p/100)) ^ 4)]

2 For 1996 use [j x (1+(q/100)) ^ 4)]

Table 4.6 WEDWC PWS average demand forecasts

CORE DATA		SOURCE							
Distribution input 1992 (Ml/d)	[a]	Input	42.3						
Total metered (Ml/d)	[b]	Input	13.4						
Unm. non-household (Ml/d)	[c]	Input	0.9						
Weighted av. PCC	[d]	Input	144						
LINKED DATA			**1992**	**1996**	**2001**	**2006**	**2011**	**2016**	**2021**
Population	[e]	Input	148020	149440	151310	152870	154040	154300	154560
PCC suppression	[f]	Input	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Occupancy rate	[g]	Input	2.67	2.64	2.59	2.55	2.51	2.47	2.43
PCC unm. growth (%) – Low	[p1]	Input	0.64	0.64	0.64	0.64	0.64	0.75	0.75
PCC unm. growth (%) – Med	[p2]	Input	0.64	0.64	0.64	0.64	0.64	0.75	0.75
PCC unm. growth (%) – High	[p3]	Input	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Unm. non hh growth (%) – Low	[q1]	Input	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unm. non hh growth (%) – Med	[q2]	Input	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Unm. non hh growth (%) – High	[q3]	Input	0.75	0.75	0.75	0.75	0.75	0.75	0.75
No. metered prop. – Low	[r1]	Input	2770	4044	5974	7724	9300	10500	11700
No. metered prop. – Med	[r2]	Input	2770	4044	5974	7724	7854	7964	8114
No. metered prop. – High	[r3]	Input	2770	4044	4174	4304	4434	4564	4694
No. unmetered prop. – Low	[s1]	Input	52610	52534	52404	52274	52144	52014	51884
No. unmetered prop. – Med	[s2]	Input	52610	52534	52404	52274	53590	54530	55470
No. unmetered prop. – High	[s3]	Input	52610	52534	52404	55694	57010	57950	58890
Unm. night flow (l/pr/hr) – Low	[t1]	Input	7.0	6.7	6.5	6.2	6.0	5.7	5.5
Unm. night flow (l/pr/hr) – Med	[t2]	Input	7.0	6.9	6.8	6.7	6.6	6.5	6.4
Unm. night flow (l/pr/hr) – High	[t3]	Input	7.0	7.0	7.0	7.0	7.0	7.0	7.0
BASELINE 1992		**SOURCE**	**1992**						
Metered households (Ml/d)	[h]	(d x f x g x r1)/10^6	1.0						
Metered non-households (Ml/d)	[j]	b – h	12.5						
Unmetered households (Ml/d)	[k]	(d x g x s1)/10^6	20.2						
Distn less UFW (Ml/d)	[l]	b + c + k	34.6						
UFW (Ml/d)	[m]	a – l	7.7						
Night flow (l/pr/hr)	[n]	((m x 10^6)/(r1+s1))/20	7.0						
LOW FORECAST		**SOURCE**		**1996**	**2001**	**2006**	**2011**	**2016**	**2021**
Unmetered PCC (l/hd/day)	[aa]	(aa" x (1+(p1/100))^5)	Note 1	147.7	152.5	157.5	162.6	168.7	175.2
Metered PCC (l/hd/day)	[ab]	aa x 0.9		132.9	137.3	141.7	146.3	151.9	157.7
Unmetered household (Ml/d)	[ac]	(g x s1 x aa)/10^6		20.5	20.7	21.0	21.3	21.7	22.1
Metered household (Ml/d)	[ad]	(g x r1 x ab)/10^6		1.4	2.1	2.8	3.4	3.9	4.5
Unmetered non-household (Ml/d)	[ae]	(ac x (1+(q1/100))^5)		0.9	0.9	0.9	0.9	0.9	0.9
Metered non-household (Ml/d)	[af]	(af" x (1+(q1/100))^5)	Note 2	13.4	13.4	13.4	13.4	13.4	13.4
Distn. less UFW (Ml/d)	[ag]	ac + ad + ae + af		36.2	37.2	38.1	39.0	40.0	40.9
Metered losses (Ml/d)	[ah]	(20 x r1 x (t1–1.5)/10^6)		0.4	0.6	0.7	0.8	0.9	0.9
Unmetered losses (Ml/d)	[aj]	(20 x s1 x t1)/10^6		7.1	6.8	6.5	6.2	6.0	5.7
UFW (Ml/d)	[ak]	ah + aj		7.5	7.4	7.2	7.1	6.9	6.6
TOTAL DISTRIBUTION INPUT (Ml/d)	[al]	ag + ak		43.7	44.6	45.4	46.1	46.8	47.5
MEDIUM FORECAST		**SOURCE**		**1996**	**2001**	**2006**	**2011**	**2016**	**2021**
Unmetered PCC (l/hd/day)	[ba]	(ba" x (1+(p2/100))^5)	Note 1	147.7	152.5	157.5	162.6	168.7	175.2
Metered PCC (l/hd/day)	[bb]	ba x 0.9		132.9	137.3	141.7	146.3	151.9	157.7
Unmetered household (Ml/d)	[bc]	(g x s2 x ba)/10^6		20.5	20.7	21.0	21.9	22.7	23.6
Metered household (Ml/d)	[bd]	(g x r2 x bb)/10^6		1.4	2.1	2.8	2.9	3.0	3.1
Unmetered non-household (Ml/d)	[be]	(bc x (1+(q2/100))^5)		0.9	0.9	1.0	1.0	1.0	1.0
Metered non-household (Ml/d)	[bf]	(bf" x (1+(q2/100))^5)	Note 2	13.7	14.1	14.4	14.8	15.1	15.5
Distn. less losses (Ml/d)	[bg]	bc + bd + be + bf		36.5	37.8	39.2	40.5	41.9	43.3
Metered losses (Ml/d)	[bh]	(20 x r2 x (t2–1.5)/10^6)		0.4	0.6	0.8	0.8	0.8	0.8
Unmetered losses (Ml/d)	[bj]	(20 x s2 x t2)/10^6		7.2	7.1	7.0	7.1	7.1	7.1
Total losses (Ml/d)	[bk]	bh + bj		7.7	7.7	7.8	7.9	7.9	7.9
TOTAL DISTRIBUTION INPUT (Ml/d)	[bl]	bg + bk		44.2	45.6	46.9	48.4	49.7	51.2
HIGH FORECAST		**SOURCE**		**1996**	**2001**	**2006**	**2011**	**2016**	**2021**
Unmetered PCC (l/hd/day)	[ca]	(ca" x (1+(p3/100))^5)	Note 1	149.8	157.5	165.5	174.0	182.8	189.0
Metered PCC (l/hd/day)	[cb]	ca x 0.9		134.9	141.7	149.0	156.6	164.6	170.1
Unmetered household (Ml/d)	[cc]	(g x s3 x ca)/10^6		20.8	21.4	23.5	24.9	26.2	27.0
Metered household (Ml/d)	[cd]	(g x r3 x cb)/10^6		1.4	1.5	1.6	1.7	1.9	1.9
Unmetered non-household (Ml/d)	[ce]	(cc x (1+(q3/100))^5)		0.9	1.0	1.0	1.0	1.1	1.1
Metered non-household (Ml/d)	[cf]	(cf" x (1+(q3/100))^5)	Note 2	13.8	14.4	14.9	15.5	16.1	16.7
Distn. less losses (Ml/d)	[cg]	cc + cd + ce + cf		37.0	38.2	41.1	43.2	45.2	46.8
Metered losses (Ml/d)	[ch]	(20 x r3 x (t3–1.5)/10^6)		0.4	0.5	0.5	0.5	0.5	0.5
Unmetered losses (Ml/d)	[cj]	(20 x s3 x t3)/10^6		7.3	7.3	7.8	8.0	8.1	8.2
Total losses (Ml/d)	[ck]	ch + cj		7.8	7.8	8.2	8.4	8.6	8.7
TOTAL DISTRIBUTION INPUT (Ml/d)	[cl]	cg + ck		44.8	46.0	49.3	51.6	53.8	55.5

Notes:

1 For 1996 use [d x (1+(p/100))^4)]

2 For 1996 use [j x (1+(q/100))^4)]

Table 4.7 CWC PWS average demand forecasts

CORE DATA		SOURCE							
Distribution Input 1992 (Ml/d)	[a]	Input	28.9						
Total metered (Ml/d)	[b]	Input	6.8						
Unm. non-household (Ml/d)	[c]	Input	0.4						
Weighted av. PCC	[d]	Input	147						
LINKED DATA			**1992**	**1996**	**2001**	**2006**	**2011**	**2016**	**2021**
Population	[e]	Input	116760	119790	124740	131270	137790	142595	147400
PCC suppression	[f]	Input	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Occupancy rate	[g]	Input	2.88	2.91	2.93	2.99	3.05	3.06	3.08
PCC unm. growth (%) - Low	[p1]	Input	0.64	0.64	0.64	0.64	0.64	0.75	0.75
PCC unm. growth (%) - Med	[p2]	Input	0.64	0.64	0.64	0.64	0.64	0.75	0.75
PCC unm. growth (%) - High	[p3]	Input	1	1	1	1	1	1	1
Unm. non hh growth (%) - Low	[q1]	Input	0	0	0	0	0	0	0
Unm. non hh growth (%) - Med	[q2]	Input	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Unm. non hh growth (%) - High	[q3]	Input	0.75	0.75	0.75	0.75	0.75	0.75	0.75
No. metered prop. - Low	[r1]	Input	1330	2270	4120	5970	7820	9670	11520
No. metered prop. - Med	[r2]	Input	1330	2270	4120	5970	6470	6970	7470
No. metered prop. - High	[r3]	Input	1330	2270	2770	3270	3770	4270	4770
No. unmetered prop. - Low	[s1]	Input	39160	38900	38400	37900	37400	36900	36400
No. unmetered prop. - Med	[s2]	Input	39160	38900	38400	37900	36750	39600	40450
No. unmetered prop. - High	[s3]	Input	39160	38900	39750	40600	41450	42300	43150
Unm. night flow (l/pr/hr) - Low	[t1]	Input	6.3	6.1	5.9	5.7	5.5	5.3	5.1
Unm. night flow (l/pr/hr) - Med	[t2]	Input	6.3	6.2	6.1	6.0	5.9	5.8	5.7
Unm. night flow (l/pr/hr) - High	[t3]	Input	6.3	6.3	6.3	6.3	6.3	6.3	6.3
BASELINE 1992		**SOURCE**	**1992**						
Metered households (Ml/d)	[h]	(d x f x g x r1)/10^6	0.5						
Metered non-households (Ml/d)	[i]	b - h	6.3						
Unmetered households (Ml/d)	[k]	(d x g x s1)/10^6	16.6						
Distn less UFW (Ml/d)	[l]	b + c + k	23.8						
UFW (Ml/d)	[m]	a - l	5.1						
Night flow (l/pr/hr)	[n]	((m x 10^6)/(r1+s1))/20	6.3						
LOW FORECAST		**SOURCE**		**1996**	**2001**	**2006**	**2011**	**2016**	**2021**
Unmetered PCC (l/hd/day)	[aa]	(aa" x (1+(p1/100))^5)	Note 1	150.8	155.7	160.7	165.9	172.3	178.8
Metered PCC (l/hd/day)	[ab]	aa x 0.9		135.7	140.1	144.7	149.3	155.0	160.9
Unmetered household (Ml/d)	[ac]	(g x s1 x aa)/10^6		17.1	17.5	18.2	18.9	19.5	20.0
Metered household (Ml/d)	[ad]	(g x r1 x ab)/10^6		0.9	1.7	2.6	3.6	4.6	5.7
Unmetered non-household (Ml/d)	[ae]	(ac x (1+(q1/100))^5)		0.4	0.4	0.4	0.4	0.4	0.4
Metered non-household (Ml/d)	[af]	(af" x (1+(q1/100))^5)	Note 2	6.8	6.8	6.8	6.8	6.8	6.8
Distn. less UFW (Ml/d)	[ag]	ac + ad + ae + af		25.2	26.4	28.0	29.7	31.2	32.9
Metered losses (Ml/d)	[ah]	(20 x r1 x (t1-1.5)/10^6)		0.2	0.4	0.5	0.6	0.7	0.8
Unmetered losses (Ml/d)	[aj]	(20 x s1 x t1)/10^6		4.8	4.6	4.3	4.1	3.9	3.7
UFW (Ml/d)	[ak]	ah + aj		5.0	4.9	4.9	4.8	4.7	4.6
TOTAL DISTRIBUTION INPUT (Ml/d)	[al]	ag + ak		30.1	31.3	32.8	34.5	35.9	37.5
MEDIUM FORECAST		**SOURCE**		**1996**	**2001**	**2006**	**2011**	**2016**	**2021**
Unmetered PCC (l/hd/day)	[ba]	(ba" x (1+(p2/100))^5)	Note 1	150.8	155.7	160.7	165.9	172.3	178.8
Metered PCC (l/hd/day)	[bb]	ba x 0.9		135.7	140.1	144.7	149.3	155.0	160.9
Unmetered household (Ml/d)	[bc]	(g x s2 x ba)/10^6		17.1	17.5	18.2	19.6	20.9	22.3
Metered household (Ml/d)	[bd]	(g x r2 x bb)/10^6		0.9	1.7	2.6	2.9	3.3	3.7
Unmetered non-household (Ml/d)	[be]	(bc x (1+(q2/100))^5)		0.4	0.4	0.4	0.4	0.4	0.4
Metered non-household (Ml/d)	[bf]	(bf" x (1+(q2/100))^5)	Note 2	7.0	7.2	7.3	7.5	7.7	7.9
Distn. less losses (Ml/d)	[bg]	bc + bd + be + bf		25.3	26.7	28.5	30.5	32.3	34.3
Metered losses (Ml/d)	[bh]	(20 x r2 x (t2-1.5)/10^6)		0.2	0.4	0.5	0.6	0.6	0.6
Unmetered losses (Ml/d)	[bj]	(20 x s2 x t2)/10^6		4.9	4.7	4.6	4.6	4.6	4.6
Total losses (Ml/d)	[bk]	bh + bj		5.1	5.1	5.1	5.2	5.2	5.3
TOTAL DISTRIBUTION INPUT (Ml/d)	[bl]	bg + bk		30.4	31.8	33.6	35.6	37.5	39.6
HIGH FORECAST		**SOURCE**		**1996**	**2001**	**2006**	**2011**	**2016**	**2021**
Unmetered PCC (l/hd/day)	[ca]	(ca" x (1+(p3/100))^5)	Note 1	153.0	160.8	169.0	177.6	186.7	189.0
Metered PCC (l/hd/day)	[cb]	ca x 0.9		137.7	144.7	152.1	159.8	168.0	170.1
Unmetered household (Ml/d)	[cc]	(g x s3 x ca)/10^6		17.3	18.7	20.5	22.5	24.2	25.1
Metered household (Ml/d)	[cd]	(g x r3 x cb)/10^6		0.9	1.2	1.5	1.8	2.2	2.5
Unmetered non-household (Ml/d)	[ce]	(cc x (1+(q3/100))^5)		0.4	0.4	0.4	0.4	0.4	0.4
Metered non-household (Ml/d)	[cf]	(cf" x (1+(q3/100))^5)	Note 2	7.0	7.3	7.6	7.9	8.2	8.5
Distn. less losses (Ml/d)	[cg]	cc + cd + ce + cf		25.6	27.6	30.0	32.6	35.0	36.5
Metered losses (Ml/d)	[ch]	(20 x r3 x (t3-1.5)/10^6)		0.2	0.3	0.3	0.4	0.4	0.5
Unmetered losses (Ml/d)	[cj]	(20 x s3 x t3)/10^6		4.9	5.0	5.1	5.3	5.4	5.5
Total losses (Ml/d)	[ck]	ch + cj		5.1	5.3	5.5	5.6	5.8	5.9
TOTAL DISTRIBUTION INPUT (Ml/d)	[cl]	cg + ck		30.8	32.9	35.4	38.2	40.7	42.5

Notes:

1 For 1996 use [d x (1+(p/100))^4)]

2 For 1996 use [j x (1+(q/100))^4)]

Table 4.8 PWS average demand forecasts for the Region (including exports)

INPUT DATA	1992		Demand (Ml/d)					
	Yield	Demand	1996	2001	2006	2011	2016	2021
Dwr Cymru Potable	1291	1039						
Dwr Cymru Non-Potable	196	138						
DWR CYMRU TOTAL	1487	1176						
WEDWC	54	42						
CWC	35	29						
WELSH COMPANIES TOTAL	1575	1247						
S.T. Elan Valley [1]	335	320						
S.T. Lydbrook [2]	36	30						
NW Water - Chester [3]	650	547						
NW Water - Llangollen	47	37						
TOTAL INCLUDING EXPORTS	2643	2181						
LOW FORECAST			Demand (Ml/d)					
			1996	2001	2006	2011	2016	2021
Dwr Cymru Potable			981	919	928	949	973	997
Dwr Cymru Non-Potable			138	138	138	138	138	138
DWR CYMRU TOTAL			1119	1057	1065	1087	1111	1134
WEDWC			44	45	45	46	47	48
CWC			30	31	33	34	36	38
WELSH COMPANIES TOTAL			1193	1133	1144	1167	1193	1219
S.T. Elan Valley [1]			335	335	335	335	335	335
S.T. Lydbrook [2]			31	32	33	34	35	36
NW Water - Chester [3]			547	547	547	547	547	547
NW Water - Llangollen			37	37	37	37	37	37
TOTAL INCLUDING EXPORTS			2143	2084	2096	2120	2147	2174
MEDIUM FORECAST			Demand (Ml/d)					
			1996	2001	2006	2011	2016	2021
Dwr Cymru Potable			985	976	977	1006	1038	1071
Dwr Cymru Non-Potable			141	146	151	157	162	167
DWR CYMRU TOTAL			1126	1123	1128	1163	1200	1238
WEDWC			44	46	47	48	50	51
CWC			30	32	34	36	38	40
WELSH COMPANIES TOTAL			1201	1200	1209	1247	1287	1328
S.T. Elan Valley [1]			335	335	335	335	335	335
S.T. Lydbrook [2]			31	32	33	34	35	36
NW Water - Chester [3]			547	547	547	547	547	547
NW Water - Llangollen			37	37	37	37	37	37
TOTAL INCLUDING EXPORTS			2151	2151	2161	2200	2241	2283
HIGH FORECAST			Demand (Ml/d)					
			1996	2001	2006	2011	2016	2021
Dwr Cymru Potable			1039	1044	1089	1137	1186	1236
Dwr Cymru Non-Potable			145	155	165	176	186	196
DWR CYMRU TOTAL			1184	1199	1254	1312	1372	1432
WEDWC			45	46	49	52	54	56
CWC			31	33	35	38	41	42
WELSH COMPANIES TOTAL			1260	1278	1339	1402	1466	1530
S.T. Elan Valley [1]			335	335	335	335	335	335
S.T. Lydbrook [2]			31	32	33	34	35	36
NW Water - Chester [3]			547	547	547	547	547	547
NW Water - Llangollen			37	37	37	37	37	37
TOTAL INCLUDING EXPORTS			2210	2229	2291	2355	2420	2485

Notes
1 Excluding 5 Ml/d yield included in DC potable demand
2 Excluding 9 Ml/d yield included in DC potable demand
3 Excluding 36 Ml/d reserved for DC non-potable demand of 27 Ml/d

Figure 4.1 Dwr Cymru PWS demand forecasts

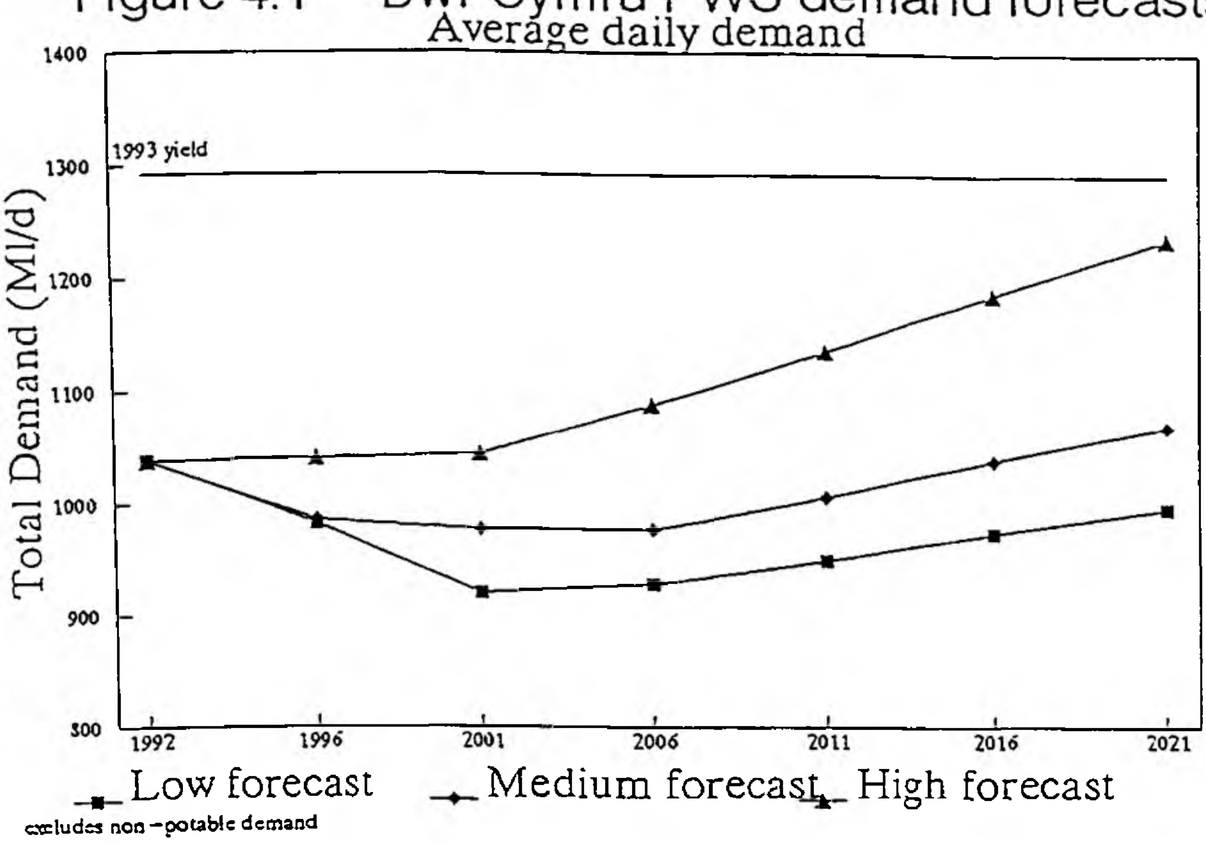


Figure 4.2 WEDWC PWS demand forecasts

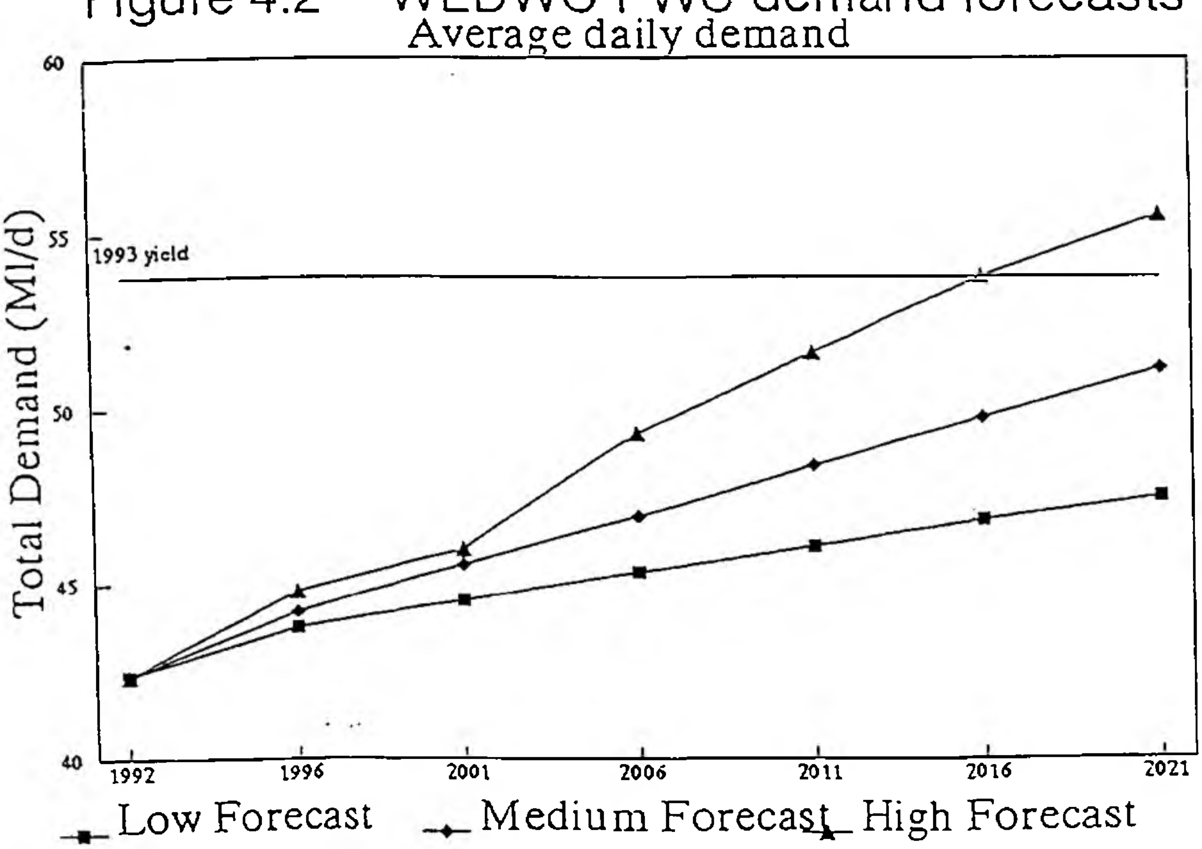


Figure 4.3 CWC PWS demand forecasts
Average daily demand

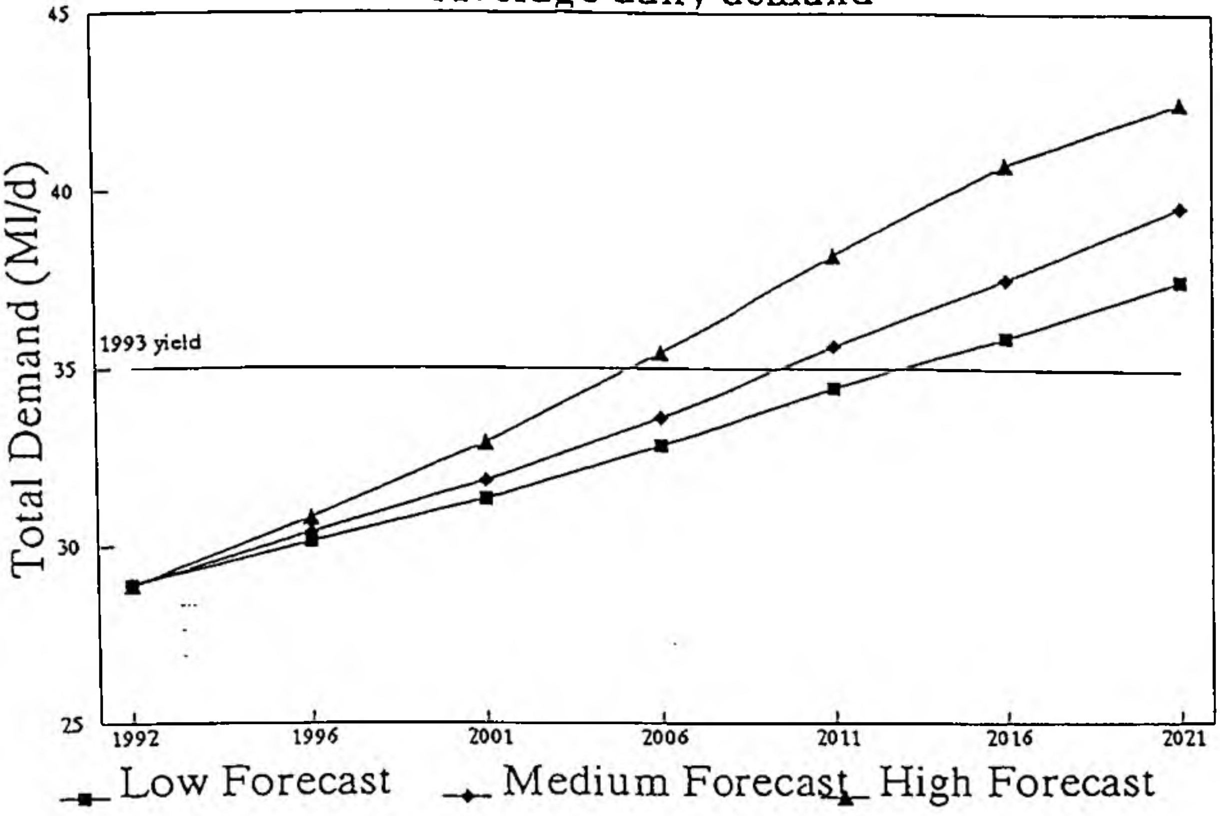


Figure 4.4 PWS demand forecasts for the Region
Average daily demand (including non-potable & exports)

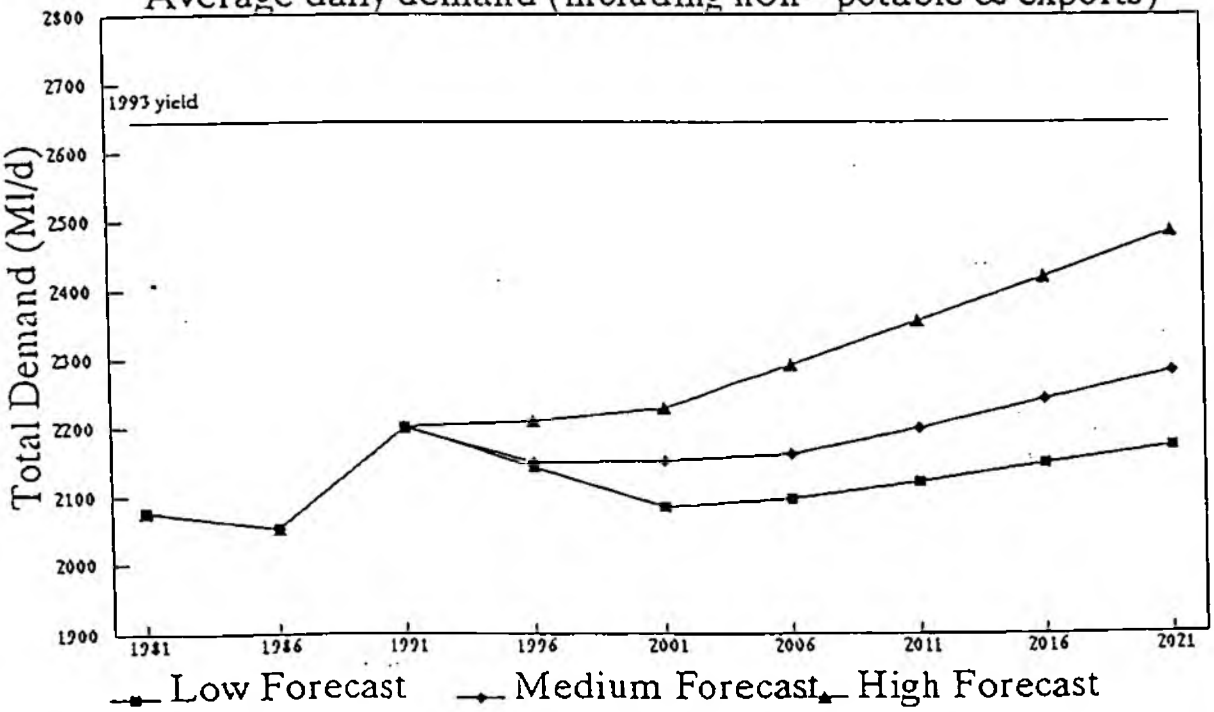


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Table 4.9 PWS peak week demand forecasts for the Region

LOW FORECAST	1992			Demand (Ml/d)					
	Population	Yield	Demand	1996	2001	2006	2011	2016	2021
DC South East div.(CUA)	1221318	543	487	461	432	436	446	457	468
DC South East div.(N)	185603	104	74	70	66	66	68	69	71
DC South West div.	864269	409	345	326	305	308	315	323	331
DC Northern div.(W)	174237	97	70	66	62	62	64	65	67
DC Northern div.(E)	312573	138	125	118	110	111	114	117	120
Dwr Cymru potable total	2758000	1291	1101	1040	974	984	1006	1031	1057
Dwr Cymru non-potable total		196	138	138	138	138	138	138	138
WEDWC	148020	54	47	49	50	51	52	52	53
CWC	107100	35	32	34	35	37	39	40	42
WELSH COMPANIES TOTAL	3013120	1575	1318	1260	1197	1209	1234	1262	1289
S.T. Elan Valley		335	320	335	335	335	335	335	335
S.T. Lydrook		36	30	31	32	33	34	35	36
NW Water-Chester		650	580	580	580	580	580	580	580
NW Water-Llangollen		47	37	37	37	37	37	37	37
TOTAL INCLUDING EXPORTS		2643	2285	2243	2181	2194	2220	2249	2277
MEDIUM FORECAST	1992			Demand (Ml/d)					
	Population	Yield	Demand	1996	2001	2006	2011	2016	2021
DC South East div.(CUA)	1221318	543	487	462	458	458	472	487	503
DC South East div.(N)	185603	104	74	70	70	70	72	74	76
DC South West div.	864269	409	345	327	324	324	334	345	356
DC Northern div.(W)	174237	97	70	66	65	65	67	70	72
DC Northern div.(E)	312573	138	125	118	117	117	121	125	129
Dwr Cymru potable total	2758000	1291	1101	1044	1035	1035	1067	1101	1135
Dwr Cymru non-potable total		196	138	139	144	149	154	159	164
WEDWC	148020	54	47	50	51	53	54	56	57
CWC	107100	35	32	34	36	38	40	42	44
WELSH COMPANIES TOTAL	3013120	1575	1318	1267	1265	1274	1314	1357	1400
S.T. Elan Valley		335	320	335	335	335	335	335	335
S.T. Lydrook		36	30	31	32	33	34	35	36
NW Water-Chester		650	580	580	580	580	580	580	580
NW Water-Llangollen		47	37	37	37	37	37	37	37
TOTAL INCLUDING EXPORTS		2643	2285	2250	2249	2259	2300	2344	2388
HIGH FORECAST	1992			Demand (Ml/d)					
	Population	Yield	Demand	1996	2001	2006	2011	2016	2021
DC South East div.(CUA)	1221318	543	487	488	490	511	534	557	580
DC South East div.(N)	185603	104	74	74	74	78	81	85	88
DC South West div.	864269	409	345	345	347	362	378	394	411
DC Northern div.(W)	174237	97	70	70	70	73	76	79	83
DC Northern div.(E)	312573	138	125	125	125	131	137	142	148
Dwr Cymru potable total	2758000	1291	1101	1102	1106	1154	1205	1257	1310
Dwr Cymru non-potable total		196	138	145	155	165	176	186	196
WEDWC	148020	54	47	50	52	55	58	60	62
CWC	107100	35	32	34	37	40	43	46	48
WELSH COMPANIES TOTAL	3013120	1575	1318	1332	1350	1415	1481	1549	1616
S.T. Elan Valley		335	320	335	335	335	335	335	335
S.T. Lydrook		36	30	31	32	33	34	35	36
NW Water-Chester		650	580	580	580	580	580	580	580
NW Water-Llangollen		47	37	37	37	37	37	37	37
TOTAL INCLUDING EXPORTS		2643	2285	2315	2334	2400	2467	2536	2604

Table 4.10 PWS peak week marginal demands for the Region

LOW FORECAST	Marginal Demand (Ml/d)					
	1996	2001	2006	2011	2016	2021
Dwr Cymru S.E. Division	0.1	0.0	0.0	0.0	0.1	0.2
Dwr Cymru S.W. Division	8.7	7.1	7.3	7.9	8.5	9.1
Dwr Cymru N(W) Division	0.0	0.0	0.0	0.0	0.0	0.0
Dwr Cymru N(E) Division	0.1	0.0	0.0	0.0	0.1	0.1
WEDWC	0.0	0.0	0.0	0.0	0.0	0.0
CWC	0.0	0.5	2.2	4.0	5.6	7.4
REGIONAL TOTAL	8.9	7.6	9.5	11.9	14.3	16.8
MEDIUM FORECAST	Marginal Demand (Ml/d)					
	1996	2001	2006	2011	2016	2021
Dwr Cymru S.E. Division	0.16	0.13	0.13	0.28	0.52	0.77
Dwr Cymru S.W. Division	8.8	8.5	8.6	9.5	11.8	14.1
Dwr Cymru N(W) Division	0.0	0.0	0.0	0.0	0.0	0.0
Dwr Cymru N(E) Division	0.1	0.1	0.1	0.1	0.2	0.2
WEDWC	0.0	0.0	0.0	0.4	1.9	3.5
CWC	0.0	1.0	3.1	5.3	7.4	9.7
REGIONAL TOTAL	9.0	9.8	11.8	15.6	21.8	28.3
HIGH FORECAST	Marginal Demand (Ml/d)					
	1996	2001	2006	2011	2016	2021
Dwr Cymru S.E. Division	0.5	0.6	0.9	1.3	15.0	39.0
Dwr Cymru S.W. Division	11.9	12.2	15.4	18.7	22.2	26.9
Dwr Cymru N(W) Division	0.0	0.0	0.0	0.0	0.0	0.1
Dwr Cymru N(E) Division	0.2	0.2	0.3	2.4	6.6	11.8
WEDWC	0.0	0.0	1.4	4.0	6.4	8.4
CWC	0.0	2.2	5.1	8.2	11.0	13.0
REGIONAL TOTAL	12.6	15.2	23.1	34.6	61.4	99.1

Figure 4.5 PWS marginal demands – low growth forecast

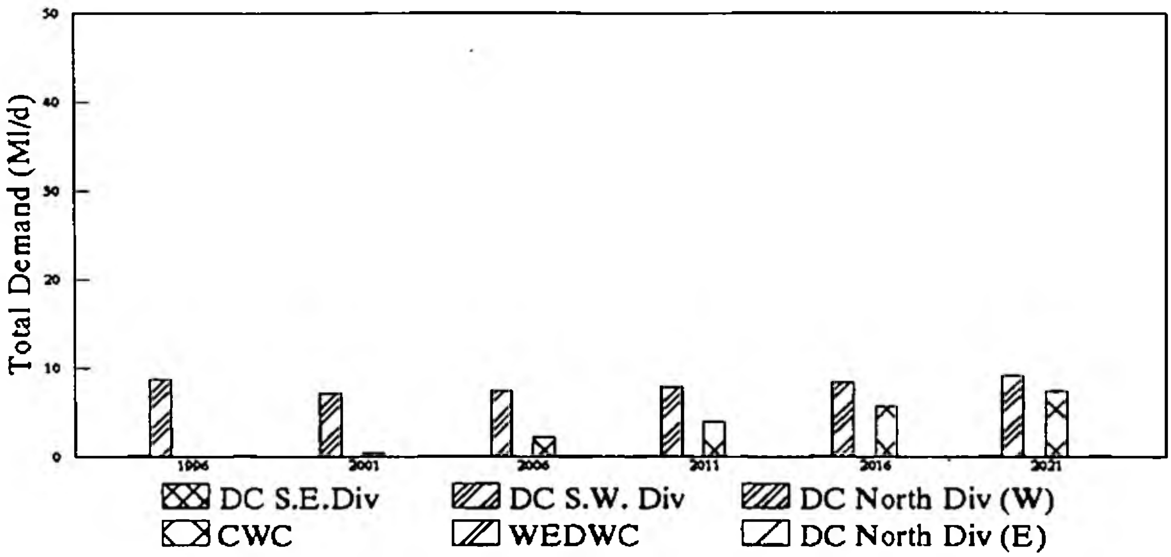


Figure 4.6 PWS marginal demands – medium growth forecast

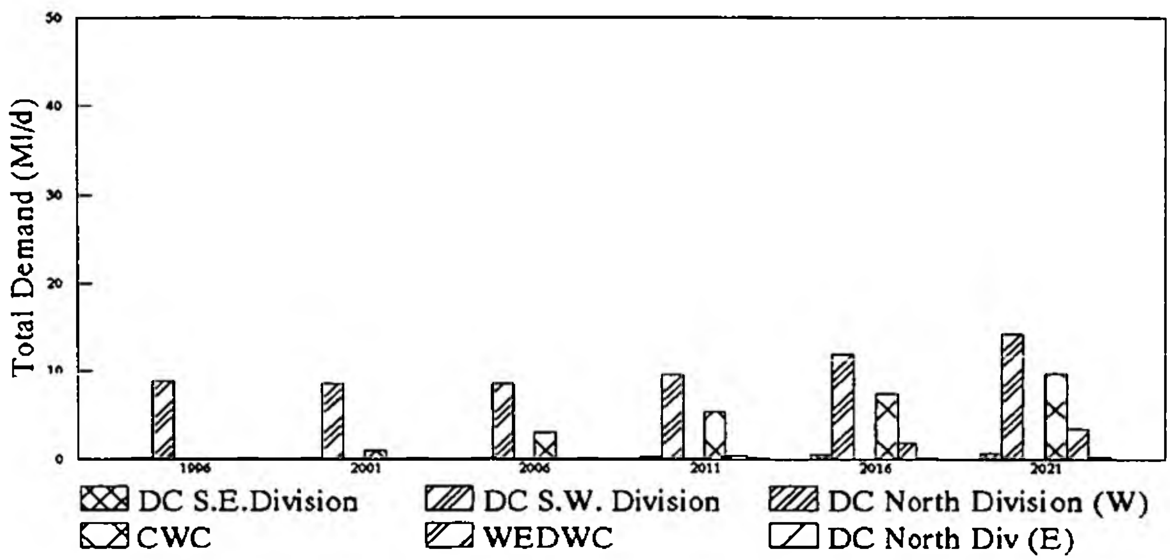
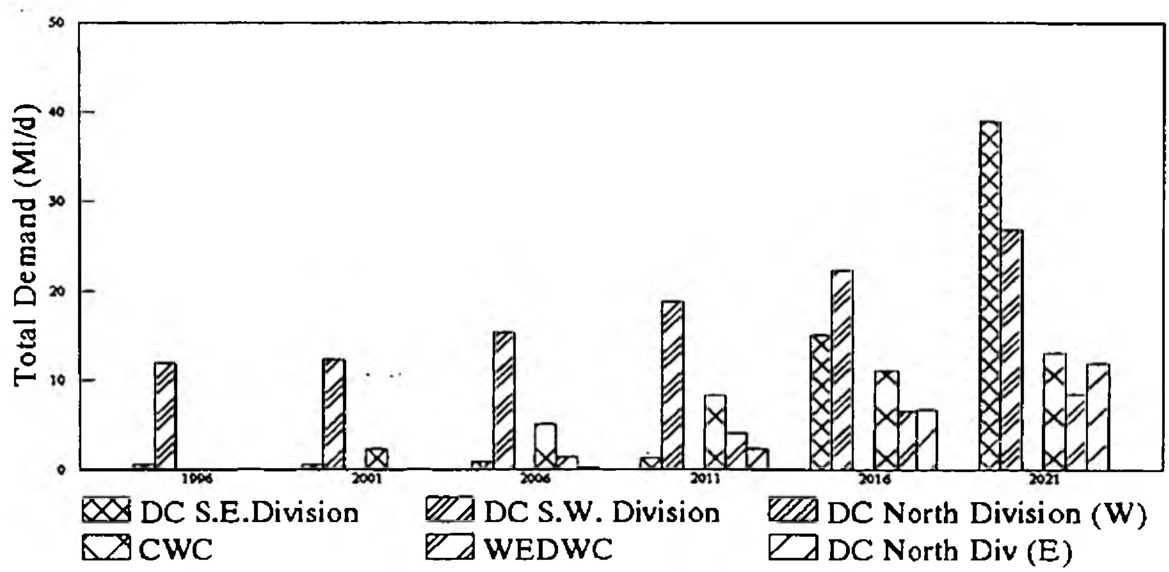


Figure 4.7 PWS marginal demands – high growth forecast



4.4 FUTURE DEMANDS FOR INDUSTRY AND AGRICULTURE

Forecasts have been made of gross demands for industry and agriculture for the period 1996 to 2021. Where practical these forecasts have been made at a sub-catchment level, otherwise forecasts have been made at a Regional level and sub-catchment figures have been estimated from the distribution of licensed quantity in 1993.

Forecasts are based on a range of sources including 1981 to 1991 trends, consultation with interested parties (see Appendix I for a list of organisations contacted), and available published information. The historic demands are included for completeness. Forecasts for the Region are presented in Figures 4.8 - 4.12. Detailed forecasts of estimated gross and net demands at a sub-catchment level are presented in Appendix H.

4.4.1 Power generation

4.4.1.1 Hydroelectric power (HEP)

Between 1981 and 1992 there has been a 3% increase in licensed quantity (excluding the three recirculation schemes), with actual abstractions amounting to 50% - 70% of licensed quantity. There are opportunities for new HEP schemes within the Region both at existing impoundment reservoirs and new low head installations at river sites.

In order to assess the likely future demands for direct abstraction for power generation, the NRA invited all power companies currently operating to submit details of how and where they saw demand increasing in the next 30 years. Nearly 50% of companies responded. The development proposals identified in the Welsh Region were:

* Competing proposals for a pumped storage scheme on the Afon Goedol at Ffestiniog (in the Glaslyn sub-catchment) from the National Grid Company and Norweb;

* A proposal for a conventional HEP scheme from Powergen on the River Dee, below the tidal limit, at Connah's Castle. This would not have a significant impact on the Region's water resources.

Dŵr Çymru holds a licence at Llyn Celyn to release 373 Ml/d (averaged over 365 days) for power generation. The Company are presently preparing proposals for the installation of an HEP station at Llyn Brianne (in the Upper Tywi sub-catchment) and an extension of the HEP installation at the lowest of the Elan Valley dams (in the Upper Wye sub-catchment).

For the purposes of this study it is assumed that Dŵr Cymru will seek licences of 340 Ml/d at Llyn Brianne (roughly the mean annual flow passing the dam), and 300 Ml/d at Caban Coch,the lowest of the Elan Valley dams (roughly the mean annual flow remaining in the Elan after the major abstraction of 341 Ml/d has been taken by STWP). Dŵr Cymru also has HEP generators installed on the compensation outlets from a number of their impounding reservoirs, but none of these are licensed because water is not released solely to generate power.

Dŵr Cymru recently commissioned consultants to undertake a feasibility study to assess the potential for HEP generation at eight sites in the Company's South Eastern Division. Preliminary findings indicate that three to five of the sites may be suitable, but this depends on overcoming any adverse environmental impacts.

At a regional level the NRA expects to receive licence applications for at least a further 10 schemes in the near future, two thirds of these being in the Glaslyn sub-catchment.

Based on the above information it is assumed that 13 HEP schemes will be developed under a low growth scenario as follows:

*	Conwy sub-catchment	-	One 200 Ml/d scheme by 1996;
*	Upper Wye sub-catchment	-	One 300 Ml/d scheme by 1996;
*	Upper Tywi sub-catchment	-	One 340 Ml/d scheme by 1996;
*	Gwrfai sub-catchment	-	One 100 Ml/d scheme by 2001, one 100 Ml/d scheme by 2006;
*	Glaslyn sub-catchment	-	Three 100 Ml/d schemes by 1996, three 100 Ml/d schemes by 2001, two 100 Ml/d schemes by 2006.

Current demand from existing licences is assumed to be 70% of licensed quantity.

Under the high growth scenario it is assumed that 20 HEP schemes will be developed as follows:

*	Conwy sub-catchment	-	One 200 Ml/d scheme by 1996;
*	Upper Wye sub-catchment	-	One 300 Ml/d scheme by 1996;
*	Upper Tywi sub-catchment	-	One 340 Ml/d scheme by 1996;
*	Gwrfai sub-catchment	-	One 100 Ml/d scheme by 1996, two 100 Ml/d scheme by 2001, one 100 Ml/d by 2006;
*	Glaslyn sub-catchment	-	Four 100 Ml/d schemes by 1996, three 100 Ml/d schemes by 2001, two 100 Ml/d by 2006;
*	Dwyfor sub-catchment	-	One 100 Ml/d scheme by 1996, one 100 Ml/d schemes by 2001, two 100 Ml/d schemes by 2006.

Again, current demand from existing licences is assumed to be 70% of licensed quantity.

The low and high growth forecasts are presented in Figure 4.8. Overall a growth ranging rom 280% to 350% by 2021 in gross demand is forecast. However, as HEP is a non-consumptive use of water this growth does not significantly affect the water resources of the Region.

The NRA is experiencing difficulties persuading applicants to accept and adhere to the conditions under which the NRA is prepared to issue a new licence. It is essential, among other considerations, that future licences should only be issued subject to the condition that future additional upstream consumptive abstractions may be licensed which may adversely affect the number of units generated and that no financial compensation would then be available. In practice there are unlikely to be many cases where a loss of income would be experienced in these circumstances, because most of the new HEP schemes are likely to draw their water from the upper reaches of rivers.

4.4.1.2 Electricity generation - cooling water (non-evaporative cooling water)

Cooling water is a minor demand on resources, with only one licensed abstraction from non-tidal waters. Demand decreased by 60% between 1981 and 1991. Virtually all water used for non-evaporative cooling is returned to the river. No new licences are envisaged in this category of use, and therefore no forecast is made. However, it should be noted that a single large new licence could dramatically change the situation.

4.4.2 Industry

With the decline in traditional heavy industries demand for water by this sector has reduced from 675 Ml/d to 340 Ml/d between 1981 and 1991. Future trends are particularly difficult to forecast but it is probably reasonable to assume there will not be a dramatic upturn in demand. There is provision in the Dŵr Cymru forecasts for provision of water to industrial users. The County Structure Plans do not reveal any plans for large scale industrial development in the Region, but many of these are due for renewal in the near future. Therefore, for the high growth scenario demand is assumed to remain at current levels and a 5% per annum decline is taken as the low growth scenario. The forecasts are presented in Figure 4.9.

4.4.3 Agriculture

4.4.3.1 Spray irrigation

Estimates of future demand have been based on a recent R&D project commissioned by the NRA (Ref 19), supplemented by historic abstractions data for the Region. The project produced forecasts of irrigation water demands for England and Wales over the horizon 1996 to 2021, using 1990 as the baseline year (selected as representing a design 'dry year'). Forecasts took account of various factors including cropping patterns, future commodity price levels, irrigation economics and informed opinion under a range of alternative agricultural policy scenarios (ranging from extreme protectionism to agriculture to complete trade liberalism).

Under the expected agricultural policy scenario, which relates to the current policy regime introduced in 1992/93 involving a reform of the Common Agricultural Policy and partial acceptance of GATT, the 'most likely' forecast is a growth in demand for irrigation water of 1.7% per annum from 1996 to 2001 and 1% per annum from 2001 to 2021. This will be due to an expansion in root crop and vegetable irrigated area, partially offset by a decline in grass and cereal irrigated area. The confidence of prediction reduces with time into the future, with forecasts beyond 2001 no better than speculative.

Ref 19 also details forecasts of irrigation demand in NRA Regions, using 1992 crop areas and 1990 fractions of crop irrigated and depths of water applied calculated from MAFF data. The derived growth rates are different to those given above, reflecting the different crop mixtures and different starting points. The report highlights the discrepancy between MAFF-based data and NRA abstraction data for 1990, with considerable differences at a Regional level.

The forecast demand for 1991 using the MAFF-based data is 3954 Ml, compared with an estimated actual abstraction of 2067 Ml from licence returns. 1991 and 1992, whilst being drier than average years, were not a period of severe drought in the Welsh Region as they were in south-eastern England. However, returns for 1991 and 1992 do indicate that abstraction in 1992 was about 50% greater than in 1991.

High and low growth forecasts of spray irrigation demand for this study have therefore been calculated using the growth rates derived for the Region in Ref 19 with 1991 demand data from Chapter 3 of this report as the baseline. Under the low growth scenario demand increases at about 2% per annum between 1996 and 2001 and at 1.4% per annum from 2001 to 2021. Under the high growth scenario the same growth rates are used but demands are set at 50% above the low growth forecast to simulate drought year demands. The forecasts are presented in Figure 4.10.

4.4.3.2 General agriculture

Demand increased at about 1.5% per annum between 1981 and 1991. However, discussions with representatives of MAFF and the NFU indicate that demand is unlikely to rise above current levels. A low growth forecast of no growth and a high forecast of 0.5% per annum are assumed. The forecasts are presented in Figure 4.11.

4.4.4 Amenity/Conservation

Demand for water for amenity or conservation purposes increased sharply from 2 Ml/d to nearly 30 Ml/d between 1981 and 1991, principally due to a single new licence. Discussions with NRA staff indicate demand is expected to remain static. Therefore growth rates of 0.25% per annum and 0.75% per annum have been assumed for the low and high forecasts respectively, shown in Figure 4.12.

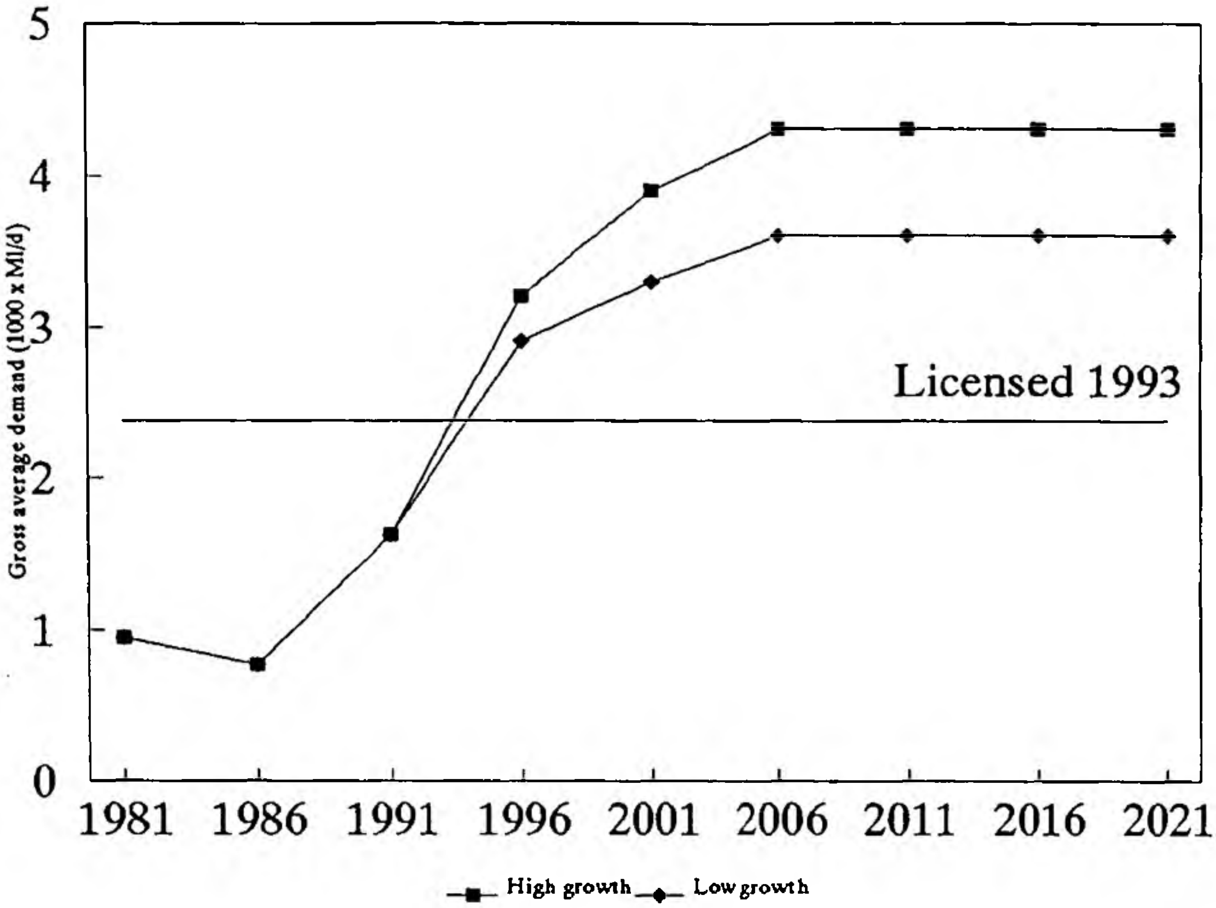
4.5 PROJECTED RESOURCES SHORTFALL FOR PRIVATE DEMANDS

It can be seen from Figures 4.8 - 4.12 that the only private demands forecast to increase significantly between 1991 and 2021 are spray irrigation and HEP. Other demands are expected to remain at current levels or decrease.

In the case of spray irrigation demand is forecast to increase by as much as 140% of 1991 demand by 2021, although gross demand in 2021 is forecast to be lower than the current licensed quantity. This large increase would have a significant impact on resources - spray irrigation is nearly totally consumptive and demands are not uniformly distributed regionally but are concentrated in a few sub-catchments. A number of sub-catchments in the Wye are already subject to an embargo on new licences for spray irrigation because of a lack of resources to meet this demand. Many licences contain the restriction that water can only be taken when flows in the river at some control point exceed a threshold figure. The forecast makes no allowance to alleviate these factors which already significantly curtail private demands.

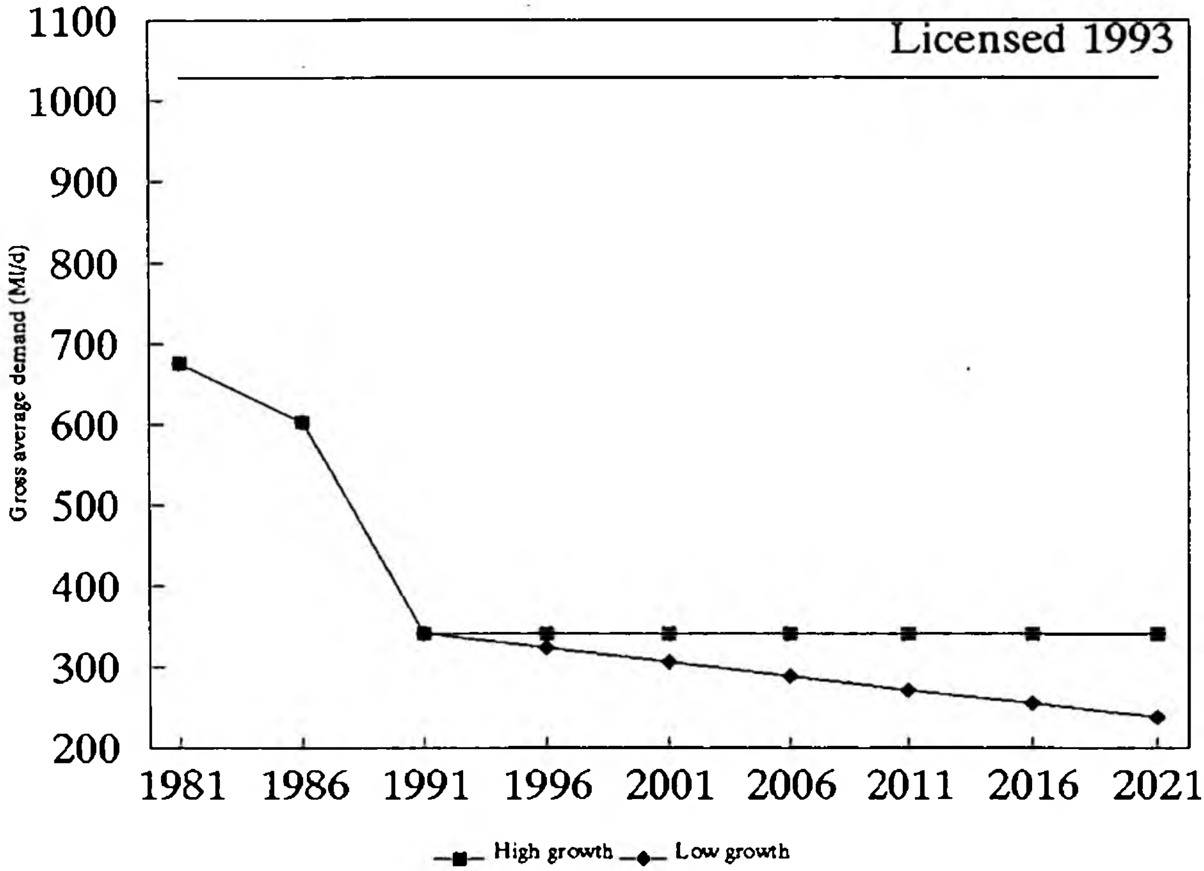
HEP also sees a large growth over the planning horizon. HEP is a non-consumptive use of water and this increase in demand should not adversely impact on the water resources of the Region as long as certain issues associated with non-consumptive uses (risk of derogation of existing licences, operational impact on fisheries and water quality) are taken into account. This is considered further in Section 6.

Figure 4.8 Power generation: HEP average demand forecast



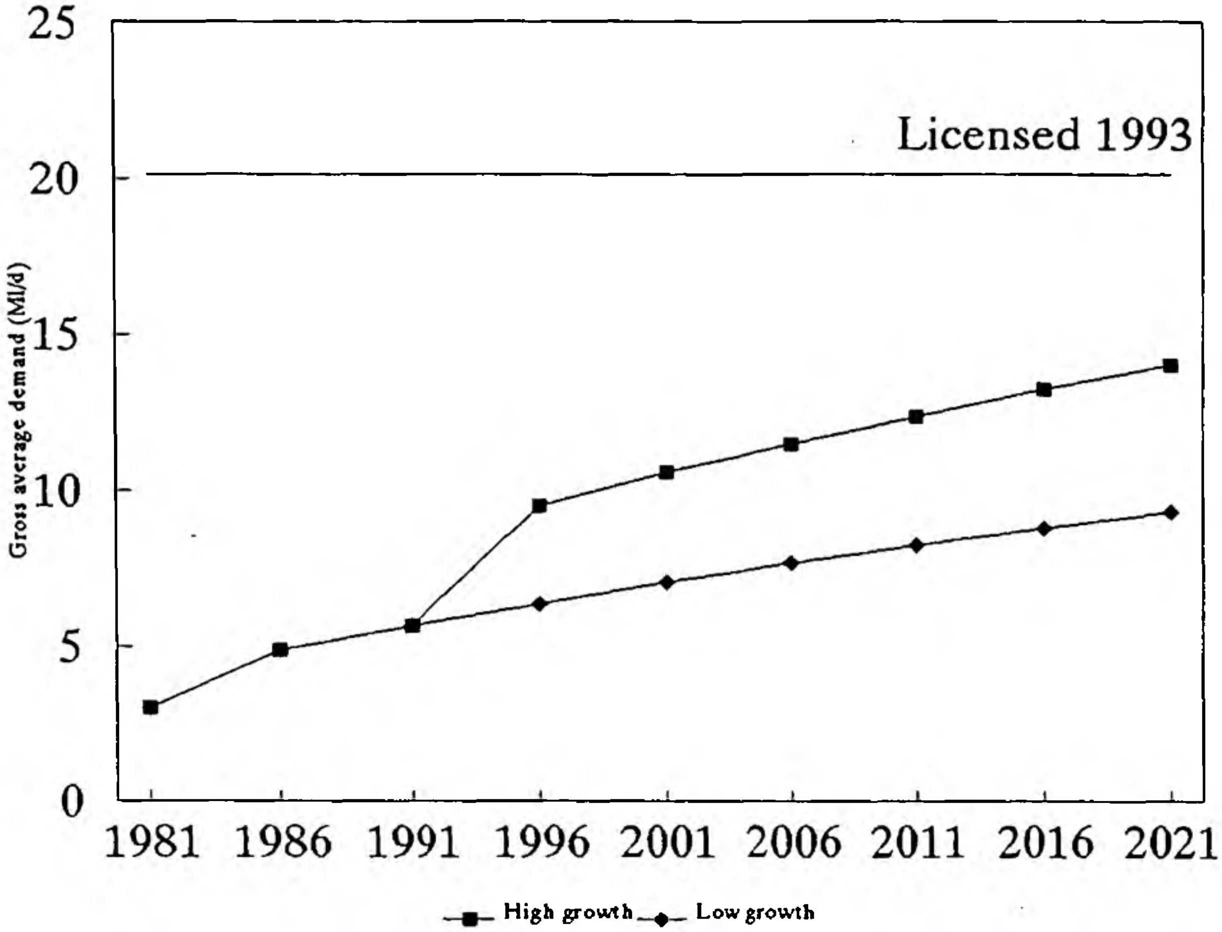
Forecast scenario	Gross demand (Ml/d)								
	1981	1986	1991	1996	2001	2006	2011	2016	2021
High	947.2	769.0	1626.2	3203.9	3903.9	4303.9	4303.9	4303.9	4303.9
Low	947.2	769.0	1626.2	2903.9	3303.9	3603.9	3603.9	3603.9	3603.9

Figure 4.9 Industrial average demand forecast



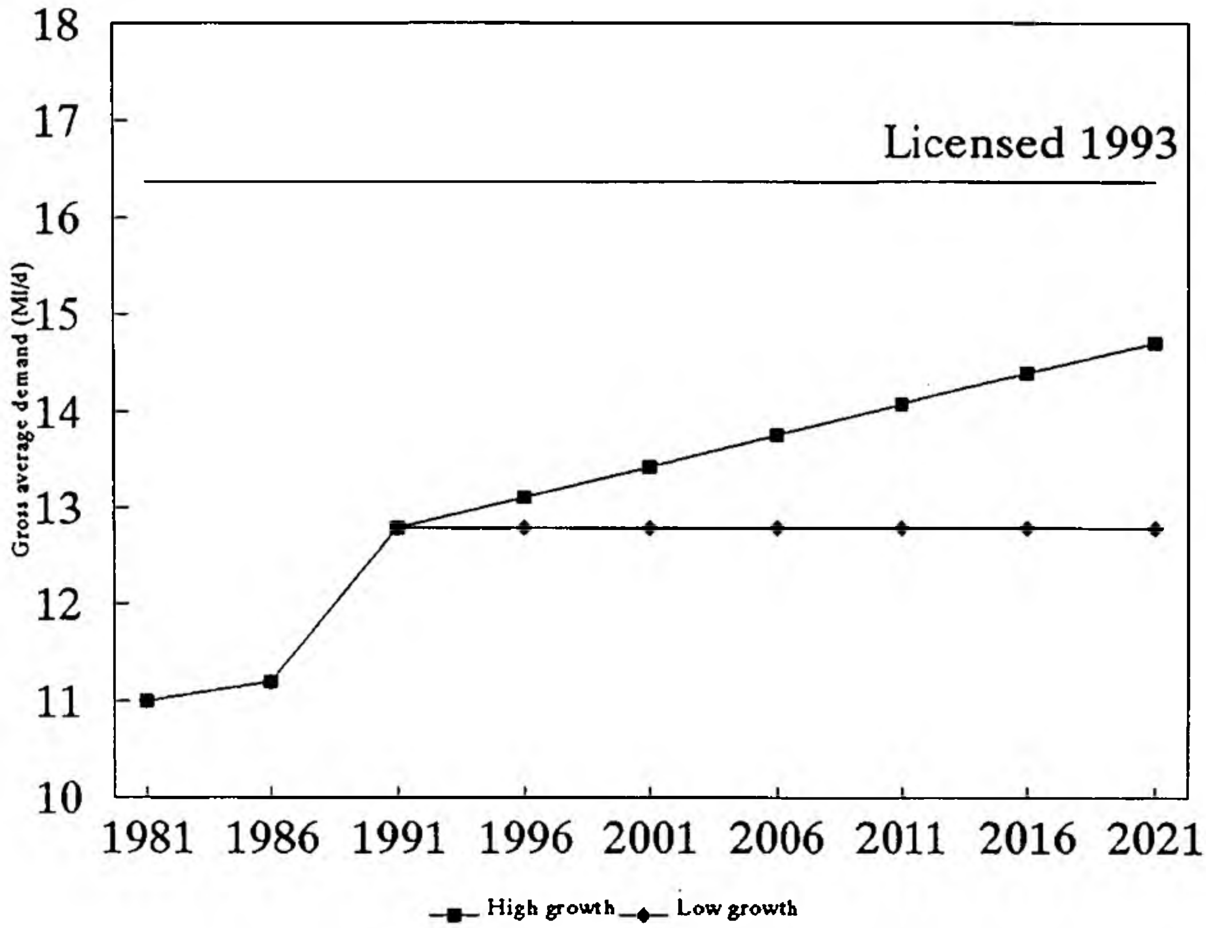
Forecast scenario	Gross demand (Ml/d)								
	1981	1986	1991	1996	2001	2006	2011	2016	2021
High – Static .	675.2	603.4	340.8	340.8	340.8	340.8	340.8	340.8	340.8
Low – 5%/yr decline	675.2	603.4	340.8	323.8	306.7	289.7	272.6	255.6	238.6

Figure 4.10 Spray irrigation average demand forecast



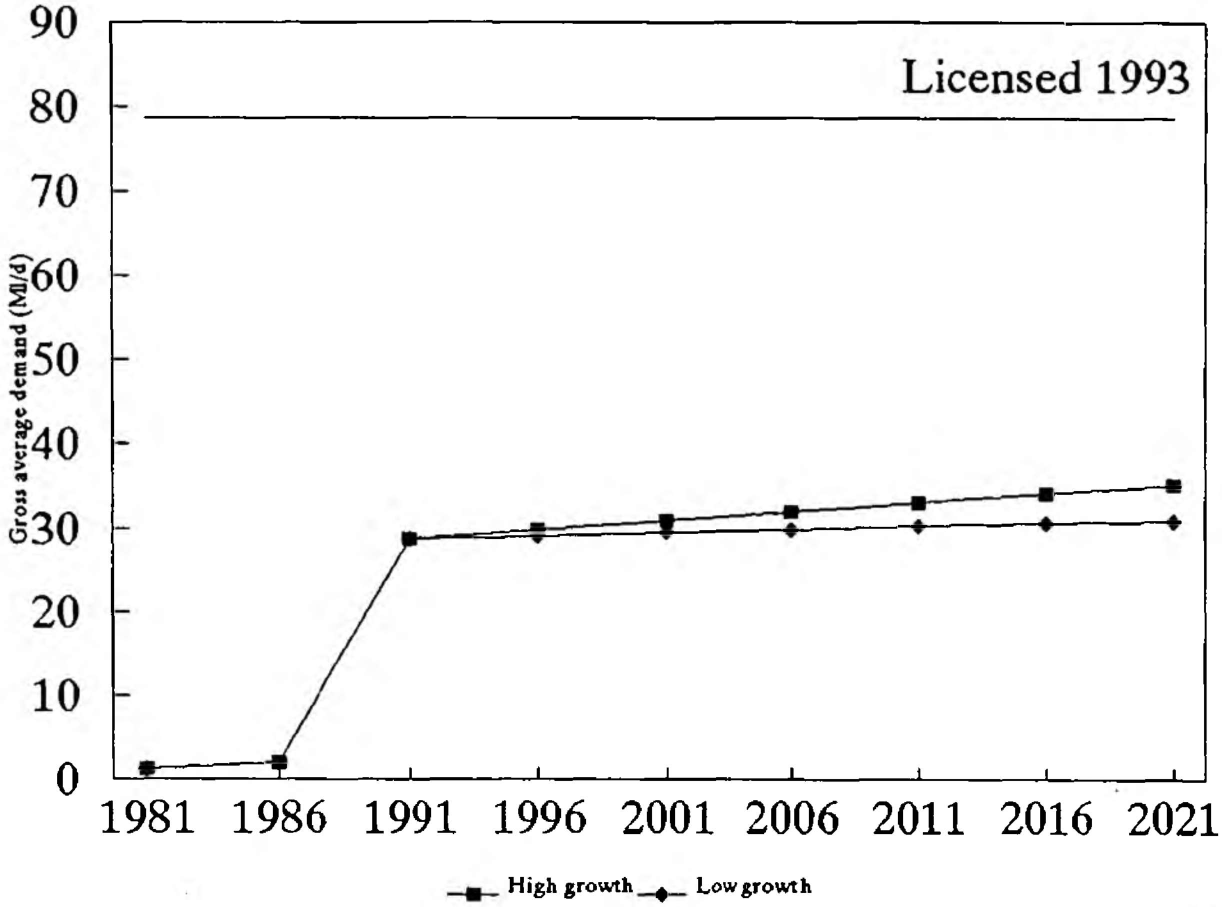
Forecast scenario	Gross actual demand (Ml/d)								
	1981	1986	1991	1996	2001	2006	2011	2016	2021
High – Drought year baseline	3.01	4.86	5.66	9.50	10.58	11.49	12.36	13.21	14.01
Low – Average year baseline	3.01	4.86	5.66	6.34	7.05	7.66	8.24	8.81	9.34

Figure 4.11 General agriculture average demand forecast



Forecast scenario	Gross demand (Ml/d)								
	1981	1986	1991	1996	2001	2006	2011	2016	2021
High – 0.60%/yr growth	11.0	11.2	12.8	13.1	13.4	13.7	14.1	14.4	14.7
Low – static	11.0	11.2	12.8	12.8	12.8	12.8	12.8	12.8	12.8

Figure 4.12 Amenity/Conservation average demand forecast



Forecast scenario	Gross demand (Ml/d)								
	1981	1986	1991	1996	2001	2006	2011	2016	2021
High – 0.75%/yr growth	1.2	1.9	28.7	29.8	30.9	31.9	33.0	34.1	35.2
Low – 0.25%/yr growth	1.2	1.9	28.7	29.1	29.4	29.8	30.1	30.5	30.9

4.6 ENVIRONMENTAL DEFICITS

The formation of the NRA in 1989 coincided with a series of dry years. The lack of rainfall during 1988 to 1992 was particularly acute in the South and South-East of England but all Regions experienced low rainfall, especially in 1989 and 1990. The drought caused a widespread reduction in river flows and groundwater levels which, in certain locations, was compounded by overabstraction. Most of these abstractions were Licences of Right authorised under the Water Resources Act 1963. This gave existing abstractors the right to a licence regardless of any environmental implications.

4.6.1 Alleviation of low flows (ALF)

The NRA, with its mandate as the guardian of the water environment, saw the alleviation of these low flow rivers as one of its top priorities. As a first step it identified 40 sites throughout England and Wales where abstractions were perceived to be affecting flows. Seven such rivers are in the Welsh Region: four in the Wye catchment on the rivers Gamber, Garren, Frome and Monnow, two in the Dee catchment on the Afon Clywedog and Afon Alyn, and one on Anglesey on the Afon Cefni.

The seven sites have been assessed using a methodology developed by the NRA in 1992 to appraise low flow sites nationally in a consistent manner. The methodology takes account of hydrological conditions, abstractions, ecology, amenity and public perception, leading to identification of the severity of the problem and the reliability of the data used (Ref 20).

Many of the sites were originally identified on the basis of public perception rather than firm evidence, and have been shown to be natural or resulting from causes unrelated to abstraction. Table 4.11 details the low flow sites in the Region, together with the current status of investigations. It should be noted that rivers whose low flows in recent summers have been shown to be due to natural, rather than artificial, causes are not listed as the NRA does not believe it is a valid objective to sustain flows above their 'natural' values. In each case detailed investigation and assessment of worthwhileness will be necessary before amelioration can be undertaken.

Table 4.11 also includes six sites which NRA Welsh Region has identified for further investigation in the process of formulating Catchment Management Plans. As the NRA completes more CMPs further sites may be identified.

4.6.1.1 Afon Clywedog

In the case of the Afon Clywedog site low flows have been shown to be exacerbated by PWS abstraction at WEDWC's sources at Minera (Licence no. 67/07/035). Much of the catchment geology is Carboniferous Limestone and the river loses water naturally through swallow holes in the river bed into the underlying limestone. Historic metalliferous mining activities, with associated drainage adits, have exacerbated this natural phenomenon. However, this water is discharged from adits a little further downstream. WEDWC has utilised some of the mine drainage system for PWS. This has further added to the loss of water from the river. When abstractions take place, the discharge from the adits is reduced.

Table 4.11 *Low flow problem sites in Welsh Region*

River	Description	Current status
Afon Clywedog (Dee)	Problem caused by natural conditions, exacerbated by PWS abstraction.	PWS sources to be abandoned and licence revoked.
Garren Brook (Wye)	Problem may be due to spray irrigation abstraction.	No new summer abstraction licences will be granted. Further work required.
River Gamber (Wye)	Abstractions for spray irrigation may be having an impact.	No new nett summer abstraction licences to be granted. Gauging station being recommissioned to monitor flows and obtain data for further investigation.
Afon Llynfi (Ogmore)	CMP identified low flow problem. Abstractions for industrial use affects river flows.	Work planned to provide additional water to river when depleted.
Afon Ritec (Tenby)	CMP identified low flow problem.	Observation boreholes installed to help monitor and identify scale and potential cause of problem. Located in licence-exempt area.
Afon Porthllwyd (Conwy)	CMP identified low flow problem downstream of dam used for HEP.	Further work required to assess severity of problem.
Alford Brook (Dee)	CMP identified low flow problem. Baseflows may be reduced by long term drop in groundwater levels.	Investigation being undertaken. Enhanced monitoring established to assess rate of reduction of baseflows.
Worthenbury Brook (Dee)	CMP identified low flow problem (linked to above site).	Investigation being undertaken.
Dolfechlas Brook (Dee)	CMP identified low flow problem.	Further work required to assess severity of problem.

An alleviation plan has recently been formulated by the NRA and WEWDC, under which WEWDC will abandon the Minera sources and NRA will revoke the licence. The loss of supply will be made good through additional abstraction from the Company's existing intake on the River Dee. The Company's total yield will remain unchanged, but the total licensed quantity will reduce by 3.6 Ml/d, the difference between the Minera sources current yield of 2.5 Ml/d and the 6.1 Ml/d licence entitlement.

WEWDC will gain a more reliable source with better quality water, but with higher operating costs and some initial capital expenditure. The Afon Clywedog will benefit from increased flows. The Clywedog Valley downstream of Minera contains a number of sites of local and national archaeological importance, and is the setting for a 12km Heritage Trail created by Clwyd County Council. Additional water will benefit not only this important amenity use, but also water quality and fisheries.

4.6.1.2 Aldford Brook/Worthenbury Brook

These sites are of major concern from a resources viewpoint as, on top of local environmental impact, these streams are small but important contributors to the baseflow of the lower Dee and therefore the low flow problem impacts on the yield of the Dee. The cause of the problem has yet to be identified. However, STWP abstractions at Overton Scar, Tower Wood, and one other location across the border are thought to be mining water. The NRA is currently undertaking an investigation to identify the cause of the problem and assess amelioration options. If the STWP abstractions are found to be the cause of the problem then it may be possible to augment the abstractions with water from Vyrnwy aqueduct during summer months in order to rest the aquifer.

4.6.1.3 Afon Alyn

In the case of the Afon Alyn, investigation has shown that natural limestone river bed drainage, exacerbated by mining, rather than as a result of abstraction. Subsequently the river is dry every year over a large stretch. The water drains to the Bagillt tunnel on the Dee estuary where Dŵr Cymru have an abstraction for non-potable supplies. Studies (Ref 21) to alleviate the low flow identified that a pipeline or channel to bypass the affected river stretch could maintain baseflows during the summer period, equating to approximately a 10 Ml/d increase in the yield of the Dee. However, this could lead to derogation of the licence at Bagillt. The preferred solution identified has not been implemented due to high cost with limited benefit. As a result the NRA will only continue to evaluate local remedial measures specific to the lower Alyn.

4.7 NATIONAL WATER RESOURCES DEMANDS

The Welsh Region is already a major net exporter of resources to other Regions. The NRA is currently looking at future water resources at a national level as well as a regional level. At this strategic level, the South and South East of England are of particular concern because they:

* have the highest anticipated increase in demand;
* receive the lowest rainfall;
* already have highly developed resources;
* have the most low flow problems associated with overabstraction.

A National Water Resources Strategy document was published by the NRA for discussion in 1992 (Ref 8). The preferred NRA strategy for future development of water resources to meet the needs of PWS, industry and agriculture was published recently for consultation (Ref 22). The preferred NRA strategy identifies a number of preferred options to meet marginal demands arising under a range of demand forecasts.

The Welsh Region, with its relatively abundant water resources and small increase in demand (under low and medium growth scenarios), does not have a need for new strategic supplies. However, it may have an important role to play - as a potential provider of water for transfer to other Regions in the South and South East of England. Table 4.12 lists the eight options that have been identified and appraised in the National Strategy. Only Option 2 has implications for the Welsh Region. This is considered below. Further, detailed studies would be required before any new inter-basin transfer was approved, including environmental appraisals. Water resources developments will only be required under medium and high demand growth scenarios, with the marginal demand focused on the Thames Region.

4.7.1 Enlargment of Craig Goch Reservoir

There is considerable scope to enlarge Craig Goch Reservoir (one of the Elan Valley reservoirs). The scheme was extensively investigated in the 1970s, when a number of sub-options of varying complexity were identified. An enlarged Craig Goch, with a top water level 49m higher than present and storage of 190,000 Ml, could be used to provide increased regulation of either the River Wye or, via catchment transfer arrangements, the River Severn. This in turn could support transfers to the River Trent or Thames catchments.

Table 4.12 *Preferred options in the National Water Resources Strategy*

Option ref.	Scheme	Additional potential yield (Ml/d)
1	Severn-Thames transfer	57 - 92
2	Enlarged Craig Goch Reservoir	Up to 775
3	Partial redeployment of Vyrnwy Reservoir	Up to 337
4	S.W.Oxfordshire Reservoir	350
5	Severn-Trent transfer	Capacity 100
6	East Anglian reservoir	Capacity 174
7	Trent-Anglian transfer	Capacity 200
8	Canal transfer to Thames	Capacity 100

The enlargement of Craig Goch can be achieved by construction of a comparatively small new dam at the downstream narrow neck of a long, wide valley. The development would not have any significant community impact due to its remoteness, but it would result in the inundation of part of the Elenydd SSSI and some other sites of nature conservation. Any proposals affecting these habitats would need to be carefully assessed and would meet with strong objections from the Countryside Council of Wales due to their national importance.

Regulation releases to the River Wye would be made via a tunnel above Rhayader. An abstraction for transfer to the River Thames would be made at an intake in the vicinity of Ross-on-Wye. Further regulation of the Wye raises a number of concerns since the whole river, including riparian habitats, has been classified as a SSSI and as such is of national importance. The Wye is also an important salmon river. Although river flows are already affected by impoundments in the headwaters and periodic regulation releases, there is concern that the salmonid spawning reaches of the Upper Wye may be affected by an altered flow regime. However, moderation of extreme low flows may provide some benefit in terms of reduced environmental risk and improved habitat stability.

An enlarged Craig Goch offers the potential to transfer water to the River Severn to support downstream demands including the possible transfers to the Trent and Thames basins. This would require a tunnel discharging at Llanidloes. Regulation of the River Severn with water from the enlarged reservoir would be in addition to that currently made from Clywedog and to a lesser extent Vyrnwy Reservoir. The effects of additional regulation would need to be evaluated and the loss of water from the Wye catchment would also need careful scrutiny.

4.7.2 Other options

Three other major resource options have been investigated as part of the National Strategy: two new reservoirs - one in Oxfordshire (Thames Water Services has proposed a 150,000 Ml storage reservoir near Abingdon) and one in Anglian Region (two possible sites for a pumped storage reservoir, at Great Bradley or Shrubhill, in Norfolk), and redeployment of Vyrnwy Reservoir for regulation of the River Severn.

The three transfer schemes (Severn to Trent, Severn to Thames, Trent to East Anglia) all involve transfers of large quantities of water between major basins. These proposals have major environmental implications which are being examined.

4.8 AFFORESTATION

Afforestation raises important issues for water resources. The preparation, planning and final development of forests, and management practices associated with forests can have major impacts on both catchment response to rainfall and the quality of runoff.

The major thrust of afforestation began in the early 20th century, when forests were encouraged around reservoirs and in the water-gathering grounds to reduce the effects of bacteria from sheep waste and to prevent soil erosion. The Forestry Commission's planting of timber following the Second World War was designed to reduce the country's reliance on imported timber. In the 1990s, following acceleration in forestry in the 1970s and 1980s, environmental concern and tax law reform have led to a hiatus in the afforestation programme.

Studies (Refs 23,24,25) have found that afforestation can result in reduced yields of water sources. The principal mechanisms for this reduction are increased transpiration and evaporation from the wetted tree canopy compared with open moorland. In general terms impact depends upon the type of trees being planted and the vegetation being replaced. Broadleaf planting tends to be preferable to coniferous as they should have less impact on water quality and quantity. Hydrological changes may also alter erosion and deposition patterns along a river, and lead to increased river maintenance costs. Furthermore sedimentation from increased erosion may directly affect storage reservoirs by reducing their capacity. Afforestation may also cause changes in flood response of streams, particularly in ploughed and drained catchments.

Upland storage reservoirs are important in the Welsh Region for provision of drinking water of high quality and for river regulation purposes. Forestry development within the catchments of such sources may have significant implications for the costs of supplying water, particularly if losses of yield necessitate provision of additional resources.

Afforestation, in the particular case of HEP generation, causes direct loss of generation by reduction in the amount of water which is available to run the turbines. The Powergen scheme at Rheidol and the Nuclear Electric scheme at Trawsfynydd/Maentwrog are thought to be the only HEP schemes affected by afforestation. In normal operation, the Welsh HEP schemes are used for "peak lopping", generating at times of daily peak demand on the National Grid. If HEP generation is not available because of water loss, it has to be replaced, and at peak times such replacement will be from one of the less efficient coal, oil, or nuclear thermal power stations. Additionally, because of their fast response, HEP schemes can be used to respond to short-term demand fluctuations, and if they are not available this function can only be performed by gas turbines, which are extremely expensive to run.

The Forestry Enterprise (FE) and the Forest Authority (FA) act as the Commission's executive wings. The FE is responsible for public sector forestry management and development, currently managing about 135,000 hectares of forestry in the Welsh Region. The FA administers private sector development under the Woodland Grant Scheme (WGS), with about 120,000 hectares of forestry in the Welsh Region under FA administration. Discussions with both organisations (see Appendix J) indicate that there have not been any new major forestry development in the last few years, and the only planned development amounts to 450 hectares (under the WGS). Afforestation is therefore not deemed to present a problem for the future water resources of the Region.

5 OPTIONS FOR A STRATEGY FOR WATER RESOURCES

5.1 INTRODUCTION

As explained in Section 1 the NRA has a statutory duty to conserve, redistribute or otherwise augment water resources and secure the proper use of those resources. To meet this important obligation a strategy is required to meet the future water requirements of the Region, optimising those resources in a sustainable manner, and ensuring that water demands are met in an environmentally acceptable manner.

The NRA's principal aim is to achieve a balance between the needs of abstractors and the those of the environment. The NRA is specifically responsible for licensing abstractions made from water held in natural underground storage and from all surface waters above the tidal low water mark (excluding certain licence-exempt areas). This is one of the key water resources activities and is fundamental in shaping how water resources are used and how the water environment is managed. The NRA applies the precautionary principle where the impact of abstraction is uncertain.

The NRA also has general environmental duties, in relation to all its functions including the need to further conservation. The Authority also has duties to promote the use of inland and coastal waters for recreational purposes.

In Section 4 forecasts of future PWS demands were made under a range of scenarios. Table 5.1 summarises the marginal demands. Section 4 also identified increases in private demands for spray irrigation and HEP and highlighted some issues associated with non-consumptive uses.

Table 5.1 *Summary of PWS marginal demands in 2021*

Water company	Marginal demand (Ml/d)		
	Low growth	Medium growth	High growth
CWC	7.4 (2001)	9.7 (2006)	13.0 (2001)
WEDWC	-	3.5 (2011)	8.4 (2006)
Dŵr Cymru			
SE area	0.2 (2016)	0.8 (1996)	39.0 (1996)
SW area	9.1 (1996)	14.1 (1996)	26.9 (1996)
NE area	-	-	0.1 (2021)
NW area	0.1 (2016)	0.2 (1996)	11.8 (1996)
REGION TOTAL	16.8	28.3	99.1

Note - Figures in brackets are start date for deficit.

In this Section options available for meeting these demands are explored. These comprise encouraging efficient use of water and adoption of water saving methods, re-allocation of water and making more water available. The marginal demands arising in the Region are relatively small.

The NRA has issued the following national policy statement: "Before any new sources are developed, it is essential that water companies make sure they are doing all they can to reduce leakage and carry out effective demand management. The NRA supports the use of selective domestic metering, with an appropriate tariff, in areas where water resources are stressed." As the high growth scenario assumes no improvements in leakage levels or metering, which is contrary to NRA policy, options to meet the high growth scenario are only outlined, with the focus on options to meet the low and medium growth scenario forecasts.

Groundwater development, effluent re-use and other esoteric options are discussed, but these options are not investigated in detail as they are not appropriate at this time given the scale of the forecast marginal demand in the Region.

5.2 THE OPTIONS FOR SAVING WATER - DEMAND MANAGEMENT

The provision of all water resources involves a cost, both financial and environmental. As the population grows so does the demand for water. It is therefore important that these demands are managed to keep them as low as reasonably practicable. Management initiatives include leakage control and metering. The NRA already advocates demand management by all water users to the extent that it is economically justified. The principles of demand management are being increasingly recognised, and fostered for example in the Government's discussion paper "Using Water Wisely" (Ref 26). Options for saving water are discussed in the following Sections.

5.2.1 Leakage reduction

Existing and future demands can be reduced by minimising leakage. This can play an important role in reducing the need for development of new water resources. Additionally, leakage is costly in supply terms since the costs incurred in treating and supplying water are wasted. However, it should be borne in mind that leakage reduction is subject to the law of diminishing returns, and realistic targets for leakage reduction need to be set. Economic levels of leakage vary from company to company, depending upon the cost of leakage and of leakage control activities, as well as the underlying level of leakage due to the physical nature of the supply system.

Total leakage consists of distribution losses (company leakage) and supply pipe leakage. There is some debate on how to assess leakage with differences in approach between water companies. Table 5.2 shows leakage data for the water companies in the Region to illustrate the variation in distribution losses (Ref 17). It is hoped that better information will become available from the National Leakage Initiative - a project set up by the Water Services Association and the Water Companies Association.

CWC and WEDWC have actively practised leakage control for a number of years and have total leakage levels below the national average. Additionally, their leakage levels are below the target levels set for PWS in the National Water Resources Strategy demand forecast scenarios, upon which the methodology used in this report has been based. However, a level of diminishing return has been reached and further significant reductions are only likely following major capital investment on water supply systems, in particular the replacement of ageing water mains. CWC's and WEDWC's marginal demands - 9.7 Ml/d and 3.5 Ml/d respectively under the medium growth scenario - will therefore have to be met by other means.

Table 5.2 *Leakage levels in the Region in 1992*

Water Company	Distn. losses /Distn. input (as a %)	Total leakage (l/prop/hr)	Supply pipe leakage/Total leakage (as a %)
Dŵr Cymru	28	15.6	21.6
CWC	14	7.0	29.9
WEDWC	12	6.0	27.3
National average	17	8.5	28.5

Dŵr Cymru have a higher level of leakage than the two smaller companies, with distribution losses substantially above the national average at 28% of distribution input, reflecting the poor state of Dŵr Cymru's supply system. The Company is undertaking a programme of leakage reduction, especially in the South East Division. However, it should be noted that this apparently high figure may be due to the way in which the Company has assessed leakage as Dŵr Cymru's figure for supply pipe leakage is significantly lower than those for CWC and WEDWC and the national average.

At 15.6 l/prop/hr Dŵr Cymru's level of leakage is significantly greater than the target levels used in the national strategy demand forecasts (Medium forecast - 11 l/prop/hr; High forecast -14.5 l/prop/hr). Clearly, if Dŵr Cymru reduce their levels of leakage in line with the medium growth forecast the need for new resource development over the planning period will be minimal.

5.2.2 Metering of domestic water use

Metering of domestic use, with appropriate tariffs, is probably the most effective way of reducing water use. Current national metering trials have been running for three to four years. Preliminary results indicate that average domestic consumption can be reduced by 11%, and peak demands by as much as 30%. There is uncertainty as to whether in the longer term such significant reductions in demands can be maintained without invoking special tariffs, but in some other countries metering plays an important role in demand management as evidenced by the growth in water-saving appliances. Additionally, as with leakage reduction there is a law of diminishing returns with metering, as well as practical, economic and social factors which influence the rate and extent to which meters are introduced.

CWC and WEDWC both have a policy of metering all new properties. Dŵr Cymru have stated their intention not to move towards universal metering, because they consider that up to 90% of the cost of supplying domestic properties is independent of the volume of water taken. The Company's current policy is to only install a meter upon request from the customer. Dŵr Cymru believe that in many parts of their area the cost of installing, maintaining, reading and billing meters would be several times greater than the value of the small percentage of delivered water which would be saved.

However, recent advances in meter reading technology mean that the cost of reading can be reduced substantially. In light of this the NRA may expect Dŵr Cymru to amend its policy.

5.2.3 Consumer education

Consumers can play their part in reducing demand by reducing their own use of water. The NRA has taken a lead in this direction ever since its formation, and it is recommended that the NRA continues to endorse moves to educate the public to use water wisely. However, most savings are more related to saving peak distribution costs than water resources.

5.2.4 Better design of water appliances

Water can be saved by improved design of washing machines, dishwashers, and other appliances, and by reducing the flush-volumes of wc's. It may require price incentives to achieve a real impact on appliance design, and there are social and public health limitations to be considered.

5.2.5 Industry

There may be scope for industry to save water by more efficient processes and/or by re-cycling water within the factory. The Centre for Exploitation of Science and Technology (CEST) is currently undertaking a project in conjunction with industry to demonstrate the benefits of waste minimisation and cleaner technology (Ref 27). In the first 18 months of the project the eleven participating companies made savings of over £2M a year. Reductions in the use of inputs such as water, energy and raw materials exceeded savings in effluent production by a significant margin thereby confirming that companies can profit from cleaner production through improved process efficiency. The NRA should continue to encourage industry to practice good water husbandry.

5.2.6 The National Abstraction Charging Scheme

The national scheme of abstraction charges was introduced on 1st April 1993. It provides a consistent basis for charges throughout England and Wales. The scheme incorporates a limited range of incentives to aid in the proper management of resources:

* charges are set to encourage abstractors to use water efficiently and keep their licensed volumes to a minimum. The NRA also audits applications to ensure that applicants do not apply for more water than they reasonably require;

* charges reflect the higher cost to the environment of summer abstractions;

* charges are lower for less consumptive uses of water.

The application of incentive charging as an economic instrument to control the environmental impact of abstraction may be developed further. Incentive charging would however require a change to the legislation if the NRA needed to recover more by way of charges than its year on year expenditure, in order to provide a real incentive to change attitudes and behaviour.

5.3 THE OPTIONS FOR RE-ALLOCATING WATER

The system of licences introduced by the Water Resources Act 1963 allocates water to the first person or organisation to show a reasonable need for it. The system is a rigid one of first come first served, and once issued a licence confers a valuable right on the holder. Recently it has become more common for licences to be time limited, but generally only for reasons of uncertainty over water availability, and most licences are valid until revoked.

The only way to re-allocate water is for the NRA to revoke an existing user's licence, then reissue it to a new user. This makes sense if the value of water to the new user is greater than the value to the old user. However, the NRA has to pay full compensation to the old user, and may gain no increase in licence income. Many of the licences in the Region are approaching 30 years old, may not have been efficiently issued and may now be inappropriate. The decline in abstraction evidenced by returns from industrial users would serve to indicate under-utilisation of licences and may not reflect current best use of water.

5.3.1 Under-used licences and 'inefficiently' used licences

The term 'inefficient' is used in its economic sense, meaning water allocated by licence to a relatively low-value use when there is an alternative high-value use needing water. Research into the economics of water resources management (Ref 10) concluded that the most appropriate way to deal with this situation, bearing in mind the incentive on licence-holders not to give up their rights and the penalties on the NRA of revocation, would be a system of tradeable permits. This would allow a free market in licensed abstraction rights (with a regulatory role by NRA). In theory in the long term this could lead to the allocation of water to the highest value users.

5.3.2 Incentive charging

The charges for water abstraction must, by law, be set to balance the costs of managing water resources. They are therefore relatively low, and are in no way related to the value-in-use of water, nor the cost of making 'new' water available. The NRA is therefore looking into whether economic principles, particularly incentive charges, could be used to improve management and allocation of water resources. However, it is too soon to build any assumptions about this into this strategy.

5.4 OPTIONS FOR MAKING MORE WATER AVAILABLE

There are various ways in which more water can be made reliably available. However, most of them involve significant cost and/or environmental impact. It should be remembered that responsibility for identifying need and making proposals for new resource schemes to meet PWS demand lies with the water companies. The NRA is in regular dialogue with each of the companies in the Region. Options to meet the forecast marginal demands are discussed below and detailed in Tables 5.2-5.15 at the end of this Section. The Tables include an outline assessment of potential environmental impacts, and costs which are given at fourth quarter, 1993, prices.

5.4.1 Local source developments and extensions

Winter water is relatively plentiful and can be stored for summer use. The low winter abstraction charges act as an incentive to farmers to use storage reservoirs to meet irrigation demands. The minor aquifers and some of the rivers of the Region provide storage that can be utilised to sustain small local supplies. It is arbitrarily assumed that local sources can meet all the forecast deficits for agriculture.

Dŵr Cymru have identified local source developments in parts of north Dyfed, Meirionnydd and Hereford & Radnor (Options 1 - 3). These developments comprise a mixture of small groundwater and surface water schemes amounting to about 50 Ml/d. The more urgent needs are in the north Dyfed and Meirionnydd areas, where the large distances between centres with very small populations make sub-regional schemes an uneconomic option.

In addition to the above new source developments, a small increase in the use of Cowlyd Reservoir for PWS could be implemented to meet the deficit arising in the Cowlyd supply zone (Option 4).

5.4.2 Regulated rivers - use of spare unlicensed yield

Of the six regulation schemes in the Region only one, the Tywi scheme,is believed to have significant spare unlicensed yield at present. There is thought to be an unlicensed yield of 10 Ml/d which could be utilised to meet marginal demands in Dŵr Cymru's supply area.

STWP are believed to have an interest in increasing their licensed abstraction of 45 Ml/d from the Wye at Lydbrook. If this is the case, there is a potential problem with any future applications for abstractions from the Wye and its tributaries for spray irrigation. The river regulating capabilities of the Elan Valley reservoirs appear to be fully exploited under the present Operating Agreement. It is unlikely that the yield of the River Wye for regulated abstractions can be increased, unless STWP are prepared to reduce their direct supply from the Elan Valley reservoirs in dry years in order to make a little more water available for abstraction at Lydbrook.

Until recently it was thought that there was a spare unlicensed yield of about 40 Ml/d in the river Dee. However, preliminary results from an ongoing project - commissioned by the NRA - which is undertaking a periodic reassessment of the yield of the major regulated rivers indicate that there is probably no spare yield in the River Dee system as presently regulated using the available storage in Llyn Celyn, Llyn Brenig and Llyn Tegid (Refs 28,29).

However, about 100 Ml/d of NWWL's combined licence of 686 Ml/d from the river at Chester is known to be surplus to both their current requirements and the combined treatment works capacity. It may be possible to negotiate with NWWL either to relinquish part of this licence or to agree that it shall be used for an inter-basin transfer to their Oswestry treatment works so as to make part of the yield of Vyrnwy Reservoir available for regulation of the River Severn. The latter consideration, however, is outside the scope of this report.

There may be very limited scope for licensing further abstractions from the regulated Rivers Usk and Eastern Cleddau, for which Section 20 Agreements were originally proposed but not implemented.

5.4.3 Regulated rivers - increases in yield

Two modest schemes to increase the regulated yields of the rivers Dee and Tywi are described below. Schemes to provide large increases in the yield of some the regulated rivers, involving major raising of the dams at Llyn Brenig, Llyn Brianne and Llys-y-fran are not detailed as they are not appropriate given the scale of forecast marginal demands.

5.4.3.1 Augmentation of the River Dee

When the Brenig scheme was promoted in the early 1970s it was intended that the reservoir as originally constructed should be substantially enlarged at a later date in order to increase the regulated yield of the River Dee by some 270 Ml/d by providing multi-season pumped storage for surplus water from the upper Dee and some of its tributaries. However, as explained above, it is now thought that the long term average run-off in the Upper Dee catchment is not sufficient for there to be value in raising the dam substantially and constructing the three intended river intakes and pipelines to the reservoir.

It should be noted that the necessary three abstraction licences for the transfer of water to the reservoir were issued in 1972, but that these authorise the abstractions only when there is surplus water in the Dee and its tributaries. These three licences allowed for pumping up to 84,000 Ml/a at rates of up to 400 Ml/d, which would have required the construction of three large capacity pumping stations and delivery through three large diameter trunk mains.

It is unlikely that the construction of a scaled down version of these works to transfer much smaller daily quantities of water from the River Alwen and the River Dee into Llyn Brenig in its present "Stage 1" form would prove economic as it would to be very costly in relation to the marginal increase in the yield of the reservoir which would be achieved. In other words the three licences are of no value to the Dee regulation scheme if Stage II of Llyn Brenig is not constructed. It appears that there is not sufficient water in the Dee and its tributaries to make Stage II a viable proposition.

Dŵr Cymru have recently abandoned the use of Llyn Bran (a small impounding reservoir at the head of the Brenig catchment) for direct supply purposes. This results in an increase of about 1.2 Ml/d in the average run-off into Llyn Brenig. Dŵr Cymru propose to construct a gravity pipeline from Llyn Brenig to the new Alwen treatment works which will increase the output of these works by allowing Alwen Reservoir to be overdrawn in dry years. The Company could enhance the long term yield of Llyn Brenig by constructing a low lift pumping station to transfer surplus water in wet years from Alwen Reservoir, using their proposed pipeline in the reverse direction. It is believed that these measures would increase the regulated yield of the Dee by 15 to 20 Ml/d (Option 5).

The value of Llyn Celyn as a means of regulating the River Dee is restricted by draw down rules which are necessary to ensure that a probable maximum flood (PMF) would not cause overtopping of the crest of the dam. A modest raising of the dam crest, with no increase in top water level, would increase the regulated yield of the River Dee by some 20 to 25 Ml/d (Option 6).

In summary, there may be scope for augmenting the regulating yield of the River Dee by 35 to 45 Ml/d by implementing the modest schemes outlined above.

5.4.3.2 Augmentation of the River Tywi

The use of Llyn-y-fan Fach impounding reservoir for direct supply purposes has recently been abandoned. Its capacity is equivalent to a raising of Llyn Brianne by 0.4 m and it could therefore augment the regulated River Tywi by 5 Ml/d in dry years (Option 7).

Schemes were recently prepared to increase the top water level of Llyn Brianne by 1 and 2 metres (Option 8) with corresponding increases of 3½% and 7% in the capacity (Ref 30). The present reassessment of the regulated yield of the existing reservoir will no doubt produce figures for the marginal increases in yield which would be provided by a 1m or 2m increase in top water levels. The provision in the original design for an increase of up to 15m assumed that a tunnel would need to be constructed to the headwaters of the River Irfon, a tributary of the River Wye, which would have necessitated a partial drawdown of the reservoir that would be difficult to achieve after the yield of the reservoir as constructed has been substantially taken up.

5.4.4 Inter-basin transfers

Several inter-basin transfer schemes could be implemented to augment the yield of the regulated River Usk and to deliver water to supply zones remote from resources.

A proportion of the uncommitted yield of the regulated River Tywi, after a 2m raising of Llyn Brianne, could be utilised to augment flows in the River Usk in either one of two ways:-

(i) Water abstracted from the River Tywi near Llandovery and pumped via a new pipeline to the head of a tributary of the River Usk near to the Halfway public house when regulation is taking place (Option 9); or

(ii) Water abstracted from Llyn Brianne delivered by gravity pipeline to the same discharge point at the headwaters of the River Usk (Option 10).

Option 9 would prove more economic for the transfer of smaller quantites of water on a seasonal basis. Option 10 would be justifed for the transfer of larger quantites of water on a regular basis. Before detailed hydrological and engineering assessments are undertaken it would be necessary to make an appraisal of the scheme's implications for fisheries arising from the introduction of water from the Tywi into the Usk. Inter-basin transfers can give rise to significant environmental implications as a consequence of introducing water from one catchment into a major watercourse in another catchment. If this scheme were to be adopted a detailed environmental appraisal would be required before it could proceed.

In order to meet marginal demands in Dŵr Cymru's South West Division an inter-basin transfer could be implemented from the Tywi to Pembrokeshire, via a new trunk main from the existing pumping station at Nantgaredig (Option 11). This would utilise some of the unlicensed yield of the River Tywi to meet demands the eastern part of the Pembrokeshire supply zone, as an alternative to increasing the regulated yield of the Eastern Cleddau by increasing the top water level of Llys-y-fran Reservoir by 1.7 metres. Dŵr Cymru is believed to be seeking an increase in its abstraction licence at Nantgaredig. In 1992 the Company deferred the need for such a main by raising the top water level by 1.7m for a very modest expenditure.

If and when the forecast demand of this supply zone approaches the yield of the various sources supplying it, including the extra 7 Ml/d now available from the Eastern Cleddau, the transfer of water from the River Tywi will again become a serious option. In order to justify the cost of constructing a trunk main some 25km in length, the size of the transfer would have to be of the order of 20 Ml/d. By reallocation of demands between the existing treatment works at Capel Dewi (near Carmarthen) and Felindre (north of Swansea) Dŵr Cymru may be able to deliver treated water through the proposed transfer main. The scheme would, like the Nantgaredig-Felindre, Usk-Llandegfedd and Wye-Court Farm schemes, abstract water from one catchment and deliver it via trunk mains and treatment works to distribution systems in other catchments.

The yield of the River Dee could be increased by a transfer scheme to divert water from the upper end of the Conwy catchment into Llyn Celyn. However, this scheme would provide only a small increase in the yield (Option 12).

5.4.5 Conjunctive use schemes

The three water companies have already developed conjunctive use schemes to a very considerable extent. Also, NWWL's single abstraction licence for their three abstraction points on the Dee upstream of the tidal limit at Chester weir enables them to use these three sources conjunctively. Dŵr Cymru's southern conjunctive use area accounted for 46% of the company's total potable water demand in 1992-93. At present 4% of the demand in this supply area is supplied by a transfer main from the adjacent Felindre conjunctive use zone which itself accounted for a further 20% of the total demand.

Works are currently in progress to enable some of the forecast increase in demand in the Southern CUA to be met by increasing this transfer so as to take up some of the presently unused treatment capacity at Felindre. In a sense the two areas therefore use the same group of sources conjunctively. If the Tywi-Usk transfer scheme proved to be a viable option, this would ensure that the regulated output of Llyn Brianne, possibly enhanced by raising the dam 2m, became available to meet future demand increases across south Wales from Pembrokeshire to Gwent, conjunctively with the other existing sources in this large area.

5.4.6 Recommissioning of Schwyll source

The Schywll source is located near Bridgend in South Wales. It draws water from major fissure systems in the Carboniferous Limestone. Water enters the fissure systems from surface water flows via 'sink holes' in river beds. Dŵr Cymru plan to "moth-ball" the Schwyll source in 1994/95 because of the high cost of improving the treatment plant to meet European Union standards compared to the cost of using presently surplus water from Felindre in the South West Division. This source has been excluded from the reliable yield for the South East Division. By 2016 when the resources of the South East CUA may be fully utilised it may economic to recommission Schwyll pumping station and treatment works to provide an additional resource for this CUA (Option 13).

Table 5.3 *Option 1 - Local supplies in Hereford and Radnor area*

Physical description and feasibility	Small groundwater and surface water schemes.
Potential beneficiaries	Local PWS in Dŵr Cymru S.E. supply area.
Yield	5 to 20 Ml/d
Construction costs (Q4 1993)	£0.1-0.5M per Ml/d
Operating costs (Q4 1993)	£10-20K per Ml/d
Environmental impact	*Hydrology* No significant adverse impacts envisaged. Risk of derogation to downstream abstractors. *Hydrogeology* Risk of impact on private boreholes and wetlands. *Water quality* Surface waters good quality. Risk of contamination to shallow aquifers. Appropriate licence conditions required. *Flood defence* None foreseen. *Fisheries* Impacts to be assessed at scheme promotion *Recreation/Navigation* None foreseen
Social impact	Minimal.
Planning implications	Sites will be chosen which have least potential adverse planning implications.
Other benefits & constraints	These small schemes will only be promoted by Dŵr Cymru in situations where a forecast local yield deficiency cannot be more economically met by importing surplus water from an adjacent supply zone.
Demand management	An appropriate level of demand management would be required prior to scheme development.

Table 5.4 *Option 2 - Local supplies in North Dyfed area*

Physical description and feasibility	Small groundwater and surface water schemes in an area where such schemes are feasible.
Potential beneficiaries	Local PWS
Yield	5 to 10 Ml/d
Construction costs (Q4 1993)	£0.1-0.5M per Ml/d
Operating costs (Q4 1993)	£10-20K per Ml/d
Environmental impact	*Hydrology* No significant adverse impacts envisaged. Risk of derogation to downstream abstractors. *Hydrogeology* Risk of impact on private boreholes. *Water quality* Rivers of good quality except Afon Rheidol. Risk of contamination to shallow aquifers. Appropriate licence conditions required. *Flood defence* None foreseen. *Fisheries* Impacts to be assessed at scheme promotion. *Recreation/Navigation* None foreseen.
Social impact	Minimal.
Planning implications	Sites will be chosen which have least potential adverse planning implications.
Other benefits & constraints	These small schemes will only be promoted by Dŵr Cymru in situations where either a forecast local yield deficiency cannot more economically be met by importing surplus water from an adjacent supply zone, or where no such surplus exists.
Demand management	An appropriate level of demand management would be required prior to scheme development.

Table 5.5 *Option 3 - Local supplies in Meirionnydd*

Physical description and feasibility	Small groundwater schemes in an area where such schemes are feasible.
Potential beneficiaries	Local PWS
Yield	5 to 20 Ml/d
Construction cost (Q4 1993)	£0.1-0.5M per Ml/d
Operating costs (Q4 1993)	£10-20K per Ml/d
Environmental impact	*Hydrology* No significant adverse impacts envisaged. *Hydrogeology* Impact on private boreholes to be assessed. *Water quality* Appropriate licence conditions required. *Flood defence* None foreseen. *Fisheries* None foreseen. *Recreation/Navigation* None foreseen.
Social impact	Minimal.
Planning implications	Sites will be chosen which have least potential adverse planning implications.
Other benefits & constraints	These small schemes will be promoted by Dŵr Cymru in situations where either a forecast local yield deficiency cannot be more economically met by importing surplus water from an adjacent supply zone, or where no such surplus exists.
Demand management	An appropriate level of demand management would be required prior to scheme development.

Table 5.6 *Option 4 - Extension of Cowlyd Reservoir*

Physical description and feasibility	Extension to treatment works and distribution system for increase in direct supply yield of reservoir.
Potential beneficiaries	PWS
Yield	3 Ml/d
Construction costs (Q4 1993)	< £2M
Operating costs (Q4 1993)	£50K/a
Environmental impact	*Hydrology* None foreseen. *Hydrogeology* None foreseen. *Water quality* None foreseen. *Flood defence* None foreseen. *Fisheries* None foreseen. *Recreation/Navigation* None foreseen.
Social impact	None foreseen.
Planning implications	To be assessed at scheme promotion stage.
Other benefits & constraints	Cowlyd is the deepest lake in Wales, operated by Powergen for HEP. Dŵr Cymru purchases water for PWS. No need to raise dam crest. Previous studies have identified available additional water for PWS.
Demand management	An appropriate level of demand management would be required prior to scheme development.

Table 5.7 *Option 5 - Pump surplus water from Llyn Alwen to Llyn Brenig*

Physical description and feasibility	Construct pumping station to deliver surplus water from Llyn Alwen to Llyn Brenig.
Potential beneficiaries	PWS and other Dee users
Yield	15 to 20 Ml/d
Construction costs (Q4 1993)	£0.9M
Operating costs (Q4 1993)	£137K/a
Environmental impact	*Hydrology* Significant impact on flow regime, especially summer flows in Alwen and Dee. *Hydrogeology* None foreseen. *Water quality* Investigation needed into impact of transfer of poor quality water from Alwen to Brenig and Dee. *Flood defence* Impact/Potential of flood flow regulation to be checked. *Fisheries* Significant impacts of Dee regulation already recorded. Impacts of increased flows to be investigated. *Recreation/Navigation* None foreseen.
Social impact	None foreseen.
Planning implications	None foreseen.
Other benefits & constraints	Llyn Brenig was designed for raising by 21m but this is considered not to be a viable proposition.
Demand management	An appropriate level of demand management would be required prior to scheme development.

Table 5.8 *Option 6 - Raise dam crest at Llyn Celyn by 1.5m*

Physical description and feasibility	Raising the dam crest by 1.5m will enable the reservoir to pass a probable maximum flood with the present draw-down rules which restrict the yield.
Potential beneficiaries	PWS and other Dee users
Yield	20 to 25 Ml/d
Construction costs (Q4 1993)	£0.70M
Operating costs (Q4 1993)	Nil
Environmental impact	*Hydrology* Change in flows within the range of flows in the Afon Tryweryn, although increase in low flows. *Hydrogeology* None foreseen. *Water quality* Celyn and Afon Tryweryn good quality water so no adverse impact envisaged. *Flood defence* Flood flow regulation to be assessed. *Fisheries* Significant impact on scouring in Tryweryn and further reduction in spawning grounds. *Recreation/Navigation* None foreseen.
Social impact	Nil.
Planning implications	Crest raising can be justified on reservoir safety grounds and TWL will be unchanged, therefore no planning problems foreseen.
Other benefits & constraints	Raising of the dam crest will not scar the downstream slope as the crest is wide enough to permit raising without downstream filling. No raising of the bellmouth overflow will be required. There will be a marginal increase in the HEP revenue as a consequence of the higher reservoir operating level.
Demand management	An appropriate level of demand management would be required prior to scheme development.

Table 5.9 *Option 7 - Llyn-y-fan Fach regulating reservoir*

Physical description and feasibility	Existing impounding reservoir used for direct supply may be used for augmenting the regulated flow of the River Tywi.
Potential beneficiaries	PWS and other users in S.W/S.E Wales.
Yield	5 Ml/d
Construction costs (Q4 1993)	Nil
Operating costs (Q4 1993)	£50K/a
Environmental impact	*Hydrology* Minor change in flows within the range of flows in the Sawdde and Tywi, although slightly increased low flows. *Hydrogeology* None foreseen. *Water quality* Sawdde has good quality water therefore Tywi water may be improved. *Flood defence* Regulation of flood flows on Sawdde to be assessed. *Fisheries* Possible adverse impacts should be investigated. *Recreation/Navigation* No adverse impact envisaged.
Social impact	None foreseen.
Planning implications	None foreseen.
Other benefits & constraints	The use of this reservoir for regulating the River Tywi could be incorporated in the existing Section 20 Operating Agreement between the NRA and Dŵr Cymru.
Demand management	An appropriate level of demand management would be required prior to scheme development.

Table 5.10 *Option 8 - Raise top water level of Llyn Brianne by 2m*

Physical description and feasibility	Raise dam crest and top water level by 2m to increase the capacity and yield.
Potential beneficiaries	PWS in SW and SE Wales.
Yield	About 20 Ml/d
Construction costs (Q4 1993)	£0.65M
Operating costs (Q4 1993)	Nil
Environmental impact	*Hydrology* Change in flows within the range of flows in the Upper Tywi. Increase in low flows. *Hydrogeology* None foreseen. *Water quality* Need to increase liming to balance acidity problem. Possible increase in adverse impact on water in Upper Tywi should be investigated. *Flood defence* Scope for flood alleviation in Tywi using additional capacity to be assessed. *Fisheries* Increased dry weather flows may have benefits for return of fish to upper reaches. Decrease in number of spills could reduce stimulus for fish movement. Impact of water temperature change on mixing to be assessed. *Recreation/Navigation* None foreseen.
Social impact	None foreseen.
Planning implications	Llyn Brianne was designed for raising by 12m which was acceptable in 1968. Therefore no planning problems are foreseen with the 2m raising.
Other benefits & constraints	Raising of the dam crest will not scar the downstream slope as the crest is wide enough to permit raising without downstream filling. Tree clearance was carried out to 3m above the original top water level. The Forestry Enterprise will lose access across the dam crest during raising.
Demand management	An appropriate level of demand management would be required prior to scheme development.

Table 5.11 *Option 9 - Tywi to Usk transfer 1*

Physical description and feasibility	Construct pumping station near to Llandovery to deliver water through a new trunk main to the head of an Usk tributary when regulation is taking place.
Potential beneficiaries	PWS and other Usk users.
Yield	60 Ml/d
Construction costs (Q4 1993)	£9.6M
Operating costs (Q4 1993)	£240K/a
Environmental impact	*Hydrology* Significant change to Usk flow regime, with increase in low flows. *Hydrogeology* None foreseen. *Water quality* Tywi and Usk good quality water, but transfer of water between catchments should be investigated. *Flood defence* Implications of intake and works in floodplain to be assessed. *Fisheries* Possible benefits to be gained from increased regulation if rate of release stable: Sea trout fishing important in Upper Tywi, but dependent on consistent flows with little variation in flow and level. *Recreation/Navigation* None foreseen.
Social impact	Disruption during construction.
Planning implications	To be assessed at scheme promotion stage.
Other benefits & constraints	The scheme would only operate intermittently as and when required to optimise conjunctive use of the Felindre and Southern conjunctive use areas. A detailed assessment of the various impacts would have to be investigated at scheme promotion stage.
Demand management	An appropriate level of demand management would be required prior to scheme development.

Table 5.12 *Option 10 - Tywi to Usk transfer II*

Physical description and feasibility	Construct gravity pipeline of 60Ml/d capacity to deliver water from Llyn Brianne, via Llandovery, to the head of an Usk tributary.
Potential beneficiaries	PWS and other Usk users
Yield	37 Ml/d
Construction costs (Q4 1993)	£19.8M
Operating costs (Q4 1993)	Nil
Environmental impact	*Hydrology* Significant change to Usk flow regime, with increase in low flows. *Hydrogeology* None foreseen. *Water quality* Tywi and Usk good quality water, but transfer of water between catchments should be investigated. *Flood defence* None foreseen. *Fisheries* Possible impact of reduced flows on the Upper Tywi. *Recreation/Navigation* None foreseen.
Social impact	Disruption during construction.
Planning implications	To be assessed at scheme promotion stage.
Other benefits & constraints	Possible adverse effect on potential HEP income from Llyn Brianne. A detailed assessment of the various impacts would have to be investigated at scheme promotion stage.
Demand management	An appropriate level of demand management would be required prior to scheme development.

Table 5.13 *Option 11 - Tywi to Pembrokeshire transfer*

Physical description and feasibility	Construct pumping station at existing Capel Dewi treatment works to deliver water through a new trunk main to E.Pembrokeshire.
Potential beneficiaries	PWS between Carmarthen and Haverfordwest.
Yield	20 Ml/d
Construction costs (Q4 1993)	£8.0M
Operating costs (Q4 1993)	£140K/a
Environmental impact	*Hydrology* None foreseen. *Hydrogeology* None foreseen. *Water quality* Increased abstraction at Capel Dewi would require support of residual flow by increased regulation to prevent adverse impact on water quality in estuary. *Flood defence* None foreseen. *Fisheries* None foreseen. Tywi water would enter supply system directly. *Recreation/Navigation* None foreseen.
Social impact	Disruption during construction.
Planning implications	None foreseen.
Other benefits & constraints	This is likely to be more economic than a major raising of Llys-y-fran dam.
Demand management	An appropriate level of demand management would be required prior to scheme development.

Table 5.14 *Option 12 - Transfer Upper Conwy to Llyn Celyn*

Physical description and feasibility	A low weir on the Afon Serw, a tributary of the Conwy, to divert the baseflow, via a 2km long catchwater of pipeline aqueduct, into the Afon Celyn.
Potential beneficiaries	PWS and other River Dee users
Yield	Small
Construction costs (Q4 1993)	<£0.5M
Operating costs (Q4 1993)	Nil
Environmental impact	*Hydrology* Minimal changes in flows in the Afon Conwy and Afon Tryweryn. *Hydrogeology* None foreseen. *Water quality* Celyn and Conwy good quality water so no adverse impact envisaged. *Flood defence* None foreseen. *Fisheries* Small impact on scouring in Tryweryn and further reduction in spawning grounds. *Recreation/Navigation* None foreseen.
Social impact	Nil.
Planning implications	None foreseen.
Other benefits & constraints	Dŵr Cymru do not consider the scheme worth investigation at this stage. Impacts on the Dee system would have to be investigated in detail at scheme promotion stage.
Demand management	An appropriate level of demand management would be required prior to scheme development.

Table 5.15 *Option 13 - Recommission Schwyll source*

Physical description and feasibility	The original pumping station and treatment plant are being decommissioned in 1994/95. New plant could be installed to improve water treatment at a relatively high cost.
Potential beneficiaries	PWS in South Wales area
Yield	22 Ml/d
Construction costs (Q4 1993)	Unknown - likely to be relatively high (dependent upon required treatment standards at the time)
Operating costs (Q4 1993)	Unknown - likely to be relatively high
Environmental impact	*Hydrology* No impacts envisaged *Hydrogeology* No adverse impacts foreseen *Water quality* Water treatment required to bring water up to quality standards for potable supply. *Flood defence* None foreseen. *Fisheries* None foreseen. *Recreation/Navigation* None foreseen.
Social impact	None foreseen.
Planning implications	None foreseen.
Other benefits & constraints	Satisfactory treatment will be difficult to achieve and expensive.
Demand management	An appropriate level of demand management would be required prior to scheme development.

5.5 DEVELOPMENT OF GROUNDWATER RESOURCES

Historically, the Welsh Region has always been perceived to have relatively abundant water resources, of which groundwater was considered to be an insignificant element. This led to a large part of the Region's groundwater resources becoming licence-exempt (see Section 2.4.1). Today, most of the Region's aquifers are acknowledged as being of only minor significance at a national level but are considered to be important in a regional context (Ref 4). The size of the resource is currently unknown, primarily as a result of historic preconceptions.

The Welsh Water Authority (Ref 31) carried out a survey of the groundwater in its area as part of a Europe-wide project undertaken as part of the European Community's Environmental Action Programme. This survey made an assessment of the gross groundwater resource based on aquifer outcrop areas and infiltration rates. The total gross resource was estimated as approximately 4000 Ml/d (averaged over 365 days).

In the 15 years since this survey was carried out understanding of recharge mechanisms has improved and recent groundwater studies (Refs 32,33) have employed lower estimates of infiltration rates. Additionally, the inadequacy of aquifer storage to even out the year to year variations in recharge, means the effective resource can be substantially lower than the gross resource. In areas where the groundwater resources are better understood the reduction can be as great as 40% in the case of limestone aquifers (Ref 15). The effective groundwater resource for the Region is therefore likely to be of the order of 2500 Ml/d.

This effective resource must support both human needs (abstractions) and environment needs (minimum river flows). Abstractions should not exceed the sustainable yield, that rate which can be sustained indefinitely without unacceptable reductions in groundwater level, discharge, or quality. It was explained in Section 3.7 that for the purposes of this strategy, in the absence of either defined minimum flow requirements or natural 95% flows, the reliable river allocation is conservatively estimated as 50% of the gross resource. This gives an estimated total resource available for abstraction of the order of 1250 Ml/d.

Currently licensed abstraction from groundwater is about 300 Ml/d. It should be borne in mind that the exact size of abstractions from groundwater in the licence-exempt area is unknown and there are many small groundwater abstractions for domestic supplies. However, there is likely to be scope for some further development of groundwater.

Some hydrogeological studies have been carried out to investigate the groundwater resources of some of the major groundwater units in the Region:

* A study of the South Pembrokeshire Carboniferous Limestone aquifer (Ref 34) concluded that there were significant resources in both the shallow and deeper aquifer. Three potential development sites were identified with a combined resource estimated at 17 Ml/d. Dŵr Cymru presently have abstractions at two of the three identified sites (Milton Springs and Pendine).

* The South East Wales Groundwater Study (Ref 35) investigated the Carboniferous limestone aquifer outcropping around the edges of the South Wales coalfield. Insufficient data prevented an assessment of the reliable yield but resources were considered to be significant.

* The Water Resources Board report on the Clwyd (Ref 36) concluded that the groundwater resource was about 21 Ml/d. Today, licensed abstraction amounts to about 20 Ml/d and the resource is considered to be exploited to its full potential.

Groundwater in the Welsh Region is of good quality, with very few problems of elevated nitrate concentrations. Concentrations have been found to be rising in Gwent, Hereford and the Upper Wye, usually located on intensively farmed agricultural land. However, the demise of heavy industry in the Region and the presence of landfills on some of the major aquifers means water quality needs to be carefully monitored. The NRA is currently producing maps of groundwater vulnerability and source protection zones, which should be available in 1996.

Dŵr Cymru have a number of groundwater sources in the licence-exempt area of west Wales. The Company's local source developments outlined above include groundwater schemes in Dyfed, Hereford & Radnor, and Meirionnydd, and there is not sufficient information available at this time to identify further specific options. The complexity of the Region's hydrogeology and the lack of data hinder a regional appraisal, and, given the scale of the marginal demands arising over the planning horizon, only the limited local development of groundwater resources identified in Section 5.4.1. is required.

5.5.1 Use of minewaters as a resource

Mining activities disturb the patterns of groundwater flow; groundwater discharges can be redirected by pumping or drainage adits, or simply by the interconnection between aquifers provided by the workings. Following the cessation of mining, groundwater levels recover. 'Minewater' breakouts occur as the water table reaches the surface. These minewaters represent a potential water resource in the Region, especially with the recent closure of three of the four remaining British Coal mines in Wales.

Minewater discharges are generally characterised by a change in chemical quality (typically high iron concentration). In some cases these minewaters have a significant adverse effect upon the quality of river water and consequential detrimental effects on aquatic life. Discharges from both active and abandoned coal mines have caused pollution problems in the UK for many years. The NRA has recently undertaken studies to investigate the quality implications resulting from the recovery of groundwater levels to 'natural' equilibrium levels (Ref 37).

The discharge of minewaters from working mines is controlled under current legislation through the consents issued by the NRA. Such consents will generally include conditions relating to the quality and quantity of the discharge. However, once mining ceases there is very limited control over any discharge because the overflow from mines which have been abandoned is exempt from control under current legislation.

In a recent assessment of the use of minewaters as a resource (Ref 38) the NRA concluded that most potential sites were ruled out by constraints of quality and quantity, and the few remaining would only be suitable for non-potable supply on economic grounds. Such demands have not been identified. Treatment of minewater prior to discharge is feasible, but further work is required to assess the costs and benefits at individual sites.

5.6 USE OF EFFLUENT RETURNS

The re-use of water can play an important role in optimising the use of limited resources. Whenever possible 'used' water should be returned to the river as close as possible to the source of abstraction. If quality can be maintained then this previously used water can be abstracted further downstream.

About 30% of returning effluents (excluding discharges from coastal power stations) are discharged to inland waters and so are re-used, whether by abstractors downstream or as contributions to river baseflows. The remaining 70% or so are discharged to tidal estuaries or to the sea and are wholly lost to water resources. Clearly these effluents could be diverted and re-used. However, the direct re-use of effluent in the locality of its origin, though perhaps technically feasible with sophisticated treatment, may be undesirable on grounds of public perception. Furthermore, case studies have shown that the costs of piping effluent a long way up river, plus the additional treatment costs to the higher standard necessary, generally far outweigh the costs of other means of providing water resources.

Given the scale of the forecast marginal demands for the Region, and the ease of meeting these from increased use of existing resources, the re-use of effluents is seen as inappropriate at this time. Should the Region's resources become significantly more stressed in the future it may become necessary to investigate effluent re-use for resource augmentation.

5.7 ALTERNATIVE WATER SOURCES

In addition to the options detailed above there are various alternative sources of water. An exhaustive list of such options has been examined on behalf of the NRA including desalination, transfers from Europe, a national water grid, transfer by ship and icebergs. These all proved to be either impractical, far more expensive than conventional schemes, or both. The only possible exception is desalination, if technological progress were to allow a substantial reduction in the cost and energy consumption. As the limited marginal demands identified in this study can all be satisfied by conventional schemes these 'esoteric' options are not considered further.

5.8 IMPACT OF BARRAGE DEVELOPMENTS

Barrages are typically promoted for amenity or power generation purposes but may be specifically developed for the benefit of water resources. Barrage developments may require an impounding licence by virtue of the Water Resources Act 1991. Where there is an associated HEP scheme then an abstraction licence may also be needed. The impact and side effects of estuarine barrage construction can be both positive and negative in water resource terms. Barrages associated with HEP schemes can have major implications for development of upstream resources. If the configuration of the barrage means water is abstracted to pass through the turbines then upstream resources could be sterilised.

The impounding effect of a barrage, with a water level retained higher than would always occur naturally, can be a net benefit to abstractors within an otherwise tidal reach. The fixed level, or higher mean level within the range, means that it is easier to create intakes, and water quality would be less variable. Exclusion of brackish or saline water by the barrage effectively moves the limit for abstraction to the barrage itself. The retention of a greater flow and level of fresh water within the river upstream may also be beneficial to the river. Depending upon residual flow requirements it may be possible to permit higher volumes of abstraction from within the ponded reach than if it were a free-flowing watercourse.

By virtue of their location, barrages are likely to affect groundwater levels. The situation may be further affected by barrages within urban areas which create a rise in groundwater levels within made ground. Additionally, increased water levels may reduce the thickness of the unsaturated zone and its effective attenuating ability on leachate egress from older landfills which are operated on the principle of non-containment. If the unsaturated zone below contaminated ground becomes saturated this may cause mobilisation of contaminants which are currently in equilibrium with groundwater.

Over the last forty years or so barrages have been proposed for abstraction on the estuaries of the Usk, Conwy, Dyfi, Mawddach, Taf and Tywi, and the Cleddau at Milford Haven. None of these proposals have gone ahead.

Three barrage developments have been proposed in recent years for amenity - Swansea barrage on the Tawe estuary, Cardiff Bay barrage on the Taff and Ely estuaries, and Usk barrage on the Usk estuary. The Swansea Bay barrage was completed in 1992. The Cardiff Bay barrage received parliamentary approval in 1993. The Usk scheme is being actively promoted, although the NRA is concerned about its potential impact on the environment.

The Swansea Bay barrage is subject to water quality and fisheries monitoring by NRA in order to assess the impact of the barrage. Initial results indicate pronounced saline stratification normally exists within the impoundment except under extreme high river flows. The NRA, in light of experience with the Swansea scheme, has agreed environmental safeguards with the developers of the Cardiff Bay barrage. These include a programme of water quality monitoring and maintenance of a specified minimum dissolved oxygen level, uprating of treatment of an industrial discharge, provision of a well-designed fish pass, and minimisation of saline intrusion. The NRA has also agreed a water budget with the developers to allow for competing demands that will safeguard the requirements of migrating salmonids. Additionally, extensive investigation of the impact of the barrage impoundment on groundwater levels in Cardiff has been undertaken and mitigation measures developed by the promoter to combat the rise in groundwater levels.

The Usk barrage is currently being promoted by Newport Borough Council and Gwent County Council under an order under the Transport and Works Act 1992. The scheme involves a partial exclusion barrage which will be overtopped by 71% of tides in order to maintain water quality and allow flushing of downstream sediments. The Usk is an important salmon fishery and the fish pass will require careful design. The NRA is strongly opposed to this scheme on environmental grounds.

Several sites in the Region have been put forward as potential sites for small-scale tidal power generation barrages. These are on the Dee estuary, Loughor estuary, Conwy estuary and at Milford Haven. However, recent research (Ref 39) indicates that this form of power generation is not economically viable and tidal power barrage schemes are highly unlikely to go ahead.

5.9 POSSIBLE IMPACTS OF CLIMATE CHANGE ON WATER RESOURCES

The water resources assessments detailed in this report make no allowance for the possibility of climate change. However, there is international concern that global warming will cause changes in climate which could have significant implications for water resources. The natural variability of rainfall means it will be many years before any underlying trend can be positively identified. It should be borne in mind that estimates of the impact of future climate change are at best only as reliable as the estimates of the size of the change itself.

Recent research indicates that annual runoff could decrease by 10% to 30% in the driest scenario or increase by 17% to 30% in the wettest scenario (Ref 40). Under the UK Climate Change Impacts Review Group's (CCIRG) 'best estimate' rainfall scenario for

Britain in 2025 (a 2-4°C rise in mean surface temperatures and a small increase in rainfall; 8% in winter, no change in summer) average annual runoff was predicted to increase by up to 5% (for a 7% increase in PE) or decrease by 15% (for a 15% increase in PE) in the south and east of the UK (Ref 14). However, in the north and west of the UK - which includes the Welsh Region of the NRA - the predicted changes were smaller, a 5% increase and a 3% decrease respectively. Climate change is likely to accentuate the current wetter north and west and drier south and east, with summer runoff likely to be reduced and winter runoff increased.

The majority of strategic resources in Welsh Region are located in upland catchments. The authors of Ref 14 postulate that in typical upland catchments summer runoff could decrease by 6%, with increases in the rest of the year of between 6% and 8%. Lower summer inflows would reduce available water during the critical period of reservoirs by up to several percent, with smaller reservoirs most affected. In lowland catchments the overall yield of sources would be expected to increase due to the greater winter inflows. Lowland rivers, additionally, have run of river direct abstraction schemes which are unsupported by storage. Most of these abstractions now have minimum flow conditions below which abstraction may no longer take place. The effect on water available would depend on the river flow, minimum flow conditions and the amount taken, and could vary from no effect to considerable effect. Preliminary results from research into possible impacts on water resources in Wales (Ref 41) confirm the above findings, identifying the smaller upland catchments and reservoirs in areas of lower rainfall as most vulnerable.

Climate change may also lead to a rise in sea level. This may have lead to increased saline intrusion, and potentially could affect abstraction points near to tidal limits - CWC's abstraction from the Dee at Chester (surface water), and Dŵr Cymru's abstractions at Pendine and Schwyll (groundwater).

Clearly more research is needed on the likely effects of climate change on water resources. If the changes postulated under current 'best estimates' were to occur, then most reservoir sources in the Region are unlikely to be affected very much, with single season reservoir yields likely to reduce by less than 3%. However, when planning new sources each development should be studied individually using sensitivity analyses.

6 PROPOSED REGIONAL WATER RESOURCES STRATEGY

6.1 INTRODUCTION

The NRA is responsible for the management of water resources in England and Wales. As the Guardians of the Water Environment, the NRA is committed to ensuring that proper use is secured through a long term strategy which will sustain water resources for generations to come. The most appropriate approach towards sustaining a healthy water environment, as well as a socially acceptable balance between the environment and legitimate demands for water, comprises efficient use of water resources and environmental sensitivity. Overall, the strategy is guided by a balanced adoption of three fundamental principles - economic efficiency, environmental sustainability and precaution.

In the preceding Sections the Region's water resources and the demands upon them, both human and environmental, have been described. The future additional demands have been forecast and options for meeting them have been explored. A number of associated issues have also been identified. In normal years there is no real problem, given the water networks which have been built up over the years to meet the needs of the population. However, that population, its needs for water, and its environmental expectations are all rising, and plans must be prepared to meet these demands.

This Section makes proposals for a framework for a Regional Water Resources Strategy in the form of proposed policies for water resources management and proposed extensions to the Region's PWS network.

6.2 PROPOSED POLICIES FOR WATER RESOURCES MANAGEMENT

6.2.1 Licensing of abstractions

Nearly all those who wish to abstract water from rivers and from aquifers require an abstraction licence from the NRA. This is one of the NRA's key water resources activities. In determining any licence application the NRA should:

* take account of other uses within the catchment as identified through Catchment Management Plans;

* consider the effects on other abstractors; abstractions should not be allowed that would derogate existing licence rights and other protected rights to abstract unless suitable arrangements are agreed;

* consider the overall availability of water; ensure the abstraction will not be in excess of the renewable resource;

* consider the impact on river flows, especially ensuring flows are not reduced to unacceptably low levels;

* consider the potential effect on wetlands and pools, and not allow abstractions which would be damaging or otherwise unacceptably affect them; and

* advise the applicant in general terms on the availability of water, the likely consequences and constraints which would have to be attached to the abstraction, and how reliable it might therefore be.

Knowledge of the available surface water and groundwater resources is fundamental to ensuring reasonable needs are met in a sustainable, environmentally acceptable, manner. The NRA is currently undertaking a project to develop a regional licensing policy. As part of the project a methodology will be formulated for the assessment of catchment resources. Once the regional licensing policy is developed the NRA will need to assess resource allocation in catchments and determine the need for revocation and/or reduction in licensed quantities.

A large part of the Region in Western Wales is exempt from licensing for groundwater abstraction. However, there are believed to be regionally significant groundwater resources in this area and it is recommended that, in keeping with the NRA's water resources obligations, the NRA looks into the possibility of abstractions over a threshold being subject to licensing legislation.

6.2.2 Demand management

The NRA should continue to advocate demand management by all water users to the extent that it is economically justified. Before any new sources are developed, the NRA should ensure the water companies are doing all they can to reduce leakage and to carry out effective demand management. Selective domestic metering, with an appropriate tariff, is to be encouraged in areas where resources are stressed.

6.2.3 The reallocation of water

In order to ensure resources are used wisely the NRA needs to assess whether abstractions are reasonably required. The analysis of water usage carried out for this project has highlighted the fact that actual demands of industrial users are significantly lower than licensed abstraction. It is therefore recommended that the NRA investigates reduction in authorised quantities where there is no need for the original licensed quantities and revokes licences that have not been utilised for over 7 years. Also, the NRA should investigate the scope for tradeable permits and for incentive charging, as means of releasing entitlements to abstract water for relatively low value uses.

6.3 PROPOSED EXTENSIONS TO THE PUBLIC WATER SUPPLY NETWORK

In Section 4 the marginal demands for PWS were forecast for a range of scenarios incorporating different assumptions about demand management, per capita consumption and commercial growth. Deficits range from a regional total of 17 Ml/d in 2021 for the low growth scenario to just under 100 Ml/d in 2021 for a high growth scenario. The high forecast combines relatively large increases in domestic and industrial consumption with no improvements in leakage control or increase in metering.

The medium growth forecast has only a small increase in domestic and industrial consumption, accompanied by an increase in metering and significant reductions in leakage. However, notwithstanding the benefits offered by improved leakage control some new developments are needed to meet deficits. The low growth forecast assumes a very modest increase in domestic demand, no net increase in industrial consumption, but very tight control of leakage (principally by Dŵr Cymru). Whilst it is recommended that the NRA continues to press all the water companies for effective demand management, it is likely that actual change in demand will lie somewhere between the low and medium growth forecasts.

6.3.1 Medium growth scenario

The following sequence of development is proposed to meet the marginal demands arising under the medium growth forecast, based on the review of options for making more water available.

i) From 1996 Dŵr Cymru to phase in local source developments in Hereford and Radnor (Option 1), North Dyfed (Option 2) and Meirionnydd (Option 3) to meet the small deficits in the Company's South East Division, South West Division and North East Division. The 10.6 Ml/d deficit in the South West Division (Ystradfellte supply zone) commencing in 1996 to be met from the 63 Ml/d surplus in the adjacent Felindre/Schywll supply zone using existing trunk mains.

ii) From 2006 CWC's deficit to be met from increased abstraction at Barrelwell Hill from the River Dee with stepped increases in their licence.

iii) From 2011 WEDWC's deficit to be met by increased abstraction at Bangor on Dee from the River Dee with stepped increase in their licences.

The total marginal demand on the River Dee system in 2021 will be 13.2 Ml/d (commencing in 2006). This deficit to be met by raising the crest of Llyn Celyn Yield 20 - 25 Ml/d (Option 6).

6.3.2 High growth scenario

Should PWS demand grow in line with the high growth forecast then the following sequence of development is recommended:-

i) From 1996 Dŵr Cymru to phase in local source developments in Hereford & Radnor (Option 1), north Dyfed (Option 2) and Meirionnydd (Option 3) to meet the small deficits in the Company's South East Division, South West Division and North East Division.

ii) From 2001 CWC's deficit to be met from increased abstraction at Barrelwell Hill from the River Dee with stepped increases in their licence.

iii) From 2006 WEDWC's deficit to be met by increased abstraction Bangor on Dee from the River Dee with stepped increase in their licences.

Dŵr Cymru also to increase abstraction from the Dee at Poulton with stepped increase in their licence.

iv) From 2011 Dŵr Cymru to meet the deficit of 3.5 Ml/d in the Cowlyd supply zone in the North East Division by increasing the direct supply yield of Cowlyd reservoir (Option 4). This is the only new resource development required in North Wales to meet regional demands.

v) From 2016 Dŵr Cymru to meet the 25 Ml/d deficit in the South West Division using the uncommitted licensed yield of 25 Ml/d in the regulated River Tywi (the surplus in the Felindre/Schywll supply zone) as follows:-

1. Implement the River Tywi to Pembrokeshire transfer scheme (Option 11), supplementing local source development, to meet the deficit of 10.7 Ml/d in the Pembrokeshire supply zone;

2. The notional deficit of 14.5 Ml/d in the Ystradfellte supply zone to be met from the adjacent Felindre/Schywll supply zone using existing trunk mains.

Also from 2016, Dŵr Cymru to meet the 37 Ml/d deficit in the South East Division from existing sources in the South West Division by one of following means:-

1. Recommission the Schwyll source (to be mothballed in 1995 and excluded from available yield in Division). Option 13 - Yield 22 Ml/d;

   Raise the top water level of Llyn Brianne by 2m (Option 8); and

   Construct the pumped River Tywi to River Usk transfer and operate at 15 Ml/d (Option 9).

2. Construct the gravity River Tywi to River Usk transfer scheme (Option 10).

The total marginal demand on the Dee in 2021 will be 28.4 Ml/d commencing in 2001. This deficit can be met by construction of some or all of the works detailed in Section 5.4.3.1 ie. Option 5 - Pumping station to transfer surplus water from Llyn Alwen to Llyn Brenig (Yield 15 - 20 Ml/d); Option 6 - Raise the crest of Llyn Celyn (Yield 20 - 25 Ml/d).

6.4 PRIVATE ABSTRACTIONS

The only private demands forecast to increase above current licensed quantity are for spray irrigation and HEP. HEP and fish farming are large legitimate uses of water which do not consume resources. Both of these uses can need reservation of large quantities of water and so can impose a constraint upon water available to others upstream. The main issues involved largely relate to the 'no-derogation' principle. This is because licensing legislation does not allow new abstractions to use water that has been reserved in a licence downstream. Non-consumptive type uses are often located in the lower reaches of catchments and where there is limited scope for the re-use of water when returned.

To avoid sterilising the future use of upstream resources when considering new licences of this type it is recommended that the NRA seeks to negotiate a quantity for other future potential uses as it is unlikely that such a reservation would have a significant impact on the viability of schemes, especially HEP, which will mainly depend on the availability of the higher winter flows. In many cases licences should be time limited to allow periodic review of licence conditions.

In some cases licences that are already held may not be appropriate for current use, as circumstances have changed, for example in industry. But, their existence prevents the issue of licences to others. Licences should be reviewed if resources are to be fairly allocated. This information would be required in support of the abstraction licence application.

The nature of HEP installations often means there are other issues specific to this category of use. They can cause extreme and often unacceptable fluctuations in flows downstream with impacts on water quality and fisheries. This is particularly so where minimum flows downstream are important for dilution of effluents and protection of fisheries.

In some cases it may be necessary for an environmental appraisal to be carried out by the promoter of the scheme including proper consultation with relevant outside bodies and organisations. It may be that the impact of schemes for HEP, fisheries, etc can be overcome by the way in which they are operated. How schemes are operated can be incorporated into agreements associated with licences.

6.4.1 Spray irrigation

The availability of water for spray irrigation is inevitably limited at critical times as peak demands will coincide with the lowest river flows. Any investment in both local and strategic resources for agricultural uses could be funded from within the industry, just as the water companies secure their resources by capital investment. A contribution to the cost of developments may be appropriate where schemes incorporate significant environmental gains alongside resource enhancement. The NRA could act as a facilitator, exploring any new initiatives proposed within the constraints of current legislation governing licensing.

Hopefully research will continue into more efficient irrigation practices and new farming methods which help conserve available soil moisture and the development of drought resistant strains of crops will help better use of available water resources.

6.4.1.1 Management initiatives

Scheduling systems designed to optimise the application and phasing of irrigation to match the specific needs of the crop are widely used. This could be assisted by the use of data-loggers. These provide detailed information on water use, and can assist farmers in future management decisions and improve the efficiency of water usage on the farm. The NRA could advise on installation and processing data.

Actual water use averages only 40% - 60% of licensed quantity (see Appendix D) in many years. This reflects a contingency element, but also the variance in the needs of many individual farmers due to crop rotation practice. Arrangements for pooling and sharing water already licensed may enable a better and fairer allocation. Where individual farmers have licences for both surface water and groundwater sources there is often scope to operate them conjunctively. This can increase the yield of water available to the farmers, especially where low river flows are a constraint, and can also frequently offer opportunities that are environmentally beneficial.

This conjunctive use principle applies also to multiple farm situations. Where low flow restrictions on licences can present difficult operational limitations on some farmers others may be in a position to overcome these restrictions by making compensatory discharges from groundwater resources elsewhere in the local system. This would for the most part be the subject of commercial arrangement between the parties, but the NRA would have to be satisfied that the wider needs of the environment are fully met and the schemes can operate within the licensing framework.

6.4.1.2 Development initiatives

Conjunctive use schemes can optimise resources, but the storage of winter water is the only true means of enhancing and securing resources at critical times. These local developments are assumed to be sufficient to meet increases in demand for irrigation water.

Where individual farmers view reservoir construction as uneconomic, it is possible to reduce unit costs by co-operative ventures by economy of scale. Distribution difficulties can be a problem for strategically placed local reservoirs. However, the NRA should consider schemes which allow the continuation of an otherwise low flow restricted abstraction at one location if offset by compensatory discharges elsewhere. For example, from reservoir storage.

6.5 RECOMMENDED AREAS OF FURTHER WORK

The following recommendations are made with regard to areas where work is required to gain additional information of assistance in water resources planning for the Region:-

i) Licence and consents databases - This project has highlighted a lack of consistency in both databases. It is recommended that the NRA undertakes an audit of the two systems.

ii) Abstraction returns - Analysis of the returns data on the licence database has shown it to be incomplete, with only about 50% of the licensed quantity accounted for. In order to improve the reliability of estimates of actual water usage it is recommended that the NRA collects together available returns data and updates the database.

iii) Groundwater resources - The exact size of the Region's groundwater resources is not currently known. However, significant demands are made of these resources. It is recommended that the NRA undertakes a detailed assessment of the long term rate of recharge to the Region's groundwater management units and evaluates the acceptable degree of development. The regional licensing policy should be extended to include provisions for licensing of groundwater abstractions.

iv) Licence-exempt areas - The management of water resources can only be hampered by the existence of large licence-exempt areas in the Region. Whilst resources and demands are probably relatively small in size it is recommended that the NRA investigates the practicalities of removal of licence exemption for larger abstractions.

v) Naturalised flows - The relative abundance of water in the Region has resulted in there being very few naturalised flow records in the Region. As naturalised flows can provide valuable information of assistance in evaluating environmentally acceptable flows in rivers it is recommended that the NRA investigates the possibility of a programme of naturalisation.

REFERENCES

1 *Water Resources Act 1991*. London: HMSO, 1991.

2 INSTITUTE OF HYDROLOGY and BRITISH GEOLOGICAL SURVEY. *Hydrological Data UK - Hydrometric Register and Statistics 1986-1990.* Natural Environment Research Council, 1993.

3 NATIONAL RIVERS AUTHORITY. *Demands & Resources of Water Undertakers in England & Wales - Preliminary Report Under Section 143(2)(a) Water Act 1989.* NRA, 1991.

4 NATIONAL RIVERS AUTHORITY (Welsh Region). *Policy and practice for the protection of groundwater -Welsh Regional Appendix.* NRA, 1993.

5 ASSEMBLY OF WELSH COUNTIES. *Strategic Planning Guidance in Wales - Overview Report.* ASWC, 1993.

6 BINNIE & PARTNERS. *Technical review of Section 20 reservoir Operating Agreements.* B&P, 1993.

7 JACK, W.L. and LAMBERT, A.O.. Operational yields. In *Water Resources & Reservoir Engineering.* Proceedings of the 7th conference of the British Dam Society. London: Thomas Telford, 1992.

8 NATIONAL RIVERS AUTHORITY. *Water Resources Development Strategy - A Discussion Document.* NRA, 1992.

9 NATIONAL RIVERS AUTHORITY. *National Water Resources Strategy: Comparative Environmental Appraisal of Strategic Options.* Howard Humphreys, 1994.

10 NATIONAL RIVERS AUTHORITY. *Economics of Water Resources Management.* NRA R&D Note 128. NRA, 1993.

11 JOHNSON, I.W., ELLIOT, C.R.N. and GUSTARD, A.. *National Rivers Authority Project B2.1 Ecologically Acceptable Flows - Assessment of Instream Flow Incremental Methodology.* Interim Report. Institute of Hydrology & Institute of Freshwater Ecology, 1992.

12 WADE, R.J., HUTCHERSON, N.T.S. and GOODHEW, R.C.. *Residual Flows to Estuaries - A Review of the Current Situation and Guidance on Determination.* NRA Severn-Trent Region, 1992.

13 NATIONAL RIVERS AUTHORITY. *Water Resources Planning - Strategic Options.* R&D Note 35. Vol. 2 - Annexes. NRA, 1993.

14 NOTT, M.R. and HALL, J.K.. *Naturalising river flow records of the Essex Region - Phase II final report.* Institute of Hydrology and Binnie & Partners, 1993.

15 NATIONAL RIVERS AUTHORITY (Anglian Region). *Regional Water Resources Strategy - Consultation report.* NRA, 1993.

16 NATIONAL RIVERS AUTHORITY. *National Water Resources Development Strategy - Methodology & Assumptions for Public Water Supply demand scenarios.* Version 3.1. NRA, 1993.

17 OFFICE OF WATER SERVICES. *The Cost of Water Delivered and Sewage Collected 1992-93.* OFWAT, 1993.

18 BINNIE, C.J.A., and HERRINGTON, P.R. *Effects of Climate Change on Water Resources and Demands.* 1992.

19 NATIONAL RIVERS AUTHORITY (Anglian Region). *Demand for Irrigation Water.* R&D Project 413, draft Final Report. NRA, 1993.

20 NATIONAL RIVERS AUTHORITY. *Low flows and water resources.* NRA, 1993.

21 HOWARD HUMPHREYS & PARTNERS. *Afon Alyn Loss of Water - Final Report.* HH, 1990.

22 NATIONAL RIVERS AUTHORITY. *Water: Nature's Precious Resource. An Environmentally Sustainable Water Resources Development Strategy for England & Wales.* NRA, 1994.

23 CALDER, I.R. and NEWSON, M.D.. *Land Use and Upland Water Resources - a Strategic Look.* Wat. Res. Bull, 1979. Vol. 16, pp. 1628-1639.

24 HUDSON, J.A. and BLACKIE, J.R.. *The Impact of Forestry and Forest Practices on the Quantity and Quality of Runoff in Upland Britain.* Proceedings ofthe 4th National Hydrology Symposium. London: Institute of Hydrology, 1993.

25 ROBINSON, M.. *Impacts of Plantation Forestry on Streamflow Regimes - A Case Study.* Proceedings ofthe 4th National Hydrology Symposium. London: Institute of Hydrology, 1993.

26 DEPARTMENT OF THE ENVIRONMENT. *Using Water Wisely.* Doe & Welsh Office, 1992.

27 JOHNSON, N.. *Waste minimisation; a route to profit and cleaner production - An interim report on the Aire and Calder project.* CENTRE FOR EXPLOITATION OF SCIENCE AND TECHNOLOGY, 1994.

28 NATIONAL RIVERS AUTHORITY. *Surface Water Yield Assessment.* R&D Project 414 Interim Report (Phase I). NRA, 1991.

29 NATIONAL RIVERS AUTHORITY. *Surface Water Yield Assessment.* R&D Project 414 Interim Report (Phase II). NRA, 1993.

30 BINNIE & PARTNERS. *Report on Llyn Brianne & Llysyfran Dams - Feasibility study on dam raising.* B&P, 1993.

31 WELSH WATER AUTHORITY. *Survey of Groundwater in the Welsh Water Authority.* WWA, 1979.

32 ASPINWALL & COMPANY. *Investigation of the Yazor Gravel Aquifer, Hereford.* AC, 1993.

33 ASPINWALL & COMPANY. *Vale of Glamorgan Carboniferous Limestone Study*. AC, 1993.

34 HOWARD HUMPHREYS & PARTNERS. *South Pembrokeshire Groundwater Study - Reconnaissance Report*. Welsh Water Authority, 1978.

35 HOWARD HUMPHREYS & PARTNERS. *South East Wales Groundwater Study - Reconnaissance Report*. Welsh Water Authority, 1980.

36 DEE & CLWYD RIVER AUTHORITY & WATER RESOURCES BOARD. *Groundwater Resources of the Vale of Clwyd*. WRB, 1973.

37 NATIONAL RIVERS AUTHORITY (Welsh Region). *Assessment of the potential for generation and discharge of acidic waters from the Taff Merthyr/Trelewis colliery*. NRA, 1993.

38 NATIONAL RIVERS AUTHORITY & DŴR CYMRU. *Minewaters as a water resource*. NRA and Dŵr Cymru, 1993.

39 BINNIE & PARTNERS. *The UK Potential for Tidal Energy from Small Estuaries - A Survey of Possible Small Sites on the West Coast*. UNITED KINGDOM ATOMIC ENERGY AUTHORITY, ENERGY TECHNOLOGY SUPPORT UNIT. 1988.

40 ARNELL, N.W. *Impact of Climate Change on River Flow Regimes in the UK*. J. Inst. Wat & Envir. Mangt, 1992. Vol. 6, pp. 432-442.

41 HOLT, C.P. and JONES, J.A.A.. *Potential Impact of Global Warming on Water Resource Management in Upland Wales*. Proceedings ofthe 4th National Hydrology Symposium. London: Institute of Hydrology, 1993.

BIBLIOGRAPHY

BINNIE & PARTNERS. *Report on Vyrnwy Resource Study*. B&P, 1993.

CHESHIRE COUNTY COUNCIL. *Cheshire Replacement Structure Plan - Explanatory Memorandum, Cheshire 2001*. CCC, 1992.

CLWYD COUNTY COUNCIL. *Clwyd Structure Plan: 1st Alteration (Policy & Explanatory Memorandum)*. CCC, 1991.

COUNTY OF SOUTH GLAMORGAN. *Structure Plan Proposed Alterations - Written Statement*. CSG, 1985.

DŴR CYMRU. *Eryri/Ynys Môn water supplies - A review following deferment of the Cowlyd-Ogwen Scheme*. DC, 1986.

DYFED COUNTY COUNCIL. *Dyfed Structure Plan (including Alterations No.1)*. DCC, 1990.

GLOUCESTERSHIRE COUNTY COUNCIL. *Structure Plan (1st alteration) - Explanatory Memorandum*. GCC, 1992.

GLOUCESTERSHIRE COUNTY COUNCIL. *Structure Plan - 2nd Review 1991-2011 Project brief.* GCC, 1992.

GWYNEDD COUNTY COUNCIL. *Statistical Review*. GCC, 1993.

GWENT COUNTY COUNCIL. *Gwent Structure Plan - Approved Plan (Incorporating 1st & 2nd alterations)*. GCC, 1990.

GWENT COUNTY COUNCIL. *Gwent Structure Plan 1991 - 2006 (Proposed amendments to deposit Plan)*. GCC, 1993.

HEREFORD & WORCESTER COUNTY COUNCIL. *Structure Plan 1986 - 2001*. HCC, 1993.

HOWARD HUMPHREYS CONSULTING ENGINEERS. *NRA National Water Resources Strategy - Strategic Environmental Assessment*. Final Report (draft). HH, 1993.

JONES, F.H.. *Barrage Developments in the Welsh Region: The Role of the NRA in Protecting the Aquatic Environment*. Proceedings of IWEM Meeting - Barrages For Regeneration. 1993.

JONES, K.. *Regeneration of Swansea*. Proceedings of IWEM Meeting - Barrages For Regeneration. 1993.

LAMBERT, A. *Regulation of the River Dee*. Regulated rivers: Research and management, 1988. Vol. 2, pp. 293-308.

MID GLAMORGAN COUNTY COUNCIL. *Mid Glamorgan County Structure Plan - Approved Plan (incorporating Proposals for Alteration No.1)*. MGCC, 1989.

MID GLAMORGAN COUNTY COUNCIL. *Mid Glamorgan County Structure Plan - Draft Replacement Structure Plan*. MGCC, 1992.

NATIONAL RIVERS AUTHORITY. *A Water Resources Development Strategy for England and Wales*. 2nd Draft. NRA, 1993.

NATIONAL RIVERS AUTHORITY. *NRA Water Resources Strategy*. NRA, 1993.

NATIONAL RIVERS AUTHORITY. *The Quality of Rivers, Canals and Estuaries in England & Wales - Report of the 1990 Survey*. NRA, 1991.

NATIONAL RIVERS AUTHORITY (Welsh Region). *Upper Wye Catchment Management Plan - Consultation Report*. NRA, 1993.

NATIONAL RIVERS AUTHORITY (Welsh Region). *River Conwy Catchment Management Plan - Consultation Report*. NRA, 1993.

NATIONAL RIVERS AUTHORITY (Welsh Region). *Menai Strait Catchment Management Plan - Consultation Report*. NRA, 1993.

POWYS COUNTY COUNCIL. *Powys County Structure Plan - 1st Alteration (Written Statement and Explanatory Memorandum, Consultation Draft*. PCC, 1992.

PRICE, J. *OFWAT Research Paper No.1 - Comparing the Cost of Water Delivered*. OFWAT, 1993.

REES, J.A., WILLIAMS, S., ATKINS, J.P., HAMMOND, C.J. and TROTTER, S.D.. *Economics of Water Resources Management*. NRA R&D Project 248. NRA, 1993.

ROSCOE, R.S. and HUNTER, P.D.. *The Cardiff Bay Barrage*. Proceedings of IWEM Meeting - Barrages For Regeneration. 1993.

SHROPSHIRE COUNTY COUNCIL. *Shropshire Structure Plan 1989-2006 - Explanatory Memorandum*. SCC, 1993.

SIR ALEXANDER GIBBS & PARTNERS. *Cowlyd - Ogwen Diversion. Reconnaissance Report*. Welsh National Water Development Authority, 1977.

SOUTH GLAMORGAN COUNTY COUNCIL. *South Glamorgan Structure Plan - Approved Structure Plan Policies*. SGCC, 1989.

WATER SERVICES ASSOCIATION & WATER COMPANIES ASSOCIATION LEAKAGE CONTROL STEERING GROUP. *Measurement and Control of Distribution Losses - Glossary of Terms (Section A)*. Working Draft 2.5. WSA, 1992.

WELSH TOURIST BOARD. *Tourism 2000 - A Strategy for Wales*. Draft Report for consultation. WTB, 1993.

WELSH WATER AUTHORITY. *Ogwen abstraction scheme. Technical Report - Part 1*. WWA, 1982.

WEST GLAMORGAN COUNTY COUNCIL. *West Glamorgan Structure Plan - Alteration No.1, Written Statement and Explanatory Memorandum*. WGCC, 1988.

WEST GLAMORGAN COUNTY COUNCIL. *West Glamorgan Structure Plan Review No.2 -Draft Replacement Plan (Pre-Deposit Consultation)*. WGCC, 1993.

APPENDIX A

TERMS OF REFERENCE

NATIONAL RIVERS AUTHORITY

WELSH REGION

WATER RESOURCES DEVELOPMENT STRATEGY

1. OBJECTIVES

1.1 The National Rivers Authority (NRA) is required under Section 143 of the Water Act 1989 to "...collate and publish information from which assessments can be made of the actual and prospective demand for water, and of actual and prospective water resources, in England and Wales".

1.2 The objective of this Consultancy Project is to carry out this Statutory requirement through the production of a Welsh NRA Regional Water Resources Planning and Development Strategy.

2. SPECIFIC OBJECTIVES

2.1 Review the current development of water resources within NRA Welsh Region and their use in meeting existing demands for water.

2.2 Collate and review estimates of future demands for Public Water Supply abstraction in the Region up to the year 2021, in 5 year steps, commencing 1981.

2.3 Collate and review estimates of future demand for all other water requirements which impact on the resources of the Region (including those from outside the Region) up to the year 2021, in 5 year steps, commencing 1981.

2.4 Consider the scope and options available to formulate a sustainable policy. Provide a plan for developing and augmenting water resources, and ensuring their proper use, to meet existing and estimated future demands for water in Welsh Region to 2021.

2.5 Compare the various options and proposals considered, take account of environmental impact and other relevant criteria, and give due weight to economic considerations.

2.6 Liaise with the Consultants undertaking the National Water Resources Development Strategy to provide Welsh Region input as necessary and ensure compatible development so far as is possible.

2.7 Take account of progress made on the NRA Welsh Region proposed Abstraction Licensing Policy and other associated National and Regional developments.

2.8 Hold monthly progress meetings between the Consultant's project Manager and the NRA's Project Leader, with other staff from both sides as appropriate. Submit a draft version of the final report one month before the final report is due.

2.9 Complete project before 15th February 1994.

3. BACKGROUND

The Welsh Region of the NRA has more rainfall than any of the English Regions; 1350 mm on average. Of this, just under half evaporates leaving the remainder to sustain rivers and groundwaters and provide all the water requirements of the Region. This accounts for 26% of the total available water resource of the NRA's Regions.

The Welsh Region has mountainous terrain, thin soil coverage and limited aquifers. Rainfall therefore finds its way quickly to the sea and little is held back to provide baseflow to sustain river flows during dry periods. The Region's river flows therefore rise and fall quickly in response to rainfall.

Historically, lack of local sources for public water supply in the industrialised Midlands and North West England, as well as South East and North East Wales, led to the development of direct supply reservoirs in the sparsely populated uplands of Wales, such as the Elan and Taf Fawr/Fechan Valleys. More recently this development has continued, but with river regulation reservoirs replacing direct supply as a more efficient way of utilising resources e.g. Llyn Brianne on the Tywi, and Llyn Celyn and Llyn Brenig on the Dee.

Industrial and agricultural abstractions are important. More recently industrial abstraction has declined with the collapse of "heavy" industry. However, the impact of these abstractions has been replaced by the growth in hydroelectric generation and agricultural spray irrigation.

The Welsh Region controls over 4,300 abstraction licences, the majority of which are for minor agricultural and domestic supplies. The total licensed abstraction is 24,200 Megalitres per day (Ml/d) from non tidal surface and groundwaters. This is equivalent to 60% of the average daily available water of the Region, or 97% during the 1 in 50 year drought. However, by far the greatest volume licensed is for non - consumptive hydroelectric generation (57%). Spray irrigation by contrast is almost totally consumptive and, even though quantities licensed are small by comparison (less than 1%), abstraction can have a dramatic effect on summer river flows.

The largest "loss" of water in Welsh Region arises from public water supply (PWS). Welsh Region is a major exporter of water; a third of licensed PWS abstraction is used outside the Region, and even within the Region almost half of PWS returns are discharged directly to tidal waters. As a result only a third of the 3,627 Ml/d licensed for PWS abstraction is returned to the Region's rivers.

4. DEMAND FORECASTS

The discussion document "Water Resources Development Strategy" published by the NRA in March 1992 identified an 8% growth in PWS requirements to 2021. If correct this would still give a surplus of 25% more water resources in Welsh Region than demand required. However, these data apply to the whole of the Region and mask local deficits and surpluses.

For example, the Dee catchment provides water locally and for export to the North West of England. This is achieved through a number of large regulating reservoirs controlling river flows. Abstractions and environmental consideration are catered for by reservoir releases when natural river flows are too low. Despite the size of this scheme, it is estimated that the surplus yield in the system will be utilised by early next century. To meet predicted demands therefore further enhancements of the current system may be required.

This study is required both to plan the future development of resources to meet Regional requirements and to feed data into the National Strategy.

5. STRATEGY

5.1 METHOD

The study will be carried out making best use of available data. Thus, a main task will be to collect and collate existing work on demand forecasting and resource planning, as well as information on the yield, performance and distribution system constraints of existing sources, and best use practices. The review would be based principally on information and data provided to the Consultants by the NRA, Water Companies, major industrial users and agricultural information sources.

The successful Consultant would be expected to work with external organisations in order to establish existing and future demands. These would include the demands both of abstractors and the aquatic environment.

All data and assessments should be broken down to a sub-catchment level where possible and practicable.

5.2 PRESENT RESOURCE/DEMAND BALANCE :

a. Identify and quantify the uses of water abstracted within Welsh Region.

b. Identify and quantify the imports/exports of water into/out of Welsh Region.

c. Compare current licensed quantities with actual abstraction and published yields.

d. Present information on the broad categories of use within the Region (See Appendix 1), including estimates of total abstraction, nett abstraction, re-use, discharges to tidal waters, and inter-basin transfers. A breakdown between surface water and groundwater should be included. Any tidal water abstraction should be noted.

e. Take account of source yields and performance as currently understood by the operators, providing where possible, the definitions used. Seek to place all yield information on a broadly comparable basis.

f. Evaluate constraints on yield such as treatability, treatment works capacity, raw water quality, OFWAT guidelines on Levels of Service Indicators, river flow, required flow to estuaries, adverse environmental impact and operating rules.

g. Where practicable, identify current sources which will close or be mothballed due to economic constraints brought about by failure to meet quality objectives.

h. Review all existing sources, including multi - use/conjunctive use schemes, and comment on efficiency and proper use of the resources. Propose alternative more effective and/or efficient methods of operation or improvements which should be further investigated. Provide preliminary resource values, engineering and economic feasibility, and environmental effects.

i. Note the distribution system into which each source feeds, insofar as this may govern source utilisation. Provide maps of distribution systems and supply zones.

5.3 FUTURE DEMANDS FOR WATER SUPPLY :

a. Review the methodology by which future demand patterns have been formulated, and comment on their validity.

b. Make forecasts at a sub-catchment level where possible of nett abstractions for industry and agriculture, including spray irrigation for every 5 years from 1981 to 2021. Special account should be taken of :

- o - Hydroelectric industry (HEP) : This relates to potential growth of this form of energy production and the impact such abstractions have on potential abstraction upstream of the HEP site.
- o - Spray Irrigation (SI) : The NRA R & D project B03 413 - "Demand for Irrigation Water" should be used as a basis for predicting the future requirements for SI. Average year and drought year SI demand for different crop types should be considered. These should be identified at a subcatchment level.

c. Make forecasts of nett abstractions for Public Water Supply. Forecasts for PWS should be at Company level for abstractions used outside the Welsh Region. For those areas within the Region, details should be provided at supply/demand zone levels; the smallest managed areas. Demand forecasts should be compiled using principal components of use. Guidance on this is provided in Appendix II.
Special account should be taken of :

- o - Tourism : Due to its importance in Wales, estimates of seasonal demand should be identified. This may be done through occupancy data and caravan park registers. Contact should be made with the Welsh Tourist Board and other interested parties. This will assist in the production of Peak and Average demands for supply zones.
- o - Housing : Forecasts of housing development, house occupancy rates and percentage of housholds connected to mains water should be identified.
- o - Metering : The take up rate of metering and its impact on demand should be addressed. To assist this records of historic metered customers should be compiled.

d. Reliability of PWS should be assessed using the current OFWAT guidelines for standards of service. Source yields should take these into account.

e. Considerable advantage is seen in making alternative higher and lower trend forecasts to produce a future demand envelope. This would make it possible to test the robustness/sensitivity and also the timing of potential solutions for meeting the range of demands postulated.

f. The forecasts obtained in b. to f. above should be collated and reviewed to :- identify the catchments and/or supply zones, use categories, nett call on resources, date the forecast relates to and whether high or low trend. Data should be presented in numeric and graphical form.

g. The aim is to present broadly consistent demand forecasts relevant to resource use and development.

h. From the foregoing collation of future demand estimates/trends, the Consultant will be required to deduce the resulting deficiency of :
(a) existing abstraction and

(b) resource capability in meeting such future demands, such as source life expectancy, and reduced/increased yields (due to afforestation, siltation, deteriorating quality, enhanced legislative constraints and improved treatment methods.)

and thus derive the scale of resource development, redeployment and efficiency steps required to meet estimated future demands.

5.4 REVIEW OF OPTIONS FOR FUTURE STRATEGY :

a. The Consultant will be required to identify and review various potential options for meeting the deficiencies recognised above. The NRA will advise on future water resources development considered to date.

b. The yield for potential schemes should be identified on a consistent basis. For surface sources these should be based on a 1 year in 50 drought severity, linked to the current OFWAT guidelines on Levels of Service Indicators.

c. Options will be reviewed with Water Companies, major industrial customers and agricultural bodies as appropriate. Their views, as our customers, are an important part of this Strategy. Regional NRA operations staff will also be formally consulted at this stage.

d. Inter-Basin transfers would be applicable where resource capacity, water quality, environmental and/or economic considerations appeared to favour transfers from areas with existing or potential surplus water resources capacity.

e. Consider the elements of demand management (eg. Leakage/waste reduction, increased re-use/recycled water effluent, tariff structuring, monitoring and metering), likely to be most effective and viable. Identify what are reasonable "economic levels" of leakage on a sub - regional basis. Consider the extent to which feasible and cost-effective demand management may help in closing or extending the output/demand balance. All reference to, and assessment of, demand management should be based on the latest methods and terminology arising from the Water Industry's 'National Leakage Control Initiative'.

f. Consider the scope for further development of groundwater throughout the Region in the light of constraints relating to natural recharge, environmental consequences of abstraction and water quality for use as water supply. This should be reported on an identifiable groundwater unit basis.

g. Consider further interlinking and conjunctive use scheme developments where yields and/or environmental factors will benefit.

h. Consider use of sewage effluent as a water resource. Propose Regional policy on dealing with this issue, which takes into account water quality issues, medical aspects, and discharge locations. Identify locations where additional resources may be viable.

i. Review the possibility of "alternative" sources of water in the context of Welsh Region demand, or as means of providing additional resources for export.

j. Consider the benefits or adverse impacts to water resources of existing and proposed barrage developments (e.g. downstream location of PWS intakes). Review and update the likelihood of estuary storage developments.

5.5 ENVIRONMENTAL CONSIDERATIONS AND ECONOMIC/COST ASSESSMENT :

a. Review environmental requirements and constraints on the various options and proposals to ensure that :-
   - o - significant environmental constraints are identified at an early stage.
   - o - environmental considerations are assessed on an equal basis with other factors.

   The exercise should be limited to discussions with NRA Regional staff concerned with environmental quality, fisheries, recreation and conservation, together if necessary with consultation with other parties on specific proposals if so agreed with the NRA.

b. Environmental aspects will interlink with the Region's Abstraction Licensing Policy study. This will cover minimum residual flows; flows to estuaries; effects of abstraction on river water quality; environmental impact constraints on resource development; fisheries, conservation, recreation, amenity and navigation impacts.

c. The possible impact of climatic change on water resource availability should be explored.

d. Consider both Capital and Running costs of all proposed schemes. This should be achieved on a consistent basis to provide appropriate cost estimates for comparison of options, rather than specific accuracy and precision. The WRc Technical Report on Costs and Rates for the UK Water Industry should be used where relevant.

e. Provide recommendations.

6. RELATED PROJECTS.

The Consultant will be expected to keep up to date with the development of other related projects which impinge on the Regional Strategy. These include :

- o - NRA R & D Project B02 282 "Environmentally Acceptable Flows".
- o - NRA R & D Project B03 248 "Economic Effects of Water Resource Managment".
- o - NRA R & D Project B03 414 "Surface Water Yield Assessment".
- o - NRA R & D Project B03 413 "Demand for Irrigation Water".
- o - NRA R & D Project B03 004 "Defining the Proper Use of Water Resources ".
- o - NRA - National Water Resources Development Strategy.
- o - National Leakage Control Initiative publications.
- o - Code Of Practice for the Measurement and Control of Distribution Losses - Leakage Control Steering Group Project.
- o - NRA Policy Guidance Notes.
- o - NRA Catchment Managment Plans.

7. MONITORING

Monthly meetings to be held with Project Leader to monitor progress. Other meetings will be held on an 'As Needs' basis.

8. DISSEMINATION

This study will form the basis of a strategy for the long term development of Water Resources in the Welsh Region of the NRA. The study will provide a number of outputs :-

a. A Report containing all the detailed analysis; for internal use only.

b. A "Public" Report containing detailed analysis as 'a' above; but excluding confidentially sensitive information.

c. A bilingual* (English and Welsh) Consultation Document summarising the main results of the study and outlining possible options for future development. This will be produced for internal and external circulation and comment and should follow a similar format to the "Water Resources Development Strategy" discussion document published by the NRA in March 1992.

d. Bilingual* Overheads/Slides to allow promulgation of the results of the study, through talks, presentations etc., both within the NRA and to outside audiences.

e. A bilingual* summary Water Resources information leaflet.

f. Cartographic output of demand zones and supply networks.

* - NRA will provide the facility for translation.

9. TARGET AND TIMESCALE

Project to be completed by 15th February 1994.

10. OUTPUTS

a.	Detailed Report	20 Copies plus disk containing text.
b.	Public Report	10 Copies plus disk containing text.
c.	Consultation Document (English & Welsh)	Typeset on disk and hard copy
d.	Presentation Material (English & Welsh)	Overheads/Slides.
e.	Information Leaflet (English & Welsh)	Typeset on disk and hard copy
f.	Maps	Four Copies of each.

11. COST

As this contract is to be awarded through competitive tender, the cost will depend on the bids. It is the standard practice of the NRA that the contract will be awarded to the lowest tender unless there is good reason not to do so.

The proposed method of payment will be negotiated on letting of the contract to the successful consultant.

RAV 8/4/93

APPENDIX 1.

USE CATEGORIES

The following categories are to be split into surface and groundwater. Tidal should also be noted.

WATER SUPPLY - PUBLIC

WATER SUPPLY - PRIVATE

INDUSTRY

ELECTRICITY - COOLING

HYDROELECTRICITY

AGRICULTURAL - EXCLUDING SPRAY IRRIGATION

SPRAY IRRIGATION

FISH FARMING

AMENITY / CONSERVATION

OTHER

APPENDIX II

DEMAND FORECASTS OF PUBLIC WATER SUPPLY.

General

The NRA will provide population data at County, District and Community/Parish level, sourced from OPCS, Welsh Office and County Councils. The Community/Parish should be used as the building block to construct supply and demand zones.

All information gathered in producing demand forecasts should be made available to the NRA in a structured format on completion of the project.

Components of Demand

Demand should be built up from its component parts :

- household unmetered consumption.
- household metered consumption.
- industrial and commercial metered consumption
- industrial and commercial unmetered consumption
- unaccounted for water.

Household Unmetered Supplies

Definitions of this will be supplied. Consumption rates per capita or per household should be based where possible on property type water use data, such as the ACORN classification.

Household Metered

Definitions of this will be supplied. Consumption rates per capita or per household will be modified by a factor derived from the measurements of consumption in the National Metering Trials.

Industrial and Commercial Metered Supplies.

These should be estimated from the Water Company's billing records, with other known industrial developments taken into account. Further detail on the methodology will be supplied.

Industrial and Commercial Unmetered Supplies

These should be estimated from the Company's records, with the Company's metering policy taken into account.

Unaccounted For Water

Further detail on this subject and the methodology to be applied will be supplied.

APPENDIX B

THE GEOLOGY OF THE REGION

APPENDIX C

LICENSED ABSTRACTIONS IN SUB-CATCHMENTS

Table C.1 Licensed abstraction from groundwater in the Region in 1993 (Daily average Ml/d)

Subcatchment	Use										
	1	2	3	4	5	6	7	8	9	10	11
Anglesey	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Dee	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Middle Dee	0.2	1.3	11.6	0.2	3.6	0.0	0.7	0.0	0.0	0.0	0.0
Lower Dee	0.2	2.2	32.4	0.3	14.9	0.0	0.0	0.0	0.0	0.3	4.6
Clwyd	0.0	0.3	18.2	0.1	1.2	0.0	0.0	0.0	0.0	0.0	5.1
Conwy	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Gwrfai	0.0	0.0	0.3	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0
Dwyfor	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Glaslyn	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Artro, Mawddach	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dysynni	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dyfi, Leri	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rheidol	0.0	0.0	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aeron, Arth	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Teifi	0.0	0.2	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N. Pembs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cleddau	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S. Pembs	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Taf	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gwendraeth	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Tywi	0.0	0.3	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cothi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gwili	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0
Gower	0.0	0.2	2.4	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
Loughor	0.0	0.1	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0
Tawe	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Neath	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Afan, Kenfig	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0
Ogmore	0.0	0.0	27.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thaw	0.0	0.2	7.2	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0
Ely	0.0	0.0	0.0	0.0	8.0	0.0	1.0	0.0	0.0	0.0	0.0
Taff	0.0	0.0	0.6	0.0	6.8	0.0	0.2	0.0	0.0	0.0	0.0
Rhymney	0.0	0.0	0.0	0.0	3.1	0.0	0.0	0.0	0.0	0.0	0.0
Ebbw	0.0	0.0	7.4	0.0	6.3	0.0	0.0	0.0	0.0	0.0	0.0
Upper Usk	0.0	0.1	18.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lower Usk	0.1	0.4	21.8	0.3	0.4	0.0	0.0	0.0	0.0	0.0	0.4
Upper Wye	0.0	0.5	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lower Wye	1.2	2.7	31.6	0.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Lugg	0.6	4.8	11.4	0.1	21.3	0.0	0.0	0.0	0.1	0.2	0.0
Monnow	0.1	0.9	4.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
USE TOTAL	3	15	204	2	72	0	2	0	0	1	10

Whole or part of subcatchment licence-exempt

Categories of use

1 Spray Irrigation
2 Agriculture
3 Public water supply
4 Private water supply
5 Industrial
6 HEP
7 Fish farming
8 Electricity-cooling
9 Amenity/Conservation
10 Others
11 Transfers

Table C.2 Licensed abstraction from surface water in Welsh Region in 1993 – excluding tidal abstractions (Daily average Ml/d)

Subcatchment	Use										
	1	2	3	4	5	6	7	8	9	10	11
Anglesey	0.0	0.0	38.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Dee	0.0	0.0	50.3	0.0	0.4	388.4	13.7	0.0	0.6	0.0	1245.7
Middle Dee	1.2	0.0	51.5	0.1	11.0	0.0	37.7	0.0	0.2	0.0	187.9
Lower Dee	1.4	0.0	758.0	0.0	12.5	0.0	0.7	0.0	2.5	0.0	0.0
Clwyd	0.5	0.1	14.3	0.0	0.3	0.0	82.0	0.0	0.6	0.0	19.4
Conwy	0.1	0.0	37.1	0.1	3.2	420.2	50.0	0.0	1.5	86.6	0.0
Gwrfai	0.0	0.0	32.7	0.4	0.4	9480.2	9.5	6.0	3.9	0.2	4.0
Dwyfor	0.3	0.0	18.6	0.0	4.9	5.2	0.1	0.0	0.0	0.0	0.0
Glaslyn	0.0	0.0	5.4	0.0	0.1	6509.8	0.3	0.0	0.0	0.0	0.0
Artro, Mawddach	0.0	0.0	8.1	0.1	0.0	17.3	2.3	0.0	0.0	0.0	0.0
Dysynni	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dyfi, Leri	0.0	0.0	7.5	0.0	0.2	23.7	0.5	0.0	0.0	0.0	0.0
Rheidol	0.0	0.0	3.6	0.0	0.1	612.6	1.6	0.0	0.0	0.0	0.0
Aeron, Arth	0.0	0.0	0.0	0.0	1.0	0.6	1.0	0.0	3.5	0.4	0.0
Teifi	0.1	0.3	23.5	0.0	0.4	128.1	4.1	0.0	2.6	0.0	0.0
N. Pembs	0.9	0.0	3.2	0.0	0.1	0.7	0.0	0.0	0.5	0.9	0.0
Cleddau	0.3	0.0	107.0	0.0	0.6	0.0	101.4	0.0	1.1	0.4	5.0
S. Pembs	3.2	0.0	1.8	0.0	0.0	0.0	1.6	0.0	0.0	0.1	0.0
Taf	0.1	0.0	0.0	0.0	8.0	0.0	2.6	0.0	1.2	0.0	0.0
Gwendraeth	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	7.0
Upper Tywi	0.0	0.0	46.7	0.0	2.5	0.0	0.0	0.0	0.5	0.0	0.0
Cothi	0.0	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Gwili	0.0	0.0	227.1	0.0	0.9	0.0	1.8	0.0	0.1	0.0	0.0
Gower	0.1	0.0	58.5	0.0	14.3	0.0	31.8	0.0	1.4	0.1	0.0
Loughor	0.0	0.0	6.8	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0
Tawe	0.0	0.0	0.0	0.0	41.4	0.0	2.6	0.0	0.0	0.2	0.0
Neath	0.0	0.0	20.0	0.0	63.5	123.2	0.0	0.0	0.0	0.0	0.0
Afan, Kenfig	0.0	0.0	0.0	0.0	648.5	0.0	0.0	0.0	0.1	0.1	0.0
Ogmore	0.0	0.0	8.0	0.0	19.6	0.0	0.0	0.0	0.9	0.0	0.0
Thaw	0.1	0.0	0.0	0.0	7.5	0.0	0.0	0.0	0.0	0.0	1.4
Ely	0.0	0.0	0.4	0.0	20.3	0.0	0.0	0.0	0.0	0.0	0.0
Taff	0.0	0.0	277.7	0.0	25.1	0.0	18.2	0.0	2.1	0.0	0.0
Rhymney	0.2	0.0	14.6	0.0	6.6	0.0	5.7	0.0	0.3	0.0	0.2
Ebbw	0.0	0.0	33.7	0.0	30.3	0.0	0.0	0.0	51.1	0.0	0.0
Upper Usk	0.1	0.0	158.7	0.0	0.9	0.0	2.1	0.0	0.0	0.0	50.0
Lower Usk	0.3	0.0	278.0	0.0	4.1	0.0	20.0	0.0	2.3	0.0	316.0
Upper Wye	0.0	0.0	376.2	0.0	0.1	0.0	7.3	0.0	1.0	0.0	0.0
Lower Wye	5.0	0.4	235.9	0.0	24.2	0.0	1.1	0.0	0.4	0.1	0.0
Lugg	2.2	0.1	2.6	0.0	2.0	0.0	14.1	0.0	0.1	0.0	0.0
Monnow	1.2	0.1	0.0	0.0	0.0	0.0	22.7	0.0	0.0	0.0	0.0
Use total	17	1	2909	1	957	17710	436	6	79	89	1837

Whole or part of subcatchment licence-exempt

Categories of use

1 Spray Irrigation
2 Agriculture
3 Public water supply
4 Private water supply
5 Industrial
6 HEP
7 Fish farming
8 Electricity-cooling
9 Amenity/Conservation
10 Others
11 Transfers

APPENDIX D

PWS SOURCES IN THE REGION

Table D.1 Dwr Cymru South East Div. supply area sources

Dwr Cymru SE Div supply area	Licence Nos	Source Name	Catchment	Licensed quantity Average (Ml/a)	Peak (Mld)	Yield (Mld)	Comments
Southern CUA	55-17-019	Grosmont Spring (Greig Hill)	Monnow	28	0.08	0.08	
	55-17-250	Garway Spring	Monnow	28	0.08	0.08	
	55-17-258	Porthgalloed Borehole	Monnow	35	0.10	0.00	DISUSED
	55-17-400	Springs at Llanthony	Monnow	6	0.05	0.0	DISUSED
	55-18-408	R.Wye - Monmouth Intake	L.Wye	49915	136.38	125.00	
	55-20-088	Newcastle Borehole	Monnow	20	0.05	0.00	DISUSED
	55-21-055	Mounton Brook and tributaries	L.Wye	830	2.27	2.30	
	55-21-056	Rogerstone Grange borehole	L.Wye	1244	3.41	3.40	
	55-21-057	Tintern Springs (Angidy Fechan Brook)	L.Wye	83	0.27	0.00	DISUSED
	55-21-058	Fedw Brook	L.Wye	100	0.36	0.16	
	55-21-067	Llandogo Spring	L.Wye	41	0.11	0.11	
	55-21-108	Great Spring well shaft	L.Wye	3983	10.91	10.90	Note 1
	56-11-005	Pant-yr-Eos, Ynysyfro Reservoir	L.Usk	1659	4.55	1.50	
	56-11-007	Pant-yr-Eos Reservoir and springs	L.Usk	1659	4.55	2.00	
	56-12-031	Springs at Blaenavon	L.Usk	608	1.66	0.20	
	56-12-046	Various sources at Cwmavon	L.Usk	682	2.27	1.00	
	56-12-047	Various points, Nantymaelor Reservoir	L.Usk	909	2.97	0.60	
	56-12-048	Spring at Abersychan	L.Usk	164	0.45	0.00	DISUSED
	56-12-050	Springs to Cwmsychan Reservoir	L.Usk	455	1.36	0.00	DISUSED
	56-12-051	Intake chambers to Penyrheol Resr.	L.Usk	1364	5.46	2.00	
	56-13-017	Llandegfedd Reservoir	L.Usk	68190	186.82	234.00	Note 2
	56-21-029	Waun Springs	L.Usk	68	0.19	0.20	
	56-21-034	River Usk at Llantrissant	L.Usk	28265	77.28	0.00	Note 3
	56-22-025	Folly Springs at Graig-y-Tar Wood	L.Usk	682	2.37	0.00	DISUSED
	56-22-026	Intake at Graig-y-Pandy Wood	L.Usk	582	1.59	0.00	DISUSED
	56-31-050	Park Lodge - Llwyndu and Cibi Brook	L.Usk	1023	2.79	2.00	
	56-31-054	Catchpit at Cherry Orchard	L.Usk	25	0.07	0.07	
	56-31-055	Tyn-y-Wern Farm	L.Usk	283	0.77	0.50	
	56-31-069	Derl Springs	L.Usk	2	0.01	0.00	DISUSED
	56-32-016	Cwm Mawr and Coulin Springs	L.Usk	374	1.02	0.00	DISUSED
	56-33-003	Cairn Mound Reservoir	U.Usk	546	2.55	0.00	DISUSED
	56-33-004	Ffynnon Gisfaen Springs	U.Usk	1400	4.00	2.40	
	56-34-012	Catchpit at Llanbedr	U.Usk	4	0.01	0.00	DISUSED
	56-34-013	Catchpit near Cwm Gegyr Farm	U.Usk	166	0.45	0.00	DISUSED
	56-34-018	Grwyne Fawr Resr., Grwyne Springs	U.Usk	3505	9.61	6.90	
	56-35-007	Cwm Onneu Spring	U.Usk	16	0.05	0.00	DISUSED
	56-35-008	Ffynnon Itan Springs	U.Usk	10	0.06	0.00	DISUSED
	56-36-020	Springs at Llanbedr (5 on Map)	U.Usk	163	0.77	0.00	DISUSED
	56-36-021	Spring at Llanbedr (No. 8)	U.Usk	10	0.03	0.00	DISUSED
	56-36-023	Spring at Bwlch	U.Usk	0	0.00	0.00	DISUSED
	56-37-002	Nant Glaisfer Intake	U.Usk	796	6.62	0.00	DISUSED
	56-37-003	Two springs at Llangynidr	U.Usk	1	0.07	0.00	DISUSED
	56-41-007	Talybont Reservoir	U.Usk	26549	163.66	46.00	
	56-41-009	Spring at Llandetty	U.Usk	1	0.00	0.00	DISUSED
	56-62-010	Cwmcarn Colliery	Ebbw	566	2.27	0.00	DISUSED
	56-62-011	Graig-y-Crochan	Ebbw	114	0.55	0.00	DISUSED
	56-62-012	Nant Carn	Ebbw	136	0.56	0.00	DISUSED
	56-63-011	Cwmtillery Reservoir	Ebbw	1991	5.46	2.00	
	56-63-012	Coity Tunnel	Ebbw	49	0.55	0.00	DISUSED
	56-64-003	Upper and Lower Carno Reservoirs	Ebbw	3328	9.12	5.20	
	56-65-013	Conduit at Argoed	Ebbw	1818	11.37	2.00	
	56-65-014	Shon Sheffrey Reservoir	Ebbw	7001	30.00	5.20	
	56-72-018	Wentwood Reservoir	L.Usk	2489	6.62	4.00	
	57-11-001	Rhymney Bridge Reservoirs	Rhymney	3148	6.62	3.60	
	57-12-033	Streams to Lisvane Storage Reservoir	Rhymney	2046	5.60	5.50	Note 1
	57-12-034	Roath Park Lake	Rhymney	136	0.37	0.00	DISUSED
	57-21-001	Taf Fawr Reservoirs	Taff	34100	93.42	46.00	
	57-21-002	Taf Fechan Reservoirs	Taff	39932	109.40	70.50	
	57-23-002	Bwllfa and NantyMoel sources	Taff	1195	12.20	2.00	
	57-23-005	Nantymoel Reservoir	Taff	1010	2.66	0.00	DISUSED
	57-23-006	Nant Cwmnanthir to Nanthir Reservoir	Taff	713	1.97	1.00	
	57-23-022	Ffrynant and stream to Pwllfa Reservoir	Taff	436	1.20	0.00	DISUSED
	57-23-048	River Dare to Bwllfa Reservoir	Taff	1825	4.99	0.00	DISUSED
	57-23-049	River Dare to Bwllfa Reservoir	Taff	666	1.82	0.00	DISUSED
	57-23-050	River Dare to Bwllfa Reservoir	Taff	832	2.27	0.00	DISUSED
	57-23-060	Penderyn Borehole	Taff	114	4.05	2.00	
	57-24-001	Llyn Fawr Resr. & Upper Rhondda	Taff	7434	20.37	7.30	
	57-24-004	Nant Selsig	Taff	1055	2.88	0.00	DISUSED
	57-24-009	Nant Cwmparc and Nant Cesig	Taff	1659	4.55	1.00	
	57-24-025	Castell Nos and Lluest Wen Reservoirs	Taff	5810	15.92	11.00	
	57-25-001	Clydach and Perthcelyn Reservoirs	Taff	1793	4.91	2.90	
	57-25-002	Nant Clydach to Perthcelyn Reservoir	Taff	68	0.19	0.00	DISUSED
	57-25-015	Disused level at Gwaelod-y-Garth	Taff	91	0.25	0.00	DISUSED
	57-31-008	Collecting pipes to Pentyrch Reservoir	Ely	136	0.37	0.00	DISUSED
	58-11-002	Biglis Wells	Thaw	1818	5.00	5.00	Note 1
	58-21-001	Borehole at Llansannor (Pwllwy)	Thaw	800	2.18	1.40	
ZONE TOTAL	76			320836	1010.45	543.20	Note 4

Table D.1 Dwr Cymru South East Div. supply area sources

Dwr Cymru SE Div supply area	Licence Nos	Source Name	Catchment	Licensed quantity Average (Ml/a)	Peak (Mld)	Yield (Mld)	Comments
Monmouth	55-20-087	Redwern Springs	Monnow	22	0.06	0.00	DISUSED
	55-21-066	Ffynnon Gaer Springs	L.Wye	183	0.50	0.50	
	55-18-201	R.Wye at Monmouth (May Hill)	L.Wye	1244	3.41	3.40	
	55-18-203	Buckholt Springs	L.Wye	714	1.95	0.40	
ZONE TOTAL	4.00			2162	5.92	4.30	
Hereford CUA	55-09-182	Dilwyn Borehole	Lugg	32	0.09	0.09	
	55-09-204	River Arrow - Hargest	Lugg	398	1.09	0.00	DISUSED
	55-09-330	Dunfield boreholes	Lugg	1206	3.30	3.30	
	55-12-431	Well at M.Summer Meadow, Leominster	Lugg	1195	3.27	3.30	
	55-12-432	Withington Boreholes	Lugg	265	0.73	0.00	DISUSED
	55-13-061	Bredenbury Borehole	Lugg	16	0.04	0.00	DISUSED
	55-15-246	R.Wye at Broomy Hill	L.Wye	16367	44.72	44.70	
	55-17-305	Malt House Spring	Monnow	2	0.01	0.00	DISUSED
	55-19-079	Keety Spring (St.Weonards)	L.Wye	90	0.30	0.30	
	55-19-081	Llancloudy Spring	L.Wye	7	0.02	0.00	DISUSED
ZONE TOTAL	10.00			19580	53.57	52.69	Note 5
Whitbourne	54-09-008			3285	9.00	8.80	Note 6
ZONE TOTAL				3285	9.00	8.80	
Leintwardine	54-09-367			365	1.00	1.00	Note 6
ZONE TOTAL				365	1.00	1.00	
Alton Court	55-18-208	Alton Court Borehole	L.Wye	830	2.27	2.30	
	55-18-220	Coughton boreholes	L.Wye	1314	3.60	3.60	DISUSED
ZONE TOTAL				2144	5.87	11.30	Note 7
Vowchurch & Dorstone	55-15-247	River Wye (Eaton Bishop)	L.Wye	996	2.73	2.70	
	55-17-451	Vowchurch boreholes	Monnow	1464	4.00	3.00	
	55-17-251	Dorstone Spring	Monnow	75	0.40	0.10	
	55-20-096	Skenfrith Borehole	Monnow	5	0.01	0.00	DISUSED
ZONE TOTAL				1544	4.41	3.10	
Portis & Brecon bhs	56-44-016	Boreholes at Brecon	U.Usk	1281	3.50	5.80	
	56-45-008	Cwrt Gilbert Farm	U.Usk	746	2.05	0.00	DISUSED
	56-54-002	River Trinant	U.Usk	282	0.77	0.00	DISUSED
ZONE TOTAL				2308	6.32	5.80	
Llyswen & Llandeilo Graban	55-06-078	R.Wye and Llan-Bwich-Llyn Lake	U.Wye	1527	4.18	3.60	
	55-06-199	Bach Howey Brook	U.Wye	1098	3.00	0.40	
ZONE TOTAL				2625	7.18	4.00	
Pilleth & Fairwell/ Harley Valley	55-08-046	Harley Valley stream	Lugg	141	0.39	0.30	
	55-08-125	River Lugg (Byton)	Lugg	415	1.14	1.00	Note 8
	55-08-179	Four boreholes	Lugg	1409	3.86	3.80	
ZONE TOTAL				1965	5.39	4.10	
Elan CUA	55-01-007	Elan Reservoirs	U.Wye	133107	386.00	341.00	Note 9
	55-02-078	Cwm Dwfnant Brook	U.Wye	332	0.91	0.00	DISUSED
	55-03-038	R.Wye at Builth	U.Wye	1348	3.68	3.70	
	55-04-002	Well at Llanbister	U.Wye	9	0.03	0.00	DISUSED
	55-04-026	Llanbadarn Fynydd Springs	U.Wye	6	0.03	0.00	DISUSED
	55-04-028	Llanfihangel Rhydithon Spring	U.Wye	91	0.25	0.10	
	55-04-029	Llaithddu Spring	U.Wye	1	0.00	0.00	DISUSED
	55-04-069	Three Wells Spring	U.Wye	512	0.91	0.00	DISUSED
ZONE TOTAL				135405	391.81	8.80	
SUPPLY AREA TOTAL				488569	1491	647	

Notes:

1. Non-potable supply licence (excluded from zone yield)
2. Including 77.3Ml/d reserved for non-potable supply (excluded from zone yield)
3. Yield included in Llandegfedd licence yield
4. Including 22.3Ml/d transfer from Felindre/Schwyll supply zone
5. Including 1 Ml/d transfer from Pilleth & Fairwell supply zone
6. Import from Severn-Trent Region
7. Including 9Ml/d sold to DC by Severn-Trent Water Plc
8. Transfer to Hereford CUA
9. Export by Severn-Trent Water Plc (5Ml/d sold to DC)

Table D.2 Dwr Cymru South West Div. supply area sources

Dwr Cymru S.W.Div supply area	Licence Nos	Source Name	Catchment	Licensed quantity Average (Ml/a)	Peak (Mld)	Yield (Mld)	Comments
Pembrokeshire CUA	61-01-001	Pont Brynberian	N.Pembs	205	0.77	0.60	
	61-01-002	Pontfaen (Pontygotti)	N.Pembs	500	1.45	0.00	DISUSED
	61-02-031	River Solva at Middle Mill	N.Pembs	100	1.36	1.30	
	61-03-001	W.Cleddau at Crowhill	Cleddau	7728	27.28	10.00	
	61-03-002	Hotwells and Glanrhyd	Cleddau	455	1.73	1.00	
	61-04-001	Prescelly No.1. Reservoir	Cleddau	5910	18.23	7.40	
	61-04-010	Llysyfran Res. - Canaston Bridge Intake	Cleddau	25000	65.00	57.70	Note 1
	61-06-001	Stembridge stream	S.Pembs	650	2.55	0.00	DISUSED
ZONE TOTAL				40548	138.37	45.50	Note 2
North Ceredigion	63-01-005	Llyn Llygad Rheidol, Maesnant stream	Rheidol	929	2.55	2.30	
	63-01-027	Maesnant and NantyMoch streams	Rheidol	372	8.18	0.50	
	63-01-029	Parcel Ganol borehole - Lovesgrove	Rheidol	1300	5.00	5.00	
	64-12-001	Llyn Craig-y-Pistyll	Dyfi	1864	9.10	3.00	
ZONE TOTAL				4465	24.83	10.80	
Middle & South Ceredigion	60-02-002	Ffynnon Nanto	Cothi	83	0.23	0.23	
	62-01-057	Teifi Pools	Teifi	2823	7.73	6.70	
	62-01-058	Pencefn	Teifi	59	0.22	0.00	DISUSED
	62-01-060	Olwen Borehole	Teifi	144	0.40	0.40	
	62-03-005	Teifi at Llechryd	Teifi	5750	19.00	19.00	
ZONE TOTAL				8778	27.35	26.10	
Felindre/Schwyll	56-53-002	Cray Reservoir	U.Usk	15775	43.19	20.40	
	56-54-001	Usk Reservoir	U.Usk	13274	42.73	5.00	
	58-41-002	River Llynfi at Blaencaerau	Ogmore	682	1.86	1.90	
	58-42-012	Hendre Ifan Goch Springs, Gilfach Goch	Ogmore	64	0.17	0.00	DISUSED
	58-42-001	Ogwr Fawr and un-named stream	Ogmore	955	2.81	2.60	
	58-42-002	Nant y Moel to High Level Reservoir	Ogmore	818	2.24	2.20	
	58-42-009	Nant Ffasg, Nant lechyd and tributary	Ogmore	477	1.30	1.30	
	58-44-005	Borehole and well, Bridgend Ind. Estate	Ogmore	1182	4.21	3.20	
	58-44-012	Borehole at Bridgend Ind. Estate	Ogmore	996	2.73	2.70	
	58-44-06	Schwyll Pumping Station	Ogmore	7956	21.80	21.80	Note 3
	59-02-050	Headwaters of Loughor	Loughor	2489	6.82	6.60	
	59-03-022	Cwm Lliedi Reservoir	Gower	6947	19.03	4.40	Note 4
	59-03-023	Upper Lliedi Reservoir	Gower	6703	18.37	6.50	
	59-04-048	Springs at Holywell, Pitton and Parkmill	Gower	400	3.20	2.40	
	59-04-065	Lliw Reservoirs	Gower	7728	21.17	10.30	
	60-01-001	Llynyfan Reservoir	U.Tywi	3783	10.36	4.00	
	60-01-068	Tywi - Manorafon abstraction	L.Tywi	13274	36.37	36.40	
	60-03-035	Tywi at Nantgaredig	Gwili	82966	227.30	227.30	Note 5
ZONE TOTAL				166469	465.47	332.50	
Tonn	60-01-065	Tonn Borehole	U.Tywi	244	0.70	0.70	
ZONE TOTAL				244	0.70	0.70	
Ystradfellte	58-71-001	Ystradfellte Reservoir	Neath	7300	20.00	15.20	
ZONE TOTAL				7300	20.00	15.20	
SUPPLY AREA TOTAL				227803	677	431	

Notes:
1 Including 37.3Ml/d reserved for non-potable supply (excluded from zone yield)
2 Including 4.8 Ml/d in licence-exempt area (Park Springs and Milton)
3 Source due to be mothballed by 1996
4 Non-potable supply licence (excluded from zone yield)
5 Including 22.3 Ml/d transfer to Southern CUA (excluded from zone yield)

Table D.3 Dwr Cymru Northern Div.(W) supply area sources

Dwr Cymru NE Div supply area	Licence Nos	Source Name	Catchment	Licensed quantity Average (Ml/a)	Peak (Mld)	Yield (Mld)	Comments
North Eryri/Ynys Mon	65-04-006	Afon Cwmllan at Nant Gwynant	Glaslyn	5	0.01	0.00	DISUSED
	65-14-002	Llyn Cwm Dulyn	Gwrfai	833	3.30	3.20	
	65-14-021	Spring at Geulan, Nantlle	Gwrfai	60	0.28	0.00	DISUSED
	65-15-018	Afon Gwyrfai at Llyn Cwellyn/Nant Mill	Gwrfai	5824	15.95	12.00	
	65-15-022	Afon Gwyrfai at BontNewydd	Gwrfai	1	0.05	0.00	DISUSED
	65-16-009	Afon Rhythallt, Llanrug, Caernarfon	Gwrfai	1245	3.41	3.40	
	65-16-064	Llyn Marchlyn Bach	Gwrfai	1460	4.00	0.00	DISUSED
	65-18-008	A.Llafar/Cefnllusg/Gwern Saeson Bach	Gwrfai	2500	7.09	1.10	
	65-18-015	Afon Caseg, Bethesda	Gwrfai	409	1.14	1.14	
	66-08-010	Ffynnon Llugwy, Capel Curig	Conwy	2828	7.73	9.00	
	102-02-007	Cefni Reservoir	Anglesey	5475	15.00	10.00	
	102-06-008	Alaw Reservoir, Rhos-y-Bol	Anglesey	8637	34.10	25.50	
ZONE TOTAL				29271	92.05	65.34	
Nant Peris	65-16-063	Pistyll Dwr Oer spring and Nant Peris	Gwrfai	44	0.12	0.10	
ZONE TOTAL				44	0.12	0.10	
Cwmystradllyn/ Dolbenmaen	65-08-018	Afon Dwyfor, Garndolbenmaen	Dwyfor	2310	8.40	0.00	DISUSED
	65-08-019	Llyn Cwmystradllyn	Dwyfor	4491	12.30	12.50	
ZONE TOTAL				6801	20.70	12.50	
Llyn Cynwch	64-03-003	Spring at Glascoed Farm, Llanfachraeth	Mawddach	9	0.02	0.00	DISUSED
	64-03-023	Afon Gamlan, Ganllwyd	Mawddach	13	0.04	0.00	DISUSED
	64-04-064	Spring at Gorwyr & tributary of Wnion	Mawddach	25	0.24	0.00	DISUSED
	64-04-065	Llyn Cynwch	Mawddach	600	2.00	2.00	
	64-04-068	Spring at Penrhiw Farm, Dolgellau	Mawddach	30	0.08	0.08	DISUSED
ZONE TOTAL				677	2.38	2.08	
Barmouth Junction	64-05-037	Bron Llettyifan,Cyfannedd Uchaf	Mawddach	175	0.61	0.61	
ZONE TOTAL				175	0.61	0.61	
Bontddu	64-05-024	Afon Cwm Mynach, Maestryfer	Mawddach	4	0.01	0.00	DISUSED
	64-05-026	Afon Cwm Llechen	Mawddach	33	0.14	0.10	
ZONE TOTAL				37	0.15	0.10	
Penybont	64-13-031	Afon Fathew	Dysynni	680	2.60	2.60	
	64-13-005	Spring near Crychnant, Aberdyfi	Dysynni	16	0.04	0.00	DISUSED
ZONE TOTAL				695	2.64	2.60	
Garreglwyd	64-01-001	Llyn Gelli Gain, Bronaber	Mawddach	341	1.36	0.50	
	65-01-002	Llyn Morynion	Glaslyn	996	3.27	2.40	
	65-01-016	Spr. at Talywaenydd,Llechwedd Quarry	Glaslyn	3	0.01	0.00	DISUSED
	65-02-006	Springs: Ffridd Odu and Moel Oernant	Glaslyn	207	0.91	0.00	DISUSED
ZONE TOTAL				1548	5.55	2.90	
Gilfor	65-03-001	Tallin Stream and Llyn Tecwyn Uchaf	Glaslyn	830	3.41	2.80	
	65-06-020	Un-named stream at Ogof Llechwyn	Glaslyn	5	0.01	0.01	DISUSED
	65-06-021	Afon Maesgwm, Croesor	Glaslyn	105	0.29	0.29	
ZONE TOTAL				940	3.71	3.10	
Rhiwgoch	64-16-008	Llyn Elddew Mawr Reservoir	Mawwdach	830	2.27	1.50	
	65-03-009	Afon Eisingrug	Glaslyn	33	0.09	0.00	DISUSED
ZONE TOTAL				863	2.36	1.50	
Llyn Bodlyn	64-15-009	Llyn Bodlyn, Dyffryn Ardudwy	Mawwdach	980	3.00	2.20	
	64-16-002	Spring:Caerffynnon Farm,Dyffryn Ardudwy	Mawwdach	106	0.48	0.00	DISUSED
ZONE TOTAL				1086	3.48	2.20	
Y Gaer	64-13-006	Spring: Llanerch Goediog, nr. Abertrinant	Dysynni	1	0.00	0.00	DISUSED
	64-13-008	Cwm Uchaf, Llanegryn, Tywyn	Dysynni	100	0.27	0.00	DISUSED
	64-13-011	Ffynnon Badrig, Llanegryn, Tywyn	Dysynni	23	0.06	0.00	DISUSED
	64-14-002	Calettwr,Pigyrallt,Parthygwyddwch Spr.	Mawwdach	91	0.44	0.40	
	64-14-003	Afon Gwril, Bodwylan, Llwyngwril	Mawwdach	159	0.65	0.65	
ZONE TOTAL				373	1.43	1.05	
Dinas Mawddwy	64-06-005	Afon Cywarch, Abercywarch	Dyfi	2	0.01	0.00	DISUSED
	64-06-010	Pen y Graig, Cwm Celydd	Dyfi	2	0.01	0.00	DISUSED
	64-06-017	Springs at Brynllys, and Nant Minllyn	Dyfi	110	0.30	0.11	
	64-06-018	Surface spring near Bryn, Llanymawddwy	Dyfi	22	0.06	0.06	
ZONE TOTAL				135	0.38	0.17	
Corris/Pennal	64-10-001	Hafoty Reservoir, Corris	Dyfi	149	0.41	0.07	
	64-11-015	Nant Cwm y Gof, Cwrt, Pennal	Dyfi	120	0.70	0.30	DISUSED
ZONE TOTAL				269	1.11	0.37	
Abergynolwyn	64-13-030	Spring at Talyllyn RS - Abergynolwyn	Dysynni	40	0.20	0.20	
ZONE TOTAL				40	0.20	0.20	
Betws y Coed	66-06-004	Llyn Elsi, nr. Betws y Coed	Conwy	150	1.09	1.09	
ZONE TOTAL				150	1.09	1.09	
Dolwyddelan	66-06-007	Ceunant y Garnedd, Mountain Reservoir	Conwy	68	0.65	0.34	
ZONE TOTAL				68	0.65	0.34	
Capel Curig	66-08-002	Afon y Bedol, Capel Curig	Conwy	68	0.32	0.30	
ZONE TOTAL				68	0.32	0.30	
SUPPLY AREA TOTAL				43240	139	97	

Table D.4 Dwr Cymru Northern Div.(E) supply area sources

Dwr Cymru NW Div supply area	Licence Nos	Source Name	Catchment	Licensed quantity Average (Ml/a)	Peak (Mld)	Yield (Mld)	Comments
Llanfairfechan	65-19-004	Llyn Anafon	Gwrfai	830	2.73	1.10	
	65-19-005	Afon Ddu at Llanfairfechan	Gwrfai	16	0.55	0.00	DISUSED
	65-19-007	Afon Glan Sais	Gwrfai	166	0.55	0.24	
	65-19-009	Afon Anafon	Gwrfai	4	0.14	0.14	
ZONE TOTAL				1016	3.97	1.48	
Alwen/Bretton CUA	67-04-016	Alwen Reservoir	U.Dee	16593	45.46	35.50	
	67-08-048	Stream at Moel Fammau, Cilcain	L.Dee	60	0.19	0.19	
	67-08-056	4 Reservoirs and pond at Cilcain, Mold	L.Dee	1364	5.00	1.50	
	67-08-079	Brithdir Mawr Intake	L.Dee	771	4.55	0.00	DISUSED
	67-09-148	Dee – Poulton, Chester	L.Dee	8652	23.64	23.60	
	67-10-083	Industrial Main, Halkyn	L.Dee	488	1.36	0.00	DISUSED
	67-10-087	Boreholes in Kinnerton area, Chester	L.Dee	227	6.55	0.00	DISUSED
	67-10-113	Nant y Fflint	L.Dee	498	1.36	0.00	DISUSED
ZONE TOTAL				28662	88.11	60.79	
Cowlyd/Dulyn	68-10-001	Llyn Cowlyd, Llyn Dulyn and Melynllyn	Conwy	9092	36.37	34.20	
	65-19-011	Afon Gyrach Impounding Reservoir	Gwrfai	4	0.01	0.01	DISUSED
ZONE TOTAL				9096	36.38	34.21	
Llyn Conwy	66-01-001	Llyn Conwy	Conwy	1245	3.41	3.67	
	66-01-004	Llyn Conwy	Conwy	132	1.42	0.00	DISUSED
	66-04-009	Afon Glascwm, Penmachno	Conwy	99	0.33	0.00	DISUSED
ZONE TOTAL				1475	5.16	3.67	
Llyn Arenig Fawr	67-02-006	Llyn Arenig Fawr	U.Dee	830	2.27	2.30	
	67-03-009	Spring at Bryn Melyn Farm, Llandderfel	U.Dee	17	0.05	0.00	DISUSED
ZONE TOTAL				846	2.32	2.30	
Glascoed/ Trecastell	66-01-038	Plas yr Esgob	Clwyd	1179	9.83	3.23	
	66-01-041	Efail Newydd Borehole	Clwyd	318	1.32	0.87	
	66-02-001	Clywedog Reservoir	Clwyd	232	0.82	0.00	DISUSED
	66-03-026	Llwyn Isaf Boreholes	Clwyd	998	3.27	2.70	
	66-03-048	Llannerch Park Boreholes	Clwyd	3410	13.64	13.60	
	66-06-007	Plas Uchaf and Dolwen Reservoirs	Clwyd	5000	18.18	11.40	
	66-07-003	Mineshaft at Mid-Nant Farm, Prestatyn	Clwyd	182	1.82	1.82	
	66-07-034	Ffynnon Asaph	Clwyd	1637	4.55	1.90	
ZONE TOTAL				12952	53.43	35.52	
SUPPLY AREA TOTAL				54047	189	138	

Table D.5 Wrexham & East Denbighshire Water Co. sources

WEDWC Company area	Licence Nos	Source Name	Catchment	Licensed quantity Average (Ml/a)	Peak (Mld)	Yield (Mld)	Comments
	67-05-02	Trefnant Brook	M.Dee	408.07	1.55	0.15	DISUSED
	67-05-03	Penycae Reservoirs	M.Dee	906.66	3.41	2.18	
	67-05-04	Oerog springs	M.Dee	1160.70	3.41	2.50	
	67-05-06	River Dee – Berwyn	M.Dee	678.90	2.27	0.00	
	67-05-07	Vived	M.Dee	331.06	1.36	0.00	Note 1
	67-05-08	Nant y Crogfrin	M.Dee	0.00	0.00	0.00	Transfer
	67-05-24	Newhall Springs	M.Dee	326.31	2.05	0.15	Note 1
	67-06-17	Glynceiriog Springs	M.Dee	193.45	0.64	0.00	Note 1
	67-06-33	Tregeiriog	M.Dee	36.50	0.10	0.06	Note 1
	67-07-05	River Dee – Bangor-is-y-coed	M.Dee				Note 2
	67-07-35	Park Day level/Speedwell shaft	M.Dee	2216	9.82	2.50	Note 1
	67-07-36	Ty Mawr & Cae Llywd reservoirs	M.Dee	2448	11.37	3.41	
	67-07-37	Talwm Borehole	M.Dee	271.93	1.43	1.00	Note 1
	67-07-182	River Dee – Bangor-is-y-coed	M.Dee	13805	40.91	43.41	
	67-08-03	Nantyffrith Reservoir	L.Dee	359.89	1.23	0.80	Note 1
	67-08-10	Pendinas reservoir and springs	L.Dee	1469	5.46	2.27	
COMPANY TOTAL*				24613	85	53.8	Note 3

Notes:
1 To be closed in near future
2 Included with 67-07-182
3 Yield after closures

Table D.6 Chester Waterworks Co. supply area sources

CWC Company area	Licence Nos	Source Name	Catchment	Licensed quantity Average (Ml/a)	Peak (Mld)	Yield (Mld)	Comments
	67-09-03	Dee – Barrelwell Hill, Chester	L.Dee	12456	34.10	32.80	
	68-06-11	Plemstall borehole		840	2.30	1.80	Note 1
COMPANY TOTAL				13295.5	36.4	34.6	

Notes:
1 Import from NW Region

APPENDIX E

COMPARISON OF LICENSED QUANTITIES AND ACTUAL ABSTRACTIONS

E COMPARISON OF ACTUAL ABSTRACTIONS AND LICENSED QUANTITIES

E.1 GENERAL

In order to assess the net demand on water resources a comparison of licensed quantities and actual abstractions and yields has been carried out. This analysis was extended to include 1981, 1986, and 1991, as well as 1992, in order to improve the reliability of assessments of estimated abstractions and provide forecasts of historic demands based on the returns data.

E.2 DATA ANALYSIS

For each category of use and water source the abstracted quantity was compared with the licensed quantity to determine the % taken. In order to assess the reliability of the calculated figures the licensed quantity of returns was compared with total licensed quantity. The results of the analysis are presented in Tables D1 to D4.

During the analysis it was found that, as well as there being substantial gaps in the records, there were a significant number of erroneous figures for actual abstractions which were rectified(eg returns as much as 1000 x licensed annual quantity).

In analysis of returns for HEP licences it was found that three large schemes - Dinorwic, Ffestiniog and Trawsfynydd - which account for about 85% of the licensed quantity, had returns data for only a few years. As these licences have no significant impact on resources they were excluded from the analysis.

The following observations are made on the results of the analysis:-

(i) The available returns data is not complete - on average only around 50% of total licensed quantity is accounted for. Annual returns are missing for licences of all sizes;

(ii) In general total abstraction is generally between 30% and 50%;

(iii) The % total licensed quantity accounted for in Public Water Supply, Industrial and Electricity-cooling is generally above 70%. In other uses typically less than 50% of licensed quantity is accounted for;

(iv) The actual abstractions in several categories of use are above 100% of the licensed quantity in odd years, but these occur in very small sample sets;

E.3 ACTUAL ABSTRACTION FACTORS

To estimate the actual abstractions made the percentage of licensed quantity taken, derived from the analysis described above, was used as the basis for setting Actual Abstraction Factors (AAFs) - multipliers to be applied to the total licensed quantity to estimate actual abstraction or gross demand.

It is assumed that in general terms the % taken is indicative of water demand, though clearly the data from which these figures have been derived is not very reliable in many cases.

The Welsh Region of the NRA undertook a similar comparison exercise in 1990 based on 1989/90 returns. The results of analysis undertaken in this study were compared with the NRA analysis and were found to be generally in agreement.

In setting the AAFs the following factors have been taken into account:-

(i) *General* In certain categories of use the proportion of the total licensed quantity accounted for is low and the reliability of the % taken as an indicator of overall demand is therefore poor. In these cases AAFs have been set conservatively or based on results of the NRA's analysis if more reliable;

(ii) *Spray irrigation* Spray irrigators, unlike other licensees, can pay a lower abstraction charge if they abstract less than their annual entitlement. Abstractors are therefore more likely to make a return if they have taken less than their annual entitlement. This introduces bias in the analysis which is likely to result in underestimation of total abstraction. The AAFs for spray irrigation have therefore nominally been set at 10% above calculated % taken figures;

(iii) *Hydroelectricity* It is assumed that the % taken is indicative of abstractions for the three pumped storage schemes excluded from analysis. The returns data for these licences indicates that this is conservative with abstractions in the range 20% to 50%.

(iv) In a few instances % taken exceeds 100% of licensed quantity. Whilst the figure may well be correct in individual licences clearly this is not indicative of overall demand in a particular category of use. In these instances the AAF has been set in line with figures for other years.

The AAFs, set in accordance with the above criteria, are presented in Table E.5.

Table E.1 *Comparison of licensed quantities and actual abstractions for 1981*

Category of use	Total licensed quantity (Ml/a)	Returns data: Licensed quantity (Ml/a)	% Total licensed quantity	Abstracted quantity (Ml/a)	% taken
Surface water					
- Agriculture	55	-	-	-	-
- Amenity/Conservation	1248	382	31	382	100
- Electricity - cooling	1820603	1820608	100	431431	24
- Fish farming	37464	5923	16	7765	131
- Hydroelectricity	691874	541223	78	497744	92
- Industrial	531595	511847	96	346028	68
- Public Water Supply	1055616	837976	79	571835	68
- Private water supply	70	1	2	< 1	26
- Spray Irrigation	3762	1656	44	262	16
- Other	128	53	42	3	5
Groundwater					
- Agriculture	4975	20	1	28	137
- Amenity/Conservation	2	-	-	-	-
- Electricity - cooling	0	-	-	-	-
- Fish farming	249	-	-	-	-
- Hydroelectricity	0	-	-	-	-
- Industrial	22246	18084	81	11373	63
- Public Water Supply	56754	48317	85	31278	65
- Private water supply	443	165	37	108	66
- Spray Irrigation	408	131	32	5	4
- Other	178	82	97	54	66

Table E.2 *Comparison of licensed quantities and actual abstractions for 1986*

Category of use	Total licensed quantity (Ml/a)	Returns data: Licensed quantity (Ml/a)	Returns data: % Total licensed quantity	Returns data: Abstracted quantity (Ml/a)	Returns data: % taken
Surface water					
- Agriculture	77	23	30	0	0
- Amenity/Conservation	2462	2462	100	750	28
- Electricity - cooling	1820608	1820608	100	249941	14
- Fish farming	39537	20591	52	14407	70
- Hydroelectricity	702140	541488	77	214967	40
- Industrial	538201	517628	96	309065	60
- Public Water Supply	1055616	861967	82	573350	66
- Private water supply	75	1	2	1	97
- Spray Irrigation	4891	3827	78	748	19
- Other	261	56	21	3	5
Groundwater					
- Agriculture	5034	103	2	26	25
- Amenity/Conservation	17	-	-	-	-
- Electricity - cooling	0	-	-	-	-
- Fish farming	322	-	-	-	-
- Hydroelectricity	0	-	-	-	-
- Industrial	24551	19453	79	9477	56
- Public Water Supply	66333	56334	85	32957	58
- Private water supply	508	55	11	31	56
- Spray Irrigation	715	543	76	178	33
- Other	179	28	16	12	41

Table E.3 *Comparison of licensed quantities and actual abstractions for 1991*

Category of use	Total licensed quantity (Ml/a)	Returns data: Licensed quantity (Ml/a)	% Total licensed quantity	Abstracted quantity (Ml/a)	% taken
Surface water					
- Agriculture	387	168	43	15	9
- Amenity/Conservation	26183	3190	12	1460	46
- Electricity - cooling	1820608	1818400	100	182093	10
- Fish farming	157286	39373	25	30543	78
- Hydroelectricity	860774	430733	50	295259	69
- Industrial	539909	519462	96	168114	32
- Public Water Supply	1062359	771961	73	462793	60
- Private water supply	207	1	<1	1	81
- Spray Irrigation	6197	4176	67	721	17
- Other	32490	603	2	125	21
Groundwater					
- Agriculture	5524	247	4	32	13
- Amenity/Conservation	37	-	-	-	-
- Electricity - cooling	0	-	-	-	-
- Fish farming	714	73	10	55	75
- Hydroelectricity	-	-	-	-	-
- Industrial	26116	17893	69	8857	50
- Public Water Supply	74582	57871	78	33067	57
- Private water supply	596	154	26	58	38
- Spray Irrigation	914	575	63	189	33
- Other	188	1	<1	<1	67

Table E.4 *Comparison of licensed quantities and actual abstractions for 1992*

Category of use	Total licensed quantity (Ml/a)	Returns data: Licensed quantity (Ml/a)	% Total licensed quantity	Abstracted quantity (Ml/a)	% taken
Surface water					
- Agriculture	387	154	40	21	14
- Amenity/Conservation	28519	5358	19	1955	36
- Electricity - cooling	1820608	1818400	100	270640	15
- Fish farming	163178	50257	31	26158	52
- Hydroelectricity	896138	632365	71	425390	67
- Industrial	540448	521003	96	148038	28
- Public Water Supply	1062392	946517	90	649599	69
- Private water supply	224	13	6	1	10
- Spray Irrigation	6373	4564	72	1183	26
- Other	32492	32226	99	143	0
Groundwater					
- Agriculture	5554	272	5	68	25
- Amenity/Conservation	39	-	-	-	-
- Electricity - cooling	0	-	-	-	-
- Fish farming	714	73	10	0	0
- Hydroelectricity	-	-	-	-	-
- Industrial	26131	18848	72	12981	69
- Public Water Supply	74582	57341	77	33971	59
- Private water supply	611	182	30	85	46
- Spray Irrigation	968	714	74	689	96
- Other	190	1	< 1	< 1	53

Table E.5 *Actual Abstraction Factors*

Source	Purpose	Actual Abstraction Factor			
		1981	1986	1991	1992
Surface Water	Agriculture	65	65	65	65
	Amenity/Conservation	35	28	40	40
	Electricity - cooling	24	14	10	15
	Fish farming	50	50	50	50
	Hydroelectricity	50	40	69	67
	Industrial	68	60	32	28
	Public Water Supply	68	67	60	69
	Private water supply	60	60	60	60
	Spray Irrigation	26	20	27	36
	Other	5	5	1	1
Groundwater	Agriculture	80	80	80	80
	Amenity/Conservation	40	40	40	40
	Electricity - cooling	-	-	-	-
	Fish farming	50	50	50	50
	Hydroelectricity	-	-	-	-
	Industrial	63	49	49	69
	Public Water Supply	65	59	57	59
	Private water supply	60	60	60	60
	Spray Irrigation	30	43	43	96
	Other	50	50	50	50

APPENDIX F

ESTIMATED GROSS ABSTRACTIONS IN SUB-CATCHMENTS

Table F.1 Estimated abstraction in 1993 from groundwater in the Region (Gross daily average Ml/d)

Subcatchment	Use									
	1	2	3	4	5	6	7	8	9	10
Anglesey	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Dee	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Middle Dee	0.2	1.1	6.8	0.1	2.5	0.0	0.3	0.0	0.0	0.0
Lower Dee	0.2	1.8	19.1	0.2	10.3	0.0	0.0	0.0	0.0	0.1
Clwyd	0.0	0.2	10.7	0.0	0.8	0.0	0.0	0.0	0.0	0.0
Conwy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gwrfai	0.0	0.0	0.2	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Dwyfor	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Glaslyn	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Artro, Mawddach	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dysynni	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dyfi, Leri	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rheidol	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aeron, Arth	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Teifi	0.0	0.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N. Pembs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cleddau	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S. Pembs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Taf	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gwendraeth	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Tywi	0.0	0.2	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cothi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gwili	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0
Gower	0.0	0.2	1.4	0.0	0.7	0.0	0.0	0.0	0.0	0.0
Loughor	0.0	0.1	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0
Tawe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Neath	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Afan, Kenfig	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0
Ogmore	0.0	0.0	16.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thaw	0.0	0.1	4.2	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Ely	0.0	0.0	0.0	0.0	5.5	0.0	0.5	0.0	0.0	0.0
Taff	0.0	0.0	0.3	0.0	4.7	0.0	0.1	0.0	0.0	0.0
Rhymney	0.0	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0
Ebbw	0.0	0.0	4.3	0.0	4.4	0.0	0.0	0.0	0.0	0.0
Upper Usk	0.0	0.1	10.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Lower Usk	0.1	0.3	12.9	0.2	0.3	0.0	0.0	0.0	0.0	0.0
Upper Wye	0.0	0.4	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lower Wye	1.1	2.2	18.7	0.1	0.2	0.0	0.0	0.0	0.0	0.0
Lugg	0.6	3.8	6.7	0.1	14.7	0.0	0.0	0.0	0.0	0.1
Monnow	0.1	0.7	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
USE TOTAL	2.6	12.2	120.5	1.0	49.4	0.0	1.0	0.0	0.0	0.3

(shaded) Whole or part of sub-catchment licence-exempt

Categories of use

1 Spray Irrigation
2 Agriculture
3 Public water supply
4 Private water supply
5 Industrial
6 HEP
7 Fish farming
8 Electricity-cooling
9 Amenity/Conservation
10 Others

Table F.2 Estimated abstraction in 1993 from surface water in the Region – excluding tidal abstractions (Gross daily average Ml/d)

Subcatchment	Use									
	1	2	3	4	5	6	7	8	9	10
Anglesey	0.0	0.0	26.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Dee	0.0	0.0	34.7	0.0	0.1	260.2	6.8	0.0	0.2	0.0
Middle Dee	0.4	0.0	35.5	0.0	3.1	0.0	18.8	0.0	0.1	0.0
Lower Dee	0.5	0.0	523.0	0.0	3.5	0.0	0.3	0.0	1.0	0.0
Clwyd	0.2	0.0	9.9	0.0	0.1	0.0	41.0	0.0	0.2	0.0
Conwy	0.0	0.0	25.6	0.0	0.9	281.5	25.0	0.0	0.6	0.9
Gwrfai	0.0	0.0	22.5	0.2	0.1	6351.7	4.8	0.9	1.5	0.0
Dwyfor	0.1	0.0	12.8	0.0	1.4	3.5	0.1	0.0	0.0	0.0
Glaslyn	0.0	0.0	3.7	0.0	0.0	4361.5	0.2	0.0	0.0	0.0
Artro, Mawddach	0.0	0.0	5.6	0.0	0.0	11.6	1.1	0.0	0.0	0.0
Dysynni	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dyfi, Leri	0.0	0.0	5.2	0.0	0.0	15.8	0.3	0.0	0.0	0.0
Rheidol	0.0	0.0	2.5	0.0	0.0	410.5	0.8	0.0	0.0	0.0
Aeron, Arth	0.0	0.0	0.0	0.0	0.3	0.4	0.5	0.0	1.4	0.0
Teifi	0.0	0.2	16.2	0.0	0.1	85.8	2.0	0.0	1.0	0.0
N. Pembs	0.3	0.0	2.2	0.0	0.0	0.5	0.0	0.0	0.2	0.0
Cleddau	0.1	0.0	73.9	0.0	0.2	0.0	50.7	0.0	0.4	0.0
S. Pembs	1.2	0.0	1.2	0.0	0.0	0.0	0.8	0.0	0.0	0.0
Taf	0.0	0.0	0.0	0.0	2.2	0.0	1.3	0.0	0.5	0.0
Gwendraeth	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Upper Tywi	0.0	0.0	32.2	0.0	0.7	0.0	0.0	0.0	0.2	0.0
Cothi	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gwili	0.0	0.0	156.7	0.0	0.3	0.0	0.9	0.0	0.0	0.0
Gower	0.0	0.0	40.4	0.0	4.0	0.0	15.9	0.0	0.6	0.0
Loughor	0.0	0.0	4.7	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Tawe	0.0	0.0	0.0	0.0	11.6	0.0	1.3	0.0	0.0	0.0
Neath	0.0	0.0	13.8	0.0	17.8	82.5	0.0	0.0	0.0	0.0
Afan, Kenfig	0.0	0.0	0.0	0.0	181.6	0.0	0.0	0.0	0.0	0.0
Ogmore	0.0	0.0	5.5	0.0	5.5	0.0	0.0	0.0	0.4	0.0
Thaw	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0
Ely	0.0	0.0	0.3	0.0	5.7	0.0	0.0	0.0	0.0	0.0
Taff	0.0	0.0	191.6	0.0	7.0	0.0	9.1	0.0	0.9	0.0
Rhymney	0.1	0.0	10.1	0.0	1.8	0.0	2.8	0.0	0.1	0.0
Ebbw	0.0	0.0	23.3	0.0	8.5	0.0	0.0	0.0	20.4	0.0
Upper Usk	0.0	0.0	109.5	0.0	0.3	0.0	1.1	0.0	0.0	0.0
Lower Usk	0.1	0.0	191.8	0.0	1.1	0.0	10.0	0.0	0.9	0.0
Upper Wye	0.0	0.0	259.6	0.0	0.0	0.0	3.6	0.0	0.4	0.0
Lower Wye	1.8	0.2	162.8	0.0	6.8	0.0	0.6	0.0	0.2	0.0
Lugg	0.8	0.0	1.8	0.0	0.5	0.0	7.0	0.0	0.1	0.0
Monnow	0.4	0.1	0.0	0.0	0.0	0.0	11.4	0.0	0.0	0.0
Use total	6.3	0.7	2007.0	0.4	268.0	********	218.2	0.9	31.4	0.9

Whole or part of sub–catchment licence–exempt

Categories of use

1 Spray Irrigation
2 Agriculture
3 Public water supply
4 Private water supply
5 Industrial
6 HEP
7 Fish farming
8 Electricity–cooling
9 Amenity/Conservation
10 Others

APPENDIX G

PWS DEMAND FORECASTS FOR SUPPLY ZONES

Table G.1 PWS peak week low growth demand forecast

DWR CYMRU	Baseline 1992			Demand (Ml/d)					
SOUTH EAST DIVISION	Population	Yield	Demand	1996	2001	2006	2011	2016	2021
Southern CUA	1221318	543.2	487.5	460.6	431.5	435.5	445.5	456.7	467.9
Monmouth	11257	4.3	4.5	4.2	4.0	4.0	4.1	4.2	4.3
Hereford CUA	102603	52.7	41.0	38.7	36.3	36.6	37.4	38.4	39.3
Whitborne	8566	8.8	3.4	3.2	3.0	3.1	3.1	3.2	3.3
Leintwardine	1140	1.0	0.5	0.4	0.4	0.4	0.4	0.4	0.4
Alton Court/S.T. Supply	16896	11.3	6.7	6.4	6.0	6.0	6.2	6.3	6.5
Vowchurch & Dorstone	8602	3.1	3.4	3.2	3.0	3.1	3.1	3.2	3.3
Portis/Brecon boreholes	10043	5.8	4.0	3.8	3.5	3.6	3.7	3.8	3.8
Llyswen/Llandeilo Graban	5595	4.0	2.2	2.1	2.0	2.0	2.0	2.1	2.1
Harley Valley/Pilleth&Fairwell	6824	4.1	2.7	2.6	2.4	2.4	2.5	2.6	2.6
Elan CUA	14079	8.8	5.6	5.3	5.0	5.0	5.1	5.3	5.4
POTABLE TOTAL	1406921	647.1	561.5	530.6	497.1	501.7	513.2	526.1	539.0
S. CUA NON-POTABLE		98.7	70.3	70.30	70.30	70.30	70.30	70.30	70.30
DWR CYMRU	Baseline 1992			Demand (Ml/d)					
SOUTH WEST DIVISION	Population	Yield	Demand	1996	2001	2006	2011	2016	2021
Pembs.	118322	45.5	47.2	44.6	41.8	42.2	43.2	44.2	45.3
North Ceredigion	22251	10.8	8.9	8.4	7.9	7.9	8.1	8.3	8.5
Mid&S. Ceredigion	57255	26.1	22.9	21.6	20.2	20.4	20.9	21.4	21.9
Felindre/Schwyll	601302	310.7	240.0	226.8	212.5	214.4	219.3	224.8	230.4
Tonn	2514	0.7	1.0	0.9	0.9	0.9	0.9	0.9	1.0
Ystradfellte	62625	15.2	25.0	23.6	22.1	22.3	22.8	23.4	24.0
POTABLE TOTAL	864269	409.0	345.0	325.9	305.4	308.2	315.3	323.2	331.1
Pembs. non-potable		37.3	29.6	29.6	29.6	29.6	29.6	29.6	29.6
Felindre non-potable		4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4
NON-POTABLE TOTAL		41.7	34.0	34.0	34.0	34.0	34.0	34.0	34.0
DWR CYMRU	Baseline 1992			Demand (Ml/d)					
NORTHERN DIVISION (W)	Population	Yield	Demand	1996	2001	2006	2011	2016	2021
North Eryri/Ynys Mon	123662	65.3	49.4	46.6	43.7	44.1	45.1	46.2	47.4
Nant Peris	120	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cwmystradllyn/Dolbenmaen	21008	12.5	8.4	7.9	7.4	7.5	7.7	7.9	8.0
Llyn Cynwch	3388	2.1	1.4	1.3	1.2	1.2	1.2	1.3	1.3
Barmouth Junction	702	0.6	0.3	0.3	0.2	0.3	0.3	0.3	0.3
Bontddu	231	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Penybont	3538	2.6	1.4	1.3	1.3	1.3	1.3	1.3	1.4
Garreglfwyd	6134	2.9	2.4	2.3	2.2	2.2	2.2	2.3	2.3
Gilfor	5833	3.1	2.3	2.2	2.1	2.1	2.1	2.2	2.2
Rhiwgoch	2015	1.5	0.8	0.8	0.7	0.7	0.7	0.8	0.8
Llyn Bodlyn	3989	2.2	1.6	1.5	1.4	1.4	1.5	1.5	1.5
Y Gaer	1042	1.1	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Dinas Mawddwy	421	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.2
Corris/Pennal	732	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Abergynolwyn	170	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Betws y Coed	540	1.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Dolwyddelan	261	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Capel Curig	451	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2
POTABLE TOTAL	174237	96.5	69.5	65.7	61.6	62.1	63.6	65.2	66.7
DWR CYMRU	Baseline 1992			Demand (Ml/d)					
NORTHERN DIVISION (E)	Population	Yield	Demand	1996	2001	2006	2011	2016	2021
Llanfairfechan	4170	1.5	1.7	1.6	1.5	1.5	1.5	1.6	1.6
Alwen/Bretton	142696	60.8	57.0	53.8	50.4	50.9	52.1	53.4	54.7
Cowlyd	79400	34.2	31.7	29.9	28.1	28.3	29.0	29.7	30.4
Llyn Conwy	6255	3.7	2.5	2.4	2.2	2.2	2.3	2.3	2.4
Llyn Arenig Fawr	3568	2.3	1.4	1.3	1.3	1.3	1.3	1.3	1.4
Glasgoed/Trecastell	76485	35.5	30.5	28.8	27.0	27.3	27.9	28.6	29.3
POTABLE TOTAL	312573	138.0	124.8	117.9	110.4	111.5	114.0	116.9	119.7
NON-POTABLE TOTAL		55.5	33.3	33.3	33.3	33.3	33.3	33.3	33.3
DWR CYMRU TOTAL	Baseline 1992			Demand (Ml/d)					
	Population	Yield	Demand	1996	2001	2006	2011	2016	2021
POTABLE TOTAL	2757999.7	1291	1100.8	1040	974	984	1006	1031	1057
NON-POTABLE TOTAL		196	137.6	137.6	137.6	137.6	137.6	137.6	137.6
WEDWC	Baseline 1992			Demand (Ml/d)					
	Population	Yield	Demand	1996	2001	2006	2011	2016	2021
TOTAL	148020.0	53.8	47.4	49.0	49.9	50.8	51.6	52.4	53.2
CWC	Baseline 1992			Demand (Ml/d)					
	Population	Yield	Demand	1996	2001	2006	2011	2016	2021
TOTAL	107100.0	34.6	32.4	33.8	35.1	36.8	38.6	40.2	42.0

Table G.2 PWS peak week medium growth demand forecast

DWR CYMRU SOUTH EAST DIVISION	Baseline 1992			Demand (Ml/d)					
	Population	Yield	Demand	1996	2001	2006	2011	2016	2021
Southern CUA	1221318	543.2	487.5	462.4	458.3	458.5	472.3	487.4	502.6
Monmouth	11257	4.3	4.5	4.3	4.2	4.2	4.4	4.5	4.6
Hereford CUA	102603	52.7	41.0	38.8	38.5	38.5	39.7	40.9	42.2
Whitborne	8566	8.8	3.4	3.2	3.2	3.2	3.3	3.4	3.5
Leintwardine	1140	1.0	0.5	0.4	0.4	0.4	0.4	0.5	0.5
Alton Court/S.T. Supply	16896	11.3	6.7	6.4	6.3	6.3	6.5	6.7	7.0
Vowchurch & Dorstone	8602	3.1	3.4	3.3	3.2	3.2	3.3	3.4	3.5
Portis/Brecon boreholes	10043	5.8	4.0	3.8	3.8	3.8	3.9	4.0	4.1
Llyswen/Llandeilo Graban	5595	4.0	2.2	2.1	2.1	2.1	2.2	2.2	2.3
Harley Valley/Pilleth&Fairwell	6824	4.1	2.7	2.6	2.6	2.6	2.6	2.7	2.8
Elan CUA	14079	8.8	5.6	5.3	5.3	5.3	5.4	5.6	5.8
POTABLE TOTAL	1406921	647.1	561.5	532.6	528.0	528.2	544.1	561.5	579.0
S. CUA NON-POTABLE		98.7	70.3	72.00	76.20	81.20	86.20	91.20	96.20
DWR CYMRU SOUTH WEST DIVISION	Baseline 1992			Demand (Ml/d)					
	Population	Yield	Demand	1996	2001	2006	2011	2016	2021
Pembs.	118322	45.5	47.2	44.8	44.4	44.4	45.8	47.2	48.7
North Ceredigion	22251	10.8	8.9	8.4	8.4	8.4	8.6	8.9	9.2
Mid&S. Ceredigion	57255	26.1	22.9	21.7	21.5	21.5	22.1	22.8	23.6
Felindre/Schwyll	601302	310.7	240.0	227.6	225.7	225.7	232.5	240.0	247.5
Tonn	2514	0.7	1.0	1.0	0.9	0.9	1.0	1.0	1.0
Ystradfellte	62625	15.2	25.0	23.7	23.5	23.5	24.2	25.0	25.8
POTABLE TOTAL	864269	409.0	345.0	327.20	324.34	324.45	334.24	344.91	355.67
Pembs. non-potable		37.3	29.6	29.60	29.60	29.60	29.60	29.60	29.60
Felindre non-potable		4.4	4.4	4.40	4.40	4.40	4.40	4.40	4.40
NON-POTABLE TOTAL		41.7	34.0	34.00	34.00	34.00	34.00	34.00	34.00
DWR CYMRU NORTHERN DIVISION (W)	Baseline 1992			Demand (Ml/d)					
	Population	Yield	Demand	1996	2001	2006	2011	2016	2021
North Eryri/Ynys Mon	123662	65.3	49.4	46.8	46.4	46.4	47.8	49.4	50.9
Nant Peris	120	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cwmystradllyn/Dolbenmaen	21008	12.5	8.4	8.0	7.9	7.9	8.1	8.4	8.6
Llyn Cynwch	3388	2.1	1.4	1.3	1.3	1.3	1.3	1.4	1.4
Barmouth Junction	702	0.6	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Bontddu	231	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Penybont	3538	2.6	1.4	1.3	1.3	1.3	1.4	1.4	1.5
Garreglwyd	6134	2.9	2.4	2.3	2.3	2.3	2.4	2.4	2.5
Gilfor	5833	3.1	2.3	2.2	2.2	2.2	2.3	2.3	2.4
Rhiwgoch	2015	1.5	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Llyn Bodlyn	3989	2.2	1.6	1.5	1.5	1.5	1.5	1.6	1.6
Y Gaer	1042	1.1	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Dinas Mawddwy	421	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Corris/Pennal	732	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Abergynolwyn	170	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Betws y Coed	540	1.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Dolwyddelan	261	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Capel Curig	451	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2
POTABLE TOTAL	174237	96.5	69.5	66.0	65.4	65.4	67.4	69.5	71.7
DWR CYMRU NORTHERN DIVISION (E)	Baseline 1992			Demand (Ml/d)					
	Population	Yield	Demand	1996	2001	2006	2011	2016	2021
Llanfairfechan	4170	1.5	1.7	1.6	1.6	1.6	1.6	1.7	1.7
Alwen/Bretton	142696	60.8	57.0	54.0	53.6	53.6	55.2	56.9	58.7
Cowlyd	79400	34.2	31.7	30.1	29.8	29.8	30.7	31.7	32.7
Llyn Conwy	6255	3.7	2.5	2.4	2.3	2.3	2.4	2.5	2.6
Llyn Arenig Fawr	3568	2.3	1.4	1.4	1.3	1.3	1.4	1.4	1.5
Glasgoed/Trecastell	76485	35.5	30.5	29.0	28.7	28.7	29.6	30.5	31.5
POTABLE TOTAL	312573	138.0	124.8	118.3	117.3	117.3	120.9	124.7	128.6
NON-POTABLE TOTAL		55.5	33.3	33.30	33.30	33.30	33.30	33.30	33.30
DWR CYMRU TOTAL	Baseline 1992			Demand (Ml/d)					
	Population	Yield	Demand	1996	2001	2006	2011	2016	2021
POTABLE TOTAL	2758000	1291	1100.8	1044	1035	1035	1067	1101	1135
NON-POTABLE TOTAL		196	137.6	139	144	149	154	159	164
WEDWC	Baseline 1992			Demand (Ml/d)					
	Population	Yield	Demand	1996	2001	2006	2011	2016	2021
TOTAL	148020.0	53.8	47.4	49.5	51.0	52.6	54.2	55.7	57.3
CWC	Baseline 1992			Demand (Ml/d)					
	Population	Yield	Demand	1996	2001	2006	2011	2016	2021
TOTAL	107100.0	34.6	32.4	34.0	35.6	37.7	39.9	42.0	44.3

Table G.3 PWS peak week high growth demand forecast

DWR CYMRU	Baseline 1992			Demand (Ml/d)					
SOUTH EAST DIVISION	Population	Yield	Demand	1996	2001	2006	2011	2016	2021
Southern CUA	1221318	543.2	487.5	487.9	490.0	511.1	533.6	556.6	580.2
Monmouth	11257	4.3	4.5	4.5	4.5	4.7	4.9	5.1	5.3
Hereford CUA	102603	52.7	41.0	41.0	41.2	42.9	44.8	46.8	48.7
Whitborne	8566	8.8	3.4	3.4	3.4	3.6	3.7	3.9	4.1
Leintwardine	1140	1.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Alton Court/S.T. Supply	16896	11.3	6.7	6.7	6.8	7.1	7.4	7.7	8.0
Vowchurch & Dorstone	8602	3.1	3.4	3.4	3.5	3.6	3.8	3.9	4.1
Portis/Brecon boreholes	10043	5.8	4.0	4.0	4.0	4.2	4.4	4.6	4.8
Llyswen/Llandeilo Graban	5595	4.0	2.2	2.2	2.2	2.3	2.4	2.5	2.7
Harley Valley/Pilleth&Fairwell	6824	4.1	2.7	2.7	2.7	2.9	3.0	3.1	3.2
Elan CUA	14079	8.8	5.6	5.6	5.6	5.9	6.2	6.4	6.7
POTABLE TOTAL	1406921	647.1	561.5	562.0	564.4	588.8	614.6	641.2	668.3
S. CUA NON-POTABLE		98.7	70.3	73.7	78.7	83.7	88.7	93.7	98.7
DWR CYMRU	Baseline 1992			Demand (Ml/d)					
SOUTH WEST DIVISION	Population	Yield	Demand	1996	2001	2006	2011	2016	2021
Pembs.	118322	45.5	47.2	47.3	47.5	49.5	51.7	53.9	56.2
North Ceredigion	22251	10.8	8.9	8.9	8.9	9.3	9.7	10.1	10.6
Mid&S. Ceredigion	57255	26.1	22.9	22.9	23.0	24.0	25.0	26.1	27.2
Felindre/Schwyll	601302	310.7	240.0	240.2	241.2	251.6	262.7	274.0	285.6
Tonn	2514	0.7	1.0	1.0	1.0	1.1	1.1	1.1	1.2
Ystradfellte	62625	15.2	25.0	25.0	25.1	26.2	27.4	28.5	29.7
POTABLE TOTAL	864269	409.0	345.0	345.3	346.7	361.7	377.6	393.9	410.6
Pembs. non-potable		37.3	29.6	30.7	32.0	33.3	34.6	36.0	37.3
Felindre non-potable		4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4
NON-POTABLE TOTAL		41.7	34.0	35.1	36.4	37.7	39.0	40.4	41.7
DWR CYMRU	Baseline 1992			Demand (Ml/d)					
NORTHERN DIVISION (W)	Population	Yield	Demand	1996	2001	2006	2011	2016	2021
North Eryri/Ynys Mon	123662	65.3	49.4	49.4	49.6	51.7	54.0	56.4	58.7
Nant Peris	120	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Cwmystradllyn/Dolbenmaen	21008	12.5	8.4	8.4	8.4	8.8	9.2	9.6	10.0
Llyn Cynwch	3388	2.1	1.4	1.4	1.4	1.4	1.5	1.5	1.6
Barmouth Junction	702	0.6	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Bontddu	231	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Penybont	3538	2.6	1.4	1.4	1.4	1.5	1.5	1.6	1.7
GarreglIwyd	6134	2.9	2.4	2.5	2.5	2.6	2.7	2.8	2.9
Gilfor	5833	3.1	2.3	2.3	2.3	2.4	2.5	2.7	2.8
Rhiwgoch	2015	1.5	0.8	0.8	0.8	0.8	0.9	0.9	1.0
Llyn Bodlyn	3989	2.2	1.6	1.6	1.6	1.7	1.7	1.8	1.9
Y Gaer	1042	1.1	0.4	0.4	0.4	0.4	0.5	0.5	0.5
Dinas Mawddwy	421	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Corris/Pennal	732	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Abergynolwyn	170	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Betws y Coed	540	1.1	0.2	0.2	0.2	0.2	0.2	0.2	0.3
Dolwyddelan	261	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Capel Curig	451	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2
POTABLE TOTAL	174237	96.5	69.5	69.6	69.9	72.9	76.1	79.4	82.8
DWR CYMRU	Baseline 1992			Demand (Ml/d)					
NORTHERN DIVISION (E)	Population	Yield	Demand	1996	2001	2006	2011	2016	2021
Llanfairfechan	4170	1.5	1.7	1.7	1.7	1.7	1.8	1.9	2.0
Alwen/Bretton	142696	60.8	57.0	57.0	57.2	59.7	62.3	65.0	67.8
Cowlyd	79400	34.2	31.7	31.7	31.9	33.2	34.7	36.2	37.7
Llyn Conwy	6255	3.7	2.5	2.5	2.5	2.6	2.7	2.9	3.0
Llyn Arenig Fawr	3568	2.3	1.4	1.4	1.4	1.5	1.6	1.6	1.7
Glasgoed/Trecastell	76485	35.5	30.5	30.6	30.7	32.0	33.4	34.9	36.3
POTABLE TOTAL	312573	138.0	124.8	124.9	125.4	130.8	136.6	142.5	148.5
NON-POTABLE TOTAL		55.5	33.3	36.4	40.2	44.0	47.8	51.7	55.5
DWR CYMRU TOTAL	Baseline 1992			Demand (Ml/d)					
	Population	Yield	Demand	1996	2001	2006	2011	2016	2021
POTABLE TOTAL	2758000	1291	1100.8	1102	1106	1154	1205	1257	1310
NON-POTABLE TOTAL		196	137.6	145	155	165	176	186	196
WEDWC	Baseline 1992			Demand (Ml/d)					
	Population	Yield	Demand	1996	2001	2006	2011	2016	2021
TOTAL	148020.0	53.8	47.4	50.1	51.5	55.2	57.8	60.2	62.2
CWC	Baseline 1992			Demand (Ml/d)					
	Population	Yield	Demand	1996	2001	2006	2011	2016	2021
TOTAL	107100.0	34.6	32.4	34.5	36.8	39.7	42.8	45.6	47.6

Table G.4 Peak week marginal demands – Low growth forecast

DWR CYMRU S.E. DIVISION	Marginal Demand (Ml/d)					
	1996	2001	2006	2011	2016	2021
Southern CUA	0.0	0.0	0.0	0.0	0.0	0.0
Monmouth	0.0	0.0	0.0	0.0	0.0	0.0
Hereford CUA	0.0	0.0	0.0	0.0	0.0	0.0
Whitborne	0.0	0.0	0.0	0.0	0.0	0.0
Leintwardine	0.0	0.0	0.0	0.0	0.0	0.0
Alton Court/S.T. Supply	0.0	0.0	0.0	0.0	0.0	0.0
Vowchurch & Dorstone	0.1	0.0	0.0	0.0	0.1	0.2
Portis/Brecon boreholes	0.0	0.0	0.0	0.0	0.0	0.0
Llyswen/Llandeilo Graban	0.0	0.0	0.0	0.0	0.0	0.0
Harley Valley/Pilleth&Fairwell	0.0	0.0	0.0	0.0	0.0	0.0
Elan CUA	0.0	0.0	0.0	0.0	0.0	0.0
DIVISION TOTAL	0.1	0.0	0.0	0.0	0.1	0.2
DWR CYMRU S.W. DIVISION	Marginal Demand (Ml/d)					
	1996	2001	2006	2011	2016	2021
Pembs.	0.0	0.0	0.0	0.0	0.0	0.0
North Ceredigion	0.0	0.0	0.0	0.0	0.0	0.0
Mid&S. Ceredigion	0.0	0.0	0.0	0.0	0.0	0.0
Felindre/Schwyll	0.0	0.0	0.0	0.0	0.0	0.0
Tonn	0.2	0.2	0.2	0.2	0.2	0.3
Ystradfellte	8.4	6.9	7.1	7.6	8.2	8.8
DIVISION TOTAL	8.7	7.1	7.3	7.9	8.5	9.1
DWR CYMRU N(W) DIVISION	Marginal Demand (Ml/d)					
	1996	2001	2006	2011	2016	2021
North Eryri/Ynys Mon	0.0	0.0	0.0	0.0	0.0	0.0
Nant Peris	0.0	0.0	0.0	0.0	0.0	0.0
Cwmystradllyn/Dolbenmaen	0.0	0.0	0.0	0.0	0.0	0.0
Llyn Cynwch	0.0	0.0	0.0	0.0	0.0	0.0
Barmouth Junction	0.0	0.0	0.0	0.0	0.0	0.0
Bontddu	0.0	0.0	0.0	0.0	0.0	0.0
Penybont	0.0	0.0	0.0	0.0	0.0	0.0
Garregllwyd	0.0	0.0	0.0	0.0	0.0	0.0
Gilfor	0.0	0.0	0.0	0.0	0.0	0.0
Rhiwgoch	0.0	0.0	0.0	0.0	0.0	0.0
Llyn Bodlyn	0.0	0.0	0.0	0.0	0.0	0.0
Y Gaer	0.0	0.0	0.0	0.0	0.0	0.0
Dinas Mawddwy	0.0	0.0	0.0	0.0	0.0	0.0
Corris/Pennal	0.0	0.0	0.0	0.0	0.0	0.0
Abergynolwyn	0.0	0.0	0.0	0.0	0.0	0.0
Betws y Coed	0.0	0.0	0.0	0.0	0.0	0.0
Dolwyddelan	0.0	0.0	0.0	0.0	0.0	0.0
Capel Curig	0.0	0.0	0.0	0.0	0.0	0.0
DIVISION TOTAL	0.0	0.0	0.0	0.0	0.0	0.0
DWR CYMRU N(E) DIVISION	Marginal Demand (Ml/d)					
	1996	2001	2006	2011	2016	2021
Llanfairfechan	0.1	0.0	0.0	0.0	0.1	0.1
Alwen/Bretton	0.0	0.0	0.0	0.0	0.0	0.0
Cowlyd	0.0	0.0	0.0	0.0	0.0	0.0
Llyn Conwy	0.0	0.0	0.0	0.0	0.0	0.0
Llyn Arenig Fawr	0.0	0.0	0.0	0.0	0.0	0.0
Glasgoed/Trecastell	0.0	0.0	0.0	0.0	0.0	0.0
DIVISION TOTAL	0.1	0.0	0.0	0.0	0.1	0.1
WEDWC	Marginal Demand (Ml/d)					
	1996	2001	2006	2011	2016	2021
Total	0.0	0.0	0.0	0.0	0.0	0.0
CWC	Marginal Demand (Ml/d)					
	1996	2001	2006	2011	2016	2021
Total	0.0	0.5	2.2	4.0	5.6	7.4
REGION TOTAL	9	8	10	12	14	17

Table G.5 Peak week marginal demands – Medium growth forecast

DWR CYMRU S.E. DIVISION	Marginal Demand (Ml/d)					
	1996	2001	2006	2011	2016	2021
Southern CUA	0.0	0.0	0.0	0.0	0.0	0.0
Monmouth	0.0	0.0	0.0	0.1	0.2	0.3
Hereford CUA	0.0	0.0	0.0	0.0	0.0	0.0
Whitbome	0.0	0.0	0.0	0.0	0.0	0.0
Leintwardine	0.0	0.0	0.0	0.0	0.0	0.0
Alton Court/S.T. Supply	0.0	0.0	0.0	0.0	0.0	0.0
Vowchurch & Dorstone	0.2	0.1	0.1	0.2	0.3	0.4
Portis/Brecon boreholes	0.0	0.0	0.0	0.0	0.0	0.0
Llyswen/Llandeilo Graban	0.0	0.0	0.0	0.0	0.0	0.0
Harley Valley/Pilleth&Fairwell	0.0	0.0	0.0	0.0	0.0	0.0
Elan CUA	0.0	0.0	0.0	0.0	0.0	0.0
DIVISION TOTAL	0.2	0.1	0.1	0.3	0.5	0.8
DWR CYMRU S.W. DIVISION	Marginal Demand (Ml/d)					
	1996	2001	2006	2011	2016	2021
Pembs.	0.0	0.0	0.0	0.3	1.7	3.2
North Ceredigion	0.0	0.0	0.0	0.0	0.0	0.0
Mid&S. Ceredigion	0.0	0.0	0.0	0.0	0.0	0.0
Felindre/Schwyll	0.0	0.0	0.0	0.0	0.0	0.0
Tonn	0.3	0.2	0.2	0.3	0.3	0.3
Ystradfellte	8.5	8.3	8.3	9.0	9.8	10.6
DIVISION TOTAL	8.8	8.5	8.6	9.5	11.8	14.1
DWR CYMRU N(W) DIVISION	Marginal Demand (Ml/d)					
	1996	2001	2006	2011	2016	2021
North Eryri/Ynys Mon	0.0	0.0	0.0	0.0	0.0	0.0
Nant Peris	0.0	0.0	0.0	0.0	0.0	0.0
Cwmystradllyn/Dolbenmaen	0.0	0.0	0.0	0.0	0.0	0.0
Llyn Cynwch	0.0	0.0	0.0	0.0	0.0	0.0
Barmouth Junction	0.0	0.0	0.0	0.0	0.0	0.0
Bontddu	0.0	0.0	0.0	0.0	0.0	0.0
Penybont	0.0	0.0	0.0	0.0	0.0	0.0
Garregllwyd	0.0	0.0	0.0	0.0	0.0	0.0
Gilfor	0.0	0.0	0.0	0.0	0.0	0.0
Rhiwgoch	0.0	0.0	0.0	0.0	0.0	0.0
Llyn Bodlyn	0.0	0.0	0.0	0.0	0.0	0.0
Y Gaer	0.0	0.0	0.0	0.0	0.0	0.0
Dinas Mawddwy	0.0	0.0	0.0	0.0	0.0	0.0
Corris/Pennal	0.0	0.0	0.0	0.0	0.0	0.0
Abergynolwyn	0.0	0.0	0.0	0.0	0.0	0.0
Betws y Coed	0.0	0.0	0.0	0.0	0.0	0.0
Dolwyddelan	0.0	0.0	0.0	0.0	0.0	0.0
Capel Curig	0.0	0.0	0.0	0.0	0.0	0.0
DIVISION TOTAL	0.0	0.0	0.0	0.0	0.0	0.0
DWR CYMRU N(E) DIVISION	Marginal Demand (Ml/d)					
	1996	2001	2006	2011	2016	2021
Llanfairfechan	0.1	0.1	0.1	0.1	0.2	0.2
Alwen/Bretton	0.0	0.0	0.0	0.0	0.0	0.0
Cowlyd	0.0	0.0	0.0	0.0	0.0	0.0
Llyn Conwy	0.0	0.0	0.0	0.0	0.0	0.0
Llyn Arenig Fawr	0.0	0.0	0.0	0.0	0.0	0.0
Glasgoed/Trecastell	0.0	0.0	0.0	0.0	0.0	0.0
DIVISION TOTAL	0.1	0.1	0.1	0.1	0.2	0.2
WEDWC	Marginal Demand (Ml/d)					
	1996	2001	2006	2011	2016	2021
Total	0.0	0.0	0.0	0.4	1.9	3.5
CWC	Marginal Demand (Ml/d)					
	1996	2001	2006	2011	2016	2021
Total	0.0	1.0	3.1	5.3	7.4	9.7
REGION TOTAL	9	10	12	16	22	28

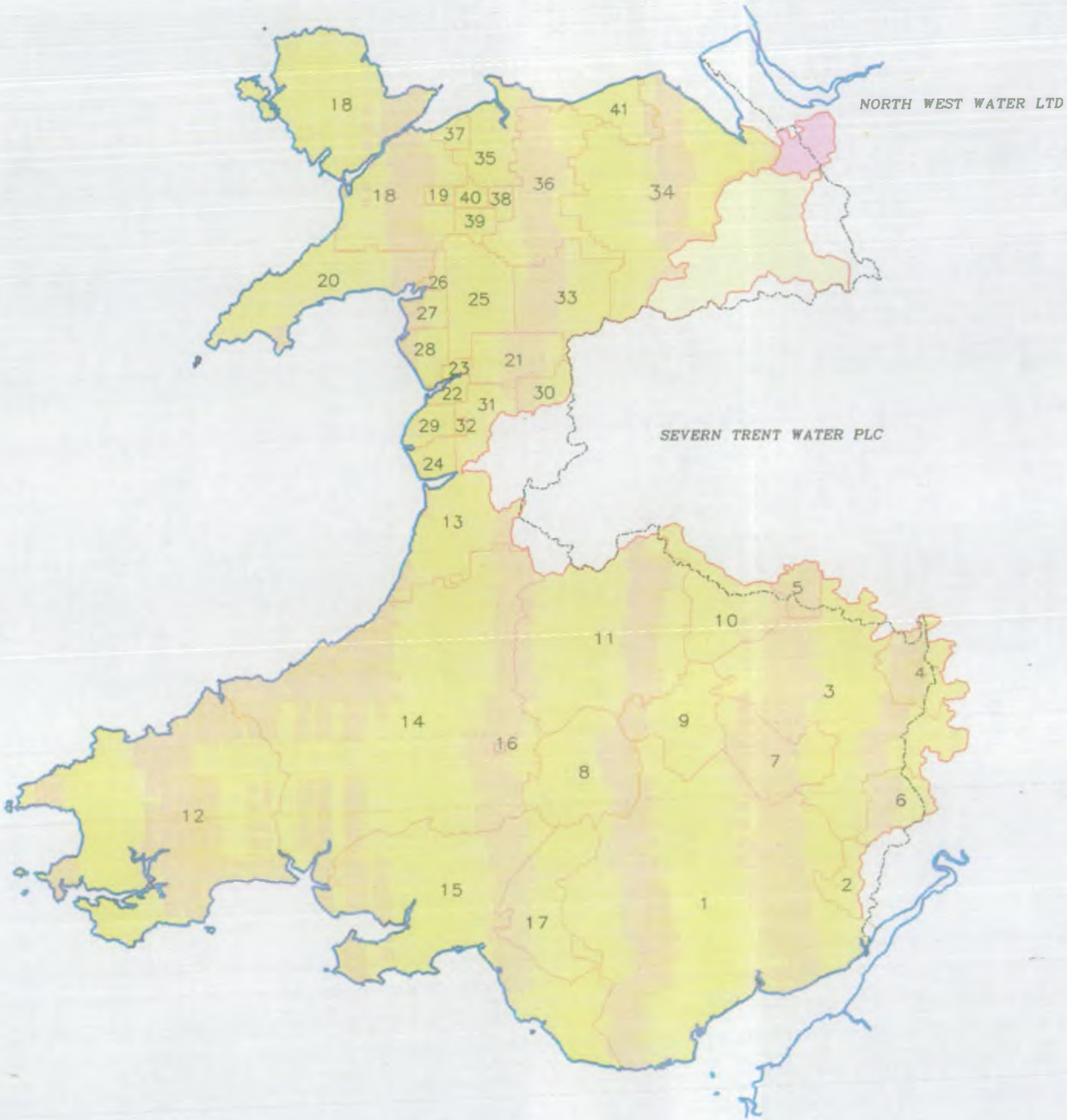
Table G.6 Peak week marginal demands – High growth forecast

DWR CYMRU S.E. DIVISION	Marginal Demand (Ml/d)					
	1996	2001	2006	2011	2016	2021
Southern CUA	0.0	0.0	0.0	0.0	13.4	37.0
Monmouth	0.2	0.2	0.4	0.6	0.8	1.0
Hereford CUA	0.0	0.0	0.0	0.0	0.0	0.0
Whitbome	0.0	0.0	0.0	0.0	0.0	0.0
Leintwardine	0.0	0.0	0.0	0.0	0.0	0.0
Alton Court/S.T. Supply	0.0	0.0	0.0	0.0	0.0	0.0
Vowchurch & Dorstone	0.3	0.4	0.5	0.7	0.8	1.0
Portis/Brecon boreholes	0.0	0.0	0.0	0.0	0.0	0.0
Llyswen/Llandeilo Graban	0.0	0.0	0.0	0.0	0.0	0.0
Harley Valley/Pilleth&Fairwell	0.0	0.0	0.0	0.0	0.0	0.0
Elan CUA	0.0	0.0	0.0	0.0	0.0	0.0
DIVISION TOTAL	0.5	0.6	0.9	1.3	15.0	39.0
DWR CYMRU S.W. DIVISION	Marginal Demand (Ml/d)					
	1996	2001	2006	2011	2016	2021
Pembs.	1.8	2.0	4.0	6.2	8.4	10.7
North Ceredigion	0.0	0.0	0.0	0.0	0.0	0.0
Mid&S. Ceredigion	0.0	0.0	0.0	0.0	0.0	1.1
Felindre/Schwyll	0.0	0.0	0.0	0.0	0.0	0.0
Tonn	0.3	0.3	0.4	0.4	0.4	0.5
Ystradfellte	9.8	9.9	11.0	12.2	13.3	14.5
DIVISION TOTAL	11.9	12.2	15.4	18.7	22.2	26.9
DWR CYMRU N(W) DIVISION	Marginal Demand (Ml/d)					
	1996	2001	2006	2011	2016	2021
North Eryri/Ynys Mon	0.0	0.0	0.0	0.0	0.0	0.0
Nant Peris	0.0	0.0	0.0	0.0	0.0	0.0
Cwmystradllyn/Dolbenmaen	0.0	0.0	0.0	0.0	0.0	0.0
Llyn Cynwch	0.0	0.0	0.0	0.0	0.0	0.0
Barmouth Junction	0.0	0.0	0.0	0.0	0.0	0.0
Bontddu	0.0	0.0	0.0	0.0	0.0	0.0
Penybont	0.0	0.0	0.0	0.0	0.0	0.0
Garregllwyd	0.0	0.0	0.0	0.0	0.0	0.0
Gilfor	0.0	0.0	0.0	0.0	0.0	0.0
Rhiwgoch	0.0	0.0	0.0	0.0	0.0	0.0
Llyn Bodlyn	0.0	0.0	0.0	0.0	0.0	0.0
Y Gaer	0.0	0.0	0.0	0.0	0.0	0.0
Dinas Mawddwy	0.0	0.0	0.0	0.0	0.0	0.0
Corris/Pennal	0.0	0.0	0.0	0.0	0.0	0.0
Abergynolwyn	0.0	0.0	0.0	0.0	0.0	0.0
Betws y Coed	0.0	0.0	0.0	0.0	0.0	0.0
Dolwyddelan	0.0	0.0	0.0	0.0	0.0	0.0
Capel Curig	0.0	0.0	0.0	0.0	0.0	0.0
DIVISION TOTAL	0.0	0.0	0.0	0.0	0.0	0.1
DWR CYMRU N(E) DIVISION	Marginal Demand (Ml/d)					
	1996	2001	2006	2011	2016	2021
Llanfairfechan	0.2	0.2	0.3	0.3	0.4	0.5
Alwen/Bretton	0.0	0.0	0.0	1.6	4.2	7.0
Cowlyd	0.0	0.0	0.0	0.5	2.0	3.5
Llyn Conwy	0.0	0.0	0.0	0.0	0.0	0.0
Llyn Arenig Fawr	0.0	0.0	0.0	0.0	0.0	0.0
Glasgoed/Trecastell	0.0	0.0	0.0	0.0	0.0	0.8
DIVISION TOTAL	0.2	0.2	0.3	2.4	6.6	11.8
WEDWC	Marginal Demand (Ml/d)					
	1996	2001	2006	2011	2016	2021
Total	0.0	0.0	1.4	4.0	6.4	8.4
CWC	Marginal Demand (Ml/d)					
	1996	2001	2006	2011	2016	2021
Total	0.0	2.2	5.1	8.2	11.0	13.0
REGION TOTAL	13	15	23	35	61	99

Note: The limits, including the heights and depths of the Works shown in this drawing are not to be taken as limiting the obligations of the contractor under the Contract.

Designed:	Date:
Checked:	Date:
Traced:	Date:
Checked:	Date:
Reviewed:	Date:

Rev.	Nature of Revision.	Drawn.	Chkd.	Rvwd.	Appd.	Date.



1 – SOUTHERN C.U.A
2 – MONMOUTH
3 – HEREFORD C.U.A
4 – WHITBOURNE
5 – LEINTWARDINE
6 – ALTON COURT / SEVERN TRENT SUP
7 – VOWCHURCH & DORSTONE
8 – PORTIS & BRECON BOREHOLES
9 – LLYSWEN / LLANDEILO GRABAN
10 – HARLEY VALLEY / PILLETH & FAIRWELL
11 – ELAN C.U.A
12 – PEMBROKESHIRE
13 – N. CEREDIGION
14 – MID & S. CEREDIGION
15 – FELINDRE / SCHWYLL
16 – TONN
17 – YSTRADFELLTE
18 – NORTH ERYRI / YNYS MON
19 – NANT PERIS
20 – CWMYSTRADLLYN / DOLBENMAEN
21 – LLYN CYNWCH
22 – BARMOUTH JUNCTION
23 – BONTDDU
24 – PENYBONT
25 – GARREGLLWYD
26 – CILFOR
27 – RHIWGOCH
28 – LLYN BODLYN
29 – Y GAER
30 – DINAS MAWDDWY
31 – CORRIS / PENNAL
32 – ABERGYNOLWYN
33 – LLYN ARENIG FAWR
34 – ALWEN / BRETTON
35 – COWLYD / DULYN
36 – LLYN CONWY
37 – LLANFAIRFECHAN
38 – BETWS-Y-COED
39 – DOLWYDDELAN
40 – CAPEL CURIG
41 – GLASGOED / TRECASTELL

KEY:

Company Areas:
- Dwr Cymru
- Chester Waterworks Co.
- Wrexham & E.Denbighshire Water Co.

- Coastline
- NRA Welsh Region Boundary
- Water Company Supply Boundaries
- 11 Dwr Cymru Water Supply Zones

SCALE 1 : 1,000,000

metres 10000 0 50 100 km

NATIONAL RIVERS AUTHORITY (WELSH REGION)

Regional Water Resources Strategy

Water Company Supply Zones

FIGURE G.1

Contract No.	Approved	Date APRIL 94	Contract drawing no.
BINNIE & PARTNERS CONSULTING ENGINEERS GROSVENOR HOUSE – REDHILL – SURREY		Scale 1:1,000,000	
		Drawing no. 4432/06/01	

g4432d00/wrw/brdc KAL GEMS DEPT 15/4/94

APPENDIX H

PRIVATE DEMAND FORECASTS

Table H.1 Power generation: HEP demands – low growth forecast

Subcatchment	Gross average demand (Ml/d)								
	1981	1986	1991	1996	2001	2006	2011	2016	2021
Anglesey	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Dee	154.8	125.7	265.7	271.9	271.9	271.9	271.9	271.9	271.9
Middle Dee	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lower Dee	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Clwyd	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conwy	167.4	135.9	287.5	494.1	494.1	494.1	494.1	494.1	494.1
Gwrfai	58.2	47.3	100.0	102.3	202.3	302.3	302.3	302.3	302.3
Dwyfor	2.1	1.7	3.6	3.6	3.6	3.6	3.6	3.6	3.6
Glaslyn	203.5	165.2	349.4	657.5	957.5	1157.5	1157.5	1157.5	1157.5
Artro, Mawddach	6.9	5.6	11.9	12.1	12.1	12.1	12.1	12.1	12.1
Dysynni	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dyfi, Leri	9.4	7.7	16.2	116.6	116.6	116.6	116.6	116.6	116.6
Rheidol	244.1	198.2	419.1	428.9	428.9	428.9	428.9	428.9	428.9
Aeron, Arth	0.2	0.2	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Teifi	51.0	41.4	87.6	89.7	89.7	89.7	89.7	89.7	89.7
N. Pembs	0.3	0.2	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Cleddau	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S. Pembs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Taf	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gwendraeth	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Tywi	0.0	0.0	0.0	340.0	340.0	340.0	340.0	340.0	340.0
Cothi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gwili	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gower	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Loughor	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tawe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Neath	49.1	39.9	84.3	86.2	86.2	86.2	86.2	86.2	86.2
Afan, Kenfig	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ogmore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thaw	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ely	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Taff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rhymney	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ebbw	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Usk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lower Usk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Wye	0.0	0.0	0.0	300.0	300.0	300.0	300.0	300.0	300.0
Lower Wye	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lugg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Monnow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LOW FORECAST TOTAL	947.2	769.0	1626.2	2903.9	3303.9	3603.9	3603.9	3603.9	3603.9

Table H.2 Power generation: HEP demands – high growth forecast

Subcatchment	Gross average demand (Ml/d)								
	1981	1986	1991	1996	2001	2006	2011	2016	2021
Anglesey	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Dee	154.8	125.7	265.7	271.9	271.9	271.9	271.9	271.9	271.9
Middle Dee	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lower Dee	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Clwyd	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conwy	167.4	135.9	287.5	494.1	494.1	494.1	494.1	494.1	494.1
Gwrfai	58.2	47.3	100.0	202.3	402.3	502.3	502.3	502.3	502.3
Dwyfor	2.1	1.7	3.6	103.6	303.6	403.6	403.6	403.6	403.6
Glaslyn	203.5	165.2	349.4	757.5	1057.5	1257.5	1257.5	1257.5	1257.5
Artro, Mawddach	6.9	5.6	11.9	12.1	12.1	12.1	12.1	12.1	12.1
Dysynni	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dyfi, Leri	9.4	7.7	16.2	116.6	116.6	116.6	116.6	116.6	116.6
Rheidol	244.1	198.2	419.1	428.9	428.9	428.9	428.9	428.9	428.9
Aeron, Arth	0.2	0.2	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Teifi	51.0	41.4	87.6	89.7	89.7	89.7	89.7	89.7	89.7
N. Pembs	0.3	0.2	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Cleddau	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S. Pembs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Taf	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gwendraeth	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Tywi	0.0	0.0	0.0	340.0	340.0	340.0	340.0	340.0	340.0
Cothi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gwili	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gower	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Loughor	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tawe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Neath	49.1	39.9	84.3	86.2	86.2	86.2	86.2	86.2	86.2
Afan, Kenfig	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ogmore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thaw	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ely	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Taff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rhymney	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ebbw	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Usk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lower Usk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Wye	0.0	0.0	0.0	300.0	300.0	300.0	300.0	300.0	300.0
Lower Wye	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lugg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Monnow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HIGH FORECAST TOTAL	947.2	769.0	1626.2	3203.9	3903.9	4303.9	4303.9	4303.9	4303.9

Table H.3 Industrial demands – low growth forecast

Subcatchment	Gross average demand (Ml/d) 1981	1986	1991	1996	2001	2006	2011	2016	2021
Anglesey	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Dee	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Middle Dee	9.6	8.6	4.8	4.6	4.4	4.1	3.9	3.6	3.4
Lower Dee	17.9	16.0	9.1	8.6	8.1	7.7	7.2	6.8	6.3
Clwyd	1.0	0.9	0.5	0.5	0.5	0.4	0.4	0.4	0.4
Conwy	2.1	1.9	1.1	1.0	1.0	0.9	0.9	0.8	0.8
Gwrfai	0.6	0.5	0.3	0.3	0.3	0.2	0.2	0.2	0.2
Dwyfor	3.3	3.0	1.7	1.6	1.5	1.4	1.3	1.3	1.2
Glaslyn	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Artro, Mawddach	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dysynni	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dyfi, Leri	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Rheidol	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Aeron, Arth	0.7	0.6	0.3	0.3	0.3	0.3	0.3	0.3	0.2
Teifi	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1
N. Pembs	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cleddau	0.4	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1
S. Pembs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Taf	5.2	4.7	2.6	2.5	2.4	2.2	2.1	2.0	1.9
Gwendraeth	0.5	0.5	0.3	0.3	0.2	0.2	0.2	0.2	0.2
Upper Tywi	1.7	1.5	0.8	0.8	0.8	0.7	0.7	0.6	0.6
Cothi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gwili	1.2	1.1	0.6	0.6	0.5	0.5	0.5	0.5	0.4
Gower	10.0	9.0	5.1	4.8	4.6	4.3	4.1	3.8	3.5
Loughor	1.3	1.1	0.6	0.6	0.6	0.5	0.5	0.5	0.4
Tawe	27.2	24.3	13.7	13.0	12.4	11.7	11.0	10.3	9.6
Neath	41.7	37.3	21.1	20.0	19.0	17.9	16.9	15.8	14.7
Afan, Kenfig	426.7	381.3	215.4	204.6	193.8	183.1	172.3	161.5	150.8
Ogmore	12.8	11.5	6.5	6.2	5.8	5.5	5.2	4.9	4.5
Thaw	5.2	4.6	2.6	2.5	2.3	2.2	2.1	2.0	1.8
Ely	18.6	16.6	9.4	8.9	8.5	8.0	7.5	7.1	6.6
Taff	21.0	18.7	10.6	10.0	9.5	9.0	8.5	7.9	7.4
Rhymney	6.4	5.7	3.2	3.0	2.9	2.7	2.6	2.4	2.2
Ebbw	24.1	21.5	12.1	11.5	10.9	10.3	9.7	9.1	8.5
Upper Usk	0.6	0.5	0.3	0.3	0.3	0.3	0.2	0.2	0.2
Lower Usk	2.9	2.6	1.5	1.4	1.3	1.3	1.2	1.1	1.0
Upper Wye	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lower Wye	16.1	14.4	8.1	7.7	7.3	6.9	6.5	6.1	5.7
Lugg	15.3	13.6	7.7	7.3	6.9	6.5	6.2	5.8	5.4
Monnow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LOW FORECAST TOTAL	675.2	603.4	340.8	323.8	306.7	289.7	272.6	255.6	238.6

Table H.4 Industrial demands – high growth forecast

Subcatchment	Gross average demand (Ml/d)								
	1981	1986	1991	1996	2001	2006	2011	2016	2021
Anglesey	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Dee	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Middle Dee	9.6	8.6	4.8	4.8	4.8	4.8	4.8	4.8	4.8
Lower Dee	17.9	16.0	9.1	9.1	9.1	9.1	9.1	9.1	9.1
Clwyd	1.0	0.9	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Conwy	2.1	1.9	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Gwrfal	0.6	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Dwyfor	3.3	3.0	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Glaslyn	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Artro, Mawddach	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dysynni	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dyfi, Leri	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Rheidol	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Aeron, Arth	0.7	0.6	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Teifi	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1
N. Pembs	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cleddau	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2
S. Pembs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Taf	5.2	4.7	2.6	2.6	2.6	2.6	2.6	2.6	2.6
Gwendraeth	0.5	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Upper Tywi	1.7	1.5	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Cothi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gwili	1.2	1.1	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Gower	10.0	9.0	5.1	5.1	5.1	5.1	5.1	5.1	5.1
Loughor	1.3	1.1	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Tawe	27.2	24.3	13.7	13.7	13.7	13.7	13.7	13.7	13.7
Neath	41.7	37.3	21.1	21.1	21.1	21.1	21.1	21.1	21.1
Afan, Kenfig	426.7	381.3	215.4	215.4	215.4	215.4	215.4	215.4	215.4
Ogmore	12.8	11.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
Thaw	5.2	4.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
Ely	18.6	16.6	9.4	9.4	9.4	9.4	9.4	9.4	9.4
Taff	21.0	18.7	10.6	10.6	10.6	10.6	10.6	10.6	10.6
Rhymney	6.4	5.7	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Ebbw	24.1	21.5	12.1	12.1	12.1	12.1	12.1	12.1	12.1
Upper Usk	0.6	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Lower Usk	2.9	2.6	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Upper Wye	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lower Wye	16.1	14.4	8.1	8.1	8.1	8.1	8.1	8.1	8.1
Lugg	15.3	13.6	7.7	7.7	7.7	7.7	7.7	7.7	7.7
Monnow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HIGH FORECAST TOTAL	675.2	603.4	340.8	340.8	340.8	340.8	340.8	340.8	340.8

Table H.5 Spray Irrigation demands – low growth forecast

Subcatchment	Gross average demand (Ml/d)								
	1981	1986	1991	1996	2001	2006	2011	2016	2021
Anglesey	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Dee	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Middle Dee	0.2	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7
Lower Dee	0.2	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8
Clwyd	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Conwy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gwrfai	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dwyfor	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Glaslyn	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Artro, Mawddach	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dysynni	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dyfi, Leri	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rheidol	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aeron, Arth	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Teifi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
N. Pembs	0.1	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.4
Cleddau	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
S. Pembs	0.5	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5
Taf	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gwendraeth	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Tywi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cothi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gwili	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gower	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Loughor	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tawe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Neath	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Afan, Kenfig	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ogmore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thaw	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ely	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Taff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rhymney	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Ebbw	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Usk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lower Usk	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2
Upper Wye	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lower Wye	0.9	1.5	1.7	2.0	2.2	2.4	2.5	2.7	2.9
Lugg	0.4	0.7	0.8	0.9	1.0	1.1	1.2	1.2	1.3
Monnow	0.2	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.6
LOW FORECAST TOTAL	3.0	4.9	5.7	6.3	7.1	7.7	8.2	8.8	9.3

Table H.6 Spray Irrigation demands – high growth forecast

Subcatchment	Gross average demand (Ml/d)								
	1981	1986	1991	1996	2001	2006	2011	2016	2021
Anglesey	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Dee	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Middle Dee	0.2	0.3	0.4	0.7	0.7	0.8	0.9	0.9	1.0
Lower Dee	0.2	0.4	0.5	0.8	0.9	0.9	1.0	1.1	1.1
Clwyd	0.1	0.1	0.2	0.3	0.3	0.3	0.3	0.4	0.4
Conwy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gwrfal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dwyfor	0.0	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2
Glaslyn	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Artro, Mawddach	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dysynni	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dyfi, Leri	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rheidol	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aeron, Arth	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Teifi	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
N. Pembs	0.1	0.2	0.3	0.4	0.5	0.5	0.5	0.6	0.6
Cleddau	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2
S. Pembs	0.5	0.8	0.9	1.5	1.7	1.8	2.0	2.1	2.2
Taf	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gwendraeth	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Tywi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cothi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gwili	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gower	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Loughor	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tawe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Neath	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Afan, Kenfig	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ogmore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Thaw	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Ely	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Taff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rhymney	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Ebbw	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Usk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lower Usk	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3
Upper Wye	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lower Wye	0.9	1.5	1.7	2.9	3.3	3.5	3.8	4.1	4.3
Lugg	0.4	0.7	0.8	1.3	1.5	1.6	1.7	1.8	2.0
Monnow	0.2	0.3	0.4	0.7	0.7	0.8	0.8	0.9	1.0
HIGH FORECAST TOTAL	3.0	4.9	5.7	9.5	10.6	11.5	12.4	13.2	14.0

Table H.7 General agriculture demands – low growth forecast

Subcatchment	Gross average demand (Ml/d)								
	1981	1986	1991	1996	2001	2006	2011	2016	2021
Anglesey	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Dee	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Middle Dee	0.9	0.9	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Lower Dee	1.5	1.5	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Clwyd	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Conwy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gwrfai	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dwyfor	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Glaslyn	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Artro, Mawddach	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dysynni	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dyfi, Leri	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rheidol	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Aeron, Arth	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Teifi	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4
N. Pembs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cleddau	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S. Pembs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Taf	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Gwendraeth	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Upper Tywi	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Cothi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gwili	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gower	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Loughor	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Tawe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Neath	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Afan, Kenfig	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ogmore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thaw	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Ely	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Taff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rhymney	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ebbw	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Usk	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Lower Usk	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Upper Wye	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Lower Wye	2.1	2.1	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Lugg	3.2	3.3	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Monnow	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.8
LOW FORECAST TOTAL	11.0	11.2	12.8	12.8	12.8	12.8	12.8	12.8	12.8

Table H.8 General agriculture demands – high growth forecast

Subcatchment	Gross average demand (Ml/d)								
	1981	1986	1991	1996	2001	2006	2011	2016	2021
Anglesey	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Dee	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Middle Dee	0.9	0.9	1.1	1.1	1.1	1.1	1.2	1.2	1.2
Lower Dee	1.5	1.5	1.8	1.8	1.8	1.9	1.9	2.0	2.0
Clwyd	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Conwy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gwrfai	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dwyfor	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Glaslyn	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Artro, Mawddach	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dysynni	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dyfi, Leri	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rheidol	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Aeron, Arth	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
Teifi	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4
N. Pembs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cleddau	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S. Pembs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Taf	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5
Gwendraeth	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Upper Tywi	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Cothi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gwili	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gower	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Loughor	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Tawe	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
Neath	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Afan, Kenfig	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ogmore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thaw	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Ely	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Taff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rhymney	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ebbw	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Usk	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Lower Usk	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4
Upper Wye	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.5
Lower Wye	2.1	2.1	2.4	2.5	2.5	2.6	2.7	2.7	2.8
Lugg	3.2	3.3	3.8	3.9	3.9	4.0	4.1	4.2	4.3
Monnow	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.9	0.9
HIGH FORECAST TOTAL	11.0	11.2	12.8	13.1	13.4	13.7	14.1	14.4	14.7

Table H.9 Amenity/Conservation demands – low growth forecast

Subcatchment	Gross average demand (Ml/d)								
	1981	1986	1991	1996	2001	2006	2011	2016	2021
Anglesey	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Dee	0.0	0.0	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Middle Dee	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Lower Dee	0.0	0.1	0.9	0.9	1.0	1.0	1.0	1.0	1.0
Clwyd	0.0	0.0	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Conwy	0.0	0.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Gwrfai	0.1	0.1	1.4	1.4	1.4	1.5	1.5	1.5	1.5
Dwyfor	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Glaslyn	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Artro, Mawddach	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dysynni	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dyfi, Leri	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rheidol	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aeron, Arth	0.1	0.1	1.3	1.3	1.3	1.3	1.3	1.4	1.4
Teifi	0.0	0.1	0.9	1.0	1.0	1.0	1.0	1.0	1.0
N. Pembs	0.0	0.0	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Cleddau	0.0	0.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4
S. Pembs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Taf	0.0	0.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Gwendraeth	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Tywi	0.0	0.0	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Cothi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gwili	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gower	0.0	0.0	0.5	0.5	0.5	0.5	0.6	0.6	0.6
Loughor	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tawe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Neath	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Afan, Kenfig	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ogmore	0.0	0.0	0.3	0.3	0.3	0.3	0.3	0.4	0.4
Thaw	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ely	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Taff	0.0	0.1	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Rhymney	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Ebbw	0.8	1.2	18.6	18.9	19.1	19.3	19.6	19.8	20.0
Upper Usk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lower Usk	0.0	0.1	0.8	0.9	0.9	0.9	0.9	0.9	0.9
Upper Wye	0.0	0.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Lower Wye	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Lugg	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Monnow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LOW FORECAST TOTAL	1.2	1.9	28.7	29.1	29.4	29.8	30.1	30.5	30.9

Table H.10 Amenity/Conservation demands – high growth forecast

Subcatchment	Gross average demand (Ml/d)								
	1981	1986	1991	1996	2001	2006	2011	2016	2021
Anglesey	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Dee	0.0	0.0	0.2	0.2	0.2	0.2	0.2	0.3	0.3
Middle Dee	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Lower Dee	0.0	0.1	0.9	1.0	1.0	1.0	1.1	1.1	1.1
Clwyd	0.0	0.0	0.2	0.2	0.2	0.2	0.3	0.3	0.3
Conwy	0.0	0.0	0.6	0.6	0.6	0.6	0.6	0.7	0.7
Gwrfai	0.1	0.1	1.4	1.5	1.5	1.6	1.6	1.7	1.7
Dwyfor	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Glaslyn	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Artro, Mawddach	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dysynni	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dyfi, Leri	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rheidol	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aeron, Arth	0.1	0.1	1.3	1.3	1.4	1.4	1.5	1.5	1.6
Teifi	0.0	0.1	0.9	1.0	1.0	1.1	1.1	1.1	1.2
N. Pembs	0.0	0.0	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Cleddau	0.0	0.0	0.4	0.4	0.4	0.4	0.5	0.5	0.5
S. Pembs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Taf	0.0	0.0	0.5	0.5	0.5	0.5	0.5	0.5	0.6
Gwendraeth	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Tywi	0.0	0.0	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Cothi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gwili	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gower	0.0	0.0	0.5	0.5	0.6	0.6	0.6	0.6	0.6
Loughor	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tawe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Neath	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Afan, Kenfig	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Ogmore	0.0	0.0	0.3	0.3	0.4	0.4	0.4	0.4	0.4
Thaw	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ely	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Taff	0.0	0.1	0.8	0.8	0.8	0.9	0.9	0.9	1.0
Rhymney	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Ebbw	0.8	1.2	18.6	19.3	20.0	20.7	21.4	22.1	22.8
Upper Usk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lower Usk	0.0	0.1	0.8	0.9	0.9	0.9	1.0	1.0	1.0
Upper Wye	0.0	0.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Lower Wye	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.2
Lugg	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Monnow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HIGH FORECAST TOTAL	1.2	1.9	28.7	29.8	30.9	31.9	33.0	34.1	35.2

WATER RESOURCES CONSULTATION DOCUMENT

	MAIN HEADINGS	TOPIC HEADINGS	SUB HEADINGS	MAPS	DIAGRAMS	PHOTOS
IB	**Prologue**	Water & Wales	Celts		Celtic	
IB			Ind Revolution			Mill
IB			Conflict & management			
IB			20th Cent Issues			
IB			This Document			
IB	**Introduction**	About the NRA	Statutory Responsibility	Geography		
IB			Mission Statement			
IB			Role & Water Co's.			
IB		Policies	Striking a balance			
IB			How we manage res's			
IB		Purpose of Document	Asking for comment			
IB		What is Res Planning				
IB		Our Vision				
IB	**About Welsh Region**	History				
RV		Surface Water	Rainfall	Isohyets		
RV			River flows	Rivers		R.Wye
RV		Groundwater	Aquifers	Location		Drill Rig
RV			Exemption			
RV			Baseflows			
RV			Minewaters			Pellenna
RV		Drought				
RV	**Present Water**	Who uses water	PWS * 5		No. Licences	
RV	**Use**		Private		Abstract Q.	
RV			HEP		PWS History	
RV			Transfers			
RV			Agriculture etc.			S.I.
RV			FCRN			Canoe
RV			WQ			
RV	**Safeguarding**	Sustaining Resources				
RV	**the Environment**	ALF				
RV		GPP				
RV		Section 20				Brianne
IB		Licensing Policy				
IB		Establish Min Flows				
IB		Incentive Charges				
IB		Env Appraisal				
RV	**Future Water**	Background Process				
RV	**Use**	Scenario Development				
RV		Growth in Demand	PWS	Reg PWS		
RV		& Deficits	Private			
RV			HEP		Graphs	
RV			Industry		Graphs	Brit Steel
RV			Agriculture		Graphs	
RV			Transfers			
IB		Env Needs (as above)				
IB		National Strategy	Transfers	Nat Map		Craig Goch
IB		Threats	NO3/Climate Change			
IB			Trees/Minewaters			
RV	**Meeting Deficits**	Demand Management	Metering			
RV			Leakage			
RV			Pressure control			
RV			Wammi			
RV		WR Schemes	Engineering Options"			
RV			Imaginative Schemes			
RV		Best Use of Current Schemes				
RV						
IB	**The Way**	Precautionary Principle	Reasonable need			
IB	**Forward**	Env Sustainability	Striking a balance.			
IB		Demand Management				
IB						
RV	**Comments**	Questionnaire				
RV	**Glossary**					

APPENDIX I

LIST OF CONSULTEES

I LIST OF CONSULTEES

I.1 GENERAL

During the course of carrying out this project representatives of the following organisations have been consultees with regard to future demands for water in the Region:-

National Farmers Union
Ministry of Agriculture, Fisheries and Food
Agricultural Development Advisory Service
Associated British Ports
Forest Enterprise
Forest Authority
Shawater Limited
Welsh Office
National Rivers Authority
Wrexham & East Denbighshire Water Co.
Chester Waterworks Co.
Dŵr Cymru
Welsh Tourist Board