NRA-Water Quality 15

# WATER FROM
# THE RIVER DEE
## a working partnership

Chester Waterworks Company

Dŵr Cymru Welsh Water

National Rivers Authority

North West Water Limited

Wrexham & East Denbighshire Water company



CHESTER WATER

DŴR CYMRU WELSH WATER

NRA

North West Water

WREXHAM WATER

# NATIONAL RIVERS AUTHORITY

NRA

## Pollution Control

Protecting the water environment is one of the primary functions of the National Rivers Authority (NRA), ensuring that its quality is safeguarded from new and existing potential sources of pollution. Local Authorities consult with the NRA on any development that could affect the water environment. Discharges of industrial, treated sewage and farm effluents are only allowed under a strict licensing system, under which the NRA sets quality standards, called "consent conditions". Consents are set in order to meet "Environmental Quality Standards". In the case of the River Dee the environmental quality standards need to take into account the uses to which the river is put, for example, as an important fishery and for abstraction to provide the public drinking water supply.

The Water Resources Act (1991) allows the NRA to apply to the government for "Water Protection Zones" to be set up, to control the storage and use of hazardous material, that could pose a threat to water abstracted for public supply. The NRA Welsh Region has already made substantial progess towards the protection of the water supply, by collecting an inventory of all substances contained at industrial sites, within the catchment.

A computer model called PRAIRIE (Pollution Risk from Accidental Influxes to RIvers and Estuaries) has been developed for the River Dee. In its simplest mode, the model can simulate the effects of spillages of different pollutants, from existing industrial sites, or from proposed developments and predict the effect on the water intakes.

Industries which are identified as being a high risk to the potable water abstractors will have to carry out a detailed risk analysis to demonstrate to the NRA that all reasonable measures have been taken to minimise the risk of pollution. The aim is to identify those industries which need to undertake remedial action, in order to control the risk at an acceptable level.

Farming is the largest industry in the River Dee catchment. Modern intensive farming represents the greatest risk to the aquatic environment and the large number of intensive farms in the middle and lower Dee catchment pose a significant risk to the potable water intakes. The Control of Pollution (Silage, Slurry and Agricultural Fuel Oil) Regulation (1991) provide the NRA with the power to insist that remedial measures are carried out to minimise the risk of accidental spillages which could have a serious effect on the aquatic environment. NRA Pollution Control Officers regularly visit farms in the area to inspect storage facilities and advise on pollution prevention measures.

Pollution incidents do, of course, still take place. NRA officers are on stand-by, 24 hours a day and may be contacted via the emergency centre at St. Mellons in Cardiff. In the event of a pollution incident on the River Dee, DEEPOL (Dee Pollution) emergency proceedures are immediately brought into effect. It is the responsibility of the NRA to investigate the source and locate the pollution plume within the river system. A River Dee "Time of Travel" model is used to estimate the time the pollution will arrive at the water intakes. The water companies and other interested bodies, such as local authorities, emergency services and wildlife organisations, are regularly updated on the progress of the pollution, as it travels down the river, in order that they can take any necessary actions. For serious incidents this may involve closing water intakes, or releasing extra water from the upstream reservoirs, to help to wash the pollutant out of the river system.

*National Rivers Authority, Rivers House, St. Mellons Business Park, St. Mellons, CARDIFF.*

NRA

# NATIONAL RIVERS AUTHORITY

## The Dee Regulation Scheme

The River Dee (Afon Dyfrdwy) rises in the mountains of Snowdonia National Park, to the west of Bala Lake (Llyn Tegid). After flowing through a broad valley to Corwen, it tumbles eastwards through the spectacular Vale of Llangollen before breaching the Welsh foothills, near Bangor-on-Dee, and meandering northwards through the Cheshire plain to its tidal limit at Chester Weir.

To those concerned with the management of water resources the River Dee represents an internationally famous example of advanced river basin management. As a result of the Dee Regulation scheme :-

- abstractions in its lower reaches for Public Supply exceed the combined supply of the reservoirs of the English Lake District.
- the frequency of flooding of the low lying land alongside the river below Bala has been reduced.
- proper consideration towards the preservation of the fishery has been achieved.
- recreational activities have been developed at appropriate locations.
- hydro-electric power is generated at Llyn Celyn

### Historical Developments

The natural flows of the River Dee, during dry summer weather, would be insufficient to sustain any significant abstractions; but if excess flood flows can be stored in reservoirs, this water may be released later in dry weather to supplement the low natural river flows, permitting continous abstraction from the river. This is the principle of low-flow regulation, and it was used by Telford as long ago as the beginning of the 19th Century. In order to guarantee a supply of water to the Shropshire Union Canal, Telford constructed sluices at the outlet of Bala Lake. Water released through these sluices was abstracted into the canal where it commences at Horseshoe Falls.

Bala Sluices

The rise in demand for water generated by the Industrial Revolution, and the public health problems of polluted rivers and other traditional local sources near cities, resulted in the construction of numerous reservoirs in natural valleys during the later half of the 19th Century; these were based on the direct supply principle, with the relatively clean upland reservoir water being subject to basic treatment processes before being piped away to the area of supply. The only substantial direct-supply reservoir constructed in the Dee catchment was the Alwen Reservoir, built in the 1920's, which was used originally to supply Birkenhead.

Celyn Reservoir

Many rivers in industrial areas became too polluted by effluents to be usable for water supply, and the relatively small amounts of compensation water discharged to the rivers by the direct-supply reservoirs were insufficient to redress the situation. However, the City of Chester provided a notable exception to this generality, having directly abstracted Dee water since the first Chester Waterworks Company was formed in 1826. This was possible because of the relatively few troublesome effluents in the Dee catchment upstream of Chester.

In the late 1950's the Dee and Clwyd River Board promoted and constructed the Bala Lake Scheme. The natural lake outlet was lowered (Telford's original sluices being by-passed), and new sluice gates were constructed downstream of the confluence with the Afon Tryweryn, a short distance from the lake exit. This provided approximately 18,000,000 $m^3$ (cubic metres) of controllable storage in Bala Lake, which could be operated on a seasonal basis for low-flow regulation to support continuous Dee abstraction totalling 235 Ml/d (Megalitres per day)by six Statutory Water Undertakings and the British Waterways Board. In addition, controlled short term detention of flood run-off from the substantial Bala Lake catchment area greatly reduced the frequency and extent of flooding in the Dee Valley downstream of Bala. In parallel with this development, more stringent standards were imposed on those effluents which discharged to the Dee upstream of Chester Weir.

Over 150 years after Telford's original scheme, the principle of river regulation had been re-established on the Dee. The next development was Llyn Celyn, a new 81,000,000 $m^3$ capacity regulating reservoir within the Bala Lake catchment area, completed in 1965 by Liverpool Corporation, and designed to operate in conjunction with the Bala Lake Scheme. Not only did this support additional Dee abstractions of 327 Ml/d but other significant benefits were additional flood control storage, a near-trebling of the dry-weather flow for most of the length of the river, with a substantial allocation of storage for special releases to the river for water quality or fisheries purposes, a 65% increase in the minimum residual flow over Chester Weir to the Dee Estuary, and a 4 MW (Megawatt) Hydro-electric station at the dam.

In 1973 the Dee and Clwyd River Authority obtained statutory powers to construct another major regulating reservoir in the Brenig valley. Stage 1 of the Brenig project was completed with the first-filling of Llyn Brenig (60,000,000 $m^3$) in spring 1979. The completion of Brenig Stage 1 increased the potential for abstraction from the river in the lower reaches to around 860 Ml/d.

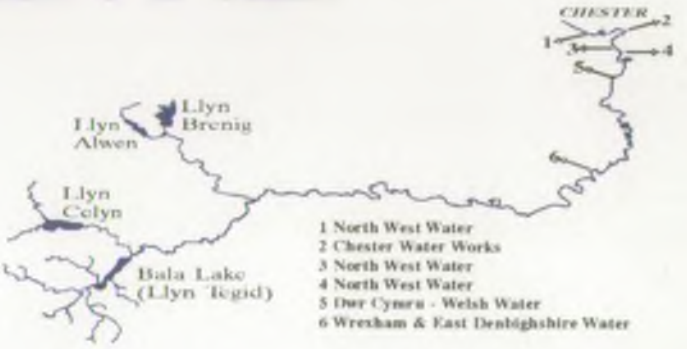
With the reorganisation of the Water Industry in 1989 regulation of the River Dee came under the control of the National Rivers Authority and in 1992 the authorised abstractions by the four statutory undertakings and British Waterways Board were:-

| | |
|---|---|
| North West Water | 709.0 Ml/d |
| Chester Waterworks Company | 34.1 Ml/d |
| Wrexham and E.Denbighshire Water Co. | 34.1 Ml/d |
| British Waterways Board | 28.4 Ml/d |
| Dwr Cymru - Welsh Water | 23.6 Ml/d |

In addition a residual flow of at least 364 Ml/d is maintained over Chester Weir in all but the most testing of droughts, safeguarding the passage of migratory fish, and limiting the ingress of saline water over Chester Weir during high tides.

## Operation of the Regulation Scheme

It is particularly important that the management of the multipurpose Dee river system should maintain a fair balance between many interests, and should be operated without undue constraint from any particular group of users. The Dee and Clwyd River Authority Act 1973 set up a Consultative Committee on which both major abstractors and river interests are represented. The "General Directions", i.e. the complex rules used to operate the system, are prepared with this Committee's advice, and the special conditions for operation in severe droughts require the approval of all members of the Committee.




The Dee regulation Scheme was used for a ten-year national research programme (1966-76), co-ordinated by the Water Resources Board/Water Research Centre, into the specialised problems of river regulation. The research programme included rainfall measurement by radar, fish counting installations, hydrological modelling, reservoir control rules and the development of a computer-based telemetry system.

The telemetry systems currently employed at the Bala control centre, collect information from reservoirs, river flow measuring stations and raingauges; weather radar and satellite pictures are also received to assist the Duty Officers at Bala in deciding upon the most appropriate releases from the reservoirs.

During low flow regulation, water released from the regulating reservoirs takes almost two days (during which rain may occur) to reach the major abstraction points near Chester, yet the accuracy of the measurement and forecasting system is such that less than 5% of the water released in a dry summer is eventually surplus to requirements down-river.

## Facts and Figures

| Reservoir | Catchment Area(km2) | Surface Area(ha) | Capacity ($m3x10^6$) | Average m3/sec | Run-off mm/yr |
|---|---|---|---|---|---|
| Llyn Celyn | 60 | 325 | 81 | 3.10 | 1590 |
| Bala Lake | 262 | 400 | 18 | 11.50 | 1380 |
| Llyn Brenig | 23 | 370 | 60 | 0.62 | 884 |
| Alwen Reservoir | 26 | 150 | 15 | 0.73 | 899 |

The catchment area to Chester Weir is 1816 km2 with an average natural run-off of 36.8 m3/sec (639mm/yr): 16% of this catchment area, and 33% of this run-off, is controlled by the regulating reservoirs.

*National Rivers Authority, Rivers House, St. Mellons Business Park, St. Mellons, CARDIFF.*

# DŴR CYMRU
# WELSH WATER

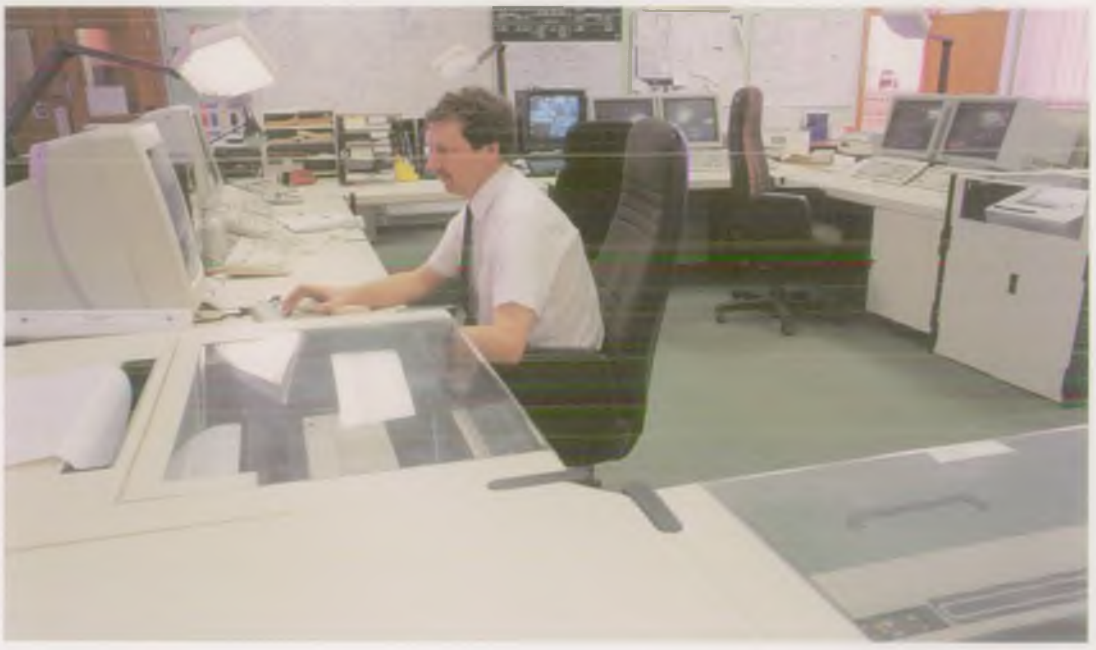
## BRETTON TREATMENT WORKS

**The works is situated near Broughton, some 7.5 km from the abstraction point on the River Dee. Although designed for a peak flow of 49 Ml/d (megalitres per day), average flows are considerably lower because of its combined use with gravity supplies from Alwen Reservoir.**

Together, these two works supply a large part of North East Wales, around 55 Ml/d, with Bretton supplies normally limited to the Deeside area.

At Poulton, river water is drawn through screens, to remove sizeable debris, and pumped to the inlet of the Treatment Works via a 700mm diameter pipeline. Because of the distance involved this can take between two and five hours depending on the rate of pumping.

In addition to the supply from the river, raw water can be drawn from three boreholes in the sandstone aquifer between Bretton and Poulton. They are very limited in quantity and would only be used in the event of an extended closure of the river intake.



DŴR CYMRU
WELSH WATER

# NORTHERN
## *Division*

At Bretton the treatment process consists of:

- **Clarification** - a chemically assisted solids/liquid separation process which removes the bulk of the suspended matter and colour. Additionally powdered activated carbon is used in the clarifiers to remove tastes and odours which can occur with a lowland river like the Dee.
- **Filtration** - a physical process of passing the clarified water through a bed of sand around 1m in depth. They are rapid gravity filters at Bretton and entrain fine suspended matter and carry over particles from the clarifiers.
- **Disinfection** - removal of harmful bacteria. Chlorine is used both before and after filtration with excess levels removed after contact before the water is pumped into the supply system. A small level of chlorine is left in the final water to protect the supply through the tap, which in some cases can take a number of days from the time it leaves the treatment works.

Finally, the acidic nature of the water following filtration is made alkaline to reduce corrosion in the pipework systems, much of it being cast iron.

The various processes are monitored by on-line water quality instruments, and data and alarms are transmitted back to the control room which is manned 24 hours. As well as monitoring and controlling the water treatment works the duty shift controller also operates the telemetry system which, via telephone lines. landlines and radio systems, monitors around 400 remote sites including other water treatment works, pumping stations, service reservoirs and sewage treatment works.

DŴR CYMRU
WELSH WATER

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WREXHAM WATER

WREXHAM AND EAST DENBIGHSHIRE WATER COMPANY

# and The River Dee

## KEY FACTS

| | |
|---|---|
| Area | South East Clwyd (266 sq mls) |
| Population | 150,000 |
| Water Supplied: Treated: Total in gallons | 3,412,000,000 |
| Daily average in gallons | 9,347,000 |
| Untreated:- Total in gallons | 110,600,000 |
| Daily average in gallons | 306,700 |

## RIVER DEE PUMPING STATION

Wrexham Water Company is the first of the abstractors on the River Dee.

Wrexham Water takes on average 65% of their total annual requirement for raw water from the River Dee at Sesswick near to Bangor on Dee. The remainder is supplied through a network of impounding reservoirs and springs. Water from the intake passes firstly through a roughing screen and then a fine band screen, this is a continually rotating mesh which filters out debris such as leaves and twigs.

The water is then pumped utilizing two of the four available high lift centrifugal pumps to the Marchwiel reservoir. Each pump is powered by a 450 horsepower electric motor.

The Marchwiel reservoir as a strategic reserve of raw water, available to even out variations in quality of the raw water and to allow the works at Sesswick to be closed down for maintenance. In the event of a suspected or actual pollution of the River Dee, Marchwiel reservoir can provide a four day strategic reserve of raw water.

Water from Marchwiel is passed to either the Llwyn Onn or Legacy treatment works or it can be utilised to provide factories on the Wrexham Industrial Estate with untreated water for boiler water cooling or washing purposes.

## TREATMENT OF WATER

The goal of a water supply system is to produce an adequate supply of pure and palatable water having the following characteristics:-

| | |
|---|---|
| Clarity | - Free from turbidity and colour. |
| Palatability | - No objectionable taste or odour. |
| Potability | - Free from bacteria, viruses and harmful minerals. |

# WREXHAM WATER

WREXHAM AND EAST DENBIGHSHIRE WATER COMPANY

Water from the River Dee must undergo very intensive treatment before it can satisfy the drinking water standards. Both Legacy and Llwyn Onn treatment works operate the same treatment process.

This consists of the addition of chemicals to release the impurities from the water into a "floc", similar to snow flakes. This "floc" is then separated out of the water by using the dissolved air flotation process. Microscopic bubbles of air are introduced into the stream of water, they attach themselves to the "floc" particles and float to the surface forming a blanket above the clarified water. This blanket is regularly scraped off and pumped away for dewatering and drying prior to disposal.

Clarified water from below the "floc" blanket passes onto the rapid gravity filters. These consist of eight reinforced concrete tanks, containing approximately one metre of filtering media suspended above a collection chamber.

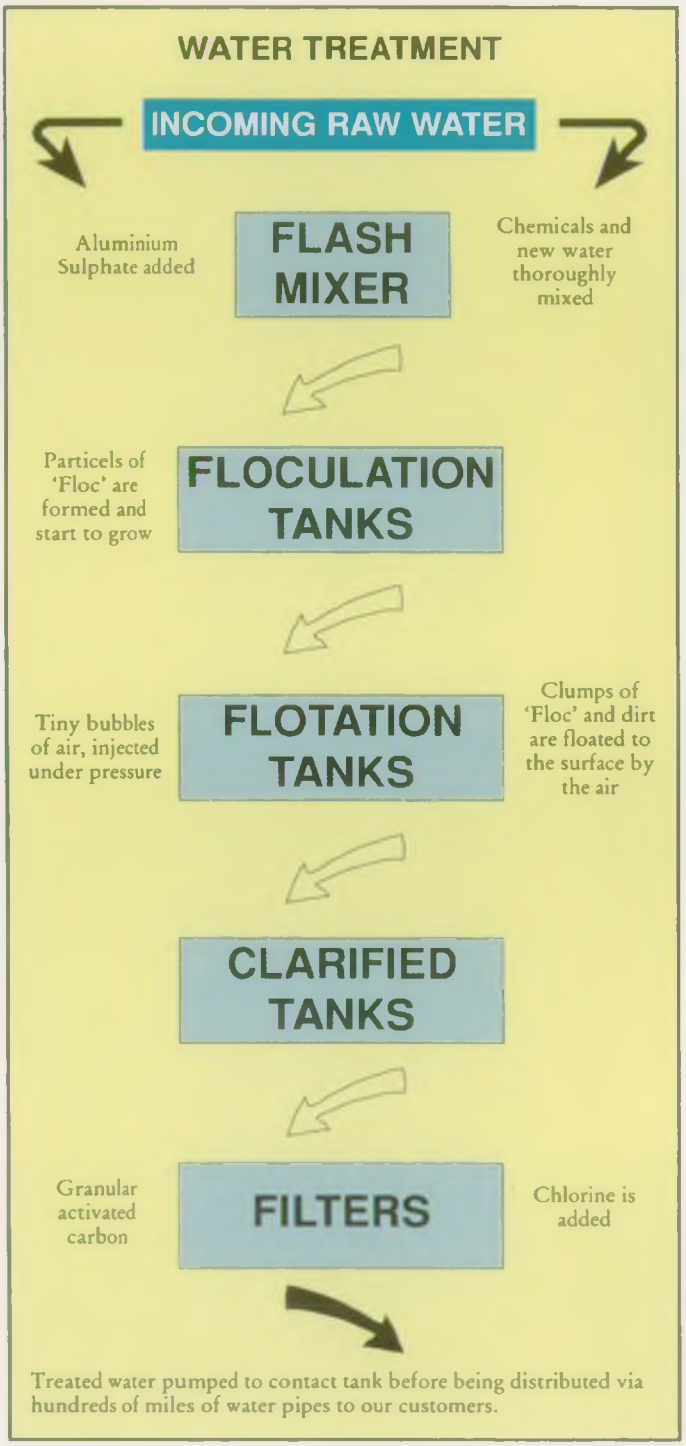
At Wrexham Water, we utilize granular activated carbon as the filtration medium. This has the advantage of removing taste and odours from the water.

Clean filtered water is then sterilized with chlorine, prior to transmission to a contact tank which allows sufficient retention time for the chlorine to be effective in removing any bacteria.

Before we finally pump the water out to our customers we remove any excess chlorine from the water and adjust the acidity using Lime. This reduces the risk of the water corroding the metallic and lead pipes in the distribution system.

Drinking water in our 266 square miles of supply is distributed to customers through 880 miles of mains.

**Wrexham Water became the first water company in Europe to obtain the Quality Standard BS5750 for its water supply and treatment of water.**





WREXHAM WATER

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# CHESTER WATERWORKS COMPANY
## BOUGHTON TREATMENT WORKS
## *GENERAL DISCRIPTION*

Raw or untreated water is abstracted from the River Dee at the intake opposite Barrelwell Hill Pumping Station. This intake, constructed partly underground to blend in with the natural surroundings, is protected by a floating oil boon and a vertical bar screen. These prevent oil and larger debris from entering. Inside the intake itself are two rotating band screens which act like sieves to remove finer material, such as leaves, from the water.

From the intake the water flows by gravity along two mains under the river to the suction wells at Barrelwell Hill Pumping station. There are four centrifugal pumps, three of different fixed speeds and one variable speed that pump the water up to the treatment works via one of the two raw water mains that could be used.

The two raw water mains join together inside the Boughton Treatment Works prior to entering the Inlet House at the South Raw Water Reservoir. Here aluminium Sulphate is added to the incoming water flow, as a coagulant, to bind the fine silts and materials present in the water together, for ease of removal.

The alum-dosed water flows into the South Reservoir after passing through the dissolved Air Flotation Plant. Water and alum enters floculation chambers each containing a paddle rotating slower than the proceeding one to help mix the alum and enhance "floc" formation - the "binding" process.

The water containing the floc/suspended solids passes into six flotation chambers via a distribution channel and is mixed with air-saturated water at the entry beneath a submerged baffle. The water then undergoes a sudden drop in pressure as it mixes with the main flow and releases micro air bubbles that attach themselves to the floc particles, floating them to the surface of each tank where they are removed as sludge by scrapers.

The air-saturated water is produced by taking clarified water from the outlet of the Flotation Plant through recycling pumps and into the saturators. Water and compressed air are passed through a medium of plastic elements to form the air-saturated solution.

With the bulk of the suspended solids removed, the water has now been clarified to some extent and normally passes into the South Raw Water Reservoir, although it can be bypassed. From this point the water flows by gravity into the next reservoir.

As the water flows into the East Reservoir, there is provision to dose with Activated Carbon. Activated Carbon is used to remove taste and odour which can occur from time to time. From the East Reservoir it flows into the North and Mid Reservoirs.

The capacity of the holding, or "raw" water, reservoirs is 115 megalitres (25 million gallons) which allows the Works to continue to supply treated water for over four days without taking river water into the plant.

This allows a measure of security in the event of a pollution incident when the intake would be closed.

Still flowing by gravity the water passes on to the battery of 14 Rapid Gravity Primary Filters. If the reservoir levels are low, flow is maintained by two vertical spindle pumps onto the Rapid Filters. Each of the filters contains a layer of Leighton Buzzard high silica sand supported on graded gravel.

# CHESTER WATERWORKS COMPANY
## BOUGHTON TREATMENT WORKS

These filters remove the remaining suspended solids from the water. The "rapid" flow through the filters results in their having a "life" of about two/three days before being cleaned by air scour and back washing manually.

The outlet from the Rapid Filters splits the flow two ways. About 60% goes on to the Slow Sand Filters and 40% to the Pressure Filters.

The Slow Sand Filters have a filtering medium of specially selected sand supported gravel on perforated collection channels.

The flow rate through the filter is, as the name suggests, much slower than the Rapid Filters and hence a special skin of algae protozoa and aquatic life builds up on the surface of the filter bed.

This skin or zoogleal layer actually filters bacteria out of the water passing through the filter making the filtering action biological. Filtered water, from all the slow sand filters, of high bacterial purity comes together to the Constant Rate Well where normally disinfection by automatic chlorination takes place.

The remaining 40% of the Water leaving the primary filters goes to the Pressure Filters.

These are arranged in four banks of six consisting of a steel cylindrical tank packed with specially selected sand. Up to four pumps force the water from the primary filter into the top of each pressure filter with a small dose of chlorine added to prevent any bacterial growth. The sand media is agitated during washing and the waste water is pumped to the canal adjacent to the Works.

Pressure filtered water and the chlorinated slow sand filtered water from the Constant Rate Well combine in the terminal Treatment Well. Delivery from the Constant Rate Pump is available through a speed controller to match the inflow of water from the filters.

Final pH adjustment is made in the Terminal Treatment Well by the dosing of an automatically batch prepared suspension of water and lime.

The water then flows through a cascade of Pure Water Reservoir. At the inlet to the first reservoir the water is monitored for pH and Chlorine Residual. Flow is also measured and the signal sent to the Ammonia Dosing Plant.

Ammonia is added to the main flow at the outlet of the first reservoir to form chloramines, which ensures continued disinfection of the water when sent out to supply. The dose rate is initially set by fixing the pump stroke and any subsequent changes in flow rate against the speed of the pump proportionally. The level of chloramination can be measured at the outlet of the second reservoir and at the Works outlet pipes to supply.

Water is drawn from the reservoirs into a common suction line from where lift pumps take it and discharge it to supply. Final water quality monitoring takes place in the common delivery line.

Connected to the discharge pipe network is a large water tower 175 feet above ordnance datum. It holds over a quarter of a million gallons and acts as a balancing tank for the area supplied with River Dee water. To cope with other local demands there are towers at Overleigh and Hawarden and a Pure Water Service Reservoir at Pipers Ash.

The Works supply an average of 27 megalitres (6 million gallons) per day of treated water derived from the River Dee to its customers. There is sufficient capacity within the Works to increase its sustained supply rate to 34 megalitres per day (7.5 million gallons).

The plant is controlled by a single operator in the Control Room, situated in the "Engine House" on a round-the-clock shift basis. All essential plant operations are remotely controlled from the Control Room, extensive use being made of floodlights and video cameras. Engineering and maintenance staff are available on call-out, but otherwise work normal hours.

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# Water from the River Dee

## North West Water supplies 709 megalitres per day to over 2 million customers in Cheshire and Merseyside. This represents about 25% of the water which the company supplies throughout the region.

North West Water is the biggest abstractor of water from the Dee. Other companies with authorisation to abstract from the river are Chester Waterworks Company, Wrexham Water Company, the British Waterways Board and Welsh Water. Each company must inform the National Rivers Authority in Bala of the amount of water it requires as the flow into the River Dee is controlled by them.

Water is pumped out of the river by North West Water at three abstraction points: Huntington, Heronbridge and Deeside. At Huntington it flows directly into a treatment works which is one of the largest in Britain with a total capacity of 400 megalitres per day.

Heronbridge supplies Welsh Water with an average of 30 megalitres per day for industrial use. The water from Deeside pumping station and the remaining water from Heronbridge joins up and is pumped to Sutton Hall Water Treatment Works which like Huntington is a modern plant staffed by skilled operations controllers. Approximately 70 megalitres per day of this non potable water is drawn off on its way to Sutton Hall for use by industry in Ellesmere Port and BNFL at Capenhurst.

Huntington Water Treatment Works, Chester, supplies 400 megalitres (91 million gallons) of water every day.

The Sutton Hall Water Treatment Works was built in the 1950s after it became clear that the Wirral could no longer rely on the reservoir at Alwen in North Wales to meet its water requirements. On completion in 1957, Sutton Hall had a capacity of 27 megalitres (6 million gallons) per day. It has since been extended on three occasions and now supplies 120 - 125 megalitres (27 - 28 million gallons) per day.

The seasons and the weather make river water very changeable. At Sutton Hall this water is initially pumped to a storage reservoir to help settle turbidity. Next in the mixing chamber it is dosed with chemicals. Aluminium sulphate, referred to as alum, is used to encourage the small particles to stick together and form larger ones which are more likely to precipitate out of the water. Lime is used to adjust the pH to the correct level of acidity. Polyelectrolyte is also added. This is a mixture of various chemicals which helps the coagulated particles to form what is known as a sludge blanket.

The next stage after the mixing chamber is the sedimentation or settling tanks. The water is pushed up through a suspended blanket of sludge and the particles of dirt remain in this blanket. The blanket is suspended above a cone containing a valve which opens when the blanket becomes too heavy and the sludge is carried off to on-site sludge lagoons. The clarified water then passes to large open concrete tanks containing layers of graded gravel and sand known as rapid gravity filters. At Sutton Hall and Huntington these beds are packed with granular activated carbon which deals with taste and odour problems. After about 24 hours the beds become clogged with particles and the filtration rate decreases leading to a build-up of pressure. At this point the filters are taken out of service and the inlet closed off allowing the remaining water to drain away. Air is firstly blown up through the beds and this is followed by an upward flow of treated water which allows dirt to float to the surface, overflow and be carried away to the sludge lagoons.

The final stage of the treatment occurs in the contact tanks where the water is disinfected with chlorine and again pH adjusted with lime. On leaving the contact tanks the water is dosed with sulphur dioxide to bring down the level of residual free chlorine so that it is sufficient to maintain the bacteriological quality of the water in the distribution system without leaving an upleasant taste.

The treated water leaves Sutton Hall via two pump houses. One of these supplies water to Heswall, Ellesmere Port and Bromborough. The other pump house, via the Mid Wirral 36" Trunk Main, pumps the water to Crosshill Reservoir which supplies the rest of the Wirral. Before it enters the reservoir it receives secondary disinfection, that is to say that it is dosed with chlorine again to ensure that there is still some free chlorine in the pipes when the water is distributed.

The total population supplied by Sutton Hall either directly or via Crosshill Reservoir is 406,000.

From Victorian days Liverpool had taken most of its water from Lake Vyrnwy in North Wales and from the reservoirs at Rivington near Bolton. By 1959 these sources were no longer sufficient for the needs of the city and the surrounding districts.

In that year work began at the new plant at Huntington in Chester. Commissioned in 1963, it initially supplied 146 megalitres (32 million gallons) daily; since then two further phases have been added and the plant now has a peak daily capacity of 400 megalitres (91 million gallons).

Huntington takes water from the Dee through a concrete structure incorporating a river boom, fixed coarse screens and an electric fish screen. The average depth of the river is 15 feet; in summer Huntington abstracts about 40 per cent of the river flow. Raw water is delivered from the intake pumping station to the treatment works via 1km of twin, 60" diameter, steel pipelines.

After being dosed with chemicals in the mixing chambers, the water passes through ten upward flow settling tanks, comprising of two superpulsators and eight accentrifloc clarifiers. These remove turbidity and colour using the same principles as at Sutton Hall. The chemicals added cause the particles to stick together producing a floc. On settling a sludge blanket is formed which can be removed and disposed of. The clarified water passes through 38 rapid gravity filters, containing granular activated carbon, similar to those found at Sutton Hall.

Final pH correction and adjustment of chlorine levels to 0.6mg/l is carried out as the water gravitates down through two contact tanks to the high lift pumping station. Here the water is fed into the supply network.

Twin pipelines of 60" and 72" diameter take the treated water to Norton Tower 15 miles away. At Norton Tower the pipelines reduce to a single 72" pipe, running in parallel with the three pipelines from Vyrnwy Aqueduct. All four aqueducts terminate at Prescot Reservoirs a further nine miles away.

Huntington serves a total population of 1.7 million and supplies the following areas with water: North Liverpool, Runcorn, Widnes, Warrington, Speke and St Helens.

Both Sutton Hall and Huntington have advanced technology. Every stage of the treatment process is computer-controlled and modern laboratories monitor samples constantly to ensure that the water is of the highest quality.

North West Water

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# AWDURDOD AFONYDD CENEDLAETHOL

AAC

## Rheoli Llygredd

Mae gwarchod yr amgylchedd dŵr yn un o brif swyddogaethau'r Awdurdod Afonydd Cenedlaethol (AAC), gan sicrhau y diogelir ei ansawdd rhag llygredd o ffynonellau hen a newydd. Bydd yr Awdurdodau Lleol yn ymgynghori â'r AAC ar unrhyw ddatblygiad a allai effeithio ar yr amgylchedd dŵr. Ni chaniateir arllwysiadau o elifiannau diwydiannol, carthion wedi'u trin nac elifiannau amaethyddol ond o dan gyfundrefn drwyddedu lem, lle mae'r AAC yn gosod safonau ansawdd a elwir yn "amodau caniatâd". Rhaid bodloni "Nodau Ansawdd Dŵr" cyn y bydd caniatâd yn cael ei roi. Yn achos Afon Dyfrdwy mae angen i'r nodau ansawdd dŵr gymryd i ystyriaeth y defnydd a wneir o'r afon, er enghraifft, fel pysgodfa bwysig ac ar gyfer darparu cyflenwadau dŵr yfed.

Mae'r Ddeddf Adnoddau Dŵr (1991) yn caniatâu i'r AAC wneud cais i'r llywodraeth dros sefydlu "Cylchfaoedd Gwarchod Dŵr" er mwyn rheoli storio a defnyddio sylweddau peryglus a allai fod yn fygythiad i dyniadau dŵr at y cyflenwad cyhoeddus. Mae Rhanbarth Cymru o'r AAC eisoes wedi cymryd camau pwysig tuag at warchod y cyflenwad dŵr drwy lunio rhestr o'r holl sylweddau hysbys a geir mewn safleoedd diwydiannol o fewn dalgylch. Mae model cyfrifiadur o'r enw PRAIRIE (Perygl Llygredd oddi wrth Fewnlifoedd Damweiniol i Afonydd ac Aberoedd) wedi cael ei ddatblygu ar gyfer Afon Dyfrdwy. Yn ei ffurf symlaf gall y model efelychu a rhagweld effeithiau gwahanol lygryddion os collir hwy i'r afon o safleoedd diwydiannol neu o ddatblygiadau arfaethedig.

Bydd yn rhaid i ddiwydiannau a allai fod yn fygythiad arbennig i dynwyr dŵr yfed wneud dadansoddiad manwl o'r peryglon er mwyn dangos i'r AAC eu bod wedi cymryd pob cam posibl i leihau'r perygl o lygredd. Y nod yw darganfod y diwydiannau y mae angen iddynt gymryd mesurau cywiro er mwyn dod â'r bygythiad i lefel dderbyniol.

Ffermio yw'r diwydiant mwyaf yn nalgylch Afon Dyfrdwy. Ffermio modern dwys yw'r bygythiad mwyaf i'r amgylchedd dŵr ac mae'r nifer fawr o ffermydd dwys yng nghanol ac yng ngwaelod dalgylch Afon Dyfrdwy yn fygythiad sylweddol i dyniadau dŵr yfed. Mae'r Rheoliadau Rheoli Llygredd (Silwair, Slyri ac Olew Tanwydd Amaethyddol) (1991) yn rhoi awdurdod i'r AAC fynnu bod mesurau cywiro'n cael eu rhoi ar waith er mwyn lleihau'r perygl o golledion damweiniol a allai gael effaith niweidiol ar yr amgylchedd dŵr. Bydd Swyddogion Rheoli Llygredd yr AAC yn ymweld yn gyson â ffermydd yn yr ardal i archwilio'r cyfleusterau storio ac i gynnig cyngor ar fesurau atal llygredd.

Ond mae achosion o lygredd yn dal i ddigwydd wrth gwrs. Mae swyddogion yr AAC ar gael 24 awr y dydd a gellir cysylltu â hwy drwy'r ganolfan argyfwng yn Llaneirwg, Caerdydd. Pe ceid achos o lygredd damweiniol yn Afon Dyfrdwy byddai trefniadau argyfwng DEEPOL (Llygredd Afon Dyfrdwy) yn dod i rym yn syth. Cyfrifoldeb yr AAC yw archwilio'r ffynhonnell a lleoli'r llygredd o fewn yr afon. Defnyddir model "Amser Teithio" Afon Dyfrdwy i amcangyfrif faint o amser a gymerai i'r llygredd gyrraedd y mannau tynnu dŵr. Bydd y cwmnïau dŵr a chyrff eraill sydd â diddordeb, megis awdurdodau lleol, gwasanaethau argyfwng a sefydliadau bywyd gwyllt, yn cael eu hysbysu'n gyson o hynt y llygredd wrth iddo deithio i lawr yr afon, er mwyn iddynt allu cymrud unrhyw gamau angenrheidiol. Yn achos digwyddiadau difrifol gallai hyn olygu cau mannau tynnu dŵr neu ollwng rhagor o ddŵr o gronfeydd yn uwch i fyny'r afon er mwyn helpu i olchi'r llygredd o'r afon.

*Yr Awdurdod Afonydd Cenedlaethol, Plas-yr-Afon, Parc Busnes Llaneirwg, Llaneirwg, CAERDYDD.*

# AWDURDOD AFONYDD CENEDLAETHOL

AAC

## Cynllun Rheoli Afon Dyfrdwy

Mae Afon Dyfrdwy yn tarddu ym mynyddoedd Parc Cenedlaethol Eryri, i'r gorllewin o Lyn Tegid. Ar ôl llifo drwy ddyffryn llydan i Gorwen mae'n troi i'r dwyrain drwy harddwch Dyffryn Llangollen cyn cyrraedd godreon mynyddoedd Cymru ger Bangor-Is-Coed a throelli i'r gogledd drwy wastadedd Swydd Gaer nes cyrraedd ei therfyn llanw yng Nghored Caer.

I'r sawl sy'n ymwneud â rheoli adnoddau dŵr, mae Afon Dyfrdwy yn enghraifft fyd-enwog o reolaeth soffistigedig ar fasn afon. O ganlyniad i Gynllun Rheoli Afon Dyfrdwy :-
- mae'r tyniadau yn ei rhannau isaf at y Cyflenwad Cyhoeddus yn fwy na chronfeydd dŵr Ardal y Llynnoedd gyda'i gilydd.
- Mae achosion o lifogydd yn y tir isel ar hyd yr afon islaw'r Bala wedi lleihau.
- llwyddwyd i feithrin ystyriaeth briodol at ddiogelu'r bysgodfa.
- datblygwyd gweithgareddau amser hamdden mewn mannau priodol.
- cynhyrchir pŵer trydan-dŵr yn Llyn Celyn.

### Datblygiadau Hanesyddol

Ni fyddai llif naturiol Afon Dyfrdwy yn gallu cynnal unrhyw dyniadau sylweddol yn ystod tywydd sych yr haf, ond pe gellid storio dŵr o lifogydd mewn cronfeydd byddai modd ei ollwng yn ystod tywydd sych i ychwanegu at lifau isel naturiol yr afon gan ei gwneud yn bosibl i dynnu dŵr ohoni'n barhaus. Dyma egwyddor rheolaeth lif-isel, ac fe'i defnyddiwyd gan Telford mor bell yn ôl a dechrau'r 19eg Ganrif. Adeiladodd Telford lifddorau yn allfa Llyn Tegid er mwyn gallu cael cyflenwad sicr o ddŵr i Gamlas y Shropshire Union. Byddai'r dŵr a ollyngid drwy'r llifddorau hyn yn mynd i mewn i'r gamlas lle mae'n dechrau yn 'Horseshoe Falls'.


Llifddorau Bala

Gyda'r cynnydd yn y galw am ddŵr yn sgîl y Chwyldro Diwydiannol, a'r problemau i iechyd cyhoeddus a achosid gan lygredd mewn afonydd a ffynonellau traddodiadol lleol eraill ger y dinasoedd, adeiladwyd nifer o gronfeydd dŵr mewn dyffrynnoedd naturiol yn ystod ail hanner y 19eg Ganrif. Seiliwyd y rhain ar yr egwyddor o gyflenwi uniongyrchol, gyda'r dŵr cymharol lân o gronfeydd yr ucheldir yn cael ei drin drwy brosesau sylfaenol cyn cael ei bibellu i'r ardal yr oedd yn ei chyflenwi. Yr unig gronfa ddŵr cyflenwad-uniongyrchol a adeiladwyd yn nalgylch Afon Dyfrdwy oedd Cronfa Ddŵr Alwen, a adeiladwyd yn y 1920au, ac a ddefnyddid yn wreiddiol i gyflenwi dŵr i Benbedw.


Llyn Celyn

Cafodd amryw o'r afonydd yn yr ardaloedd diwydiannol eu llygru gan elifiannau i'r fath raddau fel na ellid eu defnyddio i ddarparu cyflenwadau dŵr, ac nid oedd y swm bychan o ddŵr a ollyngid i'r afonydd o'r cronfeydd cyflenwad-uniongyrchol yn ddigon i wella'r sefyllfa. Un eithriad nodedig oedd cyflenwad Dinas Caer. Bu Caer yn tynnu dŵr yn uniongyrchol o Afon Dyfrdwy ers ffurfio Cwmni Gwaith Dŵr cyntaf Caer ym 1826 gan mai ychydig o elifiannau trafferthus a geid yn nalgylch Afon Dyfrdwy i fyny'r afon o'r ddinas.

Ar ddiwedd y 1950au hyrwyddwyd ac adeiladwyd Cynllun Llyn Tegid gan Fwrdd Afonydd Dyfrdwy a Chlwyd. Cafodd yr allfa naturiol o'r llyn ei gostwng (gan osgoi llifddorau gwreiddiol Telford) ac adeiladwyd llifddorau newydd islaw'r cydlifiad ag Afon Tryweryn, nid nepell o allanfa'r llyn. Roedd hyn yn darparu tua 18,000,000 $m^3$ (metr ciwbig) o le storio rheoledig yn Llyn Tegid, y gellid ei ddefnyddio yn ôl y tymor llif isel a sicrhau tyniadau parhaus o Afon Dyfrdwy gan chwech o Ymgymeriadau Dŵr Statudol a Bwrdd Dyfrffyrdd Prydain, sef cyfanswm 0 235 Ml/d (Megalitrau y dydd). Yn ychwanegol at hyn, roedd system dymor-byr o ddal dŵr llifogydd o ddalgylch sylweddol Llyn Tegid yn lleihau nifer a grym y llifogydd yn Nyffryn Dyfrdwy i lawr yr afon o'r Bala. I gyd-fynd â'r datblygiad hwn, gosodwyd safonau mwy llym ar yr elifiannau a arllwysid i Afon Dyfrdwy i fyny'r afon o Gored Caer.

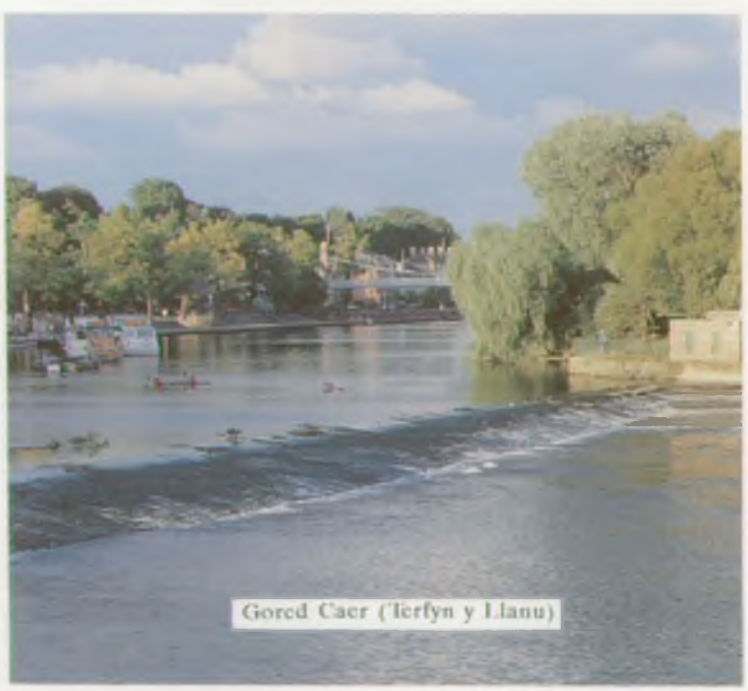
Dros 150 o flynyddoedd ar ôl cwblhau cynllun gwreiddiol Telford ail-sefydlwyd yr egwyddor o reolaeth ar Afon Dyfrdwy. Y datblygiad nesaf oedd yn dal 81,000,000 $m^3$ o ddŵr, a gwblhawyd ym 1965 gan Gorfforaeth Lerpwl ac a gynlluniwyd weithredu ar y cyd â Chynllun Llyn Tegid. Roedd hwn nid yn unig yn sicrhau tyniadau ychwanegol o 327 Ml/d o Afon Dyfrdwy, ond hefyd yn cynnig lle storio ychwanegol yn ystod llifogydd, gan dreblu'r llif tywydd sych ar gyfer y rhan fwyaf o hyd yr afon, lle storio sylweddol ar gyfer gollyngiadau arbennig at ddibenion ansawdd dŵr neu bysgodfeydd, cynnydd o 65% yn y llif gweddillol lleiafswm dros Gored Caer i Aber Afon Dyfrdwy, ynghyd a gorsaf bŵer trydan-dŵr 4 MW (Megawat) yn yr argae.

Ym 1973 cafodd Awdurdod Afonydd Dyfrdwy a Chlwyd bwerau statudol i adeiladu cronfa ddŵr reoleiddio fawr arall yn nyffryn Brenig. Cwblhawyd Cam cyntaf cynllun Brenig pan lanwyd Llyn Brenig (60,000,000 $m^3$ ) yng ngwanwyn 1979. Gyda chwblhau Cam cyntaf Brenig cynyddwyd y tyniadau posibl o'r afon yn yr estyniadau isaf i tua 860 Ml/d.

Gydag aildrefnu'r Diwydiant Dŵr ym 1989 daeth cyfrifoldeb dros reoli Afon Dyfrdwy i ddwylo'r Awdurdod Afonydd Cenedlaethol, ac ym 1992 y tyniadau awdurdodedig gan y pedwar ymgymerwr statudol a Bwrdd Dyfrffyrdd Prydain oedd:-

| | |
|---|---|
| Dŵr y Gogledd Orllewin | 709.0 Ml/d |
| Cwmni Gwaith Dŵr Caer | 34.1 Ml/d |
| Cwmni Dŵr Wrecsam a Dwyrain Dinbych | 34.1 Ml/d |
| Bwrdd Dyfrffyrdd Prydain | 28.4 Ml/d |
| Dŵr Cymru - Welsh Water | 23.6 Ml/d |

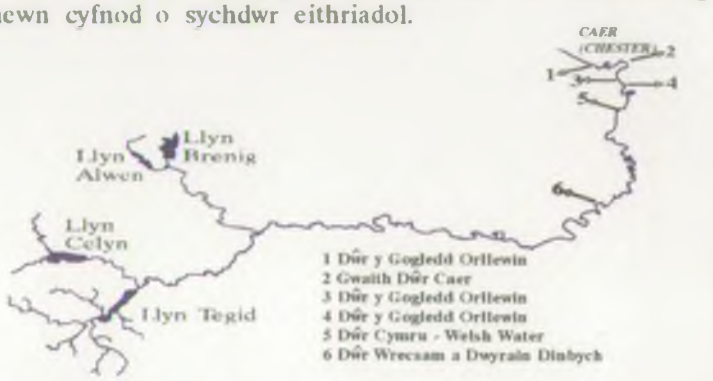
Yn ogystal, cynhelir llif gweddillol o 364 Ml/d o leiaf dros Gored Caer, oni bai bod sychder eithriadol, gan ddiogelu llwybr pysgod mudol a lleihau mynediad dŵr halwynog dros Gored Caer adeg penllanw.



Gored Caer (Terfyn y Llanu)

## Gweithredu'r Cynllun Rheoleiddio

Mae'n hynod o bwysig fod system aml-bwrpas Afon Dyfrdwy yn cynnal cydbwysedd teg rhwng amryw o fuddiannau, a'i bod yn cael ei gweithredu heb i unrhyw grwp arbennig o ddefnyddwyr osod cyfyngiadau gormodol arni. Sefydlodd Deddf Awddurdod Afonydd Dyfrdwy a Chlwyd 1973 Bwyllgor Ymgynghorol lle'r oedd buddiannau'r phrif dynwyr dŵr a defnyddwyr yr afon yn cael eu cynrychioli. Mae'r "Cyfarwyddiadau Cyffredinol", sef y rheolau cymhleth a ddefnyddir i weithredu'r system, yn cael eu paratoi gyda chyngor y Pwyllgor hwn, a bydd yn rhaid cael sêl bendith holl aelodau'r Pwyllor cyn y gellir gweithredu'r amodau arbennig mewn cyfnod o sychdwr eithriadol.




Defnyddiwyd Cynllun Rheoli Afon Dyfrdwy mewn rhaglen ymchwil genedlaethol rhwng 1966 a 1976 i broblemau arbennig rheoli afonydd a gydgysylltwyd gan y Bwrdd Adnoddau Dŵr/Canolfan Ymchwil Dŵr. Roedd y rhaglen ymchwill yn cynnwys mesur glawiad gyda radar, offer rhifo pysgod, modelu hydrolegol, rheolau dros reoli cronfeydd dŵr, a datblygu system delemetreg gyfrifiadurol.

Mae'r systemau telemetreg a ddefnyddir yng nghanolfan reoli'r Bala yn casglu gwybodaeth o gronfeydd, gorsafoedd mesur llifau afonydd a mesuryddion glaw. Derbynnir lluniau radar a lloeren o'r tywydd hefyd er mwyn helpu'r Swyddogion ar Ddyletswydd yn y Bala i benderfynu ar yr arllwysiadau mwyaf priodol o'r cronfeydd dŵr.

Yn ystod rheolaeth lif-isel mae'r dŵr â ollyngir o'r cronfeydd dwr a reolir yn cymryd bron dau ddiwrnod (gall fwrw glaw yn ystod y cyfnod hwn) i gyrraedd y prif fannau tynnu ger Caer, ond mae'r mesuriadau a'r system ragweld mor fanwl gywir fel bod llai na 5% o ddŵr yn cael ei ollwng mewn haf sych yn fwy na'r hyn sydd ei angen i lawr yr afon.

## Ffeithiau a Ffigurau

| Cronfa Ddŵr | Dalgylch (km2) | Arwynebedd Arwyneb(ha) | Cynhwysedd ($m3x10^6$) | Dŵr Ffo m3/eil | Cyfartalog mm/bl |
|---|---|---|---|---|---|
| Llyn Celyn | 60 | 325 | 81 | 3.10 | 1590 |
| Llun Tegid | 262 | 400 | 18 | 11.50 | 1380 |
| Llyn Brenig | 23 | 370 | 60 | 0.62 | 884 |
| Cronfa Dŵr Alwen | 26 | 150 | 15 | 0.73 | 899 |

Mae'r dalgylch hyd at Gored Caer yn 1816 km2 gyda dŵr ffo naturiol cyfartalog o 36.8 m3/eil (639mm/bl); mae 16% o'r dalgylch a 33% o'r dŵr ffo yn cael ei reoli gan cronfeydd dŵr.

*Yr Awdurdod Afonydd Cenedlaethol. Plas-yr-Afon, Parc Busnes Llancirwg, Llancirwg, CAERDYDD.*

# DŴR CYMRU
# WELSH WATER

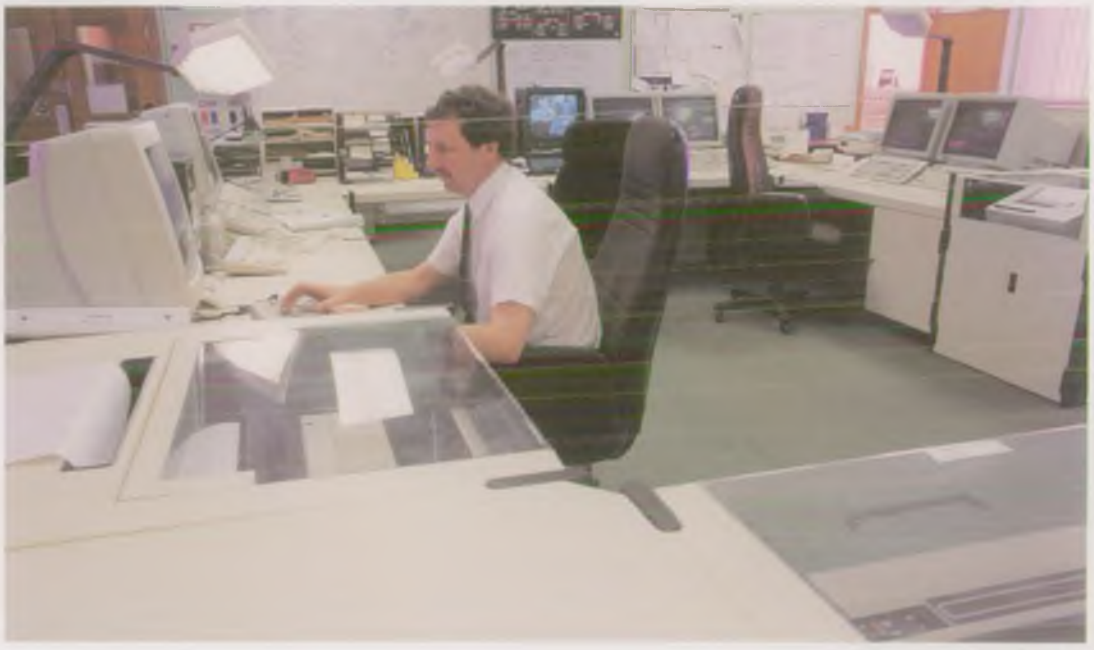
## GWAITH TRIN DŴR BRETTON

**Lleolir y gweithfeydd ger Brychdyn, rhyw 7.5 km o'r man tynnu dŵr ar yr Afon Dyfrdwy. Er ei fod wedi ei gynllunio ar gyfer llif uchel o 49 Ml/d (megalitr y dydd), mae cyfartaledd y llif gryn dipyn in is oherwydd ei fod yn cael ei ddefnyddio ar y cyd â chyflenwadau disgyrchiant o Gronfa Alwen.**

Gyda'i gilydd, mae'r ddau waith yn cyflenwi rhan fawr o Ogledd Ddwyrain Cymru, oddeutu 44 Ml/d, gyda chyflenwadau Bretton fel arfer yn gyfyngedig i ardal Glannau Dyfrdwy.

Yn Pulton, caiff dŵr o'r afon ei dynnu drwy sgriniau, er mwyn cael gwared â gweddillion o faint sylweddol, a'i bympio i fewnfa y Gwaith Trin Dŵr drwy bibell gyda diamedr o 700mm. Oherwydd y pellter gall hyn gymryd rhwng dwy a phum awr yn dibynnu ar gyflymder y pympio.

Yn ychwanegol at y cyflenwad o'r afon, gellir tynnu dŵr crai o dri treidd-dwll yn yr acwifer tywodfaen rhwng Bretton a Poulton. Maent yn gyfyngedig o ran maint a byddant ond yn cael eu defnyddio pe byddid yn ymestyn cau derbynnedd yr afon.



DŴR CYMRU
WELSH WATER

*Rhanbarth*
# Y GOGLEDD

Yn Bretton mae'r broses drin yn cynnwys:

- **Gloywi** - proses o wahanu sylweddau/hylif drwy gymorth cemegau sy'n cael gwared â'r rhan fwyaf o'r deunydd crog a'r lliw. Hefyd defnyddir powdwr carbon egnioledig yn y gloywyr i gael gwared â blasau ac arogleuon a all ddigwydd gydag afon tir isel fel yr Afon Dyfrdwy.
- **Hidlyddio** - proses ffisegol o basio'r dŵr sydd wedi ei loywi drwy wely o dywod tua 1m o drwch. Ceir hidlyddion disgyrchiant cyflym yn Bretton ac yn cludo deunydd crog mân ac yn cario darnau mân o'r gloywyr.
- **Diheintio** - cael gwared ar facteria niweidiol. Defnyddir clorin cyn ac ar ôl hidlyddio a chael gwared ar lefelau gormodol cyn i'r dŵr gael ei bympio i'r system gyflenwi. Mae ychydig o glorin ar ôl yn y dr terfynol er mwyn diogelu'r cyflenwad drwy'r tap, sydd mewn rhai achosion yn gallu cymryd nifer o ddiwrnodau o'r adeg y mae'n gadael y gwaith trin dŵr.

I orffen, caiff natur asid y dŵr yn dilyn hydlyddio ei droi'n alcali er mwyn lleihau cyrydu yn y systemau pibellwaith, llawer ohono yn haearn bwrw.

Arolygir yr amrywiol brosesau drwy offerynnau ansawdd dr, a throsglwyddir data a larymau yn ôl i'r ystafell reoli sy'n cael ei goruchwylio 24 awr y dydd. Yn ogystal ag arolygu a rheoli'r gwaith trin dŵr mae'r rheolwr ar ddyletswydd hefyd yn gweithredu system telemetri sydd, drwy linellau ffôn, tirlinellau a systemau radio, yn arolygu oddeutu 400 o safleoedd anghysbell gan gynnwys gweithfeydd trin dŵr eraill, gorsafoedd pympio, cronfeydd gwasanaeth a gwaith trin carthion.

DŴR CYMRU
WELSH WATER

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