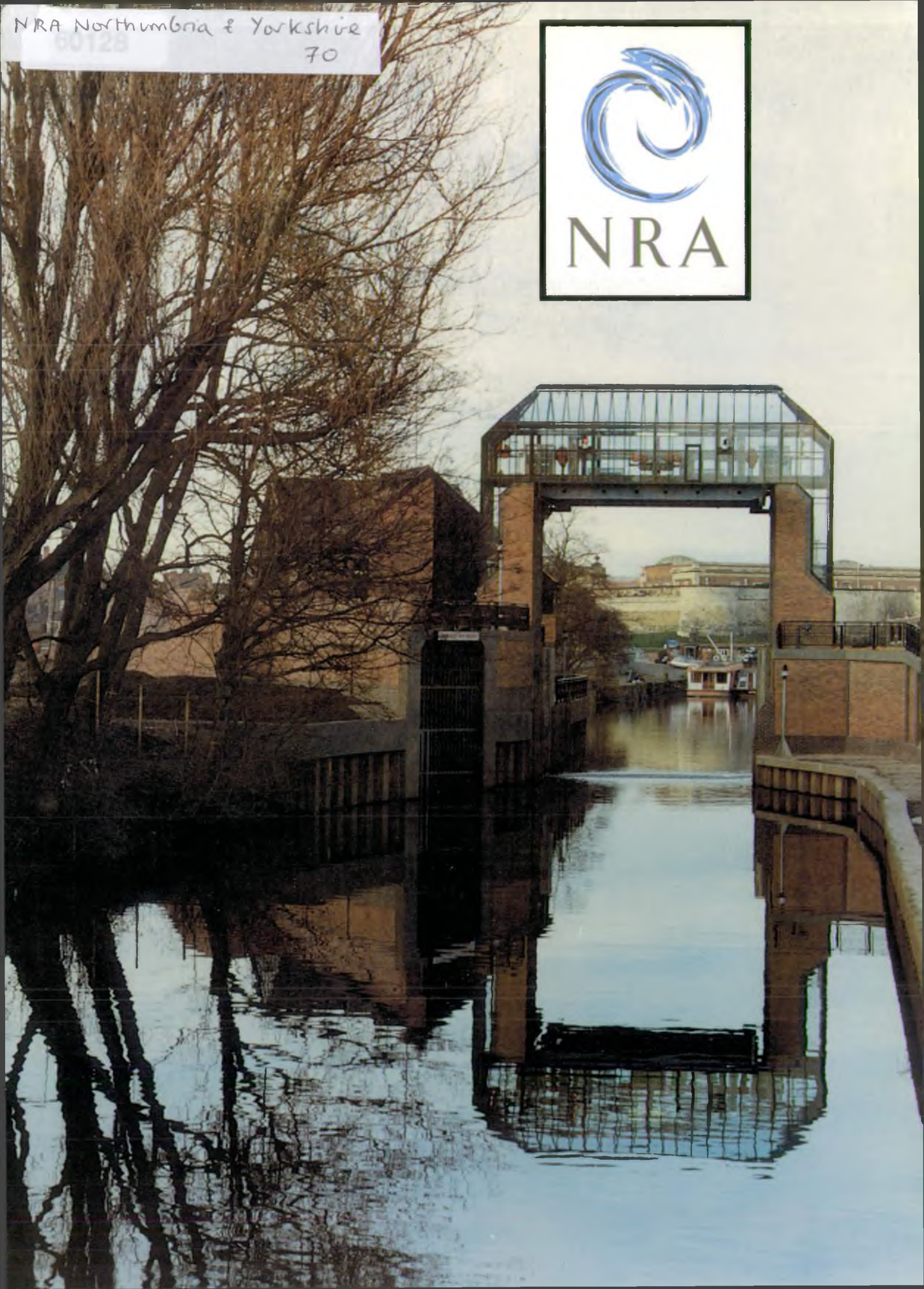
NRA



NRA - Northumbria & Yorkshire

NRA

RIVER FOSS
Flood alleviation scheme

NRA, Rivers House,
21, Park Square South,
LEEDS LS1 2QG.


RIVER FOSS
RIVER OUSE

Introduction

The City of York is subjected periodically to extensive flooding from the River Ouse, which flows through the City Centre. The Yorkshire Water Authority promoted a series of schemes to alleviate the effects of this flooding. The River Foss Scheme is part of this series.

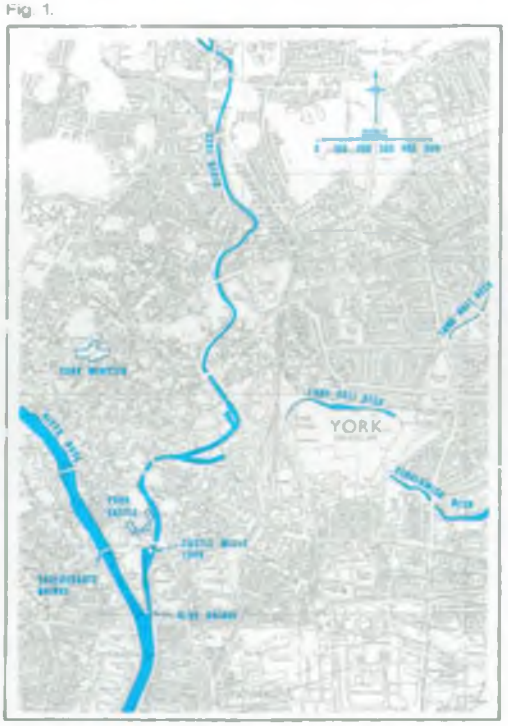
The River Foss is a left bank tributary of the River Ouse, the confluence occurring immediately downstream of York Castle as shown on Fig. 1.

In recent years serious flooding has occurred in 1947, 1978 and 1982. The flooding in January 1982, the worst since 1947, resulted from rapid snow melt in the Upper Pennine catchment of the River Ouse combined with very heavy rainfall. The river rose 5m above its normal level and caused flooding and traffic disruption over a continuous period of 3 days.

During this event an area of some 70 hA adjoining the River Foss and the two adjacent streams, Tang Hall Beck and Osbaldwick Beck was inundated causing damage and disruption with an estimated value of over £2M. The flooded area is shown on Fig. 2.

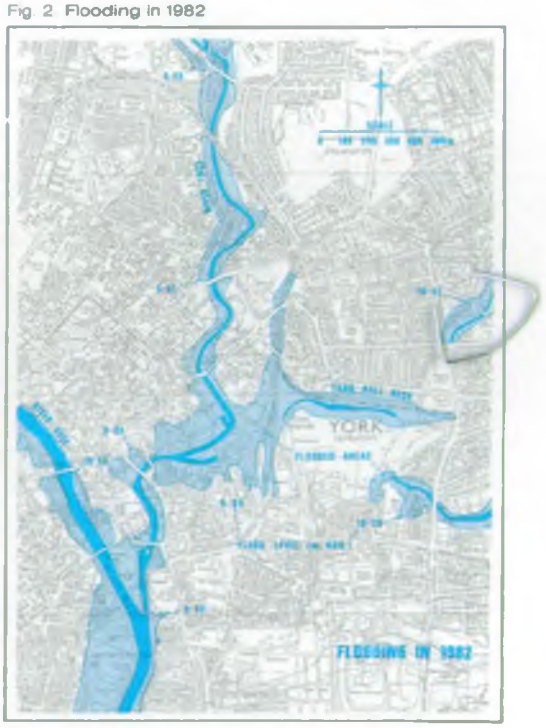
A feasibility study which was undertaken in the second half of 1982 indicated that flood levels in the River Foss are directly related to River Ouse levels.

Fig. 1.



Flooding, January 1982

Fig. 2 Flooding in 1982



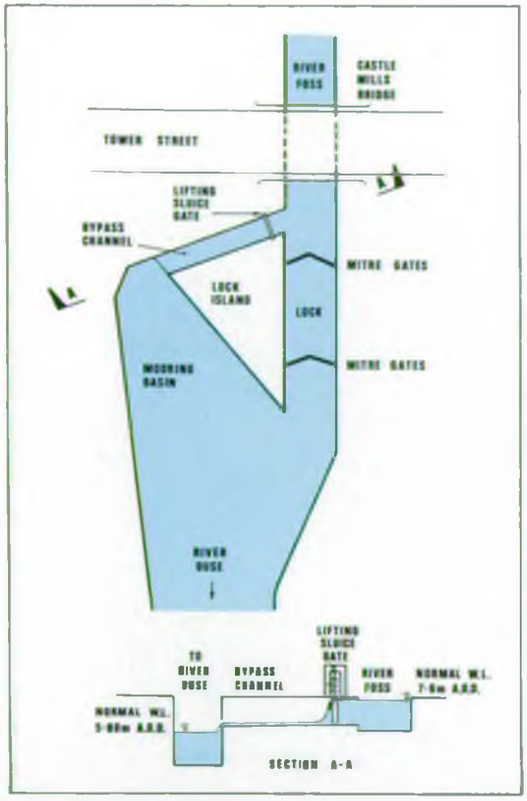
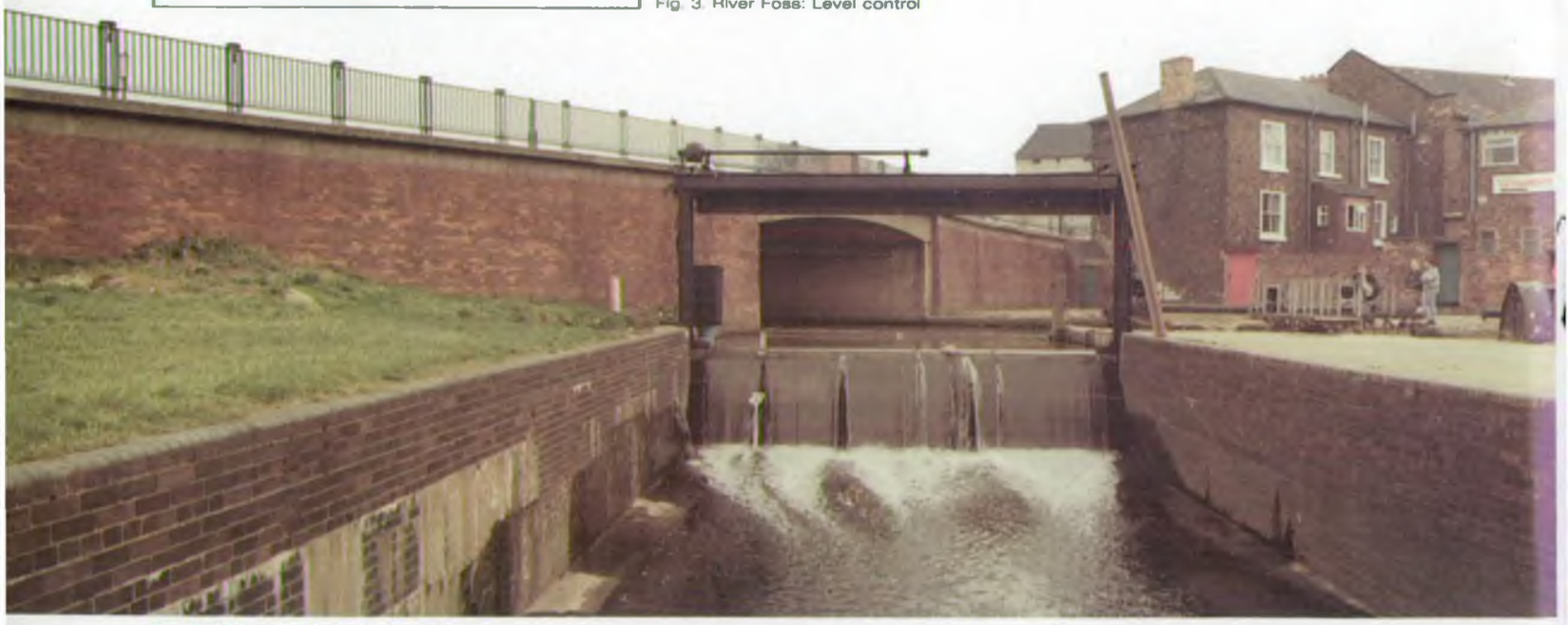


Fig. 3. River Foss: Level control

The River Foss was canalised in its lower reaches in the late 18th Century and has sufficient capacity to carry 1 in 100 year flood flows. Its normal water level of 7.6m above Ordnance Datum (A.O.D.) (2.6m above normal River Ouse level) is controlled by a lock and sluicegated bypass channel at Castle Mills Bridge adjacent to York Castle. The arrangement is shown diagramatically in Fig. 3.

Thus the most frequently occurring floods in the River Ouse which do not exceed 7.6m A.O.D. have no effect on the levels in the River Foss. However once this level is exceeded, flood water from the River Ouse backs up the River Foss and eventually overtops its banks.

A similar problem exists along the Tang Hall and Osbaldwick Becks. These were originally tributary to the River Foss but in the late 18th Century were culverted to the River Ouse. River Ouse levels are therefore reflected directly back up the culvert into the Becks.



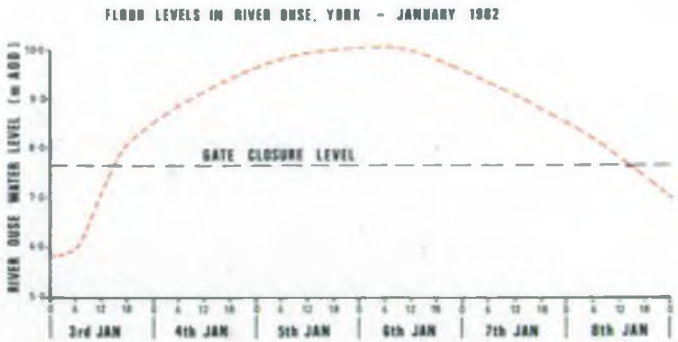
Castle Mills – By-Pass Sluice Gate

The Solution

The feasibility study considered several methods of alleviating the flooding problem. The recommended solution which has been adopted consists of a moveable flood barrier installed between Castle Mills Lock and the confluence at Blue Bridge. This, when operated, prevents River Ouse floodwater entering the River Foss. While the barrier is closed the flow in the River Foss is pumped round the gate.

A Hydrograph of the 1982 flood is shown below, on which has been imposed the gate closure level. From this it can be seen that for an extreme event such as this the gate would be closed for more than 4 days.

The layout of the main components of the scheme is shown in Fig. 4.



As the River Foss is a navigable waterway, an Act of Parliament was necessary to empower the Yorkshire Water Authority to construct and operate the barrier.

This received Royal Assent in June 1986.

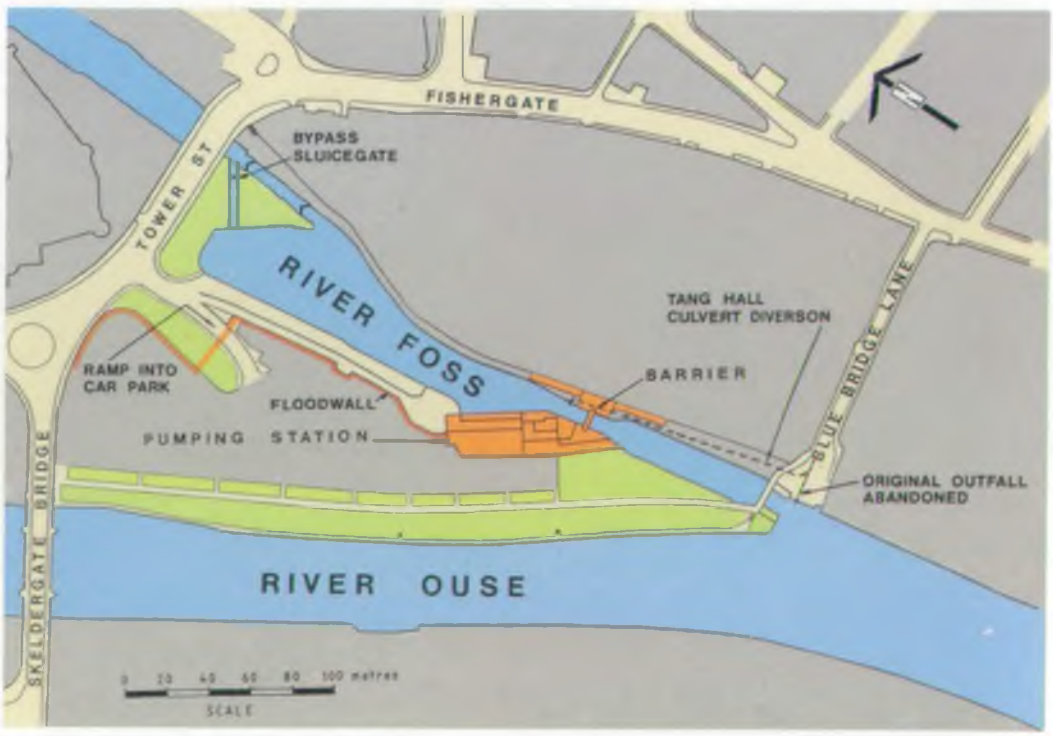


Fig. 4

Hydrology

The scheme is designed to provide protection against River Ouse floods with a return period of up to 100 years. Analysis of historic records of flooding from the River Ouse in York indicated that a flood level of 10.2m A.O.D. could be reached in the extreme design event. The return period of the January 1982 flood has been estimated at 1 in 80 years.

With the addition of a nominal allowance for wave and wind action a defence level of 10.45m A.O.D. was adopted.

The hydrological analysis also provided the capacity of the pumping station which is installed to deal with the River Foss flow when the barrier is closed. In this case no historic records were directly available and the River Foss flows had to be calculated from rainfall records and run off characteristics of the catchment.

A probability analysis was then carried out for flows in the River Foss combined with high levels in the River Ouse. This indicated a maximum flow of 30m³ per second and pumping capacity is provided for this volume.

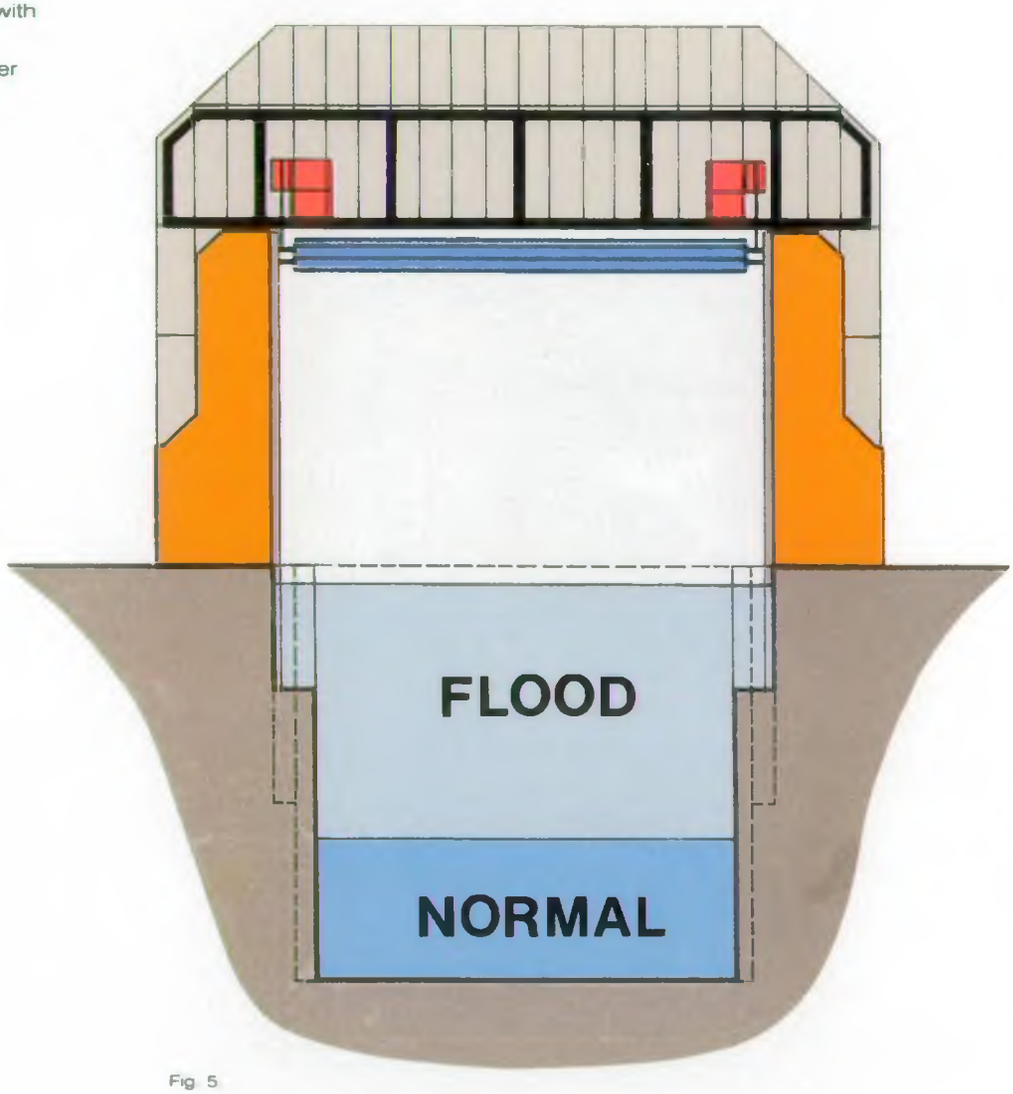


Fig 5

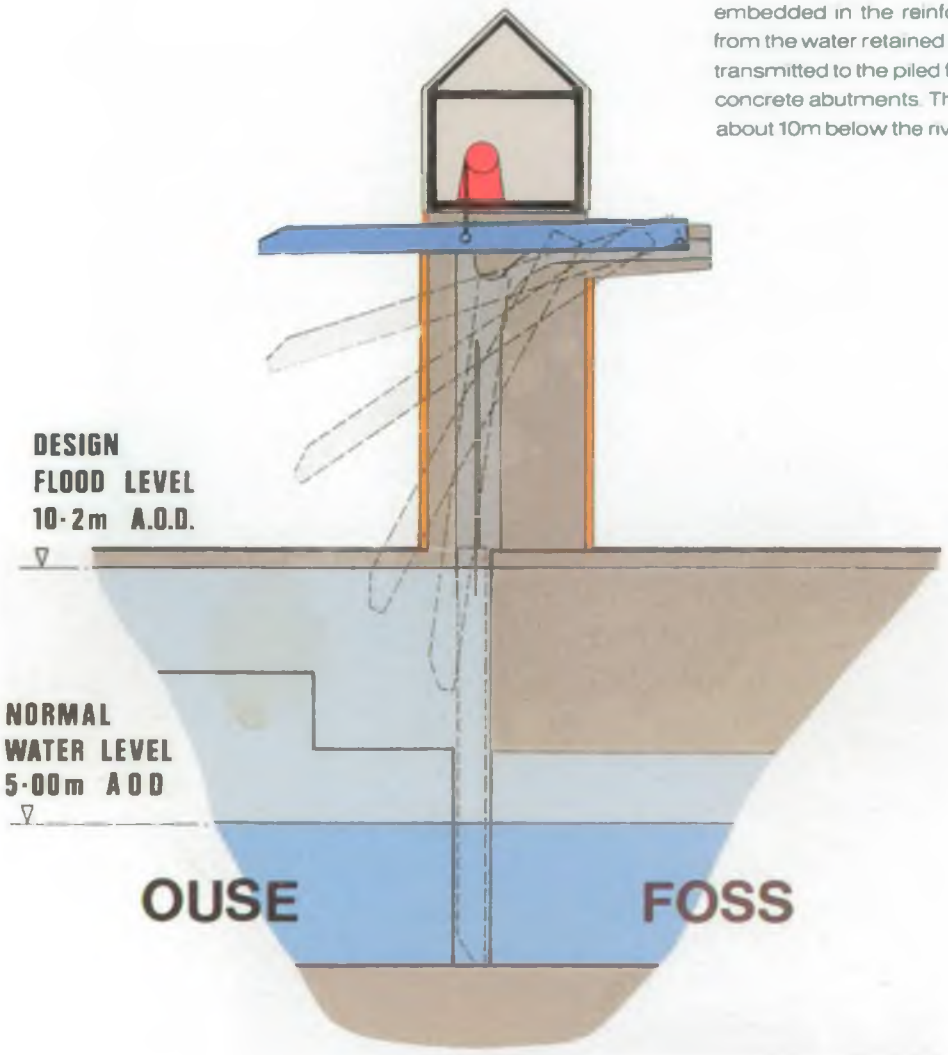
The Barrier

The barrier is a steel turn-over lifting gate of 8.3m span and 8.25m height weighing 16.5 tonnes. The general arrangement of the gate is shown in Fig. 5.

To facilitate maintenance and so prolong its overall life the gate is parked out of the water in the horizontal position, above the navigation clearance envelope.

The gate is raised and lowered on steel wire ropes which are wound onto drums at either end of the bridge connecting the two side towers. A central electric motor (with standby) drives the drums through a helical gearbox and shaft connections. In the event of failure of both mains and standby power the gate can be wound by hand through the gearbox. In the unlikely event of gearbox seizure, chain blocks are provided which could be used to raise or lower the gate independently of the normal drive arrangement. A cut away drawing of the gate is shown in Fig. 6.

When the gate is lowered it seals onto a stainless steel section embedded in the reinforced concrete cill. The horizontal thrust from the water retained on the River Ouse side (some 200t) is transmitted to the piled foundations of the cill through heavy mass concrete abutments. The piling is founded on the Bunter Sandstone about 10m below the river bed.



Discharge Culvert and Turn Over Gate

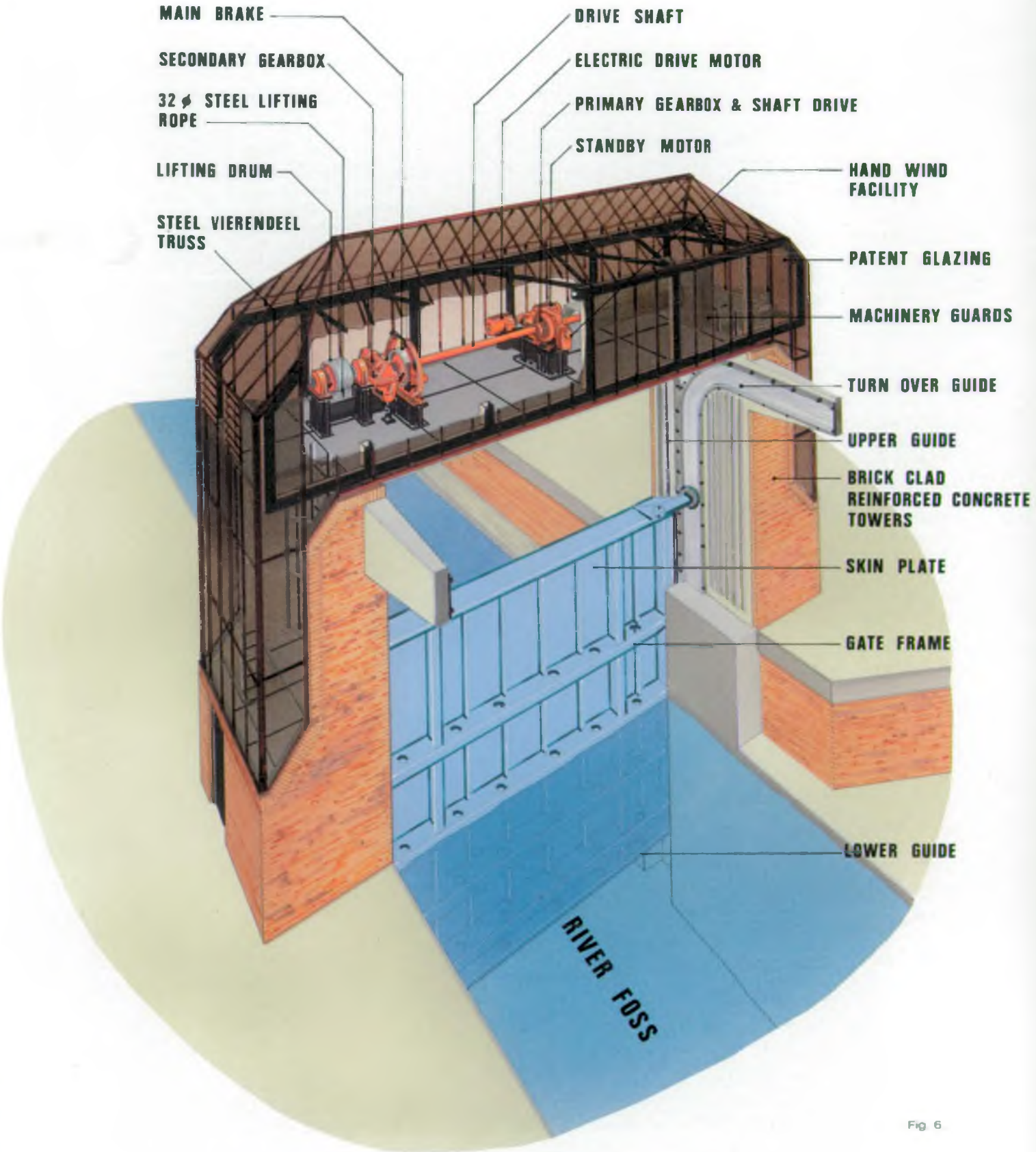

MAIN BRAKE
SECONDARY GEARBOX
32 ϕ STEEL LIFTING ROPE
LIFTING DRUM
STEEL VIERENDEEL TRUSS
DRIVE SHAFT
ELECTRIC DRIVE MOTOR
PRIMARY GEARBOX & SHAFT DRIVE
STANDBY MOTOR
HAND WIND FACILITY
PATENT GLAZING
MACHINERY GUARDS
TURN OVER GUIDE
UPPER GUIDE
BRICK CLAD REINFORCED CONCRETE TOWERS
SKIN PLATE
GATE FRAME
LOWER GUIDE
RIVER FOSS

Fig 6

Pumping Station

A cross section and plan of the pumping station is shown in Fig. 7. Eight axial flow propellor pumps pump the flow from the River Foss over the discharge weir, whose crest is set at the defence level of 10.45m A.O.D. into the discharge culvert which carries the flow round the gate. The pumps are electrically operated each having a power input of 236 kW. Standby generators are provided to operate four of the pumps in the event of a mains failure.

The transformers and switchgear for the pumps and station building services are located in the rooms above the pump inlet cells.

During the design period a programme of scale hydraulic model tests was carried out. The results of these tests led to refinements being made to the layout of the station to improve pump efficiency and reduce turbulence at the mouth of the discharge culvert under maximum flow conditions.

Hydraulic Model

Pump Installation

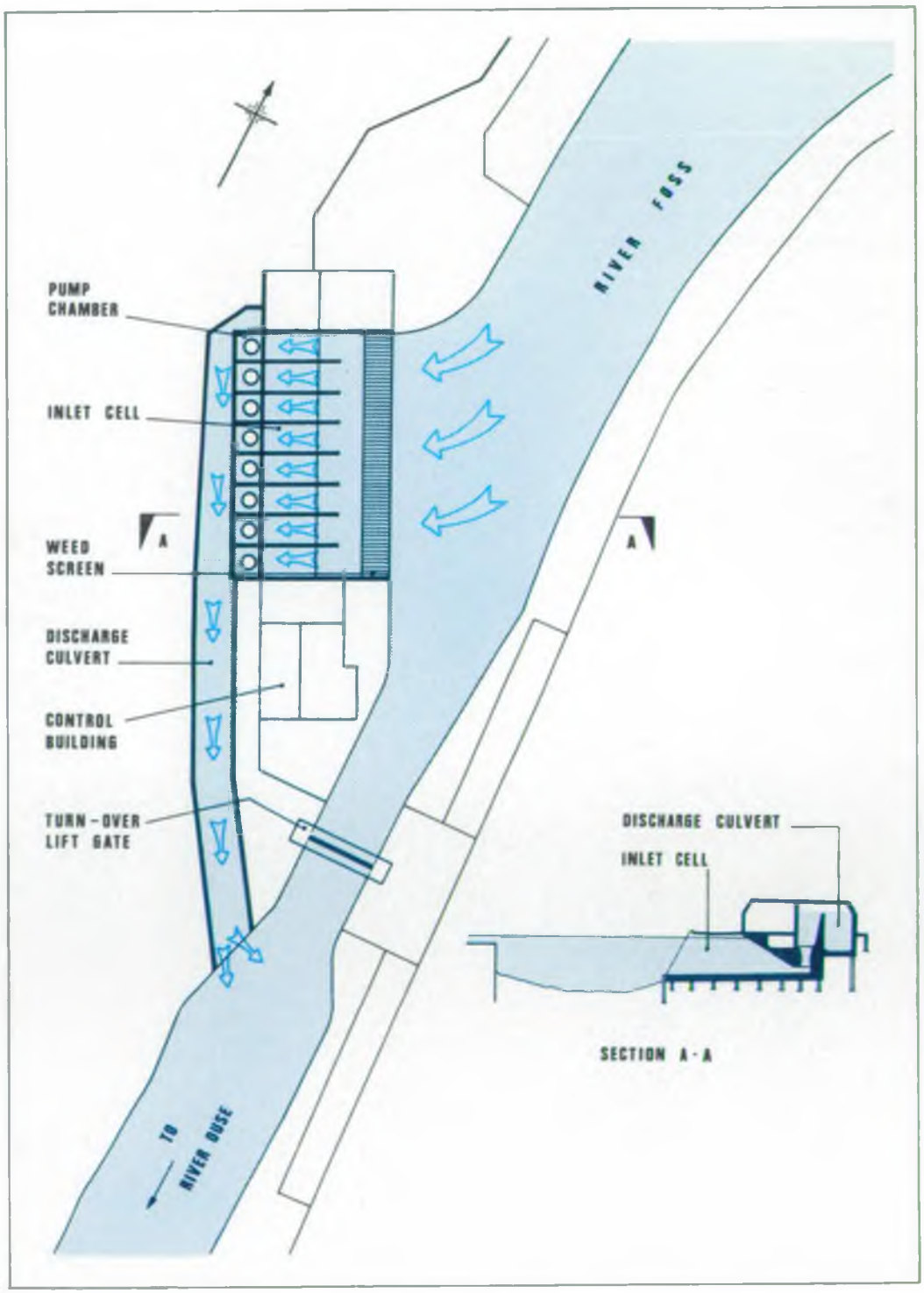

PUMP CHAMBER
INLET CELL
WEED SCREEN
DISCHARGE CULVERT
CONTROL BUILDING
TURN-OVER LIFT GATE
A
A
RIVER FOSS
TO RIVER OUSE
DISCHARGE CULVERT
INLET CELL
SECTION A-A

Fig. 7.

Flood Wall

A flood wall has been built to complete the line of defence between the pumping station and gate and the higher ground at Skeldergate Bridge. The wall, built of reinforced concrete clad in brickwork is 2m high and 200m long and protects the access road to the pumping station which follows the right bank of the River Foss from Tower Street. A ramped access has been provided to the St. Georges Field public car park, the crest of the ramp being at the defence level of 10.45m A.O.D.

Tang Hall Culvert

In order to prevent direct reflection of River Ouse water levels up the culvert, a 1.35m diameter diversion has been built which relocates the outfall in the River Foss upstream of the barrier, as indicated on Fig. 4. A branch off this diversion forms a bypass of the gate which can be used to equalise levels on either side of the gate prior to opening.

Architecture and Planning

In view of the location of the station close to the historic centre of the City of York, particular attention has been paid to the appearance and context of the buildings. Extensive use has been made of brickwork cladding, particularly on the floodwall and pumping station, where structural forms have been echoed in the brickwork.

A public viewing area has been provided adjacent to the west tower of the gate and a variety of hard surfacing materials has been used in areas adjacent to the main structures to create an integrated appearance for the whole scheme.

Patent glazing is a particular feature of the gate support structure, where plain glass has been used to minimise the visual impact.

Close liaison has been maintained throughout the execution of the scheme with the City Planning Authorities to ensure that the conditions attached to the Planning Approval were met.

Control System

The scheme is linked to the National Rivers Authority flood warning scheme. Normally the station is unmanned, but when a flood is likely the duty officer is alerted and arranges for operating staff to turn out.

The systems components are controlled through a microprocessor located in the control room.

River levels are monitored local to the barrier and pumping station and when the predetermined level is reached an audible warning is given to prompt the operator to initiate the closing sequence. On entry of the correct password an external visual and audible alarm is given to warn any river traffic that the gate is about to close. When this has ceased the pumps start automatically, the number starting being determined from information on River Foss flow. The gate then closes, this operation taking about 4 minutes, and the upstream level is automatically controlled to 6.5m A.O.D. ± 0.3m by stopping and starting pumps as necessary.

When the River Ouse level drops to 6.5m A.O.D., the levels on either side of the gate are equalised by means of the lower part of the Tang Hall Culvert Diversion. The gate is then opened after another audio visual warning, and the pumps shut down.

The system will be operated on a routine basis once a month to reduce the risk of malfunction during a flood event. As the rivers will usually be at normal levels during this routine operation, a test penstock is provided in each pump cell to enable the pumps to operate at the optimum static head.

During Construction

Scheme Details

Promoter:	Yorkshire Water, Rivers Division
Engineer:	Mott MacDonald, Newcastle
Architect:	Clouston, Durham
Landscape Architect:	Clouston, Huddersfield
Civil & Building Works Contractor:	Peter Birse Ltd., Barton-on-Humber
Mechanical & Electrical Works Contractor:	William Steward & Co. Ltd., Leeds
Pump Supply and Installation:	Flygt Pumps, Nottingham
Nominated Sub-Contract for Turn Over Lift Gate:	Boving Newton Chambers, Rotherham

Tender Prices

Civil and Building Works	– £2,100,000 (1986)
Mechanical & Electrical Works	– £1,000,000 (1987)
Pumps	– £240,000 (1986)

The Foss Barrier is now managed and owned by the National Rivers Authority Yorkshire Region.