THE UNIVERSITY OF NEW SOUTH WALES

WATER RESEARCH LABORATORY

REPORT No. 18

Cooling Water Screen Chamber

Vales Point Power Station

by

C. R. Dudgeon

APRIL, 1960

The University of New South Wales

WATER RESEARCH LABORATORY

HYDRAULIC MODEL INVESTIGATION

of

COOLING WATER SCREEN CHAMBER
VALES POINT POWER STATION, N.S.W.

by

C.R.Dudgeon

Project No. E.C. 2.2

Final Report to

The Electricity Commission of New South Wales.

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PREFACE

This study forms part of a series of hydraulic investigations undertaken by the Water Research Laboratory of the University of New South Wales at the request of the Electricity Commission of New South Wales. The study was commenced on 20th July 1959 and completed on 23rd September 1959.

Throughout the course of the study, close liaison was maintained with the Electricity Commission through an engineer on the staff of the Commission's Project Development Section, Mr. B.H. Keogh, whose friendly co-operation in the supply of all necessary data is gratefully acknowledged. Internal progress reports of test results were made available to the Commission as data became available.

The study was carried out at the Water Research Laboratory, Manly Vale, N.S.W., by Messrs. C.R. Dudgeon and I.J. Reisonas. The Electricity Commission programme is under the direct supervision of Mr. D.N. Foster of the Laboratory Research staff.

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Assoc.Professor of Civil Engineering
Officer-in-Charge of the Water
Research Laboratory.

20.4.60

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SUMMARY

To provide cooling water for the thermal power station to be built at Vales Point, an open channel is to be excavated to connect the station with Lake Macquarie. The channel is to consist of a parallel entry section 202 ft wide, designed to reduce the flow velocity below that which would carry sand to the pump pits, followed by a section which curves and converges to join the tapered channel off which the cooling water pump intakes lead.

A battery of six 36 ft diameter drum-type screens is to be installed across the 202 ft wide channel to prevent the entry of marine organisms, weed, algae etc into the channel.

Tests on a 1 to 30 scale model of the proposed design of the cooling water screens and intake structure showed that the hydraulic behaviour was completely satisfactory for all discharges. Results of tests carried out with both two and four screens completely blocked indicated no excessive turbulence or head loss and it is considered that the number of screens could be reduced without adversely affecting the hydraulic efficiency.

1. INTRODUCTION

1.1 The Prototype

Cooling water for Vales Point Power Station is to be drawn from Lake Macquarie via a concrete lined channel which has an entrance length of rectangular section 202 ft wide. To allow the water to be freed of foreign matter likely to block or damage the station's pumping and condensing equipment, a bank of five 36 ft diameter self-cleaning drum type screens is to be set in a structure built across the intake channel approximately 400 ft from the lake edge. Water will pass through the screens into a continuation of the intake channel which subsequently curves and narrows to form a convergent channel off which the pump intakes lead.

Fig 1 shows the layout and general details of the intake channel and screen chamber.

The maximum design inflow is 2,800 cusecs with flow depths of 17 ft upstream and 20 ft downstream of the screens.

1.2 Purpose of Model Tests

Model tests were undertaken to allow a study to be made of flow conditions through the screens and in the canal to ensure that excessive air entrainment and head loss did not not occur with the proposed design. The likelihood of eddies formed at the screen chamber being carried downstream to the pump intakes and the possibility of separation at the downstream bend were to be checked for various screen blockage conditions.

2. THE MODEL

2.1 Scale Ratios and Model Validity

It was necessary to model a length of the intake channel on the lake side of the screens sufficient to allow the screen structure to be moved along the channel if found desirable and to maintain a suitable approach length to obtain smooth flow to the model for all positions of the screen structure. On the power station side, the model boundary was extended beyond the curved section of the channel far enough to allow the effect of the bend to be studied without interference from backwater effects produced by the tailwater gate.

The model boundaries are marked on Fig 1.

Consideration of scale effects, accuracy required, cost, available space and water supply led to the choice of a linear scale of 1:30.

Provided flow is fully turbulent in both model and prototype, gravity is the predominant force controlling the free surface flow, and the remaining scale ratios can be fixed by the Froudian relationship.

By equating Froude Numbers in model and prototype, the following scale ratios are fixed:-

Length $\frac{Lm}{Lp} = \frac{1}{30}$

Discharge $\frac{Qm}{Qp} = \frac{1}{4,930}$

Velocity $\frac{Vm}{Vp} = \frac{1}{5.48}$

Time $\frac{Tm}{Tp} = \frac{1}{5.48}$

With a linear scale of 1:30, the minimum model flow depth would be approximately 8 inches and the openings between piers approximately 3 inches in width. The model equivalent of the maximum discharge of 2,800 cusecs is 0.57 cusecs.

From the depth and discharge quoted above, the minimum value of Reynolds Number for the model is calculated as being approximately 7,000. This value assures turbulent flow in the model.

The minimum flow dimensions of 8 inches for depth and 3 inches for width are also sufficiently large to prevent scale effects due to viscosity and roughness from becoming significant.

Comparisons made between flow conditions in the model and prototype will thus be valid.

2.2 Construction

The outer walls of the model were built of $4\frac{1}{2}$" brickwork rendered on the inner face with approximately $\frac{1}{2}$" of cement mortar. The channel floor and screen chamber were made of timber and plywood in such a manner that the screen chamber section could be moved to various positions in the intake channel if found necessary to improve flow conditions in the channel.

The back face and structural portions of the screens were made of 14 gauge galvanised steel sheet and the screen mesh was represented by 16 mesh 28 gauge brass gauze which has approximately the same per cent blockage ratio as the prototype mesh.

Provision was made to drive the screens at the required model speeds by an electric motor, pulley and cord system.

2.3 Water Supply and Control

Water was supplied to the model through a 4 inch diameter pipe, the flow being measured by a standard 3.4 inch diameter orifice. Inflow measurement would be accurate within approximately $\pm$ 2 per cent.

The water level on the upstream side of the screens was maintained at normal lake level by means of a tailwater gate installed at the downstream end of the model.

3. TESTS AND RESULTS

3.1 Tests Carried Out

It was decided that for the maximum design flow of 2,800 cusecs the following aspects should be studied:-

(i) Flow conditions in the screen chamber.

(ii) Passage of disturbances in the flow from the screens towards the pump intakes.

(iii) Effect of the bend in the convergent section of the channel between the screens and the power station.

(iv) Effect of various conditions of screen blockage.

(v) Effect of varying speed of rotation of the screens equivalent to the range of peripheral speeds, 6 to 30 ft/minute, specified by the Commission.

3.2 Test Procedure

The model flow of 0.57 cusecs was established in the model with:-

(i) all screens open

(ii) combinations of two screens blocked

(iii) combinations of four screens blocked

Water levels in the channel were set to the required values and the aspects listed above studied. Screens were blocked as necessary by placing bulkheads in position between the dividing piers.

3.3 Results

In cases (i) and (ii) listed in 3.2, only very small disturbances in the flow were observed and flow conditions were considered to be completely satisfactory. In case (iii), a much more severe blockage condition than is likely to occur, some eddies were formed on the downstream side of the screens but these were soon dissipated.

There was no indication of separation of flow from the inner wall of the bend in the channel.

No variation in flow patterns or disturbances in the flow downstream of the screens could be observed when the speed of rotation of the screens was varied through the range specified by the Commission.

Because of the satisfactory behaviour of the model at the maximum design flow it was considered unnecessary to carry out tests with lower flows.

Figures 2a and 2b show the smooth surface of the water flowing in the channel downstream of the screens for the conditions (a) all screens clear (b) two screens blocked.

4. CONCLUSIONS

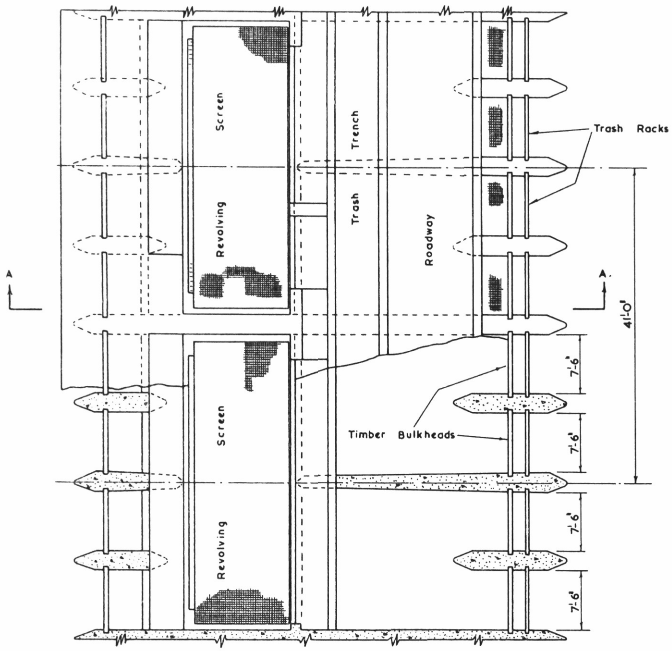
(i) No hydraulic problems are anticipated with the present design of the screen chamber and inflows up to 2,800 cusecs.

(ii) The number of screens could be reduced without reducing the hydraulic efficiency provided excessive fouling of the screens does not occur because of the increased discharge.

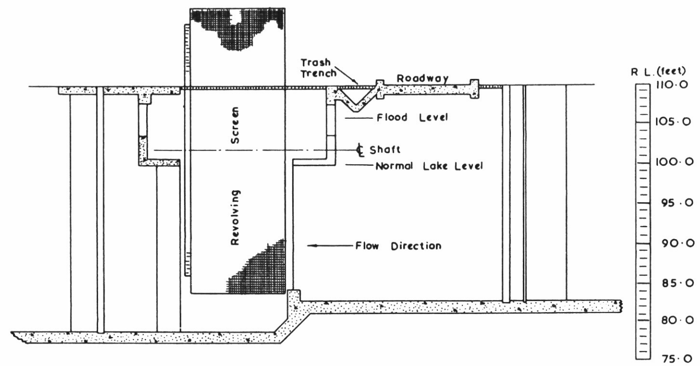
(iii) Variation of the speed of rotation of the screens over the range specified by the Commission will have no significant effect on flow conditions in the screen chamber or inlet channel.

(iv) Flow conditions in the channel approaching the pump intakes should be completely satisfactory and the curve in the channel downstream of the screens should have no adverse effects.

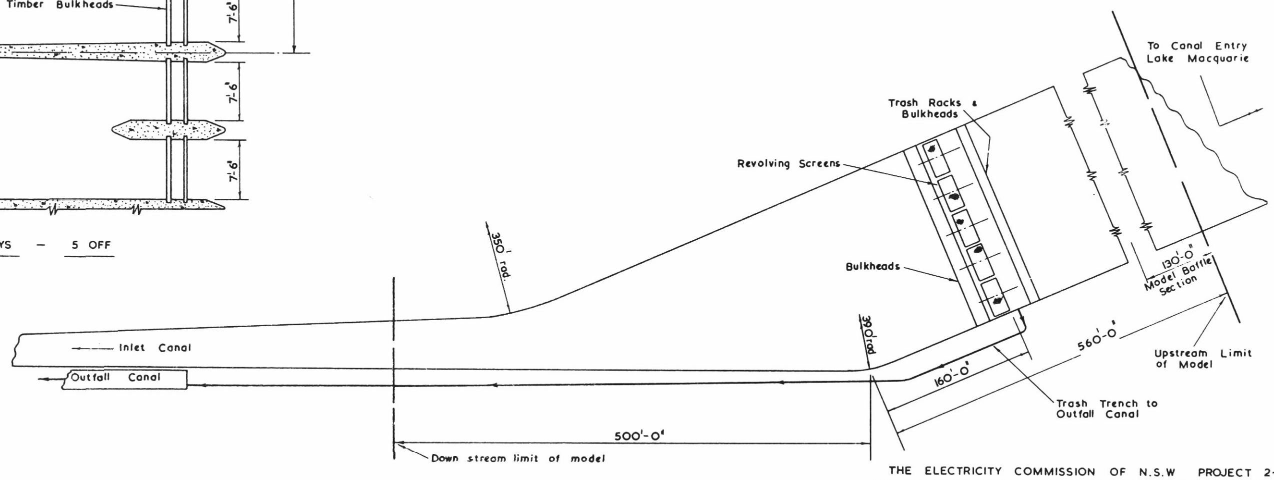
(v) As viscous effects of flow through the prototype screens could not be reproduced accurately in the model, head losses measured through the model screens would not give a direct indication of losses to be expected in the prototype. For this reason, no measurements of head loss were made. However, it is not anticipated that there will be any problem with head loss as velocities through the screens are very low and partial blockage of one or more screens will result in the re-distribution of flow to favour the remaining screens with but a small increase in head loss.

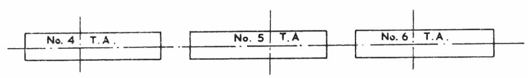


SCREEN BAYS — 5 OFF



SECTION A–A.





TURBINE HOUSE

FIG. 1.

THE ELECTRICITY COMMISSION OF N.S.W PROJECT 2·2

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VALES POINT POWER STATION
ARRANGEMENT OF
CIRCULATING WATER CANALS, SCREENS & SCREEN CHAMBER

DRAWN: G. Leach	SCALES:	CE-C-909
CHECKED:	$\frac{1}{8}$" = 1'-0"	
APPROVED:	1" = 66'-0"	

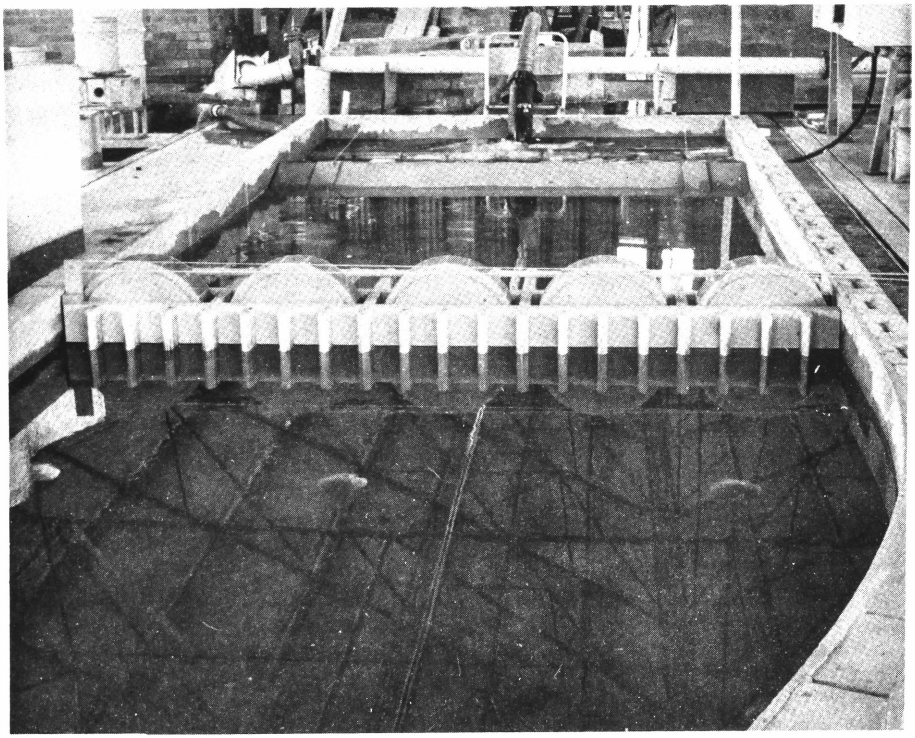

FIG. 2a
Smooth flow conditions downstream of screens for flow of 2,800 cusecs and all screens clear.

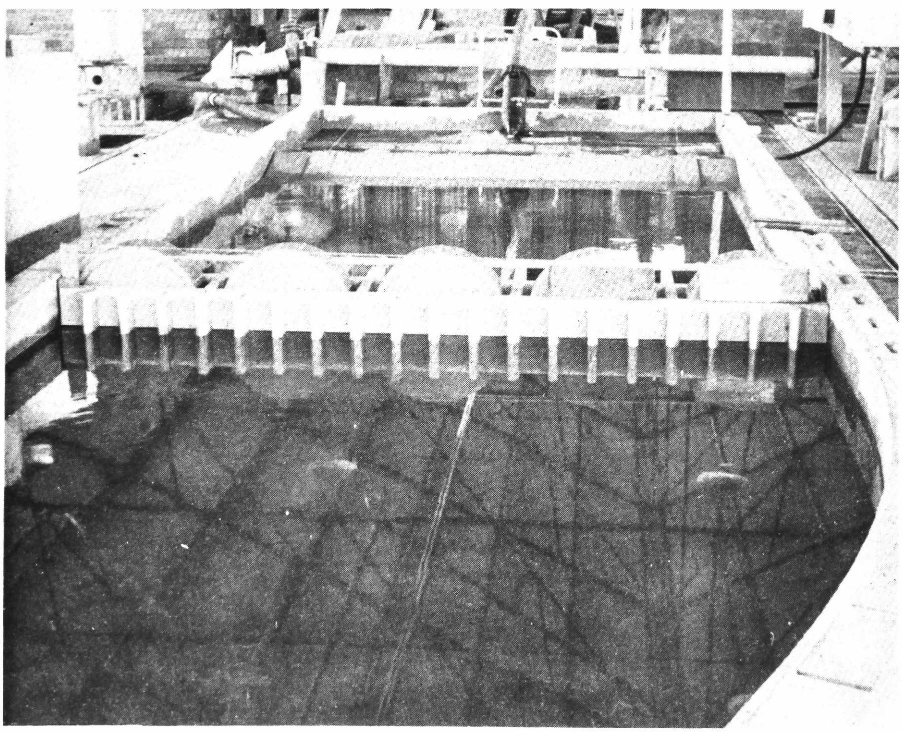

FIG. 2b
Smooth flow conditions downstream of screens for flow of 2,800 cusecs and two screens blocked.