Following calibration, details of the river flow and quality distributions were entered into the SIMPOL model. The SIMPOL model was then run with a local rainfall file containing 150 rainfall events representing the worst summer events in a 10 year period (events were limited to the summer period as this was when the worst river conditions were likely to occur). These runs provided estimates of the 1 month and 1 year return period BOD and un-ionised ammonia concentrations in the river which allowed direct comparison with the intermittent standards. The results are shown in Table 1.

Table 1 - Comparison of SIMPOL predictions with intermittent river quality standards

		River concentration exceeded for 6 hour duration at RP shown		
Determinand	Return period	Standard	SIMPOL results	Compliant? (Y/N)
BOD (mg/l)	1 year RP	15.0*	10.7	Y
Un-ionised ammonia (mg/l)	1 year RP	0.15	0.13	Y
Un-ionised ammonia (mg/l)	1 month RP	0.075	0.07	Y

* Derived from an intermittent dissolved oxygen standard by river impact modelling.

Further runs were carried out using different storages and different assumptions to determine the overall sensitivity of the river impacts to different factors. This information was used to help confirm the acceptability of the chosen upgrading option.

CONCLUSIONS

At the present time, simplified urban pollution models have an important role to play in integrated urban pollution modelling. They provide planners with an ability to run long term simulations rapidly to give an overall picture of performance against emission and environmental standards. They are an aid to conceptual thinking at a total urban catchment scale and, when calibrated against detailed models, they allow improvement strategies to be conceived and tested with relative ease.

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DYNAMIC SIMULATION OF WATER QUALITY IN RIVERS. WASP5 APPLICATION TO THE RIVER NALÓN (SPAIN).

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KEYWORDS: Receiving water quality, dynamic water quality models, effects of CSO, little rivers.

INTRODUCTION

Water quality models have already been developed for the rivers Nalón, Caudal and Nora in Northern Spain with the aim of obtaining a tool by which it was possible to plan the sewer networks and treatment plants and to determine the ecological flows (TEJERO, 1993; SAINZ, 1991). The United States Environmental Protection Agency (US EPA) QUAL2E (BROWN and BARNWELL, 1985) model was used in its QUAL2E, version NCASI. The QUAL2E permits water quality to be modelled in a steady state. The phosphorus and nitrogen cycles, algae, coliform and BOD cycles were simulated using the developed models and the dissolved oxygen balance was determined. Specific work of hydraulic characterisation and of wastewater discharge and river water characterisation were carried out. Two periods of low water during different years were used to construct the steady state models. One was used for the calibration and the other for the validation. The steps performed were as follows: a) construction of a premodel; b) construction of an initial model using calibration; c) validation of the initial model in order to obtain a final model.

In order to understand more about the pollution phenomena which affect water quality, new objectives were set based around modelling the CSO impact. In this paper a dynamic model of water quality in the river Nalón is outlined. Once the model is constructed, a simulation is made of the impact of the CSO generated by the sewer network in the town of Sama-Langreo (Asturias) (40,000 inhabitants). The main features of this river are its high gradient and short length. The catchment area is a historic coal mining region and consequently contains important industrial zones and centers of population.

GENERAL METHODOLOGY

Once all the characteristics necessary for the model had been determined, a revision was carried out on the available programs. The US EPA's WASP (Water Analysis Simulation Package) was finally adopted (AMBROSE, *et al*, 1991). The basic quality kinetics (N, P and OD) are almost mimetic with those of the QUAL2E. The WASP5 may be used in different degrees of complexity. The WASP5 Level 3 of complexity was used for the dynamic simulation of the immediate effect of a CSO on the river Nalón water quality. The parameters simulated were BOD, organic nitrogen, ammonia, nitrates, total nitrogen and dissolved oxygen.

The information obtained with the steady state model based on QUAL2E was used in the construction of the dynamic model. The construction process was structured in 2 phases: initial model elaboration or steady state WASP model, and final model construction or dynamic WASP model. The situations of calibration and validation used with the QUAL2E were studied in both models. The initial model is a steady state model based on the WASP5 to which the conceptual structure, parameters, constants and discharge data of the QUALIIe based steady state model have been applied. Some changes were necessary and some still had to be used to adapt the above data to the peculiarities of WASP5, both in hydrodynamic aspects and water quality. The final model consists of a dynamic model of the river based on WASP5. The flow and concentration of the discharges were made to change along with the water temperature throughout the day and the contaminant concentration at the head of the modelled stretch of the river Nalón.

STATIONARY MODEL WASP5 CONSTRUCTION

To adapt the hydrodynamic grid to the upper reach of the Nalón it was decided to opt for modelling the same length of river that was taken for the QUAL2E. The same segment length, 800 meters, used for calculation in the stationary model was adopted. This distance later conditions the computational stability in the numerical resolution of the equations. The complete hydrodynamic model of the river Nalón contains 51 junctions and 50 channels. An extra junction was added to the structure in order to include boundary contours simulating the existence of a reservoir. The same Manning rugosity values as those used in the stationary model were adopted. The DYNHYD resolves the equations of continuity and momentum.

In the nitrogen cycle, the nitrite stage is not taken into account, this represents an important difference with respect to the simulation of the nitrogen cycle in QUAL2E. An important problem in the simulation of river water quality was provoked by not simulating the disappearance of the carbonaceous organic material and nitrogen with sedimentation of solid particles. As they do not disappear from the water mass they continue producing a demand and affect the OD profile. The option for automatic optimisation of the time step was used in the simulation of water quality. The fact that the river has an average hydraulic retention time of 1.5 days must be taken into account.

As it was possible to modify the source code we chose to modify the superficial reaeration option included in EUTRO. In the QUAL2E, after trying different options, the formule of Lamgbien and Durum (LAMGBIEN and DURUM, 1967) was adopted. This formule was introduced into the dynamic model.

The results are compared with the river water quality values obtained during the stages of calibration and validation. It must be remembered that the work performed on water quality in order to construct the stationary model using QUAL2E were carried out using the criteria of following the drop. Three samples were taken throughout the day at each selected point. Each sample was taken at eight hour intervals. The moment of the sample was calculated by taking into account the water circulation times of the river which were obtained during the hydraulic characterisation.

TABLE N° 2.- Reference values for hydraulic characterisation.

	PARAMETER	MIN.VALUE	MAX.VALUE
CALIBRATION STAGE	Flow (m3/s)	3.86	6.22
	Velocity (m/s)	0.32	0.65
	Depth (m)	0.31	0.71
	Manning number	0.050	0.175
VALIDATION STAGE	Flow (m3/s)	2.13	4.01
	Velocity (m/s)	0.56	0.26
	Depth (m)	0.24	0.57
	Manning number	0.025	0.170

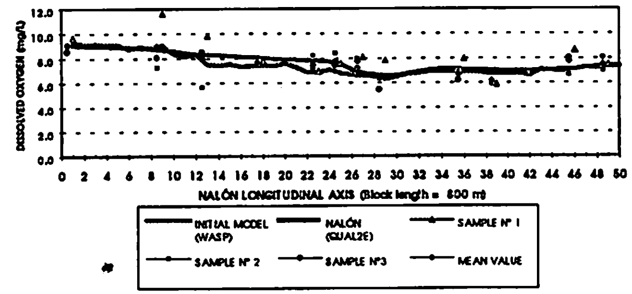

Figure 1.- Initial results of water quality for river Nalón. Model based on the WASP5.

DYNAMIC MODEL WASP5. CALIBRATION AND VALIDATION

The daily variable discharge points were at first considered to be determinate factors in the variation of the river water quality. Both the industrial wastewater and the urban wastewater discharges vary in the river basin. Industrial discharges were considered constant and more important urban discharges were made to change throughout the day. The flow and load curves for urban wastewater discharges were defined using regional data. Discharges from settlements of less than 1,000 inhabitants were adopted as constants. The number of variable discharges was six. The largest simulated discharges were generated by a town of 25,628 inhabitants, with a peak coefficient of 2.1, and the smallest of 4,617 inhabitants, with a peak coefficient of 2.40 (SUÁREZ, 1994).

The temperature of the water is also a determinant factor in the daily variation in water quality. In order to model the variation in water quality at the head, a lineal variation in time is assumed between the field values.

The numerical values of the simulation are presented in graph form. In the X-Y diagram the simulations appear as multiple lines. Each line corresponds to an instant of the day. Each day has been distributed into 0.025 days (36 minutes). Although it is very difficult to differentiate which instant corresponds to which curve, it is interesting to see the variation range of the different water quality parameters throughout the day. The simulation results are compared with those obtained during the water quality calibration and validation field work (Figure 2).

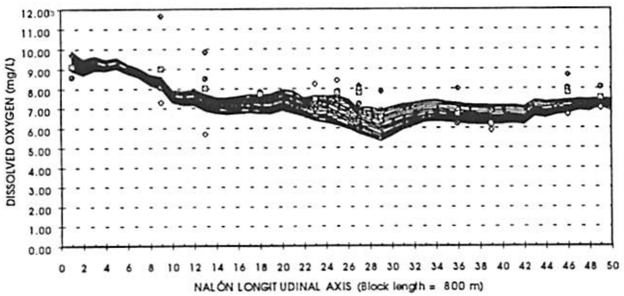

Figure 2.- Numerical values of the dinamic simulation. Final model WASP5

CSO APPLICATION

Once a dynamic water quality model is constructed for the river Nalón it will be possible to study transitory pollution phenomena. One of the most complex phenomena to study is the effect CSO has on river water. During periods of low water the river aquatic system is more sensitive to pollution. A sufficiently heavy rain storm after a period of prolonged drought may provoke CSOs and generate situations of contamination in the river, "estiaje húmedo". The accute effect of CSO on the river Nalón is studied in this work taking into account that the sanitation plan in sewer networks, overflow control and treatment systems and wastewater treatment plants are constructed and working.

Since the flow profile adopted by the river in the validation stage is similar to that of low water they have been considered as the same, with a modification caused by the elimination of a large part of the discharges, their flows being reincorporated downstream at the location of a wastewater treatment plant.

The SWMM (Storm Water Management Model) (HUBER, 1988) was used to obtain a CSO representative of the basin and of the implimented sewer system. Different CSO were studied, variations being made to the fundamental variables on which they depend. CSO is produced through an overflow structure equiped with a 1400 m3 (7 m3/Ha net) storage tank. The flow directed to the WWTP is four time the average flow during dry spells, is 464 L/s. Although the probability of a rainfall of 13.68 mm/h is high in the river Nalón basin, other situations have to be simultaneously produced in order to provoke the most unfavourable effects on the system: maximum number of dry days before the storm and minimum flow of water in the river. The return period of this very bad event will be greater than eleven months. Zero dissolved oxygen is considered for the CSO presented (Figure 3).

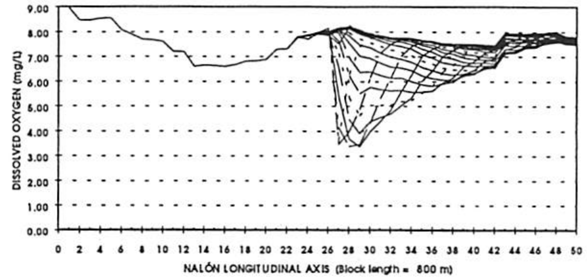

Figure 3.- Results of dissolved oxygen depletion in the river Nalón. CSO impact.

An example of the OD evolution in the strecht of river affected by CSO is presented in Figure 4. The evolution of OD level, time of infulfillement (e.g. OD≥6 mg/L) and the strecht of river affected can be seen in the topograph (Figure 4).

TABLE N° 3.- Main parameters of used CSO.

Catchment surface = 400 Ha.	Wastewater flow (dry weather) = 116 L/seg
Runoff coefficient = 0.5	BOD5 concentration = 260 mg/L
Average slope = 0.005	Ammonia concentration = 25 mg/L
Inhabitants = 40000	Rain intensity = 19.034 L/s.Ha.
Wastewater flowrate = 250 L/ha.day	Rain duration = 1 hour
N° of dry days since last rain = 7	Rain returned period = 0.90 years

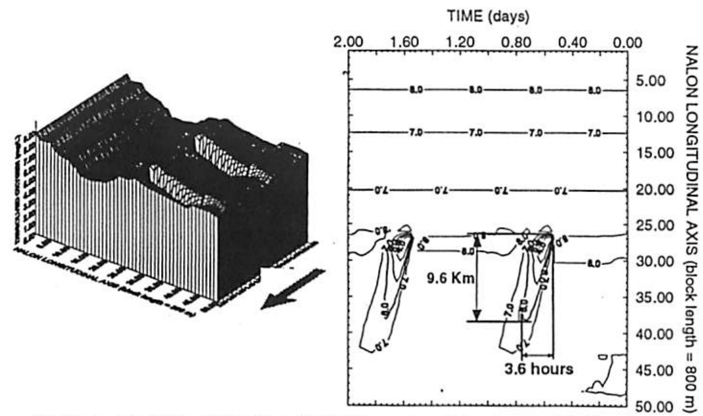

Figure 4.- Evolution of OD, time of infulfillement and the strecht of Nalón affected

CONCLUSIONS

- WASP5 may be used (with modifications) for constructing a representative dynamic model for rivers with similar characteristics to the Nalón.
- The method followed for calibration and validation based on the stationary model has turned out to be robust for the construction of the dynamic model.
- The dynamic model simulates the instantaneous effect of *estiaje húmedo* (wet low water) pollution. During low water conditions the river studied supports the impact of CSO considered in terms of dissolved oxygen, taking into account the existence in the sewer network of adequate overflow control and treatment systems (OCTS).
- The hydraulic characterisation of this type of river is very difficult and, at the same time, its influence on the evolution of water quality is very important. Limitations have been found in the dynamic model (WASP5) which reduce its possibilities for the simulation of river aquatic systems. The obligation of setting equal rates for all the river is one of these limitations. In the river studied, the consumption of dissolved oxygen by nitrification is of the same importance as that which is consumed during the oxidation of carbonaceous material.

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POLLUTEGRAPH SIMULATION WITH WATER QUALITY TANK-MODEL (III)

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INTRODUCTION

Runoff pollutants from urbanized areas have a significant effect on water quality management downstream, doe to advanced water uses with repetition of intakes and discharges. This causes such subjects as the real time-forecast of runoff pollutant load doe to a sudden copious rainfall and the long-term effect to pollutant runoff depending upon the urbanization and development in a basin.

To simulate the pollutant runoff, it is obvious that the model must have a storage system in order to explain the loads accumulated during the preceding dry days. In addition, some definite parameters to include the complicated runoff processes should be required. Therefore, the model cannot easily be defined without reference to it's lumping.

The purposes of this paper are first, to consider the parameters of the Water Quality Tank-Model that can continuously simulate long-termed pollutant runoff with storage as the peculiarity of a tank-model; second, to advance the concept of the parameter lumping; and third, to show the result of a pollutegraph from an urbanized area to a river in order to simulate the transition of the runoff process for a long term.

THE WATER QUALITY TANK-MODEL AND ITS PARAMETERS

Outline of the Water Quality Tank-Model

The first point to be discussed is that accumulated pollutants indicate a deviation in grain size according to the sediment condition as a natural riddle-mechanism (i.e. classifier) in a drainage system. The point to emphasize on the Water Quality Tank-Model is to settle the riddle to store pollutants and transport them to the lower riddle. The second point is that the runoff loads should be decided by the accumulated loads as well as by the discharge. In this model, the main stress falls on the relationship between the water level and the pollutant accumulation height in a tank.

As shown in Fig.1, this model controls the amount of runoff load using parameter β (the pollutant runoff coefficient) and a ratio of pass-by riddle. The fitting for the runoff peak and its decline is operated by parameter n (gradient of the riddle) and B (coefficient of the conversion from pollutant load to

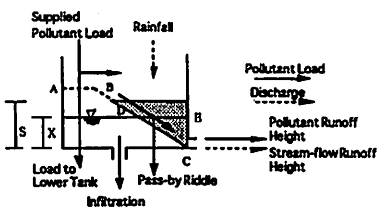

Fig.1 Outline of the Water Quality Tank-Model