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## 'Report on the Development of Mesopotamia with Special Reference to the Regeneration of the River Systems'

<b>Holding Institution</b>	British Library: India Office Records and Private Papers
<b>Reference</b>	IOR/L/MIL/17/15/53
<b>Date(s)</b>	1917 (CE, Gregorian)
<b>Written in</b>	English in Latin
<b>Extent and Format</b>	1 volume (23 folios)
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### About this record

The volume is Sir George Buchanan KCIE: *Report on the Development of Mesopotamia with Special Reference to the Regeneration of the River Systems* (Simla: Government Monotype Press, 1917).

The report contains preliminary remarks, and sections on:

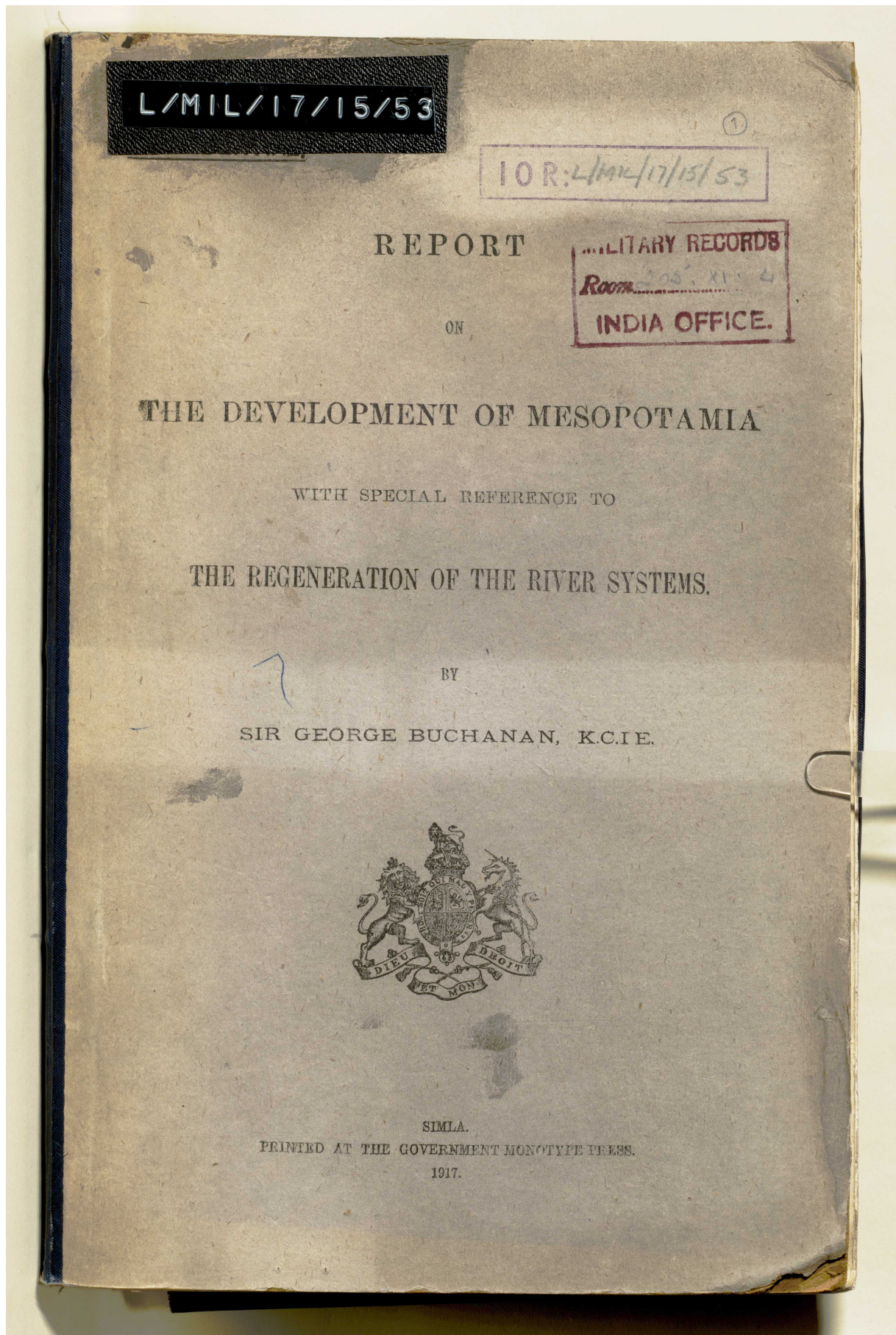
- Mesopotamia as it was;
- Mesopotamia as it is;
- Reasons for the deterioration of the country since ancient times;
- Description of the Tigris and Euphrates as they appear today;
- Sir William Willcocks's Irrigation Projects;
- Suggestions for river regeneration;
- Agriculture in Mesopotamia;

- Navigation on the Tigris and Euphrates;
- Conclusions and recommendations.

The report is accompanied by seven illustrations consisting of photographs of the River Tigris at various points (folios 16-18); and five maps illustrating the courses, delta and country surrounding the Rivers Tigris and Euphrates, and proposed irrigation works (folios 20-24).

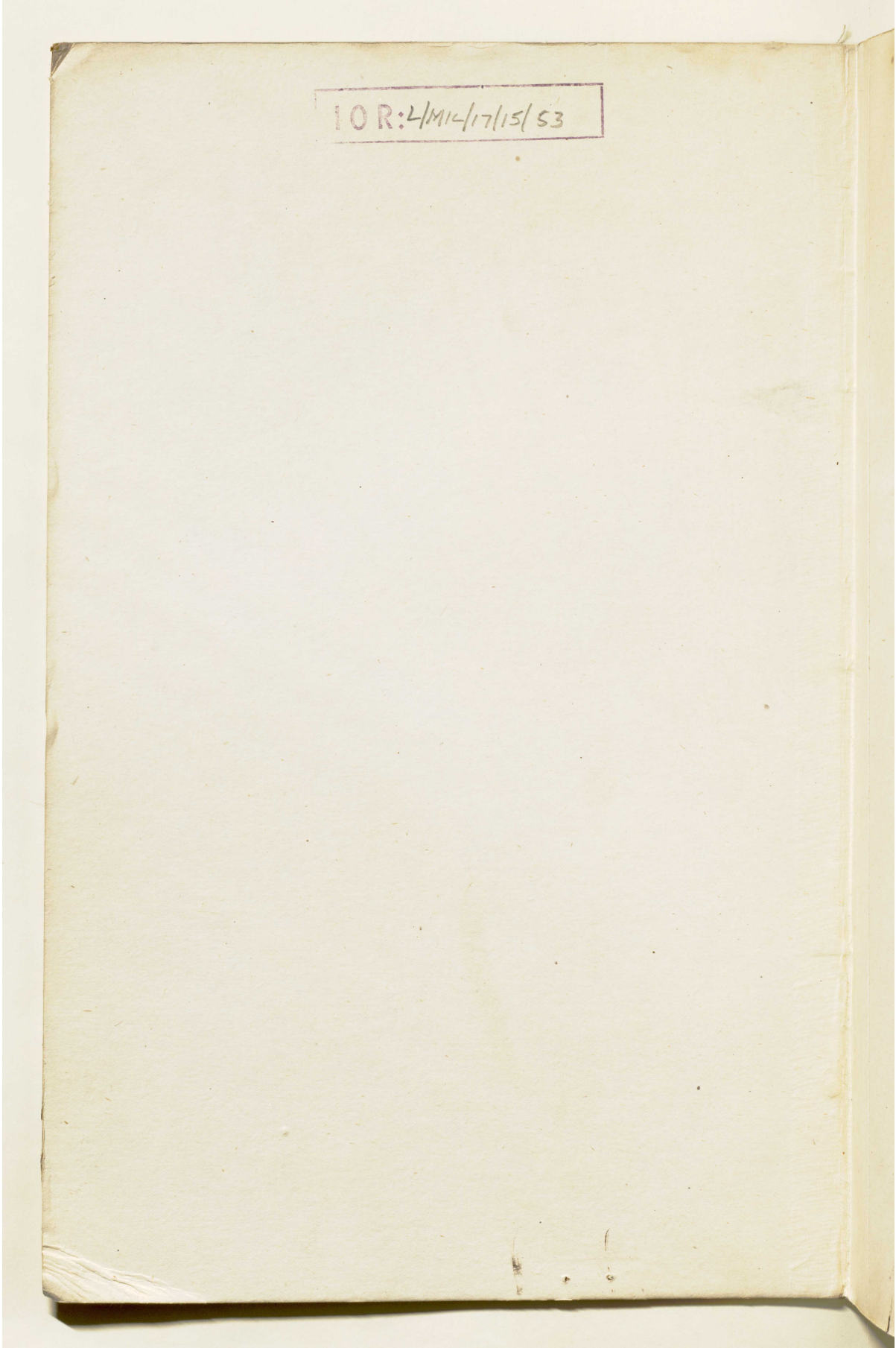


'Report on the Development of Mesopotamia with Special Reference to the  
Regeneration of the River Systems' [front] (1/50)

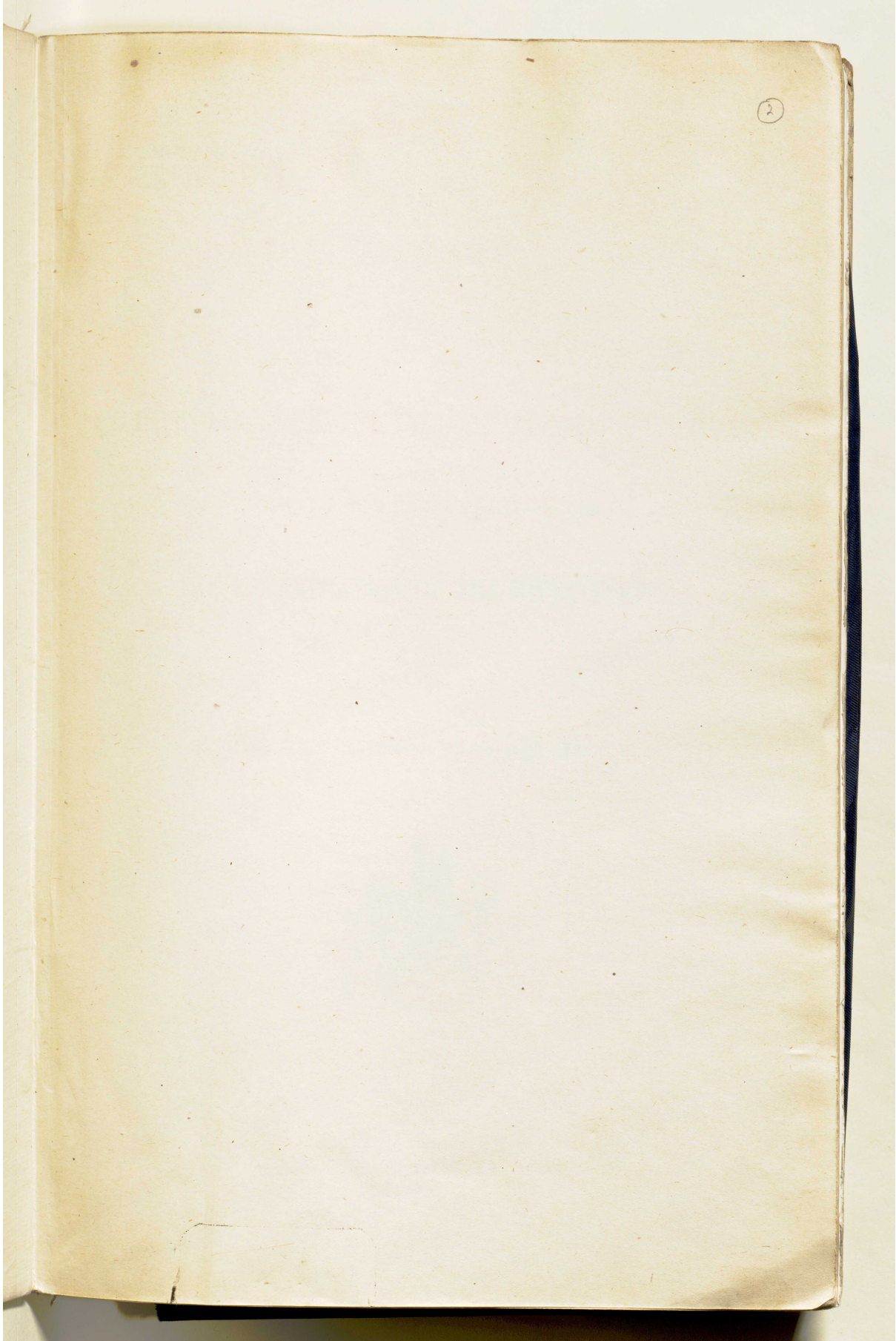




'Report on the Development of Mesopotamia with Special Reference to the  
Regeneration of the River Systems' [front-i] (2/50)

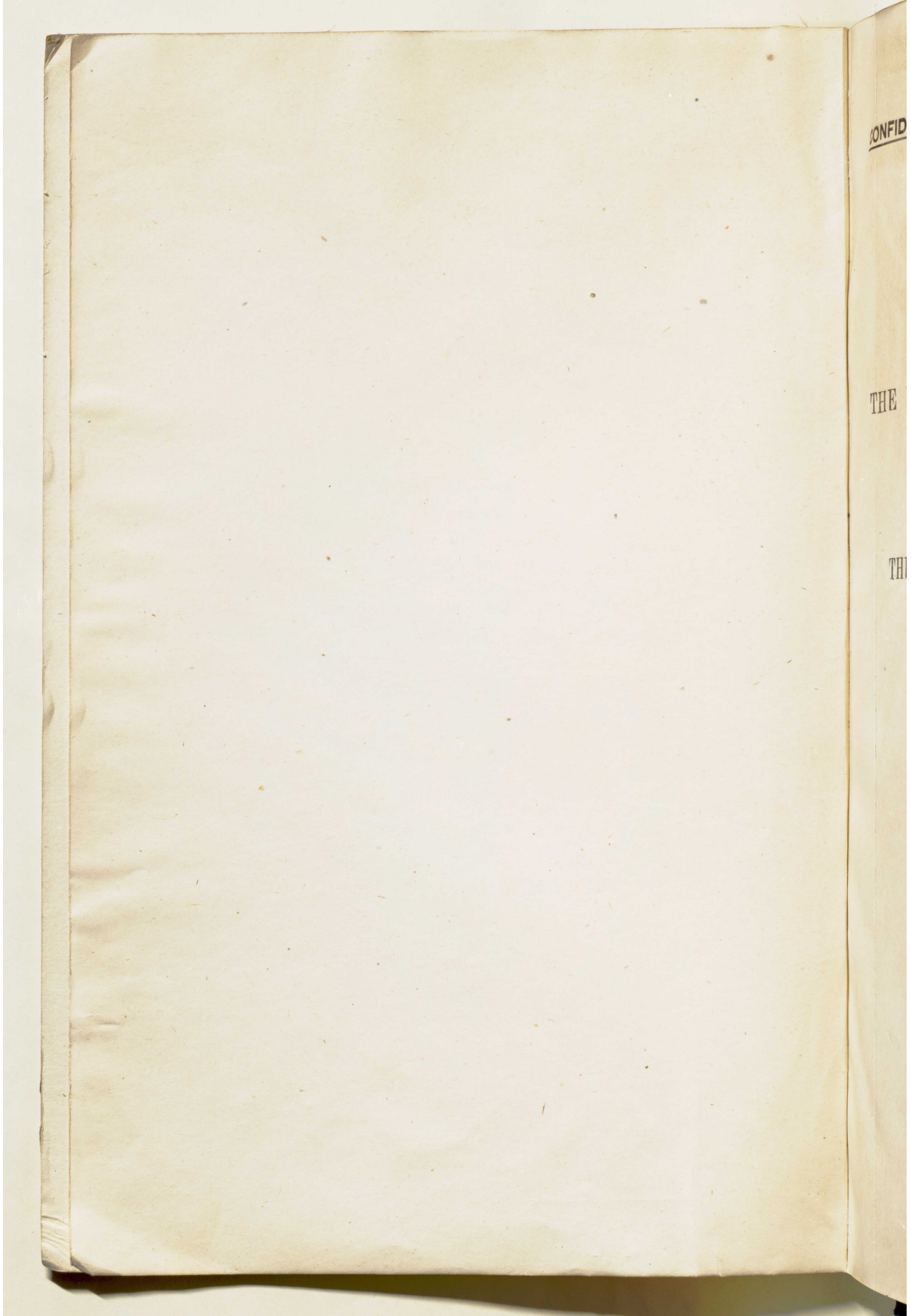


'Report on the Development of Mesopotamia with Special Reference to the  
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'Report on the Development of Mesopotamia with Special Reference to the  
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CONFIDENTIAL.

REPORT

ON

THE DEVELOPMENT OF MESOPOTAMIA

WITH SPECIAL REFERENCE TO

THE REGENERATION OF THE RIVER SYSTEMS.

BY

SIR GEORGE BUCHANAN, K.C.I.E.

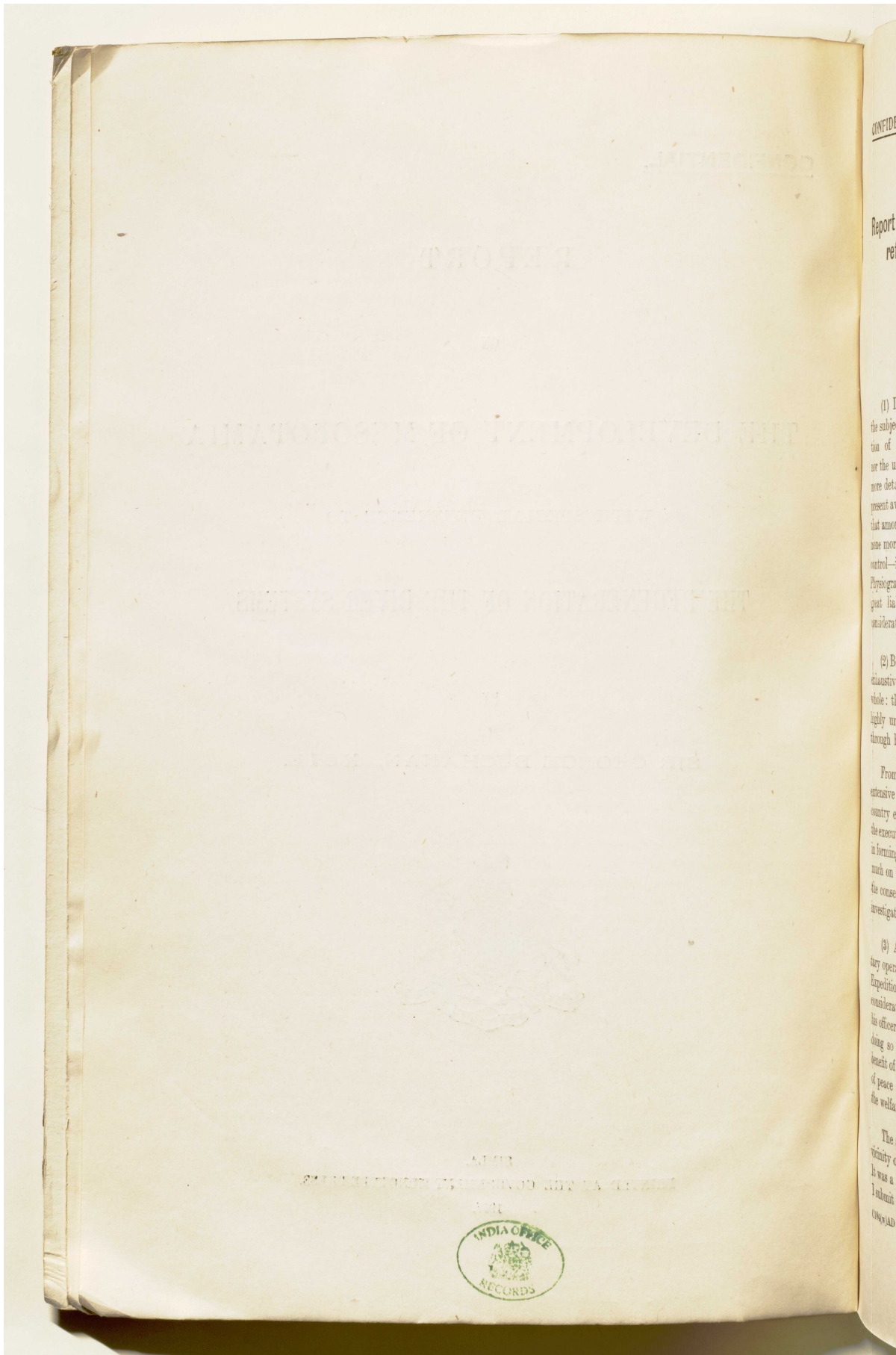


SIMLA.

PRINTED AT THE GOVERNMENT MONOTYPE PRESS.

1917.

'Report on the Development of Mesopotamia with Special Reference to the  
Regeneration of the River Systems' [ii-v] (6/50)





'Report on the Development of Mesopotamia with Special Reference to the  
Regeneration of the River Systems' [1] (7/50)

CONFIDENTIAL.

Report on the Development of Mesopotamia, with special  
reference to the Regeneration of the River Systems.

PRELIMINARY.

Necessity for Caution.

(1) In writing this report I desire to emphasize the necessity for looking at the subject from all points of view, and to impress the need for the recognition of the fact that neither the improvement of the rivers for navigation, nor the utilization of their waters for irrigation, is possible until a very great deal more detailed information has been carefully collected and studied than is at present available. It cannot, indeed, be too deeply impressed upon those in authority that amongst the many matters which engage the attention of engineers, there are none more difficult than those which relate to the subject of rivers and stream control—involving, as they do, problems which embrace the sciences of Geology, Physiography, Hydraulics, Agriculture, Forestry, and Engineering. There is very great liability to error, through failure to take all the material points into consideration.

(2) Before works of any importance can be carried out the rivers must be studied exhaustively throughout their lengths, each being treated as one comprehensive whole: this is particularly necessary in the case of rivers in such a condition of highly unstable equilibrium as the Tigris and Euphrates, which have already, through human abuse, fallen into a condition nearly approaching disintegration.

From my personal experience, I doubt the practicability of carrying out extensive surveys and studies, or the expediency of attempting to develop the country economically by means of irrigation works or river improvements during the execution of military operations, but if it is thought that no time should be lost in forming ideas on the subjects of river improvement, irrigation, and agriculture—much on the line of the reports I have prepared on the development of Basra and the conservancy of the Shatt-el-Arab river—I can see no harm in a preliminary investigation by a committee of experts.

(3) As an illustration of the difficulty of developing the country during military operations, I may point out that the General Officer Commanding, the Indian Expeditionary Force "D," submitted, in September 1915 for the information and consideration of the Government of India, an irrigation project prepared by one of his officers involving an expenditure of 54 lakhs of rupees or £360,000, and in doing so remarked that: "The undertaking of a large irrigation scheme for the benefit of the country would have the best possible effect in establishing a sense of peace and security, and would afford an earnest of our intention to promote the welfare of the people."

The scheme proposed included the reclamation of 100,000 acres of land in the vicinity of Basra, and a return of 11 per cent. on the capital outlay was anticipated. It was a local project designed without reference to the country as a whole, and I submit it is a matter for congratulation that the Government of India took no

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action on the proposal, more especially as works being carried out for military purposes would have largely interfered with the scheme.

### Subjects dealt with in this Report.

(4) The country discussed in this report is the whole of the area within the delta of the rivers Tigris and Euphrates known as Irak or Mesopotamia, and I propose to deal with the case under the following heads :—

- (a) Mesopotamia as it was.
- (b) Mesopotamia as it is.
- (c) Reasons for the deterioration of the country since ancient times.
- (d) Description of the Tigris and Euphrates as they appear to-day.
- (e) Sir William Willcocks's Irrigation Projects.
- (f) Suggestions for river regeneration.
- (g) Agriculture in Mesopotamia.
- (h) Navigation on the Tigris and Euphrates.
- (i) Conclusions and recommendations.

The report is accompanied by the following plans and photographs :—

- (i) Reproduction to a reduced scale of Sir William Willcocks's conceptions of the ancient Tigris-Euphrates delta.
- (ii) Cross-sections of the Tigris.
- (iii) Photographs of the Tigris between Baghdad and Kurnah.
- (iv) Survey of the country between Amara and Kurnah.
- (v) Survey of the country between Kurnah and Nasiriyah.
- (vi) General plan of Sir W. Willcocks's irrigation scheme.

### (a) MESOPOTAMIA AS IT WAS.

(5) I do not propose to attempt a description of Mesopotamia from earliest times ; it is sufficient that we are told by historians and others who have made a study of the subject, that in this region civilization has succeeded civilization, and kingdom has succeeded kingdom, from the earliest records of the human race, and that for thousands of years Mesopotamia was one of the richest countries in the world—in a high state of cultivation, with giant canals taking off from the rivers Tigris and Euphrates, the remains of which can be seen to-day, prosperous cities in great number, and a population which was calculated by millions.

Babylon was at the height of its prosperity about 2,000 B.C., and Baghdad 833 A. D. when its population numbered 2 million souls and the city was 5 miles across within the walls.

The general configuration of the country must have greatly changed since the beginning of the Babylonian Empire : we know that the delta has extended seaward 130 miles since Eridu was the principal seaport of the Sumerians, with the result that the slopes of the rivers must have flattened considerably, whilst at that period the Tigris and Euphrates entered the Persian Gulf as separate rivers with their mouths a full day's journey apart. The country was also covered with dense forests and probably had a larger rainfall and more equable climate than obtains to-day. Accompanying this report is a reproduction of Sir William Willcocks's conception of the ancient Tigris-Euphrates delta.



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(b) MESOPOTAMIA AS IT IS.

(6) For practical purposes it is useless to dwell on the glories of the past, and the fact remains that Mesopotamia is to-day a miserable wilderness of barren desert alternating with vast swamps; there are stretches of cultivation along the river banks and on the outskirts of the marshes, and large date groves thrive on the Shatt-el-Arab and in the vicinity of Suk-esh-Sheyukh; but between Basra and Baghdad, on the Tigris, there is only one collection of houses that can be dignified by the name of town, whilst, on the Euphrates, Suk-esh-Sheyukh, Nasiriyah, Samawa and Kerballa, are the only villages of any size between Basra and Hit. All traces of civilization have disappeared except the mounds which cover the remains of Ur of the Chaldees, Babylon, Nineveh and Seleucia, to mention a few of the many cities of the past; and ancient Baghdad is represented by a vast area of broken bricks and rubbish; whilst the inhabitants of Mesopotamia to-day consist mostly of nomadic tribes with an ancient prescriptive right to the occupation of large areas of country.

The climate is divided between intense heat in the summer and considerable cold in the winter, and the mean annual rainfall at Baghdad is  $8\frac{1}{2}$  inches.

(c) REASONS FOR THE DETERIORATION OF THE COUNTRY SINCE  
ANCIENT TIMES.

(7) Sir William Willcocks, in his lecture before the Khedivial Geographical Society, gave as a reason for the destruction of the Tigris canals a change in the course of the river whereby the headworks of the canals were destroyed, and he also gave the following lucid explanation for the destruction of the Euphrates irrigation system:—

“When the ancient Chaldeans—the men who travelled from the East and found a resting place in the plain of Shinar—first settled in these regions, they must have found the Tigris and Euphrates flowing in well-defined and capacious beds. Such capacious beds all silt-laden streams naturally form for themselves when not interfered with by external agencies. There were occasional heavy inundations of the country, and occasional droughts, but generally the streams kept within their channels. Such a state of affairs in a dry climate like that of Mesopotamia, was eminently suited to irrigation, and the early settlers must soon have undertaken irrigation works. As the population and resources of the region increased, the irrigation canals become larger until eventually the whole face of the country was covered with gigantic canals, and the amount of water withdrawn from the rivers must have greatly exceeded that left in the main streams. The main rivers accommodated their beds and channels to suit the new conditions and gradually dwindled away. Weirs and obstructions to raise the water levels in years of insufficient supply still further told against the rivers; until eventually the rivers were quite unable to carry the waters when not relieved by the canals. Dykes along the river banks protected the country from occasional inundations, but the chief protection existed in the well maintained canals which carried between them no inconsiderable portion of the floods. In the unsettled times with which for many generations these regions were cursed the dykes were swept away, the canals silted up at their heads and were choked with weeds lower down their courses and the rivers found themselves quite incapable of carrying the extra supplies thus thrust upon them. The



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country became a swamp. These waters which had once 'nourished her and run about her plantations, and sent out channels unto all the trees of the field' now stagnated, and became as great a curse as they had been a blessing. Such is this region as we see it to-day."

(8) Sir Mark Sykes, in his book "The Caliphs' Last Heritage," attributes the destruction of the country to the Mongol inroad in 1258 A. D., and graphically describes the episode in the following words:—

"Sweeping on to the south-west the huge force poured into Irak and surrounded Baghdad itself. The wealth of ages lay at the conqueror's feet. Baghdad was besieged—schism and rebellion broke out within—the irresistible forces thundered without—Baghdad fell. The town was sacked and burnt—the inhabitants were massacred—the women carried off into slavery—the Abbasid caliph was executed—gold was thrown about like lead, and long streams of caravans marched eastward carrying away the incredible booty. The most fatal accident of all, in this colossal disaster, was the irretrievable ruin of the whole system of irrigation of Mesopotamia. Baghdad was destroyed and with it the very sources of life. Mesopotamia, which had known wealth for perhaps five thousand years, now sank back into desert and swamp. This is a calamity almost beyond human comprehension—a populous land reduced to emptiness; the granary of the world, a wilderness of reeds and sands. The region whence Semite, Elamite, Babylonian, Persian, Macedonian, Seleucid, Parthian, Sassanian, Omayyad and Abbasid had successfully drawn perennial riches, became, under the devastating hand of Hulagu, a place of mounds and sherds, a waste of unfruitful waters intersecting arid plains of dust and scrub. Having destroyed the work of three hundred generations of men in a single year Hulagu retired to Persia, leaving a famine and desolation which endure to this day.

\* \* \* \* \*  
\* A thousand mule loads of gold and jewels to Persia, or a thousand penniless architects, philosophers, dyers and tanners in Cairo were as nothing in compensating force to the disappearance of canals which for 5,000 years had supported abundant life and produced certain and perennial prosperity. Henceforward we must look at Mesopotamia not as a centre of vitality but as an hiatus in the scheme of things."

(9) It is possible that the change in the course of the Tigris was deliberately brought about by the Mongol raiders led by Hulagu, but in any case it seems to me probable that a gradual deterioration of the canals had been proceeding for thousands of years. The canals at the time when Baghdad was at the height of its prosperity were admittedly far inferior to those of the old Babylonian and Sassanian times. Sir William Willcocks, in his book, points out that never in the history of Mesopotamia has the whole country been under irrigation at one and the same time. The centre of cultivation was at first in the lower reaches of the two rivers between Nippur and Ur of the Chaldees; then it travelled to the tract between Sippara and Babylon. In Persian times the centre was Ctesiphon, while Basra, Wasit and Kufa in the lower part of the delta were the first capitals of the Arabs, and Baghdad became the centre in the time of the Caliphs.

Sir William Willcocks attributes the complete obliteration of the ancient canals to the heavy silt deposits, and it is not unlikely that the centre of cultivation



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shifted as the various irrigation systems were used up owing to lack of proper drainage and scientific grading of the canals. We know that in Egypt there was no scientific irrigation until after the British occupation, and there is no reason to suppose that the Babylonians were further advanced than the Egyptians.

(10) There has, however, been a further and progressive deterioration in comparatively modern times, which can be seen in operation to-day.

The final destruction of the irrigation system by Hulagu took place in 1257 A.D. and the country came under the rule of the Turks in 1638 A.D. On the disappearance of the ancient canals, it became necessary for the remaining inhabitants, along with such of the invaders who had settled in the country, to construct new works or die of starvation; and as the irrigation engineering of the ancients had become a lost science, there was a reversion to primitive methods. Numerous channels and ditches were cut opening direct on to the main stream in order to irrigate a fringe of cultivable land, and although the volume of water taken by each channel was in the first instance small, the effect in the aggregate was sufficient to prevent the river from scouring out the accumulation of silt deposited during flood time, with the result that there was a corresponding rise in the bed of the river. Further, the reduction in the volume of water which reached the lower regions of the river facilitated encroachments on the river bed by cultivators, thus strangling the river and narrowing its bed. This again had a reactive effect in flood time, since the river being no longer able to discharge excessive floods was compelled to overflow, and thus increased and extended by silt deposits the elevated area along the banks of the river, which, in turn, acted as an effective bar to the natural drainage of the country; and the drainage water unable to work its way to the river automatically created marshes.

At a later stage, the river being raised above the surrounding country, the irrigation channels leading from the river to the land beyond the elevated crest began to scour since they had a steeper gradient than the river itself, and in some cases—notably, the Chahala, Majar Kabir, and Michiriyah, on the Tigris, and the Uam Nekhla, Mezlik, and Hakika, on the Euphrates—absorbed the greater part of the river's flow. Such an escape had the effect of increasing and perpetuating the marshes originally caused by the obstructed drainage, and the accumulated water was compelled to find its way back to the river at a lower point in its bed or to make a fresh channel to the sea.

The result of the whole of the operations has been a further disintegration of the rivers and the creation of marshes.

(d) DESCRIPTION OF THE TIGRIS AND EUPHRATES AS THEY APPEAR  
TO-DAY.

General Remarks.

(11) The following information is partly from personal knowledge acquired during my eighteen months' experience of the country, and partly collected from the available literature on the subject. The total amount of reliable data is lamentably scant, and emphasizes my remarks in paragraph (1) of this report on the necessity for caution until the completion of surveys and studies.

Both rivers have the characteristics of silt-carrying rivers, that is to say—the surface of the country through which they flow has been gradually raised by silt deposited when they overflowed their banks; and as the greatest deposition has taken place nearest the bank, the rivers flow on ridges with the banks sloping

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downwards on either side ; and the lowest ground level is between the two rivers. Although the high-flood level is above the level of the surrounding country, the beds of both rivers are considerably below the lowest level of the ground, and in that respect differ from some other rivers of the same class, notably, the Hoang Ho in China.

The Tigris.

(12) The Tigris rises in the hills to the south and west of Lake Van, and enters its delta in the neighbourhood of Beled 102 miles above Baghdad. Its sole tributaries between Beled and Kurnah, a distance of 555½ miles, being the Shatt-el-Adhem near the ruins of Opis, and the Diala a few miles below Baghdad.

When Colonel Chesney made his expedition in 1837-38, there was direct communication between the Euphrates and the Tigris by the Saklawia canal which left the Euphrates above Felujah and joined the Tigris 5 miles below Baghdad *via* the lake Akar Kuf. The distance from river to river was 45 miles with a depth of water, in July 1838, of 6 to 18 feet. This canal was closed about 45 years ago by Midhat Pasha as a flood preventive measure, but was reopened by the Turks within the last few months, just after our capture of Baghdad. It may be now a useful waterway for military purposes, but will require most careful watching and ultimate closure.

At Kut, 214 miles below Baghdad, the Shatt-el-Hai, which was for many years the main stream, takes off from the Tigris and runs out into the Euphrates marshes near the Hamar Lake. It has a considerable flow in the flood season but is practically dry at low-water.

The Tigris is at its lowest in the months of September and October, and begins to rise with the winter rains in December ; but it is not in flood until the melting of the snows in the high hills, which generally commences towards the middle or end of March.

During high-floods the river overflows its banks, from Baghdad downwards ; whilst in the low-water season, the water escapes down numerous irrigation canals and ditches on both sides of the river—more particularly in the lower reaches.

(13) The following table gives the discharges of the Tigris at various points :—

Name of locality.	Flood cusecs.	Low-water cusecs.	REMARKS.
Baghdad .. .. .	106,000	10,600	
Kut-el-Amara .. .. .	160,000	10,600	Increase in flood due to Diala which is dry in low-water season.
Amara, above Chahala Canal	35,000	10,100	Great reduction at Amara in flood due to spill over bank between Baghdad and Amara.
Amara, below Chahala Canal . .	20,000	5,600	
Qualat Saleh .. .. .	4,000	2,800	
Ezra's Tomb .. .. .	13,400	7,700	
Kurnah .. .. .	28,000	..	



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Discharge of Effluents.

Name of Effluent.	Flood cusecs.	Low-water cusecs.
Chahala Canal .. .. .	14,424	4,503
Majar Kabir Canal .. .. .	7,818	..
Abu Tabar .. .. .	862	..
Michiriyah Canal .. .. .	4,296	1,500

The discharges for Baghdad and Kut-el-Amara are taken from Sir William Willcocks's book and the remainder from my own observations. In high-flood the figures are all probably greatly exceeded for short periods.

(14) Sir William Willcocks estimates the high-flood discharge of the Chahala at 35,000 cusecs and the Majar Kabir at 21,000 cusecs. Assuming his figures to be reasonably correct, conditions must have greatly altered since 1908, as I believe my discharges to be as nearly accurate as possible and 15,000 to 16,000 cusecs to be the maximum flow down the Chahala and 8,000 cusecs for the Majar Kabir.

Accompanying this note are a sheet of cross-sections of the river from Baghdad to Basra, some photographs of the river between these points, and a survey sheet from Amara to Kurnah; a study of these drawings and photographs, with the discharge tables, is very illuminating and clearly indicates the disintegration of the river through human abuse and neglect described in paragraphs 9 and 10 *supra*.

(15) A river under ordinary conditions increases in width as it reaches its mouth, but the Tigris at Baghdad is a fine stretch of water, and at Qualat Saleh a ditch.

Between Amara and Aziziah no less than 81 canals, exclusive of the Hai, take off from the right bank; but the bulk of them are dry at low-water, which accounts for the low-water discharge at Baghdad and Amara being practically the same, whereas the flood discharge at Amara is only one-third of the discharge at Baghdad.

(16) The real menace to the existence of the Tigris as a river takes place, however, between Amara and Ezra's Tomb where large canals carry away the greater part of the low-water discharge. The principal offenders are the Chahala, Majar Kabir, and Michiriyah canals.

The Chahala, sometimes known as the Hud, was opened out as a small irrigation ditch about 100 years ago. It now takes nearly half the low-water discharge of the Tigris above Amara, and, after irrigating in an extravagant manner the country through which it and its many branches pass, loses itself in the swamps.

The Majar Kabir and the Michiriyah are equally wasteful of water, and the gravity of the situation has been greatly increased by the Arabs having been allowed to reclaim large areas of land on both banks of the Tigris between Qualat Saleh and Ezra's Tomb, thus still further reducing the sectional area of the river which now, in time of floods, spreads over the whole of the surrounding country like a sea.

In the neighbourhood of Ezra's Tomb the water from the swamps begins to return into the river from both sides, and at Kurnah the low-water discharge is practically the same as at Amara and Baghdad.

Slope of river.

(17) The following table gives the slope of the water in flood and at low-water between Kassar Hassan Bey, 177 miles above Baghdad, and the sea.



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The levels are taken from Sir William Willcocks's book and reduced to feet :—

*Slope of Tigris above and below Baghdad to the sea.*

(Heights above mean sea-level.)

	Distance in miles.	High Flood level feet.	Low- water level feet.	Range feet.	Distance between points.	High Flood slope per mile inches.	Low water slope per mile inches.
Kassar Hassan Bey	0	362·87	339·58	23·29	..	..	..
Samarra .. ..	68·31	206·04	183·73	22·31	68·31	27·5	27·3
Sheikh Mohamed Hassein	99·36	151·25	124·67	26·58	31·05	21·2	22·8
Baghdad .. ..	176·98	114·83	94·49	20·34	77·62	5·5	4·6
Baghdad .. ..	0	114·83	94·49	20·34	..	..	..
Kut .. ..	214·34	57·41	39·37	18·04	214·34	3·2	3·1
Amara .. ..	366·56	28·54	21·32	7·22	152·21	2·2	1·4
Qualat Saleh .. ..	397·63	21·00	13·45 <i>16·45</i>	7·55 <i>4·55</i>	31·06	2·9	3·0 <i>1·87</i>
Ezra's Tomb .. ..	422·48	14·76	8·20 <i>7·07</i>	6·56 <i>7·60</i>	24·85	3·0	2·6 <i>4·5</i>
Kurnah .. ..	453·54	10·17	3·93	6·74	31·06	1·8	1·6 <i>1·22</i>
Basra .. ..	498·28	8·53	1·80	} Tidal.	44·73	..	..
Fao 蘆 .. ..	561·41	8·56	·065		63·13	..	..

Baghdad to Kurnah. } High-flood, 2·77 inches per mile.  
} Low-water, 2·39 inches per mile.

The figures italicised opposite Qualat Saleh, Ezra's Tomb, and Kurnah are from my own observations and differ considerably from Sir William Willcocks's. I do not think the river has, within recent years, reached the low level at Qualat Saleh assumed by Sir William Willcocks, as in that case it would be nearly dry and all navigation would cease. The effect of the large effluents which leave the river above Qualat Saleh and send a great deal of their water back through the marshes at Ezra's Tomb, is to flatten the slope between Amara and Qualat Saleh and largely to increase it between Qualat Saleh and Ezra's Tomb.

**Velocities.**

(18) I am of opinion that the velocity of the Tigris has been greatly over-estimated, especially in the lower reaches where 4 miles per hour, or nearly 6 feet per second, has been commonly quoted.

The velocity is influenced by depth as well as by slope, and between Amara and Kurnah, with a slope of say 3 inches per mile, the depths in flood are such as should by calculation give a velocity of 2 to 3 feet per second, or say 2 miles per hour, and that is what I obtained from actual observation.

At Baghdad, in high-flood, the mean velocity probably reaches 5 to 6 feet per second, and at Samarra 10 feet per second, or 6 to 7 miles per hour. Chesny



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estimated the velocity of the Tigris at Baghdad at 7.33 feet per second, and discharge 164,103 cusecs; and as he probably took the surface velocity, his figures and mine agree fairly well.

Sir William Willcocks's greatest velocity registered at Baghdad on a rising river, on the 25th April 1909, was 6.5 feet per second, surface velocity; and his lowest velocity, in September 1909, was 1.01 feet per second.

Meanderings of river.

(19) The length of the river between various points, measured direct and round bends, with the percentage of meandering, is shown below:—

From.	To.	Length direct.	Length round bends.	Percentage of meandering.
		Miles.	Miles.	
Baghdad .. .. .	Kut .. .. .	103	214	108
Kut .. .. .	Amara .. .. .	120	153	27
Amara .. .. .	Kurnah .. .. .	63	86	14
Kurnah .. .. .	Basra .. .. .	..	47	..

The percentage of meandering between Baghdad and Kut is enormous, and its cause is open to conjecture until the matter has been properly investigated.

(20) A considerable amount of information respecting the river was obtained by the Chesney expedition in 1837, and from the figures given below—even if only approximately correct—it would appear that the length of the river has considerably increased in the last eighty years.

From.	To.	Distance by Chesney.	Distance by Willcocks.
		Miles.	Miles.
Baghdad .. .. .	Kurnah .. .. .	431	453
Baghdad .. .. .	Kut .. .. .	199	214
Kut .. .. .	Kurnah .. .. .	232	239

(21) In describing his journey up the Tigris, Chesney wrote as follows:—

“The ascent of the Tigris commenced on the afternoon of September 15th and passing the Tomb of Ezra, we brought up for the night at Janchu, having ascended rather more than 38 miles of river during that afternoon, with an average depth of from 2 to 6 fathoms, and a width of 200 yards. The water was necessarily low at this season, so that we were prepared for some difficulty in the ascent, which, in one or two places, caused us to lose time. Thus we accomplished only 33 miles in 6¾ hours to the village of Bistoa. The next day, the river still winding very much through wooded banks, we made our way onwards with less difficulty, the depth varying, as before, from 2 to 6 fathoms. One bend of the river is so exactly like another that the pilots have to place stones, to enable them to distinguish between the different reaches, to which they give separate names.

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As the river improved in depth, so our progress became more satisfactory, and we made  $67\frac{2}{3}$  miles to Ras-al-Kheyran during this day \* \* \* \* \* The river flows between high and well-wooded banks, winding very much, and varying in breadth from 200 to 400 yards. We brought up about dark at El-Media : on the 18th we passed two shallow places, and with them got over all present difficulties—the rest of the navigation being favourable during our ascent of 54 miles to Kut-el-Amrah."

To anyone who knows the river as it is to-day, it is astonishing to read of "well wooded banks" and an average depth, in the low-water season, of 12 to 36 feet and a width of 600 feet in what is now the "Narrows."

The Euphrates.

(22) The Euphrates rises in the Armenian mountains, and enters its delta at Hit some 560 miles from the Persian Gulf. From Hit to Feluja is about 80 miles and from there to Mussaib 56 miles.

Below Mussaib there has been since earliest times a bifurcation of the river. The right arm was the original bed, and the left arm, on which Babylon was built, the artificial deviation. In the time of Alexander, the right arm was known as the Pallacopus; but to-day the river of Babylon is known as the Hillah branch of the Euphrates, and the right arm the Hindia canal.

It is curious that Colonel Chesney, in his book, makes no mention of the bifurcation, and the Hindia canal is only just indicated on his charts—the main river running in a broad, deep channel past Babylon. He does, however, remark that below Babylon the river begins to assume a different appearance owing to the numerous canals drawing from each side at short intervals from each other.

To-day the Hindia canal is the main river, and the Euphrates past Babylon has practically ceased to exist; this change being attributed by Sir William Willcocks to the closing of the Saklawia canal, whereby the high-lying Euphrates being incapable of carrying the extra supply it found its way into the low-lying Hindia branch and scoured out a new bed. To combat this evil the Hindia barrage has been built, and presumably will be taken over and maintained as soon as the country is in a sufficiently settled state.

The mean flood discharge of the Euphrates at Hit is given by Willcocks as 97,100 cusecs, and the low-water discharge 14,100 cuseces.

The slope of the river from Hit downwards is given in the following table. The levels are taken from Sir William Willcocks's book and reduced to feet:—

	Distance in miles.	High Flood feet.	Low-water level feet.	Range feet.	Distance between points.	Flood slope per mile.	Low-water slope per mile.
						inches.	inches.
Hit . . . . .	0	185.7	165.36	20.34	..	..	..
*Felujah . . . . .	80.73	139.44	124.67	14.77	80.73	6.8	6
Imina Hamza . . . . .	118	126.64	111.55	15.09	37.27	4.1	4.2
Hilla . . . . .	161.46	106.96	93.50	13.46	43.46	5.4	5
Below barrage		101.71	86.94				
†Shamia . . . . .	226.6	60.69	50.85	9.84	65.14	7.5	6.6

\*Nearly opposite Baghdad.

†Nearly opposite Kut.

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(23) At Samawa, 240 kilometres below Mussaib, the two branches, Hindia and Hilla, of the river unite and flow in one broad channel past Nasiriyah to Suk-esh-Sheyukh, a distance of 190 kilometres, and from this point there is complete disintegration.

At the date of the Chesney expedition, 1837, the river ran in a well-defined and deep channel from Suk-esh-Sheyukh past Chabaish to Kurnah, where it joined the Tigris—the two rivers forming the Shatt-el-Arab; but between that date and the present, the right bank from near Suk-esh-Sheyukh to Kurnah has been destroyed, and the river running in numerous shallow channels forms in the flood season one huge lake which enters the Shatt-el-Arab at Garmat Ali, five miles above Basra. Sir William Willcocks puts the date of the breach in the bank of the river between Suk-esh-Sheyukh and Kurnah at about 1880, and attributes it to the river being unable to carry its own water *plus* the spill from the Tigris when in flood; but Commander Felix Jones writing in 1853 remarks as follows: "The Euphrates has entirely lost its character as a navigable river for many years past, owing to the embankment which formerly controlled the spring floods in the lower part between Suk-esh-Sheyukh and Kurnah having been swept away about 10 years back."

The exact date is of little importance; the fact remains that the river at present is in as bad a state as a river can possibly be. The accompanying plan of the district between Nasiriyah and Kurnah illustrates the position, which I will describe in detail as follows.

(24) After the bursting of the right bank and the formation of the Hamar Lake, the bulk of the water still ran past Suk-esh-Sheyukh and down or near the Mezlik, but about 40 years ago the Arabs of the Beni Khaizan tribe cut the Hakika channel originally as a small stream a yard wide. As time went on the Hakika channel increased in size, other creeks formed, until finally the bulk of the water of the Euphrates was diverted to the Hakika, and the Euphrates began rapidly to deteriorate and to silt up, with the result that the extensive date gardens extending from above to 12 miles below Suk were threatened with destruction; whilst the area under rice cultivation in the Suk delta, which is recognised as the principal rice-growing district in Mesopotamia, was greatly curtailed in area. The tribes were seized with a panic and made a desperate effort to remedy matters: six tribes combining forces to build a bund across the Hakika channel. The first and second year the dam burst, but the third year the work was completed and the waters diverted to their original channel.

(25) With the advance of the Expeditionary Force to Nasiriyah, the Hakika channel was selected as the most suitable; and on the force reaching the bund it was demolished. From that time to the present the Hakika channel has remained open and increased in size to the detriment, not to say destruction, of all agriculture in the neighbourhood of Suk-esh-Sheyukh and the ruin of the tribes in that locality.

(e) SIR WILLIAM WILCOCKS'S IRRIGATION PROJECT.

(26) Sir William Willcocks contemplates the ultimate utilization of the greater part of the low-water flow of the rivers Tigris and Euphrates and their tributaries for irrigation purposes; but for the schemes he has immediately in view, he estimates that in time of low supply 7,060 cusecs would be taken from the Euphrates and 4,240 cusecs from the Tigris, or, from both rivers, 11,300 cusecs. It may be noted that the low-water discharges of the Tigris at Baghdad averages 14,000 cusecs, and the Euphrates at Hit 16,000 cusecs: so that during the low-water season about one-third of the total supply would be diverted for irrigation purposes. The project comprises six independent irrigation schemes, watered from the Tigris, Euphrates, and Diala, respectively, and the following analysis of the various



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scherfes is compiled from his book "The Irrigation of Mesopotamia," and the plan accompanying this note is taken from the port folio published with the book.

In the matter of cost, the principle adopted by Sir William Willecocks has been to estimate, as nearly as possible, the actual cost of the works and to add  $33\frac{1}{3}$  per cent. for contingencies, thereafter doubling the total thus arrived at to allow for interest on the money spent during the execution of the works and their subsequent development; the grand total is the estimated true cost of the irrigation work. The cost of the agricultural operations or works is thereafter separately estimated at £T. 10 per hectare, or £3-12-0 per acre.

Irrigation from the Tigris.

(1) BELED BARRAGE SCHEME.

*Works proposed.*—

- (i) A barrage across the Tigris at Beled.
- (ii) Irrigation, by means of canals, of the country between Beled and Baghdad.

*Irrigated area.*—

420,000 acres.

*Estimated cost.*—

	£T.
Irrigation works .. .. .	2,118,240
Agricultural works .. .. .	1,700,000
Total .. .. .	3,818,240

(2) KUT BARRAGE SCHEME.

*Works proposed.*—

- (i) A barrage across the Tigris at Kut.
- (ii) An embankment 130 kilometres long from Kut to Erech, to protect the lands to be irrigated against inundations from the Tigris.
- (iii) Canals to irrigate the land on either side of the Hai.

*Irrigated area.*—

620,000 acres.

*Estimated cost.*—

	£T.
Irrigation works .. .. .	2,757,980
Agricultural works .. .. .	2,500,000
Total .. .. .	5,257,980

(3) & (4) FELUJAH AND HINDIA BARRAGE SCHEMES.

*Works proposed.*—

- (i) An escape for the Euphrates floods into Lake Habania.
- (ii) Tigris protection works between Mansura and Kazamain.
- (iii) A barrage across the Euphrates at Felujah.
- (iv) A barrage across the Euphrates at Hindia. (Said to be completed.)
- (v) Canals irrigating the area between Baghdad on the Tigris, and Felujah on the Euphrates, Kut on the Tigris and Kufa on the Euphrates.



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*Irrigated area.*—

1,700,000 acres.

*Estimated cost.*—

					£T.
Irrigation works	..	..	..	..	6,091,340
Agricultural works	..	..	..	..	6,500,000
Total					12,591,340

(5) BASRA BARRAGE SCHEME.

*Works proposed.*—

- (i) A barrage across the Euphrates at Garmat Ali.
- (ii) The construction of a bank from Suk-esh-Sheyukh on the Euphrates to Kurnah on the Tigris, for the control of the flood water from the Tigris.
- (iii) The construction of canals to irrigate the country between Basrah and Fao.

*Irrigated area.*—

222,000 acres.

*Estimated cost.*—

					£T.
Irrigation works	..	..	..	..	1,996,980
Agricultural works	..	..	..	..	900,000
Total					2,896,980

Reclamation of land on Euphrates.

*Work proposed.*—

- To reclaim 124,000 acres of land within the area at present inundated by the Euphrates.

*Estimated cost.*—

					£T.
Irrigation works	..	..	..	..	425,000
Agricultural works	..	..	..	..	250,675
Total					675,675

(6) IRRIGATION FROM THE DIYALA.

*Works proposed.*—

- (i) The diversion of the Diyala canal from the point where it leaves the Hamrin Hills to an alignment east of the Beled Ruz canal finally joining the Tigris east of Kut.
- (ii) A dam across the Diyala.
- (iii) The resuscitation of the Nahrwan canal.

*Irrigated area.*—

494,000 acres.

*Estimated cost.*—

					£T.
Irrigation works	..	..	..	..	1,817,120
Agricultural works	..	..	..	..	2,000,000
Total					3,817,120

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Tigris Navigation Works.

Sir William also proposes certain works for the improvement of navigation on the Tigris, which are discussed in a later paragraph of this report.

Sir William Willcocks's scheme discussed.

(27) To summarize, Sir William Willcocks's scheme comprises the irrigation of  $3\frac{1}{2}$  million acres at a total capital cost of £T. 29,000,000 or say 26 million pounds sterling, and he estimates a profit on the whole under-taking of 24.9 per cent., and on the irrigation works of 9 per cent.

Apart from the fact that the project is mainly a revival on modern lines of old and worn-out irrigation systems, one radical defect in the scheme to my mind is that apparently Sir William Willcocks accepts as a permanency the present degenerate state of the rivers, and leaves the vast swamps in Lower Mesopotamia spreading ruin and desolation over large areas of country. It may be that his treatment of the subject is the best, but the scheme must be condemned if the regeneration of the rivers and the re-formation of the drainage of the country, on natural lines, is practicable, and that, I submit, is a subject which has neither been investigated nor discussed up to the present.

(28) Another matter which deserves more consideration than it has at present received is the question of population. In the two neighbouring countries of India and Egypt where extensive irrigation works have been carried out, there has been a teeming population waiting to form irrigation colonies the moment the water was available. The population of Egypt is 1,000 per square mile; the Indian Punjab, 177 per square mile; Bengal, 540 per square mile; and Burma, the least populated province of India, has 45 per square mile: but in Mesopotamia the population is only 10 per square mile, consisting chiefly of untamed nomadic tribes who—from all accounts—would bitterly resent the intrusion of peaceful colonists.

(29) Sir William Willcocks has visions of labourers from Kurdistan flocking down from the hills, digging canals, constructing weirs and regulators, and then settling down in hundreds of thousands to reclaim and cultivate the land. But when his scheme is looked at in the cold light of finance, I am of opinion that a more substantial guarantee will be required, and that the works will probably be begun on a very small scale. Possibly, in the first instance, the waters of the Euphrates alone will be used for irrigation, and, as pointed out by Sir William Willcocks, these waters can be made to irrigate the whole area capable of irrigation between Felujah and Kut, and also all the lands on both the Hillah and Hindia branches.

(f) SUGGESTIONS FOR RIVER REGENERATION.

(30) Whether the rivers be used for navigation, or their waters for irrigation, I am of opinion that their regeneration and re-constitution as the main drainage channels of the country is the first *desideratum*; and to that end I make the following suggestions which are, of course, subject to confirmation or otherwise when proper surveys have been carried out.

River Tigris.

(31) The objects to be aimed at are—

- (i) The retention of the flood waters within the river banks, so far as possible.
- (ii) The regeneration of the river between Amara and Kurnah.
- (iii) The retention of existing systems of irrigation until supplanted by permanent works.



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Sir William Willcocks, in his report, suggested that for provision against heavy floods the natural way was to follow the practice of ancient Egyptian and Babylonian engineers, and to confine attention to one bank of each river and ensure that bank against inundation, the floods being allowed to waste their energies on the other bank. With that object the left bank of his right Tigris canal (the water for which was to be supplied from the Euphrates) was to act as a bund up to Kut-el-Amara where it joined the proposed bank down the Hai.

I agree with Sir William Willcocks's proposal so far as it goes, but I would continue the process from Kut-el-Amara downward, and I assume that the Kut barrage and Hai embankment are not works which will be carried out in the near future.

(32) I am intimately acquainted with the country between Kut and Basra, but have only travelled twice between Kut and Baghdad and am unable to express any definite opinion as to the best method of flood control between those points.

Between Kut and Amara, I am of the opinion that the following works should be carried out :—

- (i) General maintenance and improvement of existing bunds, and construction of new bunds—especially on the right bank of the Fadiyah reach, and the left bank of the Subadiah reach.
- (ii) Restriction of carrying capacity of all irrigation canals in accordance with the requirements of agriculture.
- (iii) The closure of unimportant and useless channels.

Between Amara and Kurnah, the real work of regeneration will take place, as it is from Amara downwards that the various branches take off to such an extent as to threaten the existence of the river.

(33) Sir William Willcocks proposed to build regulating heads or weirs across the Chahala, Majar Kabir and Michiriyah canals, which would allow that portion of the high flood to escape which the river itself could in no wise carry, but would prevent the escape of a large volume of water at low supply. I examined this project with a view to the provision of temporary weirs in order to improve navigation for military purposes, but decided against its expediency because the cutting off of the low-water supply would throw large tracts of land out of cultivation and stop all navigation on the canals, without any sufficient benefit to navigation on the main river. I did, however, construct a weir across the Michiriyah canal putting in bye-passes to provide sufficient water for irrigation, and the results were highly satisfactory.

The Michiriyah carried off about 40 per cent of the volume of the water of the Tigris at that point, and a section taken after the closing of the canal shewed a wonderful capacity on the part of the river for accommodating itself to increased discharge, as, for some distance below where the Michiriyah canal takes off, the cross-sectional area of the Tigris had increased by something like 25 per cent., and the discharging capacity of the river in about the same proportion; moreover, the improvement was not merely local, but evidences were traceable for some thirty or forty miles.

The experiment shews that the river, if encouraged to do so, will sink its bed, lower its surface level, establish a better shaped channel, and maintain these general improvements, which so far as can be seen are of a permanent character.



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(34) From my knowledge of the country and with the experience noted above, I make the following suggestions for regenerating the river between Amara and Kurnah :—

- (i) Retired bunds or levees should be constructed on both banks as surveys and levels would indicate, in order to provide for the ultimate flow of the bulk of the flood waters of the Tigris down the regenerated channel.
- (ii) The carrying capacities of the Baitiria, Chahala, Majar Kabir, Michiriyah, and other canals to be strictly limited to the water actually required for existing agricultural and domestic purposes.
- (iii) All unimportant or useless channels to be closed.
- (iv) The widening of the existing channel and easement of severe bends such as,—the Devil's Elbow, by means of dredgers.

Besides these works, it will be most necessary to prevent Arab cultivators from reclaiming any further lands from the river bed or, indeed, doing any agricultural work inside the bunds.

It will be as well to point out how these measures, as between Kut and Kurnah, will affect existing cultivation. The existing embankments would be maintained to protect cultivation, and new embankments built to protect land at present subject to heavy flooding. The restriction of the carrying capacity of channels applies to those such as the Chahala, which, having increased beyond the requisite size, merely serve as feeders to the marshes and to further the degeneration of the river. The question of the extent of the restriction will depend upon the result of the surveys to ascertain the amount of irrigation proposed, and particular care would be exercised to prevent any diminution of the irrigated tract.

(35) The question as to what extent, if any, it will be possible to eliminate some of the existing bends between Baghdad and Kut, and bends such as the Peardrop Bend near Kurnah, requires the very closest study, as in many cases much more harm than good is done by interfering with the natural régime of the river.

The immediate result of a cut-off is to increase the slope through the cut-off over that which previously existed around the bend; whilst the energy which had been expended in overcoming the friction of the bend and that resulting from a steeper slope would be expended in largely increasing the velocity. Increased velocity would produce scour, and the deepening of the river bed above the cut-off; the eroded material being deposited on the gentler slope below—thus raising the bed, and this action would continue until the slope through the cut-off was less than formerly existed around the bend. The river would be affected for long distances above and below the cut-off, whilst a considerable period would be required before the river again came to equilibrium; and although ultimately a good channel with a gentle slope would be formed through the cut-off, the slope, and the low-water navigation would be found to have been seriously affected for several miles above and below. For these reasons all engineers regard the short-circuiting of bends with great apprehension; indeed, on the Mississippi active measures are taken to prevent the river effecting a cut-off in the ordinary course of nature.

The above remarks are not to be taken as meaning that no improvements can be effected on the Tigris (because if all bends were eliminated between Baghdad and Kurnah, the high water slope would be only 4·4 inches per mile), but to indicate the necessity for extreme caution.



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River Euphrates.

(36) I have not the necessary data to express any opinion as to the works to be executed on the Euphrates between Hit and Nasiriyah, but from Nasiriyah downwards my proposals are as follows :—

At present, the whole of the water from the Euphrates *plus* the spill from the Tigris down the Hai and other canals finds its way to Garmat Ali, and Sir William Willcocks proposes to continue this arrangement so far as the Euphrates water is concerned, but to construct a bund from the right bank of the old Euphrates channel at Kurnah to the left bank of the Euphrates at Suk-esh-Sheyukh and so arrange a passage for the spill waters of the Tigris down the old channel to Kurnah.

I have examined the Euphrates delta from Garmat Ali to Nasiriyah, and am unable to see the advantage of these proposals. There seems no sound reason for adhering to what is known as the new Euphrates channel, which is really no channel at all but a vast shallow lake with no more claim to permanency than the old channel. The river could, of course, be made to adhere to this alignment, but it would always be unsatisfactory, and would make the marshes which mark its course a permanent feature of the landscape.

(37) The scheme I recommend is the re-establishment of the Euphrates in its old channel *via* Suk-esh-Sheyukh, Mezlik, Chabaish and Kurnah (as indicated on the plan accompanying this report), the closing of the Hakika channel by a permanent bund and the retention of the Tigris spill in its own bed. A certain amount has been done in this direction, as a military work, to form a low-water channel to Nasiriyah; and, until recently, three powerful dredgers were at work cutting a channel between Chabaish and Mezlik, but I am informed the work has been abandoned owing to a change in the military situation.

The closing of the Hakika channel is a work requiring considerable engineering skill, and every year it will be increasingly difficult to accomplish.

Effect of works.

(38) The regeneration of the rivers will result in their undertaking their normal functions as the main drainage channels of the country, and the elimination to a great extent of the swamps which might then be planted with trees, but it must not be overlooked that whatever action is taken in respect to the rivers will be felt at the mouth of the Shatt-el-Arab. The draining of the swamps will mean that the silt hitherto deposited there will be carried down the river and tend to the more rapid extension of the delta seawards, and possibly an increase of dredging on the Outer Bar: whilst, on the other hand, the utilization of the low-water supply of the Tigris and Euphrates for irrigation will mean an increased volume of salt water coming up the Shatt-el-Arab.

(g) AGRICULTURE.

(39) The Mesopotamian Trade Commission have given in their report a general description of the agricultural resources of the country, and I endorse their remarks that all schemes for the agricultural development of Mesopotamia are conditional on, and limited by, the capacity, character and temperament of the inhabitants.

There is little doubt that with irrigation and population, cotton, jute, wheat, barley, rice, fruits and vegetables can be grown in immense quantities; but existing systems of agriculture will have to be swept away, and with a people so conservative

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as the Arabs and assuming no outside colonization is to be allowed, this will be a very slow process. The agricultural implements used in Mesopotamia and the methods employed are probably identical with those of 5,000 years ago, and very great patience will have to be observed in teaching new methods.

I had a certain amount of experience of the existing system of agriculture in connection with the Michiriyah canal, which for military purposes I blocked with a dam allowing water for irrigation to flow through by means of bye-passes. The works caused consternation amongst the tribes, not only because the water sent through the bye-passes was, according to their lights, insufficient, but because it reached them deprived of its silt. The Arab attaches enormous importance to the water for irrigation purposes arriving on the land laden with silt, and the following brief description of the Arab method of cultivation of the rice crop will explain the reason.

(40) The crop usually consists of:—

- (i) "Harfi" or early broadcast rice, sown on highest middle lands, below wheat and barley. Sowings in May ripen at the end of August.
- (ii) "Affli" or late broadcast rice, sown on lower middle lands next below "harfi." Sowings in June, ripen October 15th. Requires watering up to September at least, probably one week more.
- (iii) "Shittal" or transplanted rice, sowings in May and transplanted in August, ripen at the end of October.

No. (ii) usually consists of about two-thirds of the whole area.

The land is divided into "habbals," more or less rectangular strips 150 feet wide, running from, and normal to, the main channel and down into the marsh. Each habbal has its own watercourse.

During the high Tigris flood of the third week in March, water pours through each watercourse into the marsh, rapidly raising its level till only narrow strips along the margins of the main channel remain uncovered. The backing-up so caused, makes the main channel spill over its banks and deposit a rich layer of silt along its margins. As the flood subsides seed, previously germinated by being soaked several days in water, is sown on the soft silt, forming the earliest or "harfi" rice.

Subsequent floods in April give repeated waterings to this crop, and, should the river remain high, it is harvested in August. If the river falls the plants are dug out of the dried up soil and transplanted to lower ground, forming part of the "shittal" crop.

With the fall of the Tigris and subsequent fall of the marshes in late April and May, the sowings of "affli" start on the first land laid bare by the receding waters. The "affli" may either be harvested in place or transplanted to lower ground to form "shittal" according to the prevailing level of the river.

The "shittal," accounted the best rice for eating, and comprising rather less than  $\frac{1}{3}$  of the whole, consists entirely of plants unmaturing in the "harfi" or "affli" transplanted with the falling of the marsh to lower levels which have been covered with some depth of water for upwards of three months. The growth of the plant is hindered by its transplantation when the ground is hard and dry, and the crop does not mature until November.

It will be seen that the "harfi" crop gets a great deal of silt, the "affli" a moderate amount of silt and perhaps six weeks soakage with water, and the "shittal"



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the least silt but at least three months' soakage. The Arab system, at the cost of perhaps ten times the normal amount of water, does away with the need for ploughing and if Arab figures of 150 to 250 "jelas" to the "gubala" are reliable results in an outturn equal to the best irrigated paddy.

The slow velocity of my restricted supply passing down the large channels of the old system caused it to drop all its silt before reaching the fields; whilst, at the same time, the local marshes deprived of the flood waters did not rise to their usual height. Doubtless an excellent crop could be obtained by flooding the country, field by field, and ploughing it up before sowing, as is done in all other rice growing countries; but unfortunately the tribe concerned had never ploughed, whilst the horse-drawn single-tooth plough available locally was unsuited to ploughing in water.

With any organized irrigation system it will be impossible to give the Arabs the quantity of water they now think necessary, nor will it be so fully laden with silt, and they will perforce have to adapt themselves to modern methods.

(h) NAVIGATION ON THE TIGRIS.

(41) Navigation for commercial purposes cannot be said ever to have had either a fair trial or fairplay. The Mesopotamia Commission in an appendix to their report have given a brief résumé of events from the arrangement of 1846, whereby British merchant vessels were given the right to navigate the Mesopotamian rivers, up to the signed but not ratified convention of 1913-14 which gave exclusive rights of navigation to a joint Anglo-Ottoman company. Prior to the war the maintenance of an efficient river service between Baghdad and Basra, as a British monopoly and controlled by a British company, was considered of the utmost importance to British trade; as it was feared that if the Baghdad Railway Company got a footing on the river, their policy would be to put an end to our competition in the interest of the railway. There was also apprehension that Sir William Willcocks's irrigation projects would automatically cause the suspension of navigation between the months of August and October inclusive, as the needs of irrigation would take up almost all the water.

The British Resident in Baghdad took the view that even if measures were taken to ensure that the navigation of the Euphrates should not be imperilled by irrigation schemes, still there would be little prospect of steam navigation on that river surviving competition with the railway. He pointed out: that the distance by railway between Baghdad and Basra would be about 325 miles; as against 540 miles by river; that the ascent of the river by steamer would take five days, as against one day by rail; that communication by rail would be daily and regular, and by steamer uncertain and interrupted; that the railway would be able both to collect exports and distribute imports with greater facility than by steamer, if short feeder branches were constructed, and that by railing goods direct from Basra, transfer from boat to rail for onward despatch to Persia *via* Khanyken would be avoided; and, finally, that the position of the guarantee would enable the railway to kill the steamer traffic by adopting low and unpaying freights in the beginning.

(42) The position is now materially changed, because it is to be presumed that the railway from Basra to Baghdad when made will be a purely British concern.

The question may, therefore, be considered under the following heads:—

- (i) Whether, having regard to irrigation projects, there would be a navigable river.
- (i) Whether, from the commercial point of view, river transport can compete with a railway.



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(43) It is an axiom that if water is required for irrigation, navigation must give way and a railway take its place; but, as I have already pointed out in this report, I am disposed to doubt the economic advantage of carrying out, in the near future, the vast works proposed by Sir William Willcocks, and I am of opinion that for many years to come there will be from the combined waters of the Euphrates and Tigris ample supply of water both for irrigation and navigation, and that if my proposals for the regeneration of the rivers are given effect to there will be a broad, deep, and well conserved river, admirably adapted for navigation purposes between Basra and Baghdad, and possibly between Basra and Kurnah and towns on the Euphrates.

In the matter of railway competition, I consider a well managed river service will easily hold its own. The position will not be dissimilar to that which obtains on the Irrawaddy river, in Burma, where a river steamer company has for many years had to compete with the railway company on all the heads suggested by the Resident at Baghdad, and yet has paid a very handsome dividend. The distance from Rangoon, in Burma, to Mandalay is, by river, 780 miles, and by railway 386 miles. The time taken by a steamer is about 160 hours up-river and 132 hours down; and by rail 19½ hours. After a considerable amount of competition and rate-cutting, the railway company and the steamer company have found it to their mutual advantage to charge practically the same rates. Freights vary considerably according to the nature of the goods, but to take one staple product—namely, paddy, as an example: the rate from Mandalay to Rangoon is £0-10-6 per ton, at owner's risk, or 23/6d. per ton at company's risk; a rate which I think will compare very favourably with river rates in Mesopotamia before the war.

(44) Whether there will be sufficient trade for both railway and river transport is another question; but although in the first few years after the war there might be some difficulty in making both railway and river pay, there can be little doubt that in the future there will be sufficient trade to keep both well employed.

(i) CONCLUSIONS AND RECOMMENDATIONS.

(45) (1) In the first place, I would deprecate anything being done in a hurry. The country is in the most deplorable condition through human abuse in the past, and it is essential that treatment should be on correct lines—all questions being dealt with on the broadest basis, instead of being narrowed down at the outset.

(2) An engineering survey of the country and rivers is a *sine qua non*, before money is expended on capital works.

Sir William Willcocks's surveys are of the greatest value, so far as they go, but they were carried out under most difficult conditions and require to be very much amplified.

(3) In my judgment the problems before the engineer are:—

- (a) The regeneration of the rivers as the main drainage channels of the country and their preservation for navigation if compatible with irrigation.
- (b) The economical application of the water for irrigation.
- (c) The drainage of the swamps.

I have placed irrigation as second to river regeneration, because I am of the opinion that better results will be obtained by improving the rivers and developing local agriculture than by beginning at once with irrigation works on a heroic scale,—this will follow in due course.



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I have made some definite recommendations (subject to my views being confirmed by surveys) in the matter of the regeneration of the rivers ; and if desired to do so, I shall be glad to assist on any committee of experts appointed to go further into the matter.

(4) Although it is to be taken for granted that if water is required for irrigation, navigation must give way, I believe it will be many years before irrigation develops to such an extent ; and meanwhile navigation for commercial purposes should be encouraged, whilst if river improvements are carried out small tolls or charges would be justified.

(5) There is a wide field for a really competent Agricultural Adviser.

(6) Although I do not think it practicable to develop the country during military operations, there is a great deal of preliminary work in the organization of survey parties, and the consideration of the lines on which to start work, which might be put in hand at once.

(46) Finally, I would respectfully recommend that in the development of Mesopotamia and in the preliminary investigations incidental thereto, the services be obtained of the best experts in their respective professions ; and so far as irrigation is concerned, I need hardly point out that India, who supplied the original engineers for Egypt, possesses the most extensive irrigation works in the world and the engineers with the widest experience.

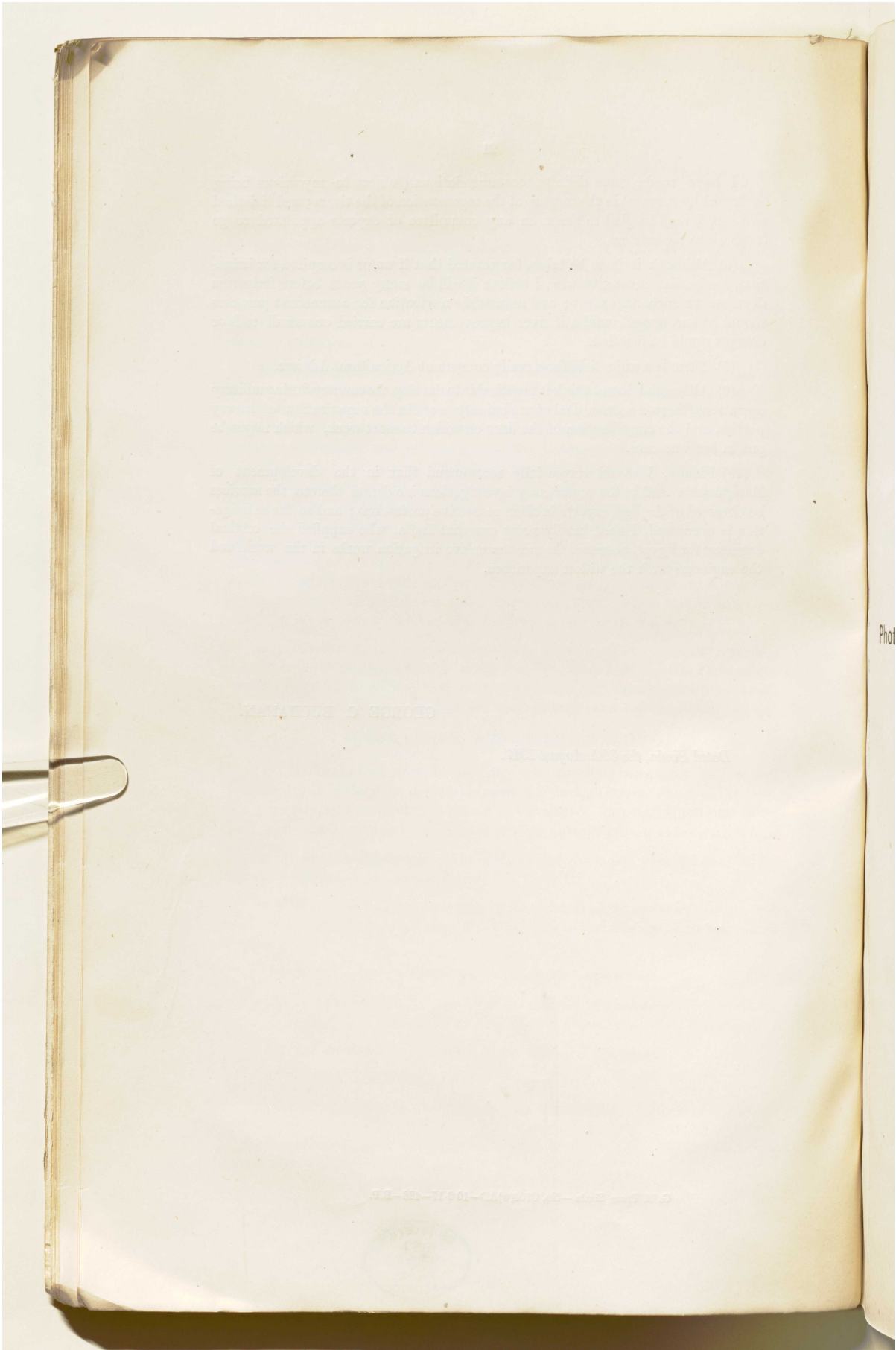
GEORGE C. BUCHANAN.

*Dated Simla, the 30th August 1917.*

G. M. Press, Simla,—No. C104(w)AD—10-9-17—488—B.P.

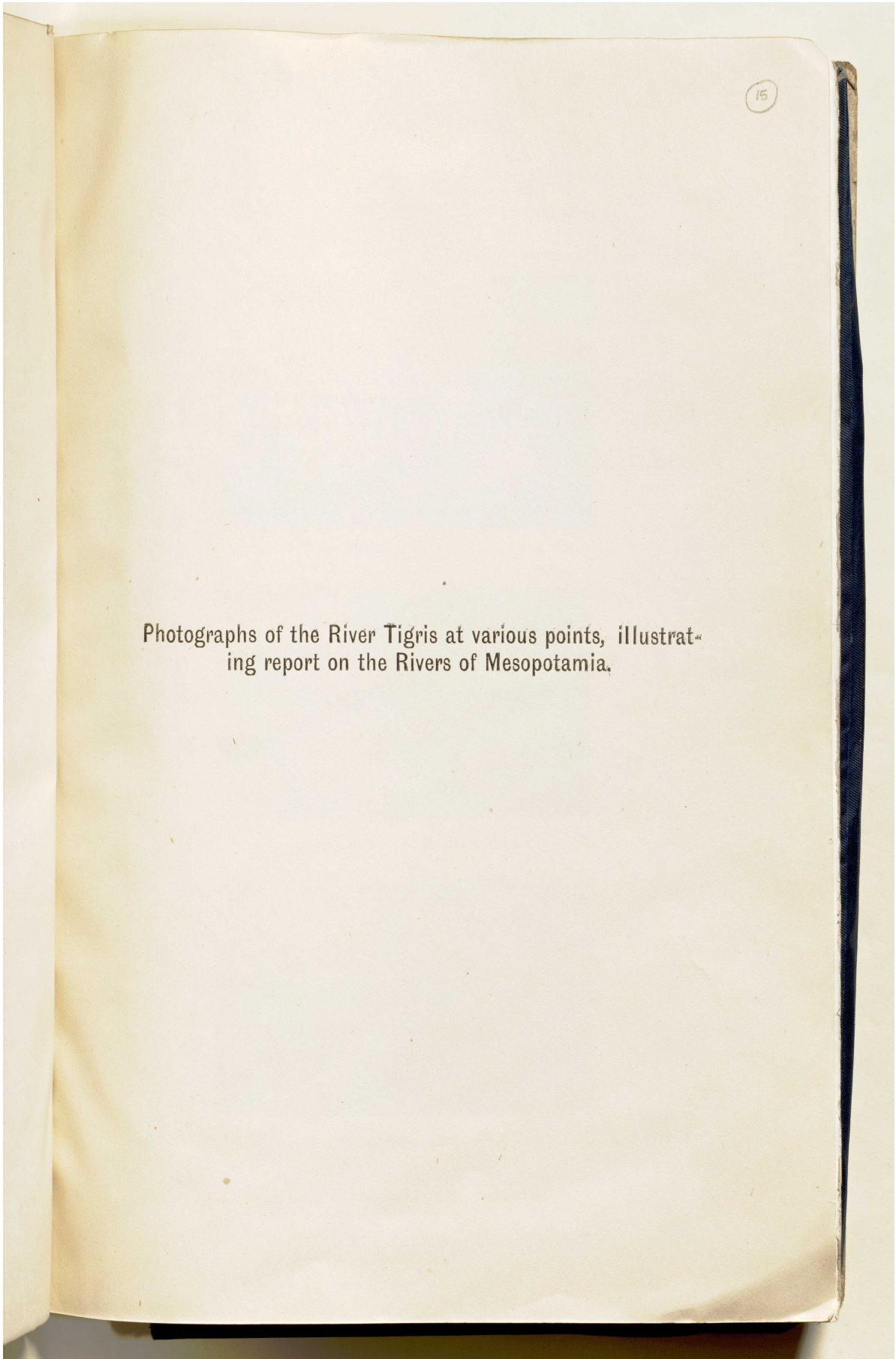


'Report on the Development of Mesopotamia with Special Reference to the  
Regeneration of the River Systems' [22] (28/50)

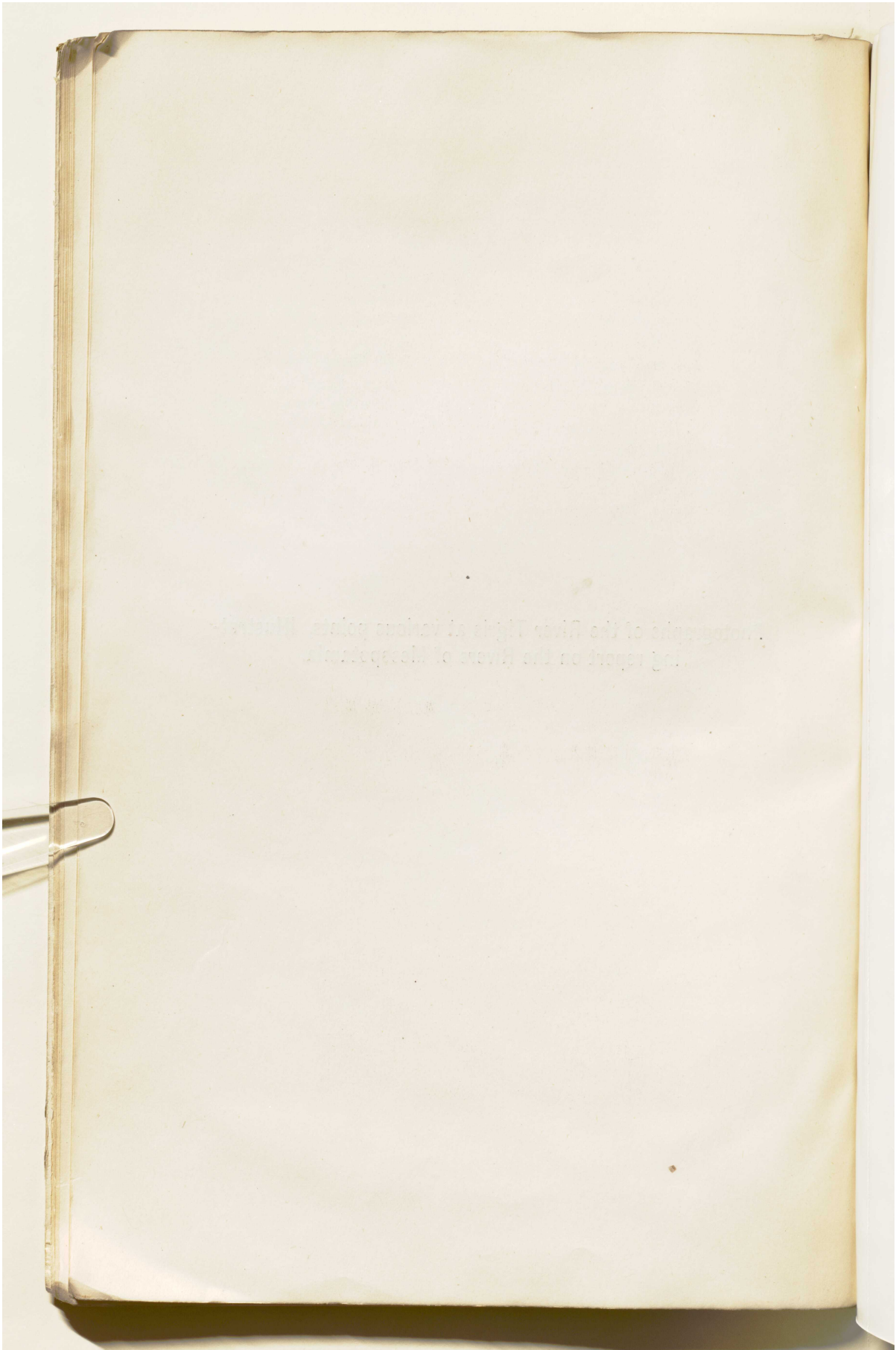




'Report on the Development of Mesopotamia with Special Reference to the  
Regeneration of the River Systems' [23] (29/50)



'Report on the Development of Mesopotamia with Special Reference to the  
Regeneration of the River Systems' [24] (30/50)





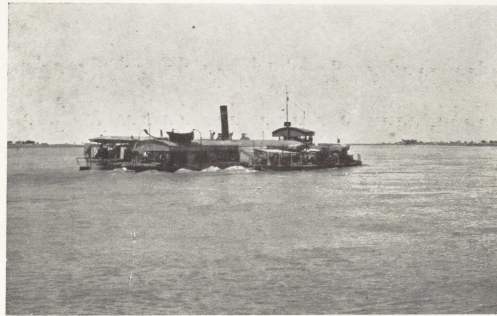
'Report on the Development of Mesopotamia with Special Reference to the  
Regeneration of the River Systems' [25] (31/50)

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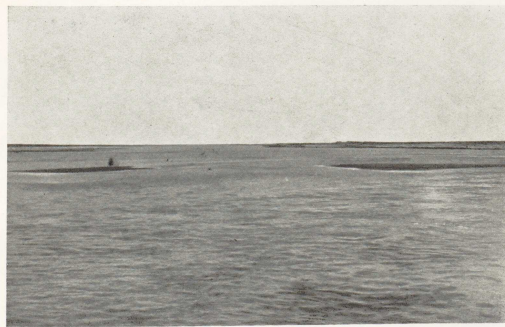
PHOTOGRAPHS OF THE RIVER TIGRIS AT VARIOUS  
POINTS, ILLUSTRATING REPORT ON THE  
RIVERS OF MESOPOTAMIA.



THE TIGRIS AT BAGHDAD.



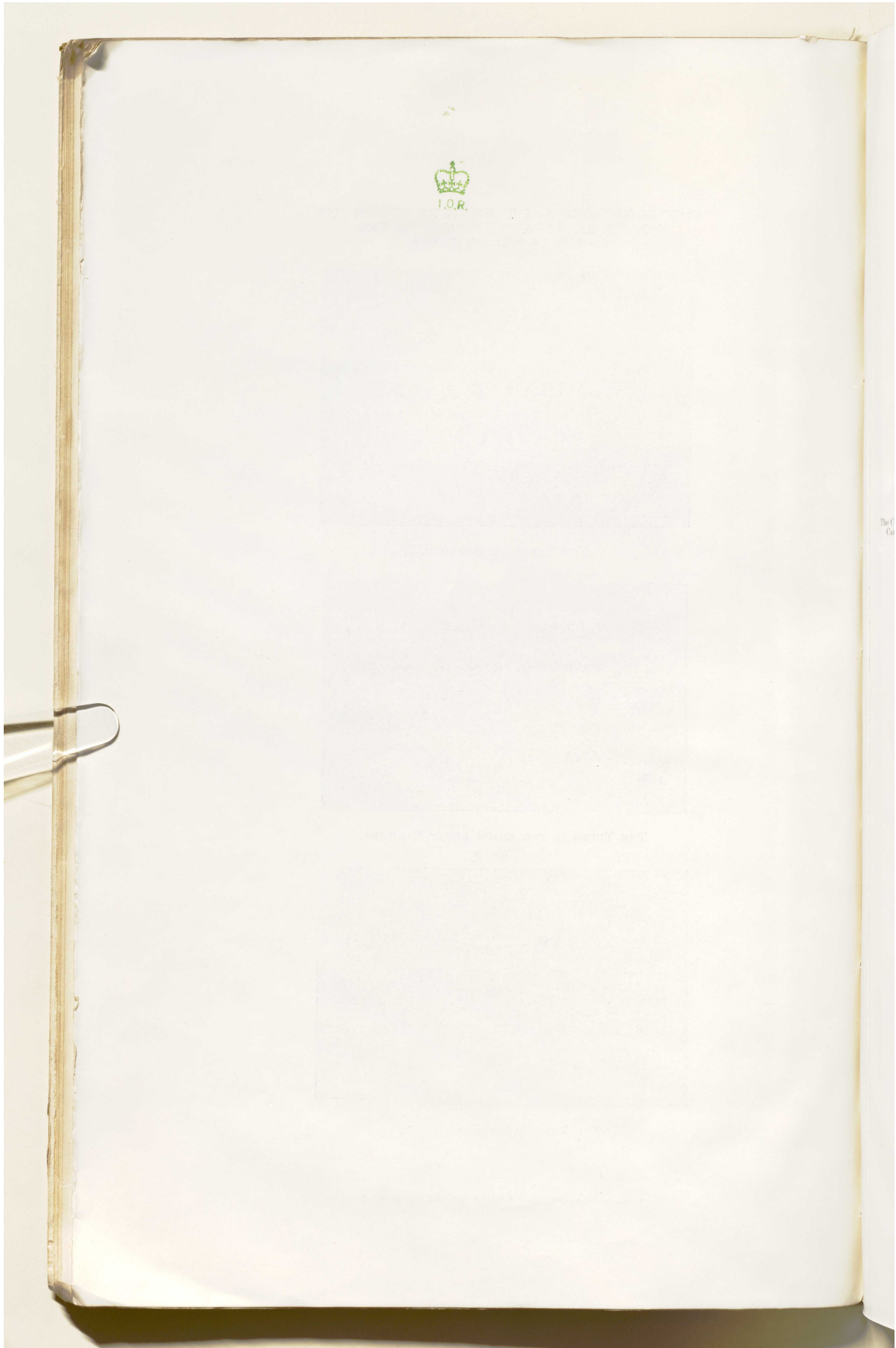
THE TIGRIS IN THE REACH BELOW BAGHDAD.



THE TIGRIS NEAR SHEIK SAAD.

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'Report on the Development of Mesopotamia with Special Reference to the  
Regeneration of the River Systems' [26] (32/50)





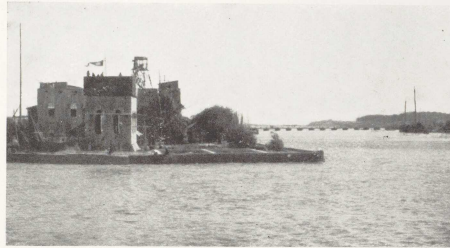
'Report on the Development of Mesopotamia with Special Reference to the  
Regeneration of the River Systems' [27] (33/50)

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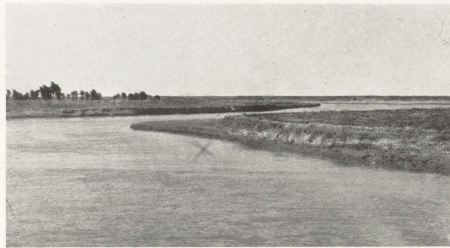
NORFOLK HOUSE.

THE TIGRIS.

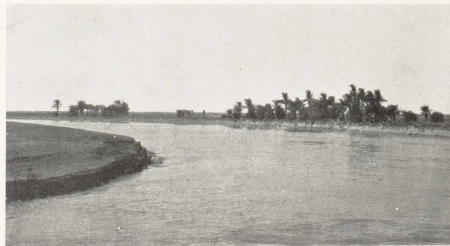
The Chahala  
Canal. ←



THE TIGRIS AT AMARA.



THE TIGRIS AT DEVIL'S ELBOW IN THE "NARROWS".



THE TIGRIS IN THE "NARROWS".

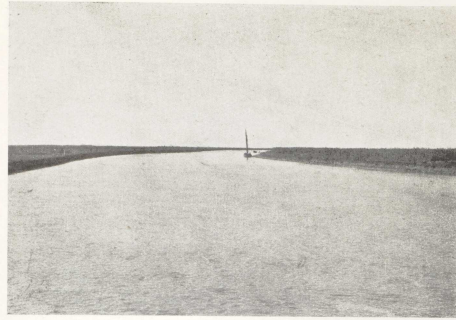
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'Report on the Development of Mesopotamia with Special Reference to the  
Regeneration of the River Systems' [28] (34/50)





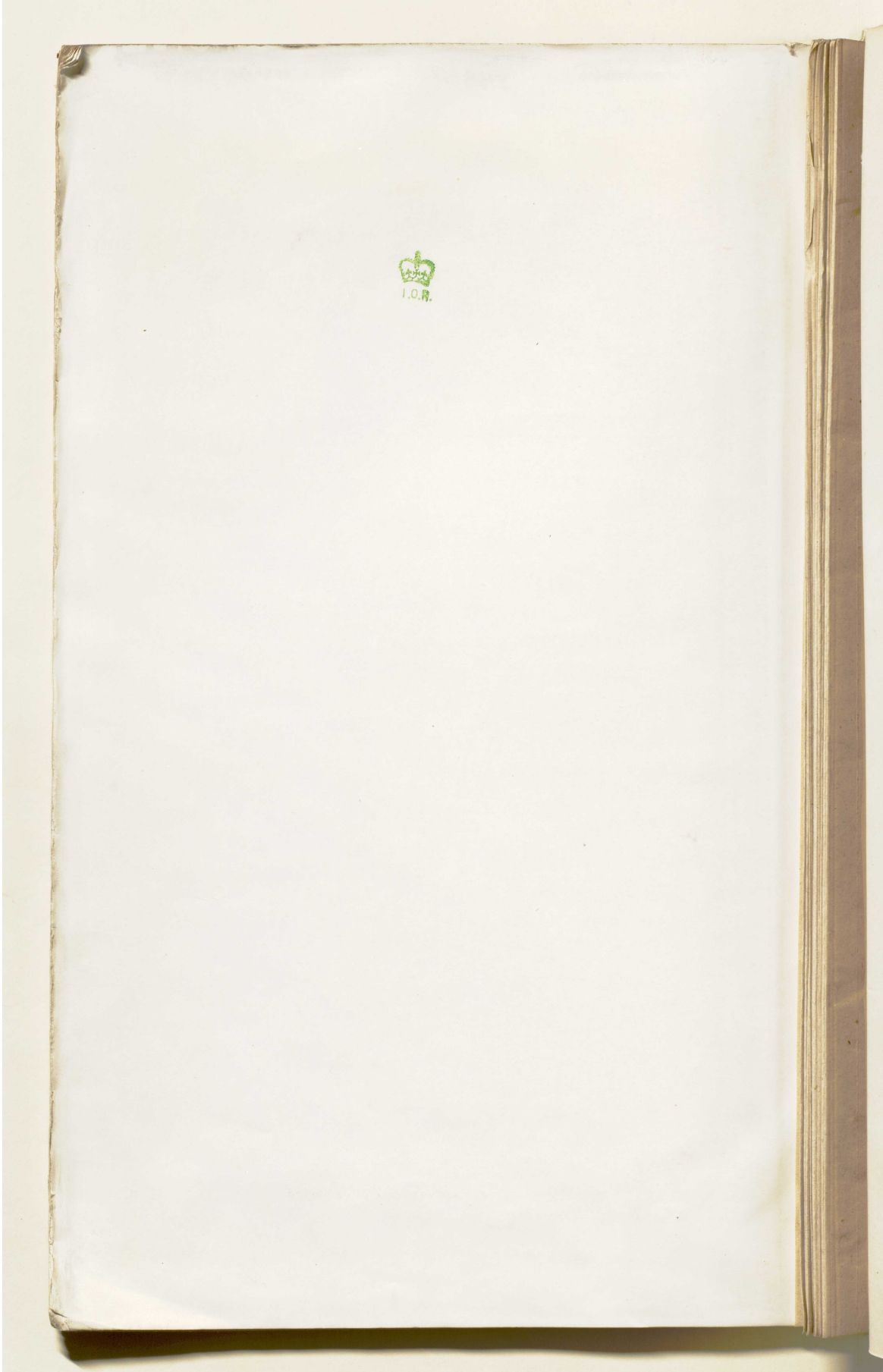
'Report on the Development of Mesopotamia with Special Reference to the  
Regeneration of the River Systems' [29] (35/50)



THE TIGRIS IN THE "NARROWS".

Photo-engraved & printed at the offices of the Survey of India, Calcutta, 1917.

'Report on the Development of Mesopotamia with Special Reference to the  
Regeneration of the River Systems' [30] (36/50)





'Report on the Development of Mesopotamia with Special Reference to the  
Regeneration of the River Systems' [31] (37/50)

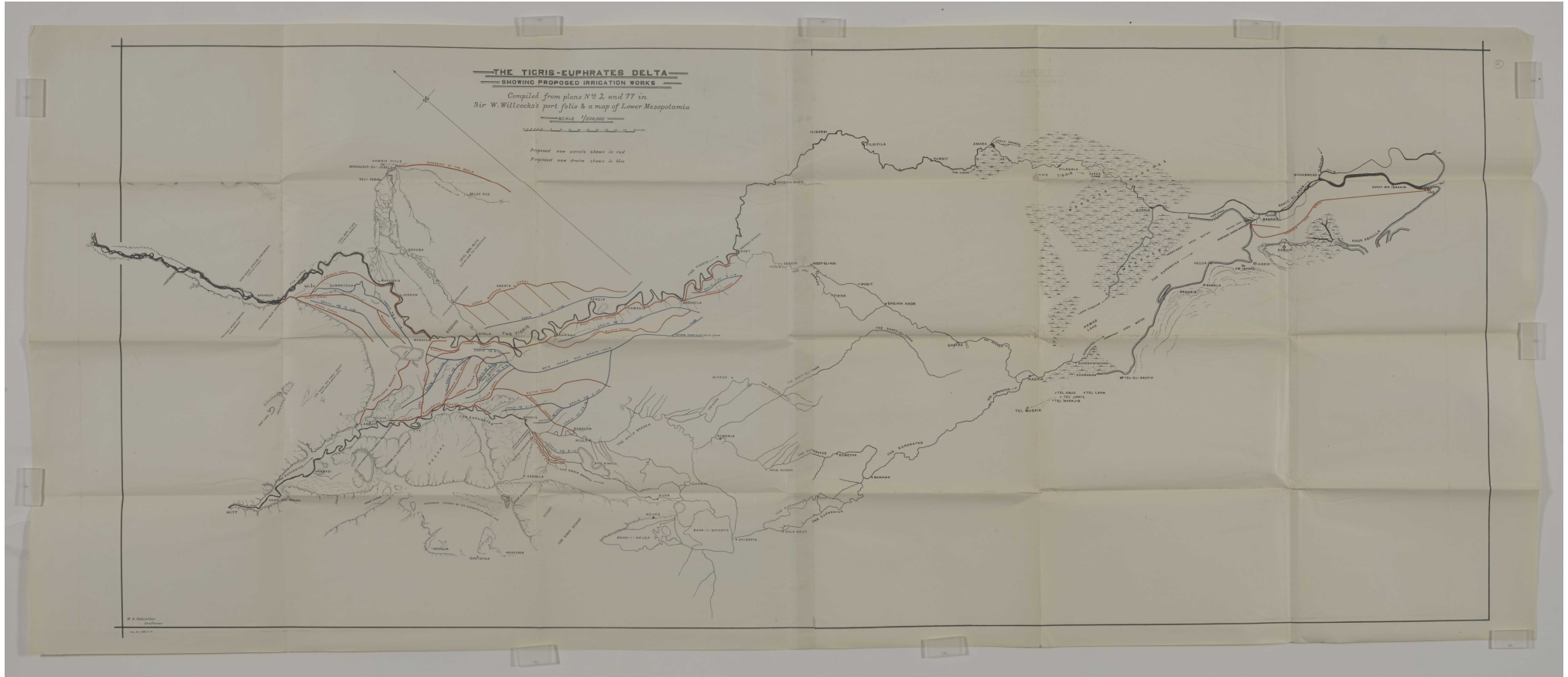


**'Report on the Development of Mesopotamia with Special Reference to the  
Regeneration of the River Systems' [32] (38/50)**

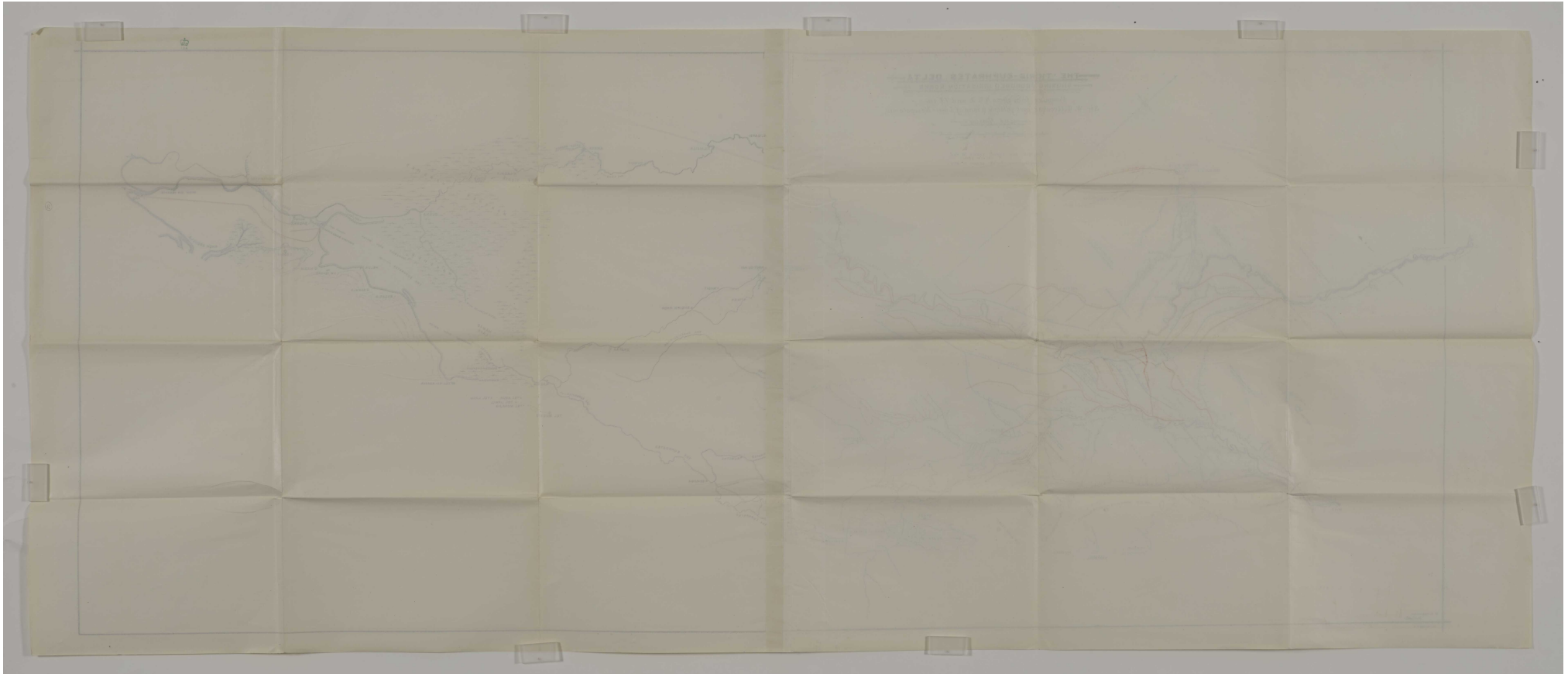




'The Tigris-Euphrates Delta Showing Proposed Irrigation Works' [33] (1/1)



'Report on the Development of Mesopotamia with Special Reference to the Regeneration of the River Systems' [34] (40/50)

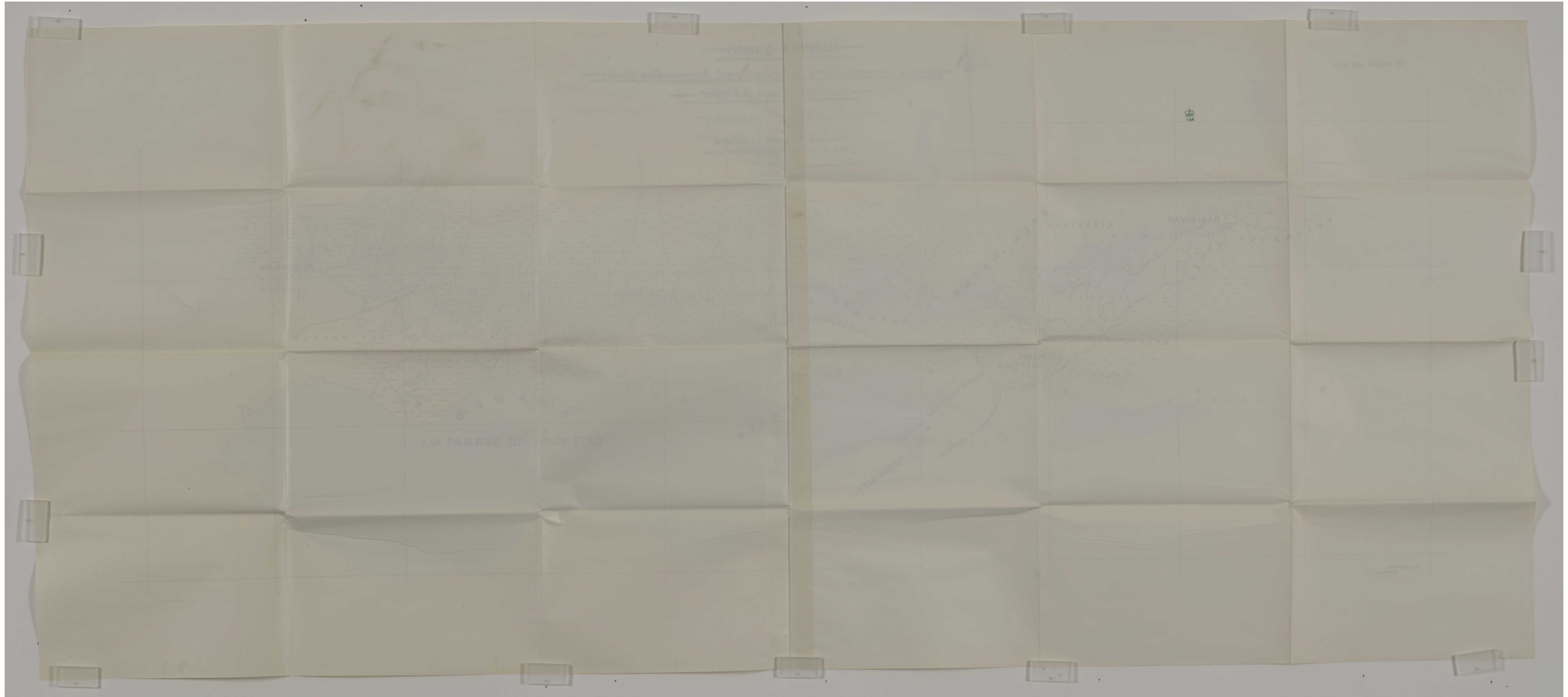




'Nasiriyah-Qurnah. Showing Communications, Waterways and Surrounding Country' [35] (1/1)

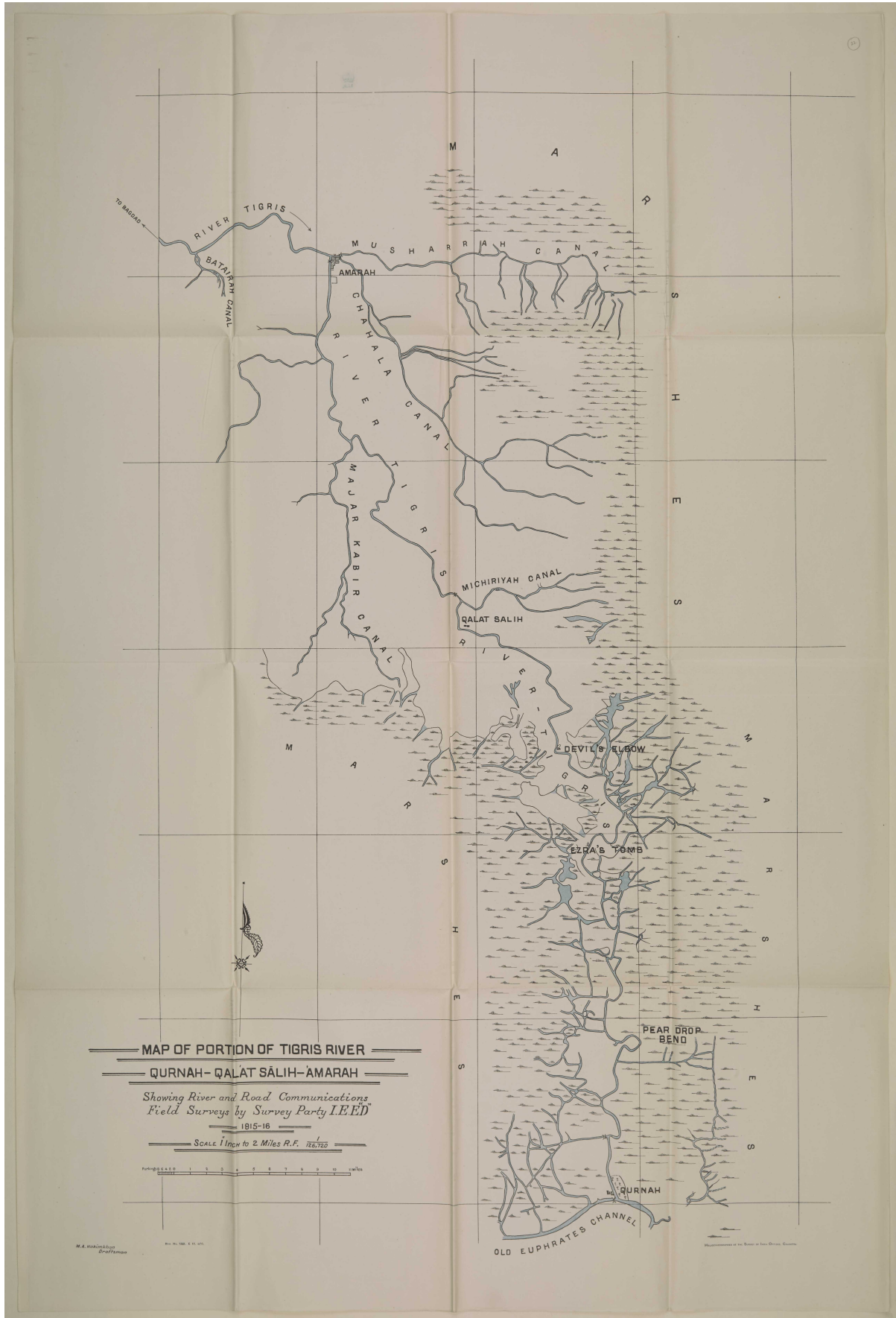


'Report on the Development of Mesopotamia with Special Reference to the Regeneration of the River Systems' [36] (42/50)

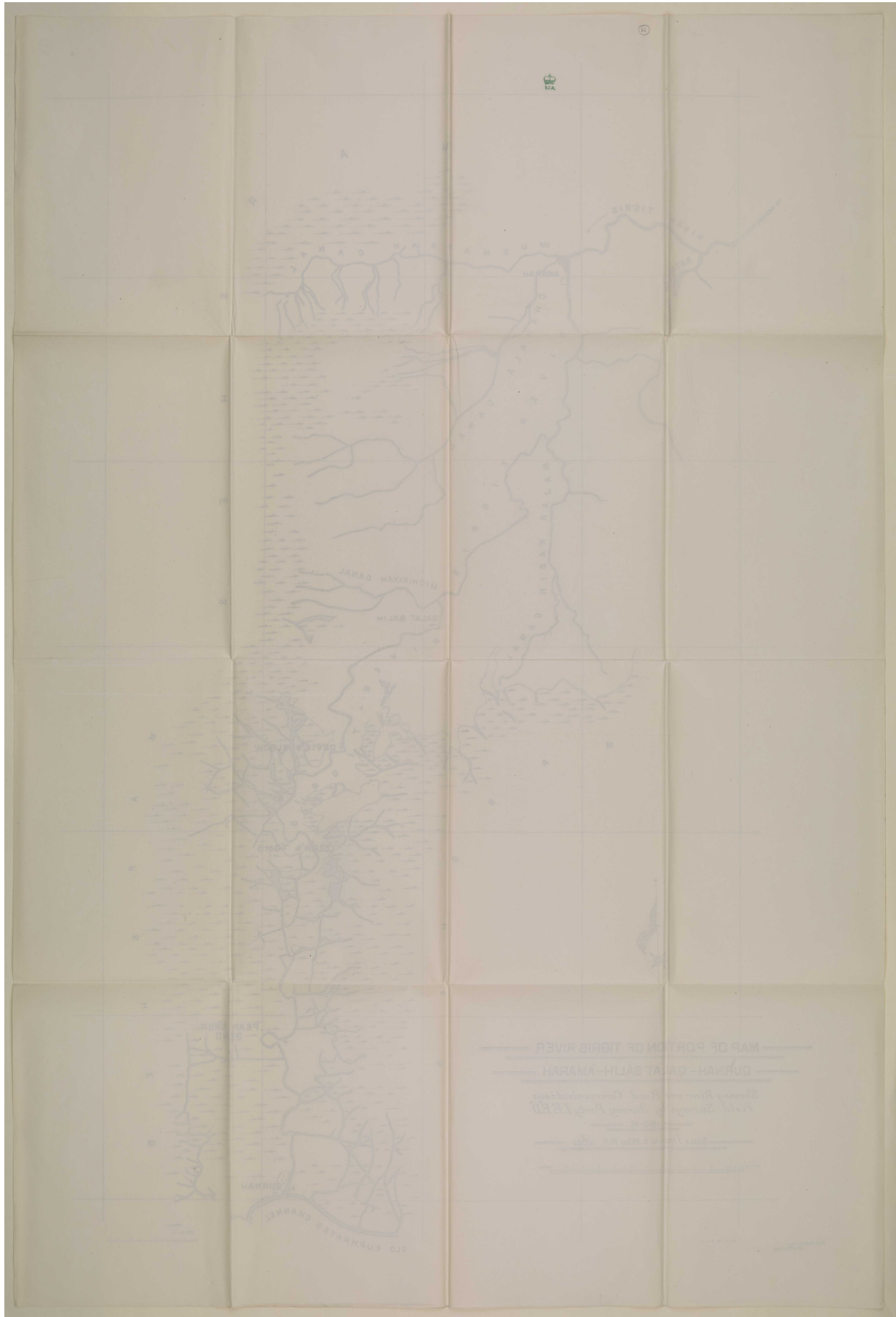




'Map of portion of Tigris River, Qurhan-Qal'at Salih-Amarah Showing River and Road Communications. Field Surveys by Survey Party I.E.E. "D". 1915-15' [37]  
(1/1)



'Report on the Development of Mesopotamia with Special Reference to the  
Regeneration of the River Systems' [38] (44/50)





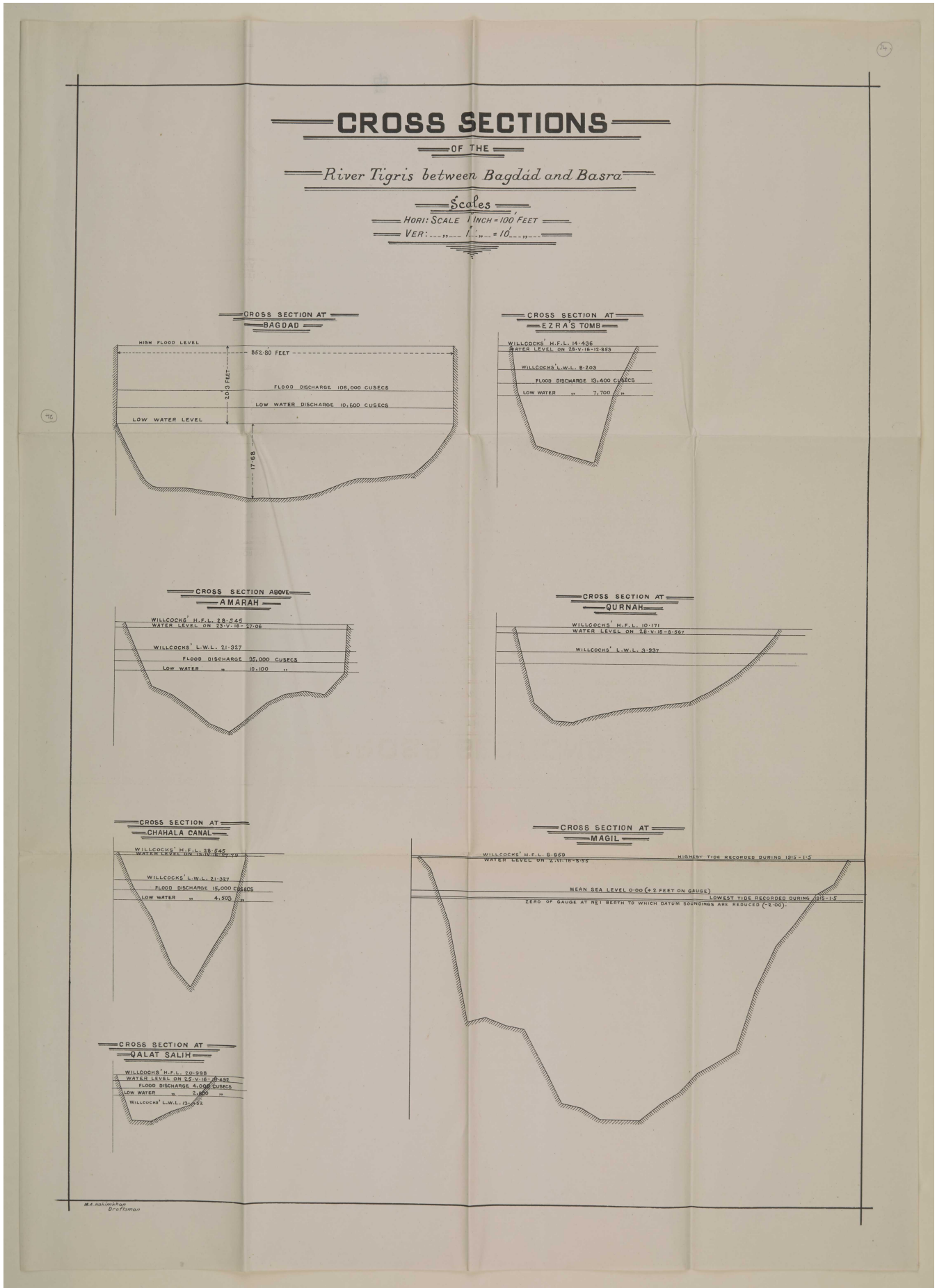
'The Ancient Tigris-Euphrates Delta' [39] (1/1)



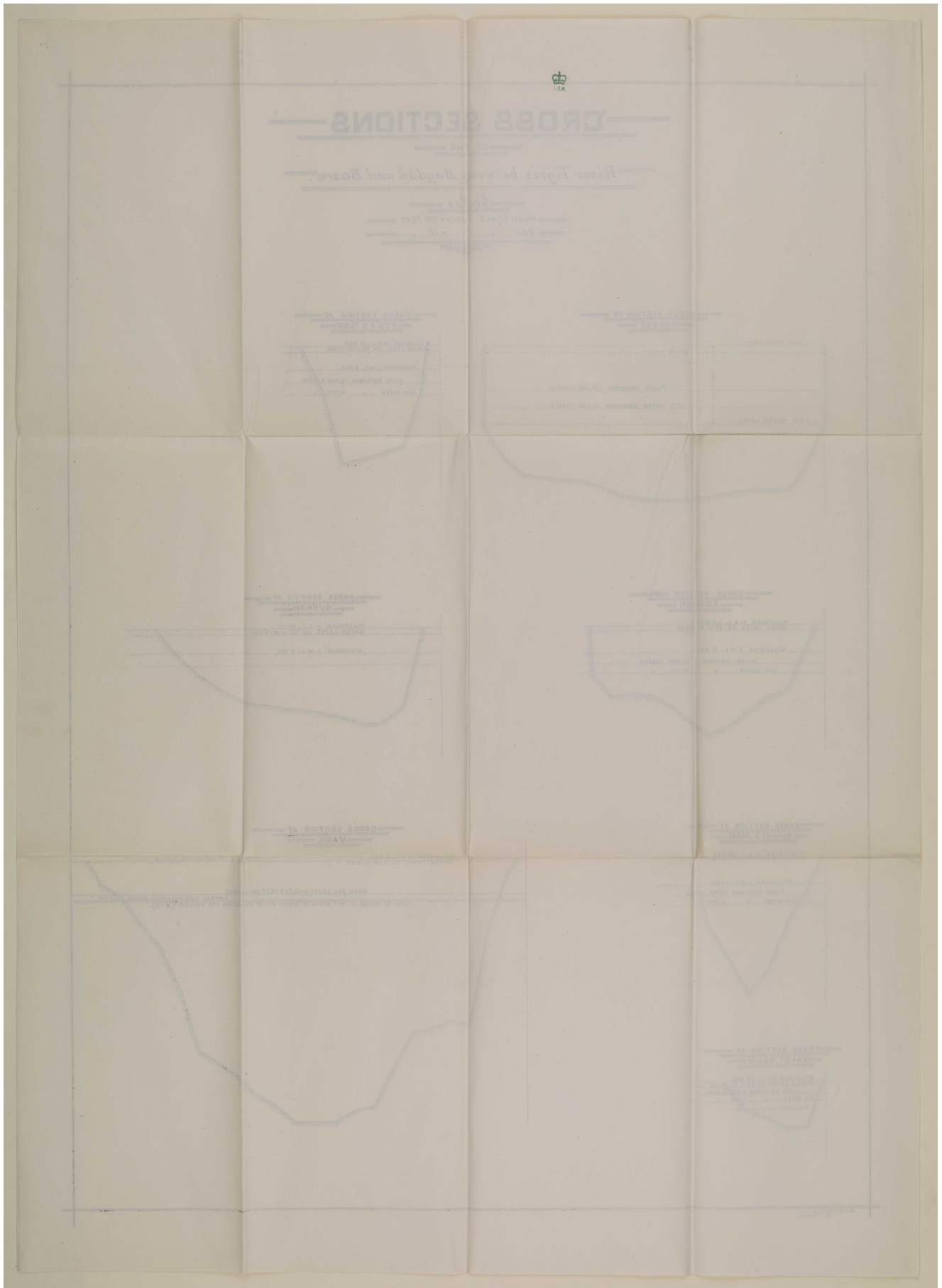




'Cross Sections of the River Tigris between Badgad and Basra' [41] (1/1)

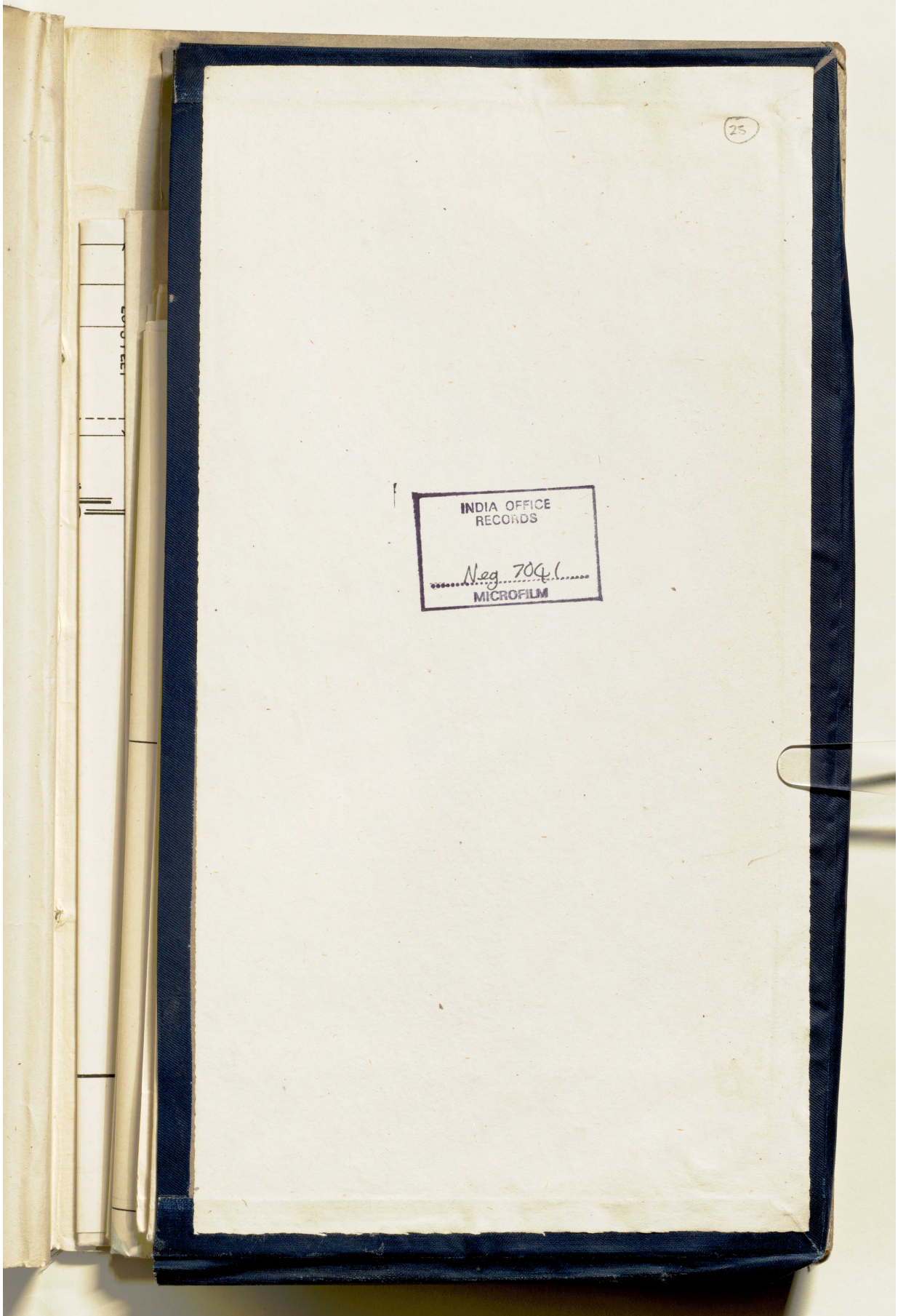


'Report on the Development of Mesopotamia with Special Reference to the  
Regeneration of the River Systems' [42] (48/50)





'Report on the Development of Mesopotamia with Special Reference to the  
Regeneration of the River Systems' [back-i] (49/50)





'Report on the Development of Mesopotamia with Special Reference to the  
Regeneration of the River Systems' [back] (50/50)

