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KENYA

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X. 593
16 JAN 1926

OVR'S DEPTY
DENHAM

1675

DATE

24th December 1925

CULATION:—

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MAGUGA VIADUCT
REVISED PLANS AND REPORTS

Encloses -- by the Chief Engr for examination by the Consulting Engineers.

MINUTES

Ask 477 [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] by [illegible] C.E.

[I [illegible] have [illegible] the C.C.'s minute in 477]

[illegible]
8.1.26

Ask C.A. [illegible] a ~~[illegible]~~ report [illegible]
[illegible]
[illegible]
26/2
[illegible]

Previous Paper

C.A. 477 Minute

~~12159/26~~

To C.A. Cons. 4/3 —5 MAR 1926

C.A. / 12159/26

[illegible] 30th ~~[illegible]~~ [illegible] '26 and 11 and 477

Subsequent Paper

C.A. 2459

W^t. 14607/35 [illegible] 11/23 Harrow B.2382

98

KENYA.

No. 1578

GOVERNMENT HOUSE,
NAIROBI,
KENYA.

X. 593
6 JAN 1926

30th December, 1925.

Gov. 57171/25

~~Macupa Causeway~~
Plans, Reports etc.

Sir,

With reference to my telegram No.588 of the 18th December, regarding the Macupa Causeway, I have the honour to forward herewith in duplicate revised plans and reports submitted by the Chief Engineer, Uganda Railway, for examination by the Consulting Engineers.

I have the honour to be,

Sir,

Your most obedient, humble servant,

EM Denham

for GOVERNOR.

THE RIGHT HONOURABLE
LIEUTENANT COLONEL L.C.M.S.AMERY, P.C., M.P.,
SECRETARY OF STATE FOR THE COLONIES,
DOWNING STREET,
LONDON, S. W.

No.12/8.

COPY.

CHIEF ENGINEER'S OFFICE,
UGANDA RAILWAY.

NAIROBI, 22nd December, 1925.

The Hon'ble General Manager,
Uganda Railway, Nairobi.

MACUPA CAUSEWAY.

1. Under my direction Mr.C.H.M.Johns has prepared a project for the proposed Macupa Causeway which is designed to replace the existing screw pile structure.

2. As you will remember the existing bridges must be strengthened to permit the use of engines with 18 ton axle loads. Owing to the urgent need of a road to the mainland at this point, I sumbitted a proposal to build a causeway for both railway and road, as being the soundest method of meeting the needs of the Island.

3. A preliminary report and estimate was submitted to you vide my No.9854/8 of the 14th September last and I understand this report has been sent home to England to the Consulting Engineers.

4. As the scheme has been approved in principle by Government, further survey work was immediately undertaken and the enclosed report embodies the result of this survey.

5. As pointed out in my No.12/8 of the 10th instant, suggesting a cable to the Consulting Engineers various alterations and suggestions have been embodied in the design. The principal alterations have the reduction of the bridge opening to 60' the clearance to 18' and the grading of the road to 5% grades. These changes have resulted in considerable economy, and the total cost of the causeway is now estimated to be under £60,000.

6. In preparing the estimate fair prices have been selected, but the final cost cannot be definitely known until tenders have been submitted by Contractors.

7. In this connection, unless we receive contrary instructions from the Secretary of State, I propose asking Messrs.Paulings to submit a tender for the whole of the work.

8. With regard to the report, I should like to draw the attention of the Consulting Engineers to the following points:-

Para 5. page 2. Design of Bridge.

All calculations should be checked.

The design appears to provide ample bearing power, as low values for bearing and friction have been selected.

The question of over-turning should be carefully considered. Owing to the shape of the cylinders being circular the resistance to over-turning for the whole abutment is somewhat difficult to calculate accurately. The slab deck however is intended to brin all seven caissons to work in resisting over-turning.

The

The slab for this purpose will act as a beam and as such might be somewhat more scientifically reinforced. As a platform it is amply reinforced with old rails.

As pointed out in the addendum to the report the resistance to overturning can if necessary, be increased by moving the sheet piles out into line with the front face of the Caissons. I should like the Consulting Engineers opinion on these points.

Para 7. Tide and Flow.

It is difficult to estimate accurately the effect on the tidal flow, of building a causeway across the channel. This question will however have to be closely watched during construction. As the causeway is so near the meeting point of the two tides no serious difficulty is anticipated and ample protection will be afforded by the sheet piles and rubble flooring.

Para8. General remarks.

I strongly recommend the building of the causeway to take a double track. I also recommend that the width of the road-way should be increased from 16' as shewn in the plans to 20' at an additional cost of Shs:12,322 only.

[illegible] 9. I would be glad if this report could be sent home to the Consulting Engineers by the first possible means so that any suggestions or changes in design can be carried out without delaying the scheme.

SD/- G. D. RHODES.

CHIEF ENGINEER,
UGANDA RAILWAY.

Govr. X593/26 Kenya

C
R 19 JAN
D 19

Mr. Brett Jan 18
Mr. Allen 18/1
Mr.
Mr. E. J. Harding
Mr. ~~Strachey.~~
Sir J. Shuckburgh.
Sir G. Grindle.
Mr. O. Davis.
Mr. S. Wilson.
Mr. Ormsby Gore
Earl of Clarendon
Mr. Amery.

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S.X

DRAFT.

Ca

Cr X477/26

17 Jan 1926

Gentlemen,

I am etc to ack the recd of your letter, E.438/4, of the 13th of Jan, & to transmit to you a copy of a desp from the Govr of Kenya, transmitting revised ~~of the Macupa causeway~~, plans and reports, relating to the Macupa ~~submitted by the Chief~~ Causeway ~~Engineer, Uganda Railway~~

P.T.O.

Govr. No 1575. 18 Dec

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Ind.

Mr. E. J. Harding.
Mr. Strachey.
Sir J. Shuckburgh.
Sir G. Grindle.
Sir C. Davis.
Sir S. Wilson.
Mr. Ormsby-Gore.
Earl of Clarendon.
Mr. Amery.

Conf x 598/26 Kenya

DRAFT.

Crown Agents for Colonies.

5 March, 1926.

Gentlemen

I am etc. to refer to the letter from this Dept. of the 19th of January last transmitting for consn by yourselves & the Cons. Engrs a copy of a despt. from the Gov. of Kenya ~~drawings plans and reports~~ relating to the Macupa Causeway and to enquire when a report thereon may be expected.

I am etc.

(Signed) W. C. BOTTOMLEY

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102A

(Signed

X.595/1926 Downing Street,

5 March, 1926.

Gentlemen,

I am directed by Mr. Secretary Amery to refer to the letter from this Department of the 19th of January last transmitting for consideration by yourselves and the Consulting Engineers, a copy of a despatch from the Governor of Kenya relating to the Macupa Causeway and to enquire when a report thereon may be expected.

I am,

Gentlemen,

Your most obedient servant,

(Signed) W. C. BOTTOMLEY.

HE CROWN AGENTS

FOR THE COLONIES.

19^d December, 1925.

The Chief Engineer,
Uganda Railway,
Nairobi.

Sir,

I have the honour to forward herewith "Report on The Macupa Causeway Survey".

I have the honour to be,
Sir,
Your obedient servant.

RESIDENT ENGINEER,
MACUPA CAUSEWAY SURVEY.

J/MAM.

Report

REPORT ON MACUPA CAUSEWAY SURVEY & PROJECT.

(1) **SURVEY** Plan No.8

A survey has been made of the existing bridge and the adjoining lands. Levels for spoil with borings have been taken. Soundings have been taken across the estuary on both sides of the existing bridge. No further borings have been taken in the estuary as the old Macupa Bridge Plans are undoubtedly correct. This is proved by the screw piles. Valuable information was obtained from the P.W.D., Mombasa as regards tidal flow, etc. These figures were roughly checked and found to be correct. Copy of P.W.D. information herewith. The Land Office assisted in every way as regards land plans, and their plans for future development. The Town Planning Expert was in agreement, as to the road scheme proposed. The Advisory Port Control Committee agreed to the various suggestions which were made with a view to economy.

(2) **LOCATION.** Plan No.1

The location of the proposed causeway 100 feet North of the existing bridge was based on the following:-

(a) Using the existing bridge for dumping would not be feasable without raising the track. This would cause a serious extra weight which it is doubtful if the bridge would stand.

(b) Only a few trips could be dumped per day, owing to existing traffic which would double the time for the construction.

(c) If new caissons are sunk between existing spans then, should it not be possible to draw existing piles, these would have to be cut off under water, and would always form an obstruction in the channel.

(d) The existing bridge would be lost with the exception of the girders.

(e) By throwing out the centre line 100 ft. the approach curves to the bridge at present 700 ft. radii are increased to 1504 ft. and 970 ft. respectively which will tend to easier running.

In view of the above mentioned reasons the proposed centre line of track was thrown out a sufficient distance to allow of the building of a double track abutment, the footing of which would come at a reasonable working distance from the near screw pile of existing bridge. See Plan No.3. The line of caissons being in line with the screw piles and the centre line of clear span being that of existing span.

(3) **ROAD LOCATION.** Plans Nos. 1 & 7.

The line of the road is taken on the North side of the causeway so as to avoid a level crossing of the Railway and this, on reaching the mainland, follows the Railway either near the track or outside the 100' Railway boundary until a point is reached whereby the road can cross the Railway with a bridge. This in view of the possibility of heavy traffic within the next few years, is extremely advisable.

The question of the location of the road passed this point of crossing has not been gone into.

(4) GRADING. Plan No.2

Owing to the reduction in height of clearance under bridge it has been necessary to grade down the Railway on Causeway to bridge, this grading has however been kept within the Railway Standard and has a reasonable length of horizontal over the bridge. This grading will in no way affect future improvement to grades on existing Main Line on either side. The road is gradedvdown and then rises up over bridge with a grade of 5%. This grade is allowed by the P.W.D. and is a satisfactory grade for all classes of road vehicles. This grading is for the following reasons:-

(a) A large economy in earthworks is affected.

(b) The high level roadway would be liable to more serious accidents in the event of run-aways, motor smashes owing to exceeding the speed limits, breakdowns of steering gear, or loss of control owing to vertigo.

(5) DESIGN OF BRIDGE. Plan No.3

In view of the height of this bridge, the depth of the soil to rock it was considered best to use Caissons sunk 15 feet. Circular Caissons were chosen as against other shapes for the following reasons:-

(a) Cheaper construction in caisson itself.

(b) Easier to sink.

(c) Less danger of drifting or crooking in sinking.

(d) Quicker in construction.

Coffer damming was considered, but in view of the high rise and fall of tides this form was not considered as good as Caissons. The need of strutting the Coffer dams for the excavation would lead to subaqueous work, which is a thing to be avoided if possible, and no gain would be derived from the finished construction, extra plant would be necessary for this form of construction and a longer time would be required for completion.

Calculations as to the bearing of these Caissons have been made on several different bases, all of which show a reasonable factor of safety. See Appendix I. and Plans Nos. 4 and 5.

The sheet piling between the caissons has been calculated to withstand the earth pressure at the back. The bearing power of these sheet piles has also been included with the bearing power of the caissons.

The Caissons have been designed for being made of either brick or concrete blocks.

The concrete block system is recommended for the following reasons:-

(a) Initial expense more than amply compensated for by waste of brick work in subaqueous work.

(b) Rapidity of construction owing to simp.licity of design.

(c) Blocks used and construction carried on with side loading if necessary for guiding.

Complete Caisson rings are not recommended owing to:-

(a) weight and necessity of lifting for placing over vertical reinforcements.

(b) Should Caisson require side loading for guiding, weights would have to be placed, stopping ordinary progress.

The spacing of the Caissons is carried out with a view to their bearing power and to protect toe of rubble defence in bank.

The vertical reinforcements for the prevention of breaking away of lower rings is more than sufficient up to the top ring.

The slab deck for the carrying of the abutment has been placed at the level of highest water for the following reasons:-

(a) Facility of construction above water level.

(b) No danger to shipping owing to being submerged.

(c) Can be used for mooring when tugs and dhows are awaiting tides to pass under bridge.

(d) Can be used as landing stage to main road for launches etc.

The ample reinforcement of this slab has been necessary to ensure the bearing being carried over all seven caissons to the end one, so as to include this caisson in assisting against the overturning moment and supporting power, though these end caissons have not been included in most of the theoretical calculations of pressures, forces, etc.

The abutment is of mass brickwork with vertical reinforcement of old 8-lb. rails to prevent any sliding movement on slab and to assist against train impact. This reinforcement has not entered into calculations of overturning moment, but is an additional factor of safety. The front line of these rails enter the Reinforced Concrete bearing block of girders, so as to prevent slip and cracking of abutment face.

The sheet piling across the bridge opening is to prevent scour. This may not be necessary, but can be observed and decided on during construction of bank. These piles are driven one foot below ground level to allow of the deepening of the water under bridge to that extent. Heavy rubble filling is placed between the two lines of sheet piling level with top of piles to prevent scour between.

With regard to the girder bridge of 60 ft. clear span it is recommended that the Standard Design of the Uganda Railway for this type of bridge should <u>not</u> be used, but that a special design be made using troughing resting on the bottom flange of girders, so that the height of the railway on bank may be reduced as much as possible. The clearance from High Spring Tide level to the bottom of plate girder being the deciding factor in the height of bank and bridge.

(6) CALCULATIONS. Plans Nos. 4 & 5

The brick abutment has been calculated to withstand earth pressures plus impact. Sliding is prevented by vertical reinforcement. The resultant pressure comes well inside the 1st. fifth.

A calculation for the whole abutment has been taken to bottom of Caissons as if standing on ground, the weight only of the soil in front being taken into consideration and only the resistance of five of the Caissons entering into the factor of safety. The resultant in this case comes half way between first fifth and one quarter, which should prove ample. Additional safety is caused by the Caissons at each end which owing to the slab assist in the overturning moment to a large extent.

(7) TIDES & FLOW.

It is impossible to state exactly what the effect of the closing down to 60.ft. of the existing bridge will lead to as regards flow. Only an opinion can be given. The flow at present runs North with the incoming tide, gaining a maximum velocity of 1.3 feet per second. On a falling tide the flow out under the existing bridge is not so great, the estimated amount of water passing under the bridge is about ten million cubic feet per rising tide. See Appendix 2. This is undoubtedly caused by the friction owing to the narrow and twisting channel passed Mombasa Town as against the wider and straighter channel passed Kilindini. See Chart Appendix 3.

It is impossible to definitely state what the rate of the future flow may be, but in my opinion this should not reach more than between 5 to 6 feet per second. The raising of the water on the South Side of the New Causeway to cause this flow, combined with the holding back of the height of the water in Port Tudor should cause the friction to be overcome in the Mombasa reach and the amount of water entering Port Tudor by this channel to be increased. The amount of water entering Port Tudor from Ras Junda at Spring Tides is about 340 million cubic feet per tide, so that the proportion through the bridge is small. In any case all designs have been carried out for a fast flow, in which case shipping will have to pass under bridge with the tide, for this reason mooring bollards have been provided on the Bridge abutment slab. It will be necessary for careful studies of increase of flow to be taken as construction proceeds, and the gap becomes narrower. Allowance for earth carried off by flow during construction has been made.

(8) GENERAL REMARKS.

In view of the certainty of the necessity for double tracking for some distance outside Mombasa within the next few years, combined with the economies effected by the reduction in weight, shortening of span, etc, all designs and calculations, costings, etc., have been carried out for a double track, with the exception of the special girders for the double track bridge. It will undoubtedly be cheaper to build the full width bank for a double track now, and allow for the settlement of same, than to widen earth-works a few years hence, losing thereby all the rubble defence against tides at toe of bank which would have to be covered up and a fresh rubble defence placed.

As it is absolutely necessary to sink the Caissons now for a future extension to a double track, which includes the sheet piling and slab deck, it will be more economical to complete the whole abutment to double track width at once.

(contd).

CONSTRUCTION. See Construction Plan No. 1^{a}.

The method of construction proposed is as follows. At each end make a cutting which will become the future road and from the main line join up a temporary track with a grade of [illegible] down to high water level, the bank for which will be constructed from the spoil of the cutting. On getting down to high water level, construct a bank up to 10 feet by forward throwing and on same run out construction track. A back shunt from this track will run up to the level at which it is decided to excavate with steam shovels; this can be done by passing round the hill. The same method of construction for spoil applies to the main land. An alternative method would be to open up the old construction line as shown on Plan No.1. On completion of earthworks to roadway height the Railway bank will be continued by means of lifting, two or three trains being used to avoid delay. The soil on the mainland is bad for making banks, being mostly crumbling form of disintegrated shale. There is however to the north a spur running out composed of a heavy clay, and it is proposed to use this for the bank. Samples herewith. Should, however, after further observations it be found unsuitable, then the core of the bank can be built up of this material and on completion of bridge good soil from the Island side be dumped to a depth of 6 ft. over the clay core.

To prevent cracking occurring in this high bank which allows water to percolate and cause slides, it is strongly advised to put in old [illegible] lb. rails vertically to the slope, at about 20 ft. intervals in two rows one row 10 feet from the top and one row 20 feet from the top - see plan No.7.

The borings taken in the spoil on the Island side shew a reef of hard sandstone dipping from East to West. This stone can be used for the concrete rubble fill of the Caissons provided there is sufficient and is also good enough for the concrete blocks. Sample herewith. See Plans No.8. The depth of the stone in this reef could not be ascertained. Behind this reef is a soft semi-coral formation but at such a depth as to not interfere with what spoil is required. This spoil is of a sandy nature.

With regard to the formation of the banks in the estuary. If during the closing of the gaps, the flow increases to such an extent as to carry away spoil, it may be necessary to sheet pile out in the centre of the bank with the cheapest form of piling which can be left in; or to sand bag out a bank over high water mark for dumping from. This contingency has not been allowed for in the estimates.

Before the construction of the [illegible] road, it will be necessary to roll the bank or to allow it to stand for, from six to nine months, for due settlement to take place.

The railway can be built on the line of the second track on a murrum ballast, and the bank allowed to settle before stone ballasting same.

The sinking of the Caissons should not present any difficulties. It would be as well however to aid their descent by a water jet so as to ensure straightness, though entire excavation must be made before placing rubble concrete. One layer of bagged concrete should be placed at the bottom as far under the inside edge of curb as possible.

As there are the screw piles of the existing bridge as proof of bearing qualities, there should be no

109

necessity of sinking a test Caisson, though should this thought to be desirable, and end Caisson can be sunk and loaded before building slab or driving sheet piles.

The rubble defence should be built up with the bank to avoid waste either of stone or earth.

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(10) <u>COST.</u>

With regard to the estimated cost these figures are based on several contracts recently carried out and in conjunction with the Mombasa Contract prices of the Uganda Railway.

The cost allotted between the P.W.D. and the Uganda Railway is worked out on the following basis as shown in Appendix No.4:-

(a) The earthworks are divided vertically by a line through the Railway and Road boundary. All savings effected by road grading have been allotted to the P.W.D.

(b) The stone pitching is allotted in the proportion as to the bank is pitched whether P.W.D. or Railway.

(c) The cost of the Caissons is divided into two halves, as the sizes and strengths of these caissons are to withstand the earth packing, and no saving in dimensions would be possible for a roadway only.

(d) The sheet piling, slab and abutment is divided by a vertical line from half was between the two outside girders of the Road and Railway bridges.

(e) The girders for the road bridge are a credit to the Railway and charged to the P.W.D. at stores price.

(f) The moving of the water main is taken as a charge against the P.W.D. as it is understood that this main was placed on the bridge at the risk and expense of the P.W.D. no charge being made by the Railway.

(g) The contingency charges are made in proportion of cost.

(h) Stores and supervision charges are halved.

(j) The remaining items are either charged at 50% to each or totally to one or the other.

The following savings in cost could be effected but are not recommended:-

(a) By reducing earthwork to a single track width a saving of Shs.44,608/- is effected on the Railway cost only.

(b) By using grass instead of stone pitching. (there is a special rapidly spreading grass used for this purpose by the Zanzibar Government) a saving of Shillings.52,809 can be effected, Shillings 46,047 going to the credit of the Railway and Shgs.6,762/- to the credit of the P.W.D. The feasibility of this saving can be decided on better during construction.

(c) By building single track brick abutment on slab a saving of Shgs.7,102 is effected to the credit of the Railway.

110

Should these savings be effected then the total costs are as follows:-

Railway	503,906/-
P.W.D.	537,335/-

This price to the Railway does not include an allowance for the salving of the existing Bridge. This saving is estimated at £.5 per ton and gives a credit of Shillings 187,000/- on the Railway Estimate.

CHW Johns

RESIDENT ENGINEER,
MACUPA CAUSEWAY SURVEY.

CHWJ/MAM.

MACUPA CAUSEWAY.

ADDENDUM TO REPORT.

ABUTMENT, CALCULATIONS FOR

Should the design and forces on Toe of Caissons not be considered to have a great enough factor of safety. An additional factor can be provided by moving the sheet piles out into a line with the front face of the circular Caissons.

On one abutment using friction only, at 3 tons per sq. yard. There is added an extra bearing power of 600 tons minimum to each abutment.

With regard to the overturning moment as shewn in Plan No.5. The result would be that the moment would come well inside the middle third 5'8" from Toe.

The additional cost to the estimate would be Shillings 37,500.

ADDENDUM TO REPORT. PARA.10 COST.

To widen the Roadway from 16 ft. to 20 ft. would require 138,516 cubic feet which equals and extra cost of Shgs.12,322 making the total for the P.W.D. Shgs.361,778.

APPENDIX I.

stimate of supporting power of each pile in existing Bridge.

No allowance for friction.

---

4 Piles. Interior 1'8", Exterior 4'6" = 13.7' per pile = Say 55 sq.ft.

ngine weighs 91.55 + 100% impact = 183 Tons.

eight of Pile. 180 l.ft. 2'6 x 2'.3 = Say 180 Cub.ft. = 40 Tons.

eight of superstructure 41 Tons.

∴ on 55 sq.ft. Total load = 264 Tons. or Say 5 Tons per sq.ft.

Allowing for friction at 2 Tons per sq. yard for cast iron cylinders (vide Trautwine P. 593).

= 72 lin.ft.2'6" diam. =4.9 x 72 = Say 350 sq.ft. = 700 Tons.

∴ Friction alone more than sufficient to support bridge.

Taking mud and silt with friction of only 1 Ton per sq.yd. for steel Caissons we have 350 Tons: which is still more than sufficient to support bridge.

With 160 Ton engines load on bridge will equal 400 Tons.

As regards actual supporting power. Piles should be sufficient for new engines, though lateral weakness from shock owing to tired steel, it would be advisable to replace them. Constant shock under water allows admission of water between pile and soil which may have considerably reduced the friction.

CAISSON CALCULATIONS. 14 feet under ground level.

Frictional Area of Caisson under ground = 660 sq.ft. = 73 sq. yards.

Bearing power of 1 Caisson on ground at 1½ tons per sq.ft = 265 Tons

" " " 1 " by friction at 2 tons per yd. = 216

Minimum Total bearing for 1 Caisson. = 481 Tons.

(Maximum " " " " ") = 572 "
(using 2 tons on ground & 3 T.friction)

∴ Bearing of five Caissons Minimum per abutment = 2405 Tons.

" " seven " Maximum " " = 4004 Tons.

Contd.

CONTINUED.

er abutment.

To total bearing power of Caissons add Sheet piling } { at 2 tons = 1510
9 lin.ft = 50 sq.ft on ground frictional area = 605 sq.yds. } { at 3 Tons. = 1955

eight per Caisson taken as concrete throughout = 150lbs.p.s.f. = 300 Tons

∴ Weight of 5 Caissons. =1500 "

" of Concrete Slab. = 130 "

" of abutment 7050 Cub.ft. = 250 "

= 220 "

Load on Abutment = 2100 Tons

TOTAL

NOTE Using brick concrete 100 Tons may be deducted.

To compare weight of abutment over 7 Caissons using **MAXIMUM FRICTIONS**

ETC, add 800 Tons. = 2900 Tons.

∴ Weight of Abutment. = 5969 Tons.

Bearing power of Caissons. Maximum. 3069 Tons.

FACTOR OF SAFETY.

Using minimum friction etc. over 5 Caissons. = 2000 Tons.

Weight of abutment. = 3191 Tons.

Bearing over 5 Caissons = 2405 + 786

= 1191 Tons.

FACTOR OF SAFETY.

NOTE

Using Calculations of existing piled bridge at 3 tons per square foot.

Bearing power of Caissons Area 1237s.f.& Sheet piling 59 ft. = 6460 Tons.

MAH.

appendix 2

APPENDIX 2.

EXECUTIVE ENGINEER'S OFFICE,
PUBLIC WORKS DEPARTMENT,
Mombasa, 30th.June, 1925.
No.212/2/13.

THE HONOURABLE
THE DIRECTOR OF PUBLIC WORKS,
NAIROBI.

EMBANKMENT, MAKUPA.
Ref. Your No.1909 dated 16,6,25.

In reply to your above quoted letter, I send herewith a diagram and two statements illustrating the results of my very rough observations on tidal flow at Macupa Bridge.

2. The diagram is interesting. It appears that the actual rate of rise and fall of the tide is independent of the velocity of water through the Bridge. There is no slack time after high water, the tide falling at once at a rapid rate, while at the same time the flow through the Bridge has only about half the velocity of the rising tide.

3. Statement (1) shews the velocities of individual floats from which the velocities written on the diagram and used in calculating quantities have been arbitrarily selected. Statement (2) gives the volume of water passing at different heights and velocities of the tides after making certain assumptions, which are noted on the statement.

4. A figure for the total volume of water passing through the Makupa Bridge is thus arrived at.(10177060 cubic feet per Rising Tide).

MAM.

Velocities of flow deduced from observations
taken on 16th June 1925.

Distance 400 feet.

No.1			No.2			No.3			No.4				No.5			No.6		
No. of Floats.	Time Min.	Speed Ft. per sec.				1	6½	1.02	8	Feet 450	5	1.43	1			7	16	0.42
7	7	0.95	1	7	0.96	2	5	1.33					2	22	0.30	14	13½	0.48
6	9	0.74	4	5	1.33	3	6	1.11					3	22½	0.30	13	13½	0.49
5	10	0.67	5	6	1.11	4	5	1.33	9	450	6	1.05	4	21	0.32	12	9½	0.78
4	11	0.60	6	5½	1.21	5	5½	1.21					5	18	0.37	10	17½	0.38
3	9	0.74	7	7	0.95	6	5½	1.21	10	400	6	1.11	6	19	0.35	8	30½	0.17
2	10	0.67				7	6	1.11										
1	14	0.48																
Time 10.31 to 10.37 - 2½ hrs.before high water.			Time 10.49 to 10.56½ - 2 hrs.20min before high water			Time 11.24½ to 11.34 - 1 hr.45 min. before high water			Time 11.43 to 11.5 - 1 hr.25 min.before high water.				Time 1.23 to 1.4 - 20 minutes after high water.			Time 1.53 to 2.51 - 1 hour after high water.		

NOTE. Tide turned between 1.3 and 1.27, say at 1.15 P.M. or 53 minutes after Nominal time.

Floats of 1" x 1" x 3 feet wood, weighted with metal vanes so as to float with 9" exposed and 2'3" immersed. Intd. R.N. 2.7.25.

Statement No.2

ESTIMATE of Actual number of Cubic feet passing
MAKUPA BRIDGE in half a tide
from float observations taken on 4 and 16th June 1925.

ASSUMPTIONS:-

(1) That the Cross Section of the Channel taken for the road across Makupa Ferry is the correct section for the observation at all points. (See enclosure to this office letter No.36/R/13 dated 31.3.25 to D.P.W).

(2) That the arbitrarily selected mean velocities from each of the eight observations taken is the mean velocity of the whole of the water in the selected section.

(3) That the velocity for the period of time that elapsed between one observation and the next is the mean of the two velocities concerned.

NOTE:- The cross sectional area of the channel has been calculated from ground level to reduced level of 100.00 and for every feet of rise of water from 100.00 to 106.00 - also from 106.00 to Nominal High water Spring Tide at Reduced level 111.60

Where cross sectional areas have been required at other levels they have ascertained by the addition of proportional parts.

	Time	Level Staff Reading	Reduced levels		Cross Section Dimensions at various Vertical Distance.		Proportional area for fractions of a foot	Areas between each observation.			
			Railway.	P.W.D.	Width. lin.ft.	Area sq.ft.				Velocity. Ft per sec	Cubic Feet
			100.85								
	8.15	Assumed time of low water deduced from observation taken on 4/6/25.		99.25	zero						
						337					
				100.00	450						
						505					
				101.00	575						
						702					
				102.00	830						
						920					
				103.00	1010						
							0.0				
1.	10.34	4.58		103.75		1067			3264	0.70	26280.8
							367				
				104.00	1125						
							174				
2.	10.58	5.08		104.28				441	3705	1.20	75630
						1197	694				
3.	11.30	5.68		104.85				694	4399	1.25	168700
							289				
4.	11.42	5.83		105.00	1190			289	4688	1.20	86130
							123				
	Noon	5.90		105.10				123	4811	1.10	72384
							74				
	12.40	5.96		105.16		1230		74	4885	0.66	16220
			106.5				49				
	1.15	6.05	High Tide	105.20				49	4934	Nil	36290
							904	Total Volume in one half Tide			1 177080
				106.00	1270						
						7546					
	High Spring Tides.		112.00	110.40	1280						

From 5 hours before high water until 2 hrs.41 m. before high water Velocity rose from zero to 0.7 feet per sec. Volumed water passing in this time of 2 hrs.11.mins. will be:-
131' x 60" x 0.7 x 3264 cubic feet.
4 962800 cubic feet.

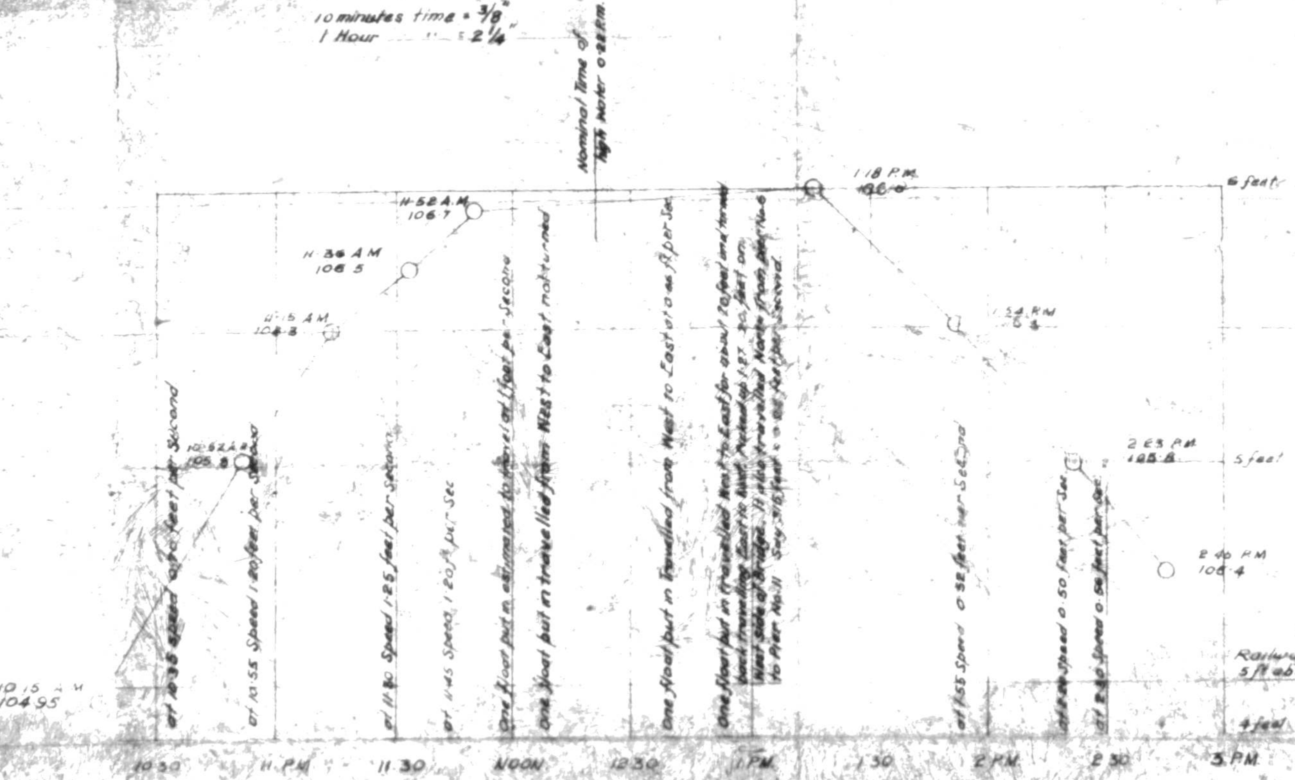
MM.

DIAGRAM OF TIDAL FLOW AT MAKUPA BRIDGE.

P.W.D. MOMBASA PLAN No. 26/25.

Reduced Level of Nominal high Water Spring Tide 112.00 Railway

SCALES
VER. 1/4" = 1/10 feet
10 minutes time = 3/8"
1 Hour " = 2 1/4"



at 10.35 speed 0.70 feet per Second

at 10.55 Speed 1.20 feet per Second

at 11.30 Speed 1.25 feet per Second

at 11.45 Speed 1.20 ft per Sec

One float put in estimated to travel at 1 foot per Second

One float put in travelled from West to East not turned

One float put in Travelled from West to East at 0.66 ft per Sec

One float put in travelled West to East for about 20 feet and turned back travelling East to West. Picked up 1.27. 20 feet on West side of Bridge. It also travelled North from pier No. 6 to Pier No. 11 Say 3.16 feet x 0.88 feet per Second

at 1.55 Speed 0.52 feet per Second

at 2.20 Speed 0.50 feet per Sec

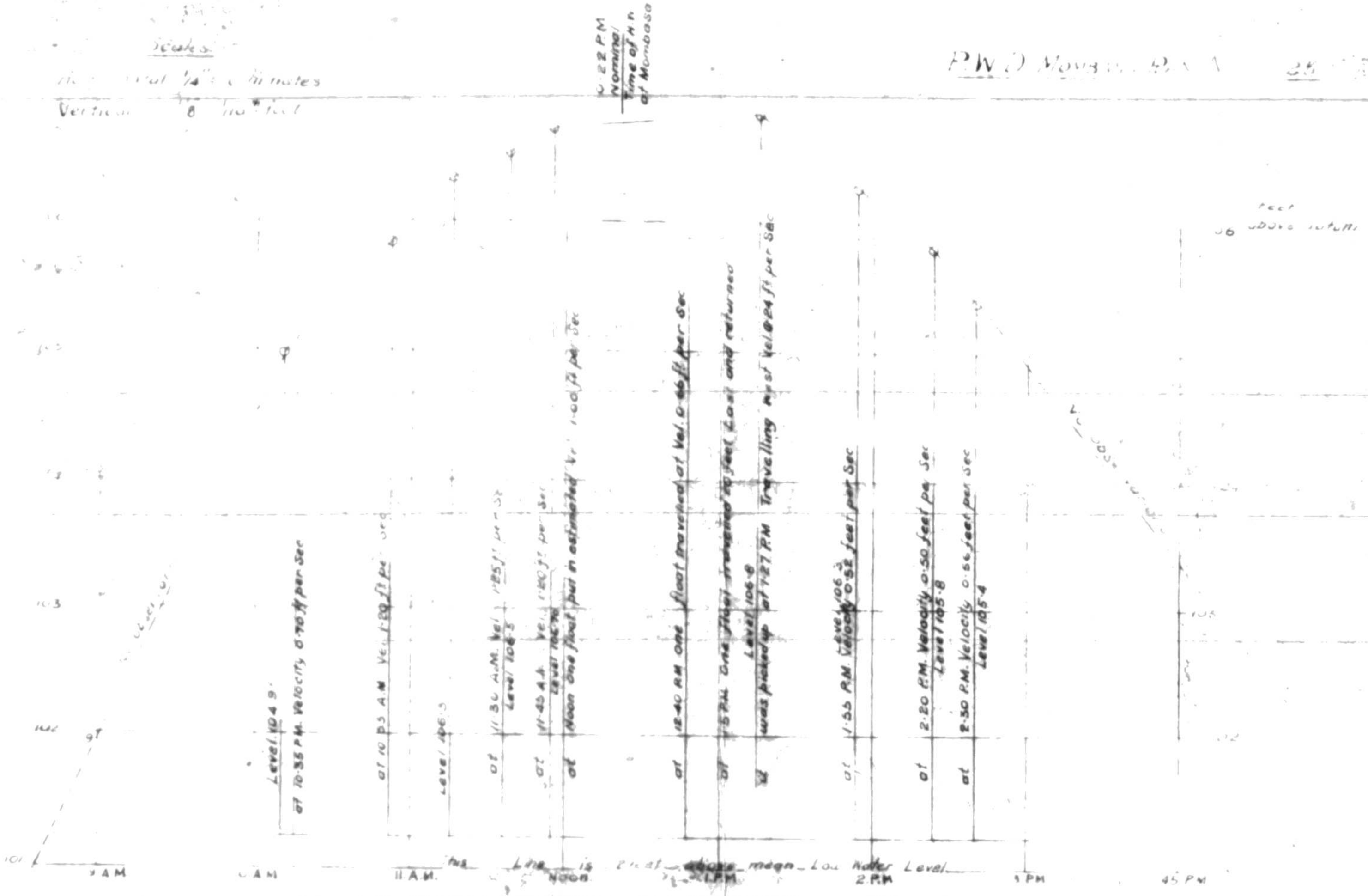
at 2.40 Speed 0.56 feet per Sec

Railway reduced level 105 feet or 5 ft above mean Low Water Datum

Sd. E. Napier.

EXECUTIVE ENGINEER
P.W.D.
MOMBASA

E. Napier E.E.



This Diagram Shews Rate at witch Tide Rose and Fell on June 16th 1925 at

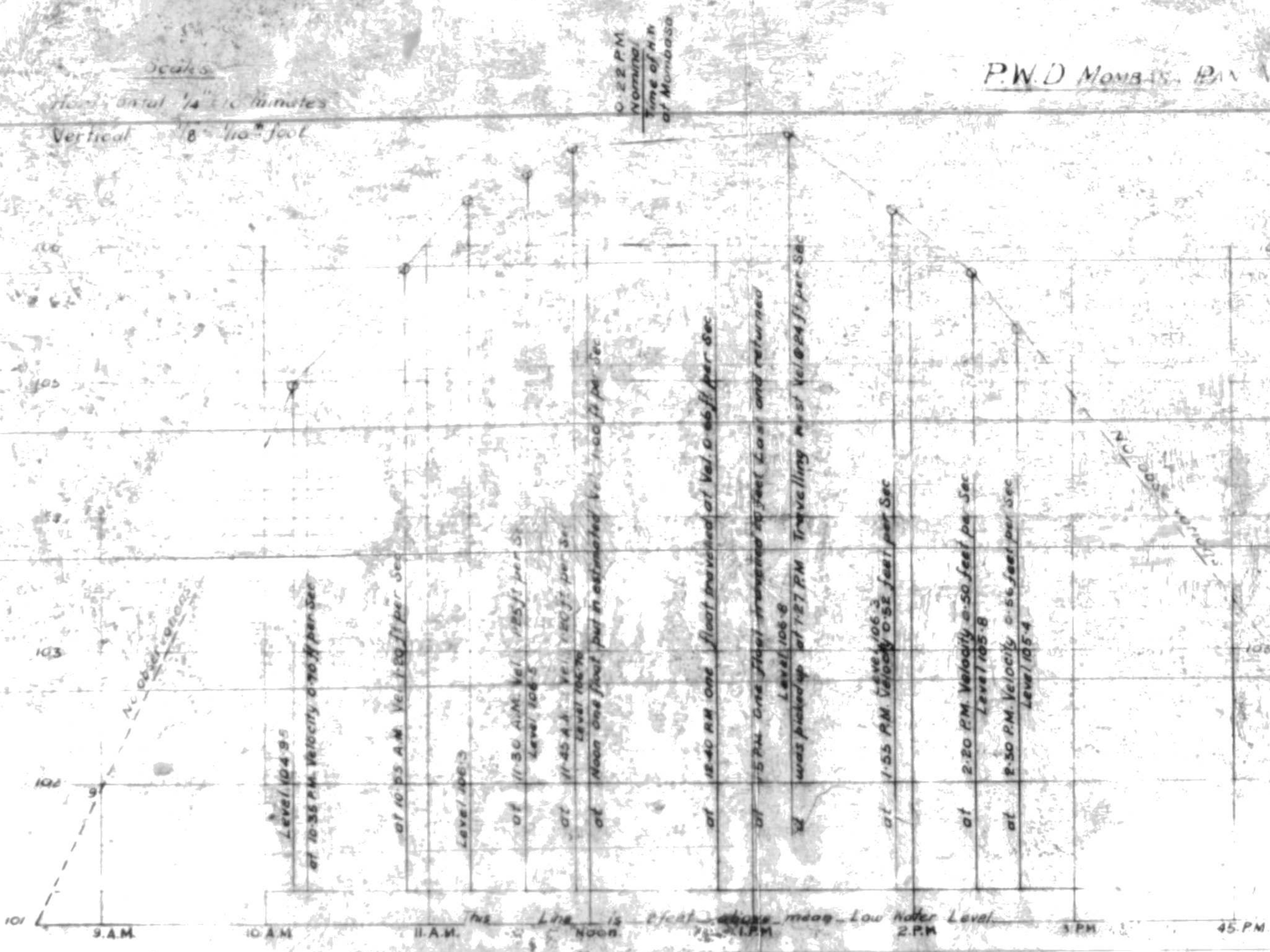
Makupa Bridge Mombasa Island.

The velocity at witch the tide was flowing at certain times is entered on this diagram ...

Drawn by E. N...
Traced by ... Abdullah
Checked by

... E. Napier
EXECUTIVE ENGINEER.
P.W.D.
Mombasa.
Dated 29 6 25

P.W.D Mombasa Plan No 25



This Diagram Shews Rate at witch Tide Rose and Fell on June 16th 1925.
at
Makupa Bridge Mombasa Island.

The Velocity at witch the tide was flowing at certain times is entered on this diagram for convenience

Drawn by E. Napier, E.E
Traced by .M. Wolullah
Checked by

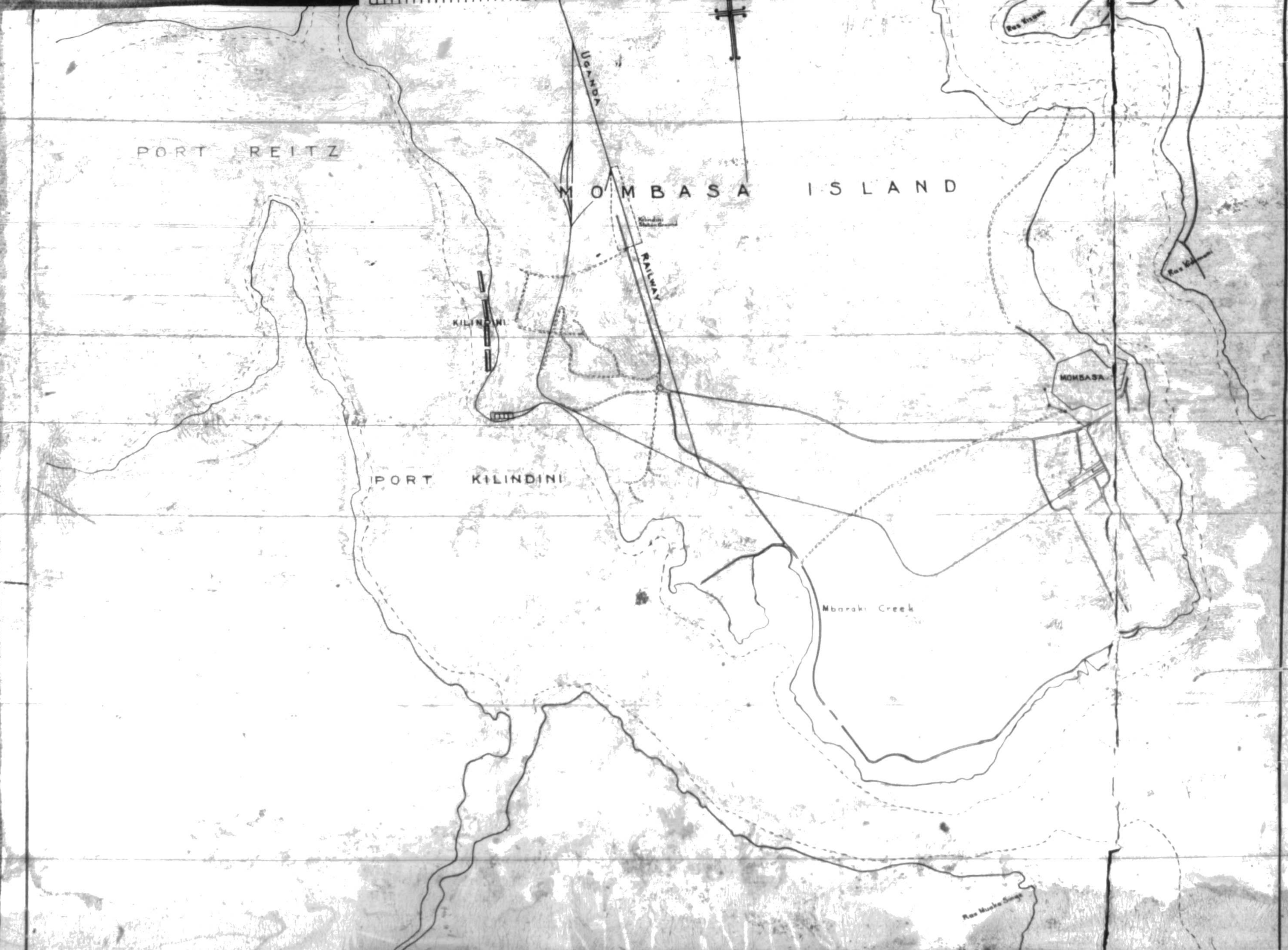
Sd. E. Napier,
EXECUTIVE ENGINEER.
P.W.D.
Mombasa.
Dated 29.6.25

APP

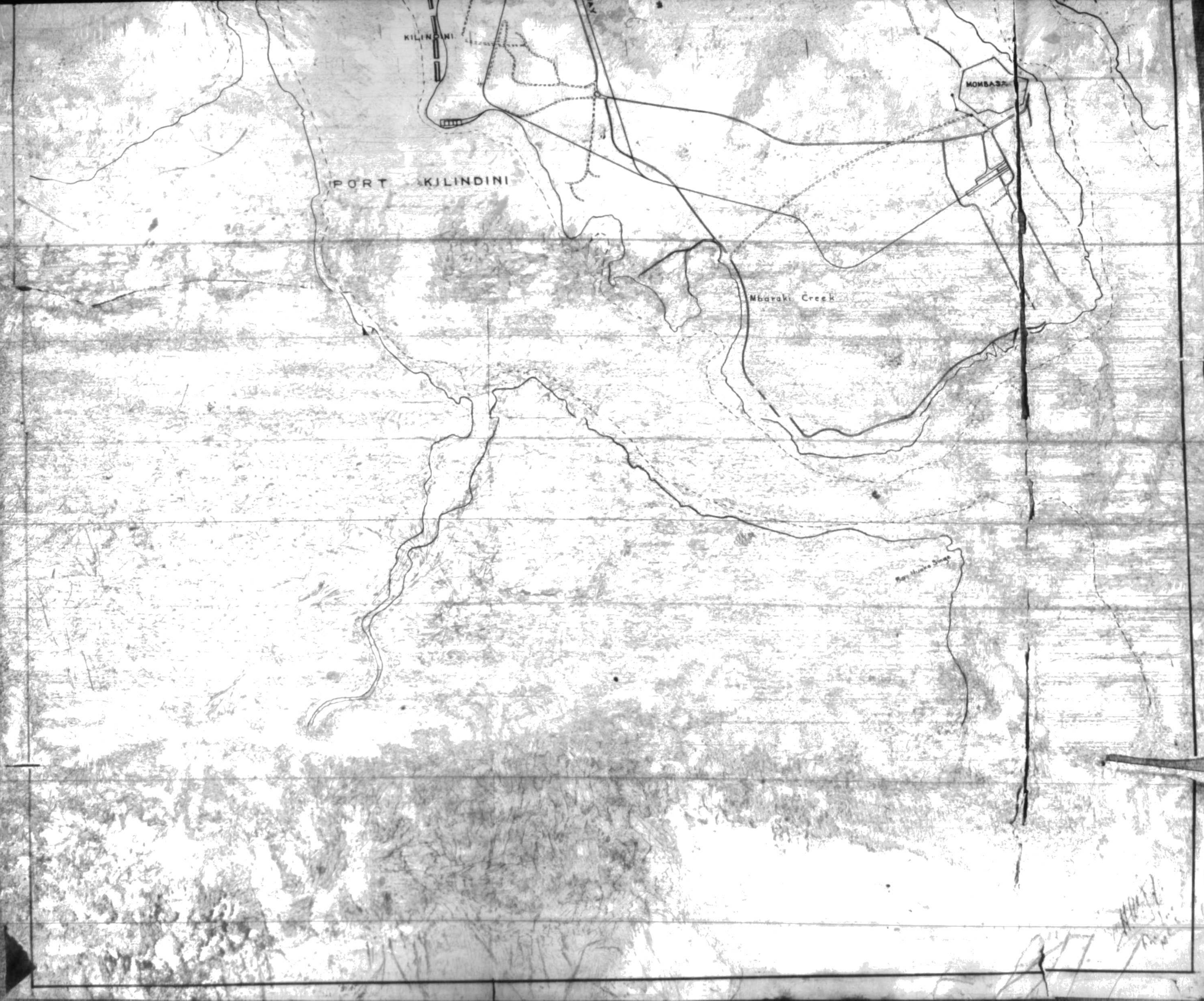
UGANDA RAILWAY CHART PLAN OF MOMBASA ISLAND.

Scale: 1 in 1010·8 Feet.


Ras Kisauni
UGANDA
RAILWAY
PORT REITZ
MOMBASA ISLAND
Ras Kidomoni
KILINDINI
MOMBASA
PORT KILINDINI
Mbaraki Creek
Ras Mwaka Singa


PORT REITZ
UGANDA
RAILWAY
MOMBASA ISLAND
Kilindini Station Ground
Ras Kisauni
Ras Kiberamni
KILINDINI
MOMBASA
PORT KILINDINI
Mbaraki Creek
Ras Mwaka Senga


KILINDINI
MOMBASA
PORT KILINDINI
Mbaraki Creek


AY
KILINDINI
MOMBASA
PORT KILINDINI
Mbaraki Creek
Ras Mwaka Singe

APPENDIX 4.

MAGUPA CAUSEWAY.

S OF DOUBLE TRACK EARTHWORKS & ABUTMENT WITHOUT DOUBLE TRACK GIRDERS.

Description.	Quantity	Unit	Rate	COST. SHS.CTS.
rthworks lead 1200ft.Av.	4884000ft^3	1000ft^3	93/-	454212.00
bble Bank.	236076 "	1000 "	210/-	49576.00
one Pitching. 1.50 ft. thick.	211235 "	"	250/-	52809.00
isson Curb. 1:2½:4½.	1144 "	ft^3	11/-	12584.00
" Blocks. 1:3:6 in place.	26306 "	"	5/-	131530.00
einforcement Rods. 16 lbs.	7602L.ft	L.ft.	-/40	3041.00
aisson Filling. 1:4:8.	33250ft^3	ft^3	3/-	99750.00
oncrete Slab. 1:3:6.	13754 "	"	4/-	55016.00
ickwork. 5:1 Mortar.	15860 "	"	2/30	36478.00
il reinforcement.	7560L.ft.	L.ft	1/20	9072.00
heet piles in place 1:2½:4½.	3916ft^3	ft^3	12/50	48950.00
oncrete Beam R.C. 1:2½:4½.	232 "	"	9/-	2088.00
irders for Railway Bridge.	24Ton.	Ton.	500/-	12000.00
oving water main.	Job.	Job.	4000/-	4000.00
rack laying & packing up track.	½ Mile	Mile	3200/-	1600.00
acadam Road. Soling etc.	½ "	"	60000/-	30000.00
oad drainage & Fencing.	½ "	Lin.ft.	5/-	13200.00
				1015906.00
% for contingencies.				50795.00
				1066701.00
tores charges 6% on materials only. Shgs.178,000				10680.00
				1077381.00
upervision Charges.				107738.00
				1185119.00

MAKUPA CAUSEWAY.
APPENDIX [illegible].

ESTIMATE SHEWING DIVISION OF COST BETWEEN P.W.D. & UGANDA RAILWAY.

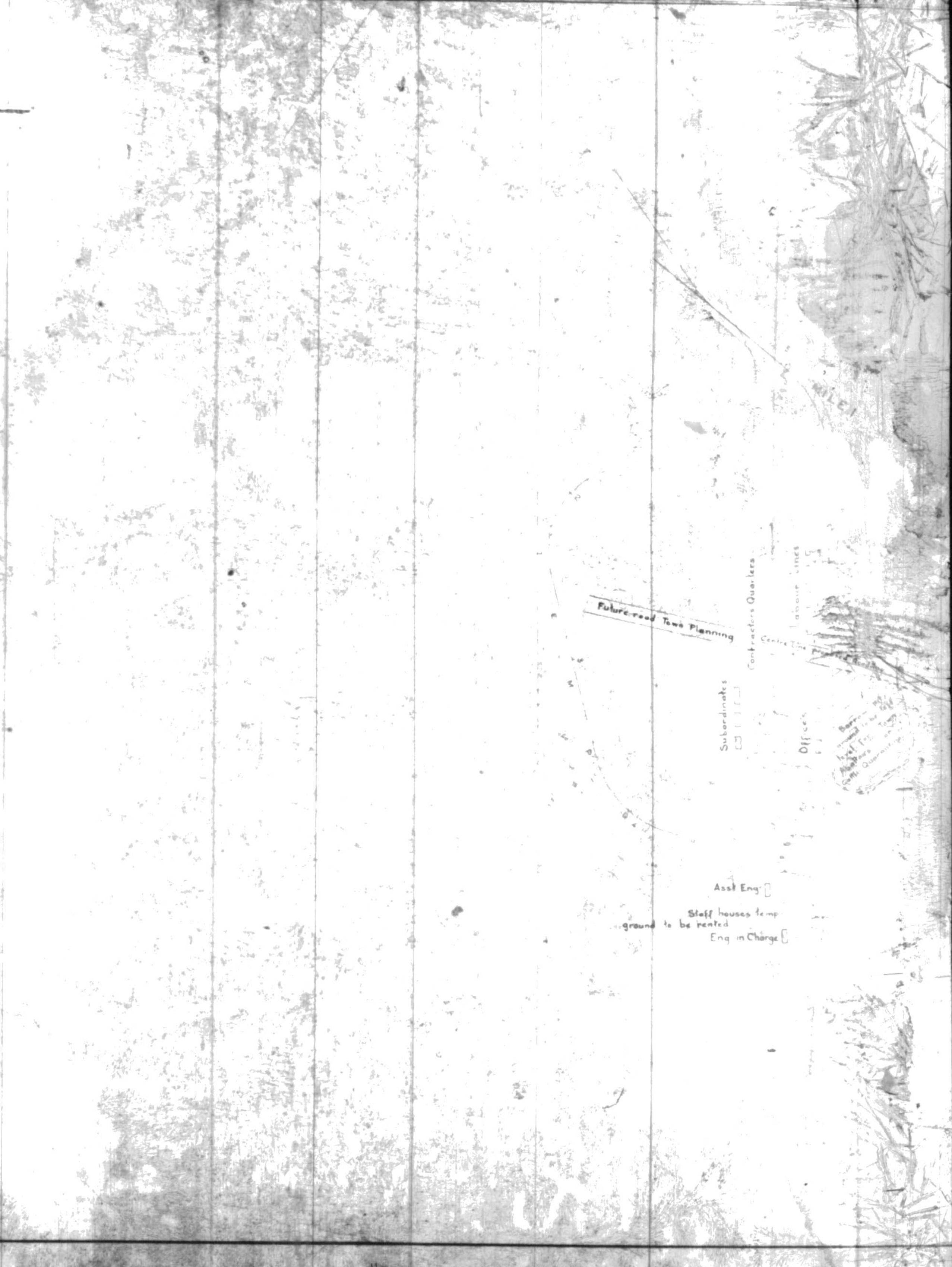
	DIVISION.	RAILWAY.	P.W.D.
		SHS.CTS.	SHS.CTS.
rthworks.	Cal'd.	262974.00	192138.00
ubble Bank.	50% each.	24786.00	24786.00
tone Pitching.	Cal'd.	46047.00	6762.00
isson Curb.	50% each	6292.00	6292.00
" Blocks.	" "	65765.00	65765.00
einforcing Rods.	" "	1521.00	1520.00
isson Filling.	" "	49675.00	49675.00
oncrete Slab.	Cal'd.	29218.00	25795.00
rickwork.	"	22894.00	13584.00
Reinforcing Rails.	50% each.	4536.00	4536.00
heet piles.	Cal'd.	22550.00	22600.00
oncrete Beam.	50% each	1044.00	1044.00
irders for Road Bridge.	Special	12000.00	5000.00
oving water main.	P.W.D.	-	4000.00
rack laying and picking up.	Railway	1600.00	-
acadamizing Road & Soling etc.	P.W.D.	-	30000.00
oad drainage & Fencing.	P.W.D.	-	13800.00
		554004.00	466902.00
redit to Ry.Road Bridge Girders.		5000.00	
		549004.00	466902.00
ontingencies.	5% of Cost.	27450.00	23345.00
		576454.00	490247.00
tores Charges.	50% of each.	5340.00	5340.00
		581794.00	495587.00
upervision Charges.	50% of Each	53869.00	53869.00
		635663.00	549456.00

TOTAL COST. = Shs. **1,185,119/-**

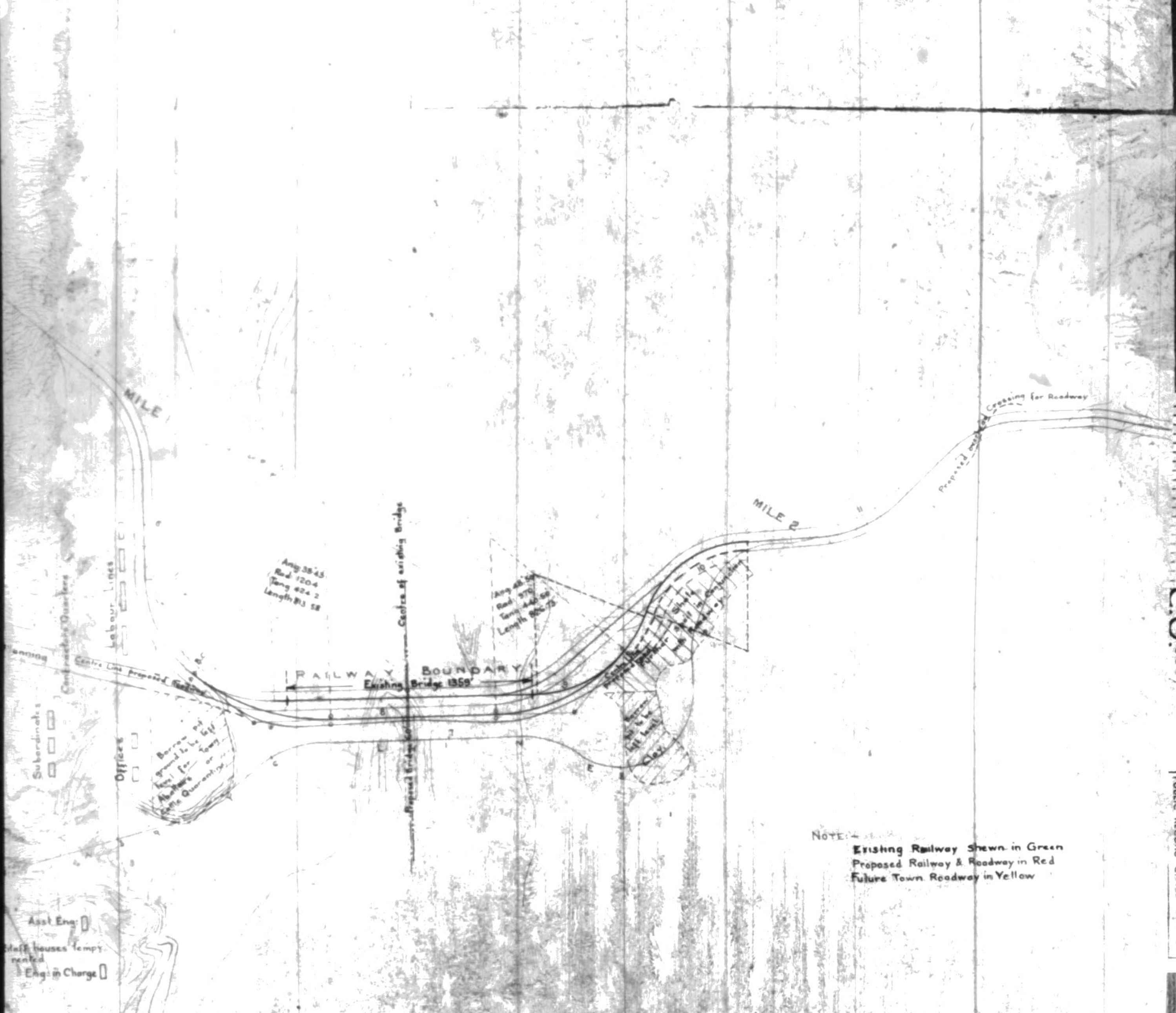
NAM.

Enclosures of ....

UGANDA RAILWAY. PROPOSED MACUP



D MACUPA CAUSEWAY GENERAL PLAN. SCALE 40 FEET T



NOTE:—
Existing Railway Shewn in Green
Proposed Railway & Roadway in Red
Future Town Roadway in Yellow

APPROVED

Resident Engineer
Macupa Causeway Survey

MACUPA CAUSEWAY_ GENERAL PLAN.

SCALE 40 FEET

NOTE:— Construction Tracks Shown in Red.

~~Existing Railway Shown in Green~~
~~Proposed Railway & Roadway in Red.~~
~~Future Town Roadway in Yellow.~~

Enclosures of ....

UGANDA RAILWAY. — LONGITUDINAL SECTION OF PROPOSED M

RAILWAY	BANK		C.5	C.6	C.5.C.C	C.5	C.5	C.5	30.1	34.8	36.3	36.3	35.2	34.3	34.2	34.4	34.3
	RLY. FORMATION LEVEL	43.5	41.4	40.6	39.7	38.5	38.4	38.0	37.3	36.9	36.4	35.8	35.2	34.6	34.1	33.5	33.5
ROADWAY	BANK								8.1	13.4	15.4	18.3	22.1	25.0	28.5	32.5	34.3 34.3
	FORMATION LEVEL		20.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	18.4	22.1	25.3	28.4	31.6	33.5 33.5
GROUND LEVEL		43.5	41.4	35.8	26.0	22.8	23.2	9.1	7.4	2.1	0.1	-0.5	0.0	+0.3	-0.1	-0.9	-0.8
CHAINAGE		1178.2	1078.2	978.2	878.2	778.2	718.2	678.2	616.5	553.5	490.5 485.8	427.5	352.5	289.5	226.6	163.5	125.5 100.5

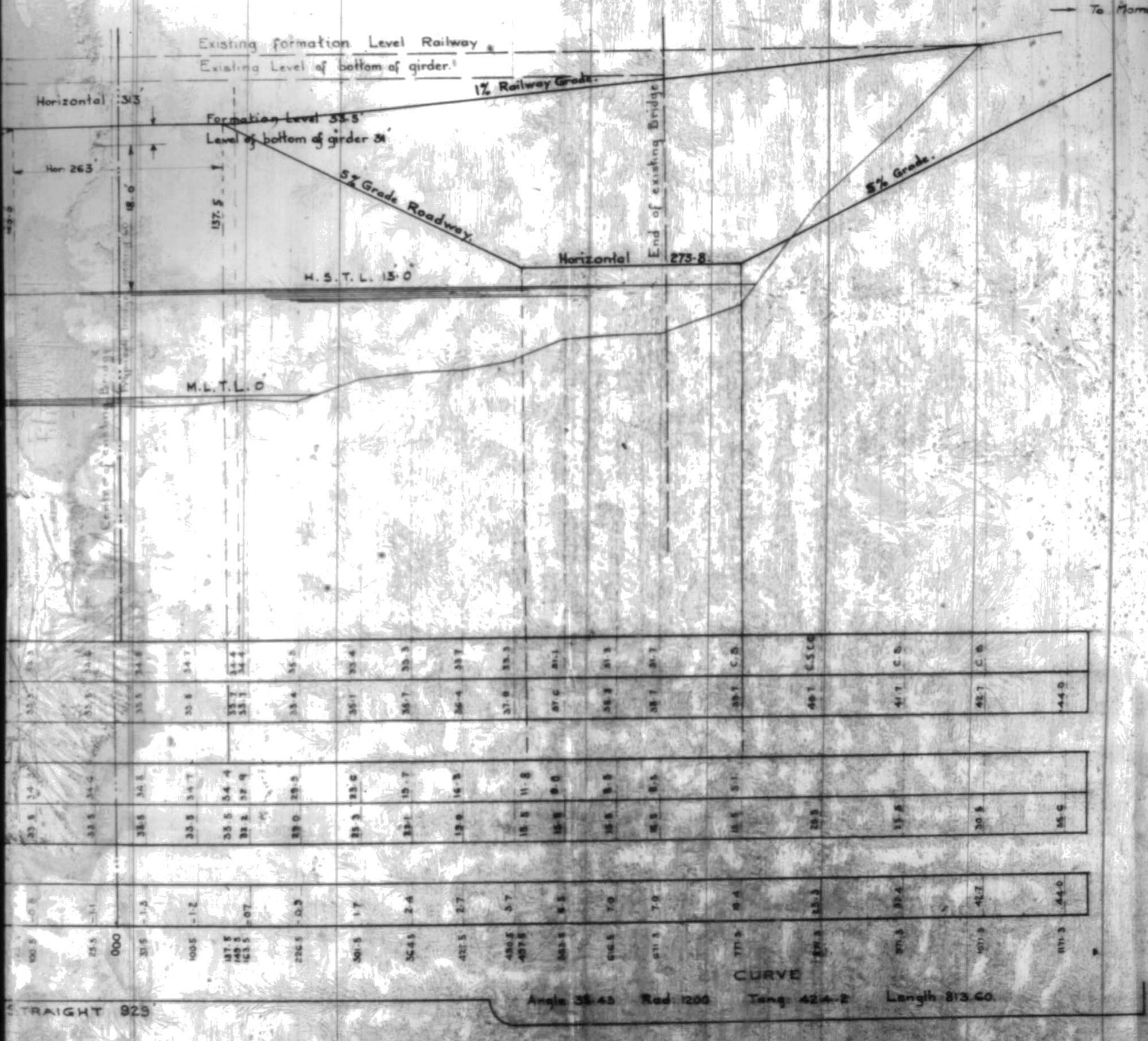
CURVE
Angle. 48° 50 Rad: 970 Tang: 440 Length 826·73.

STRAIGHT

SED MACUPA CAUSEWAY.

SCALES: HORIZONTAL 1 IN 1200.
VERTICAL 1 IN 120.

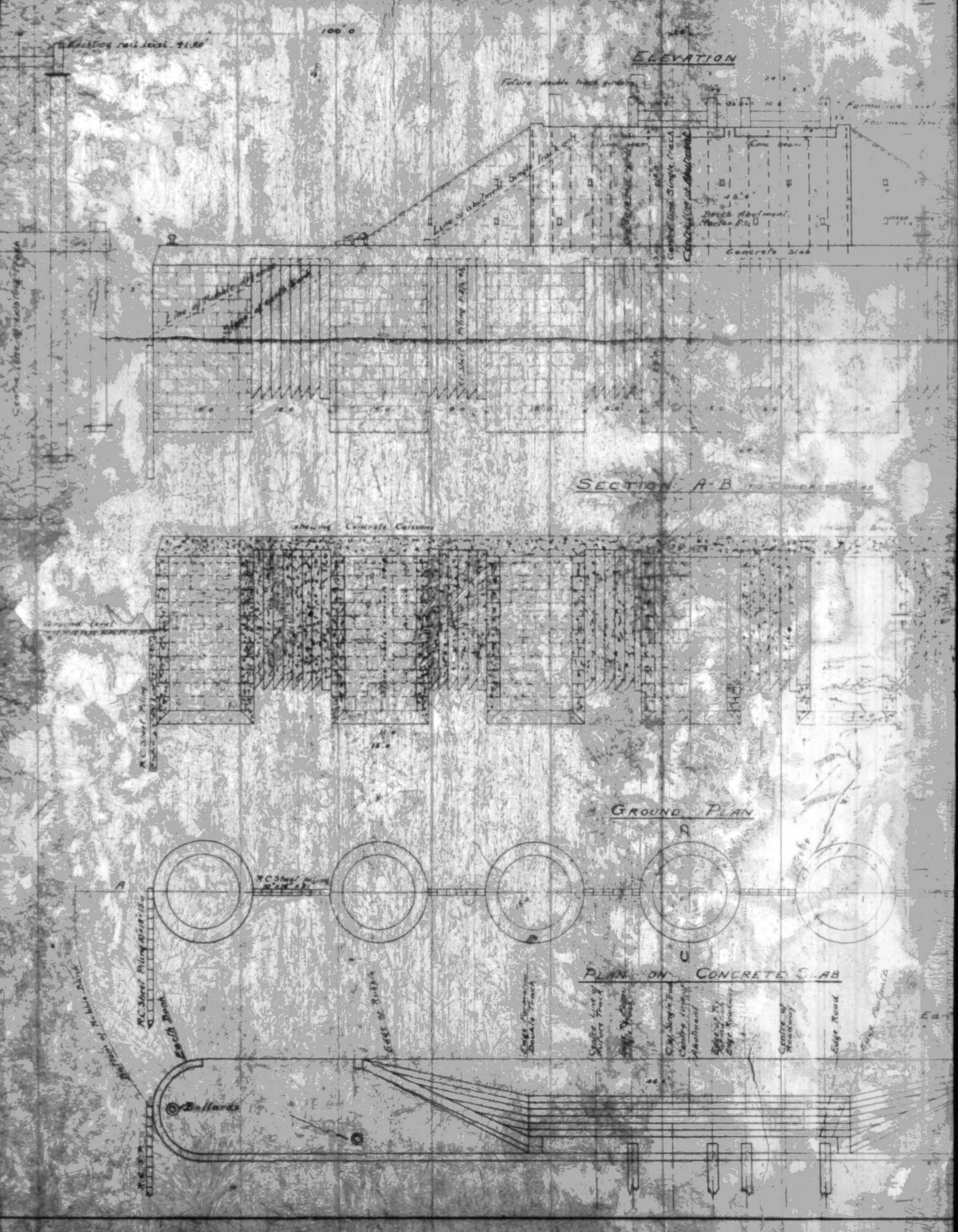
Nº 2.



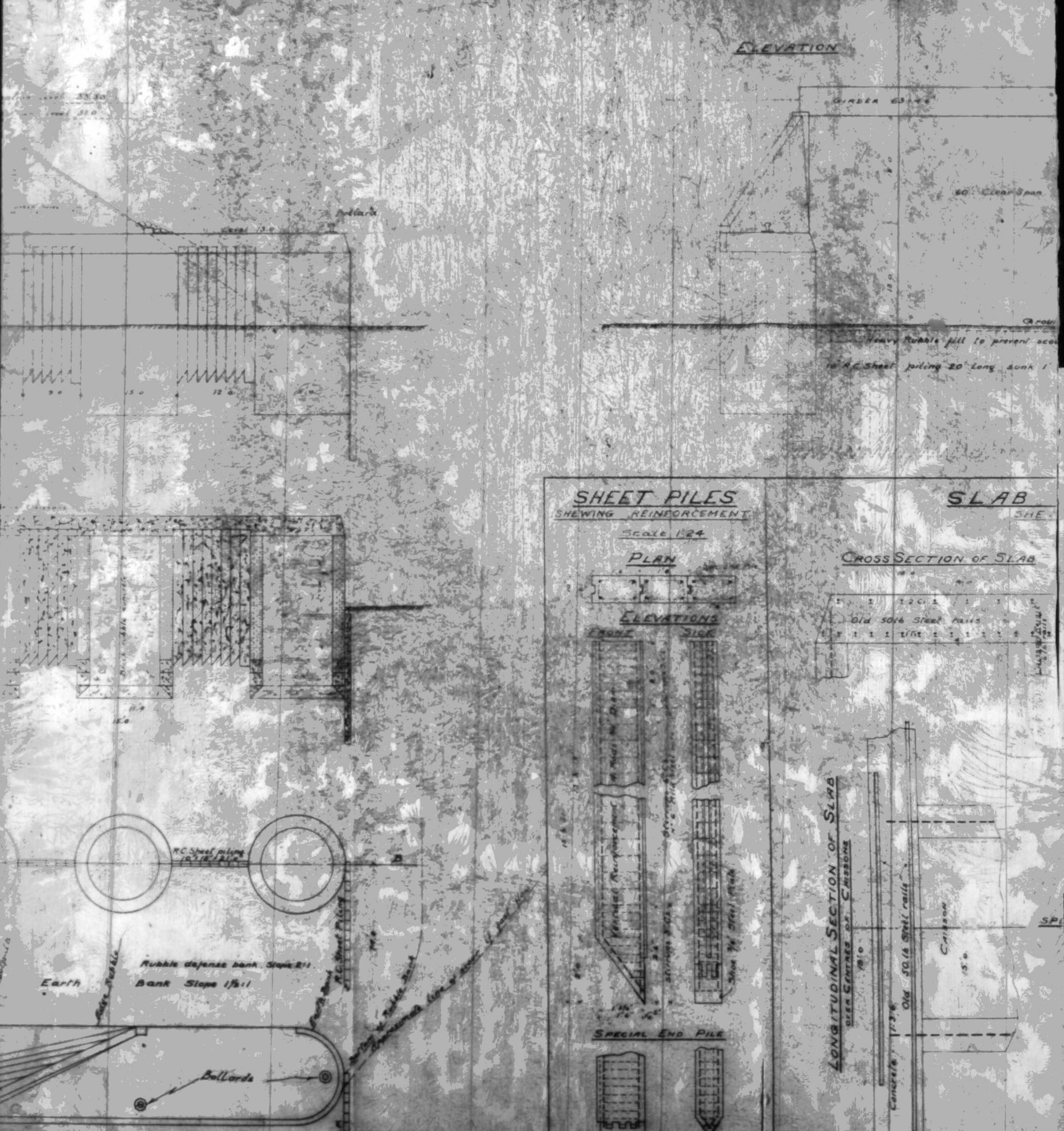
C.H.M. Johns
Railway Manager
16/12/25

APPROVED .... CHIEF ENGINEER .... GENL MANAGER

UGANDA RAILWAY — MACUPA CAUSEWAY



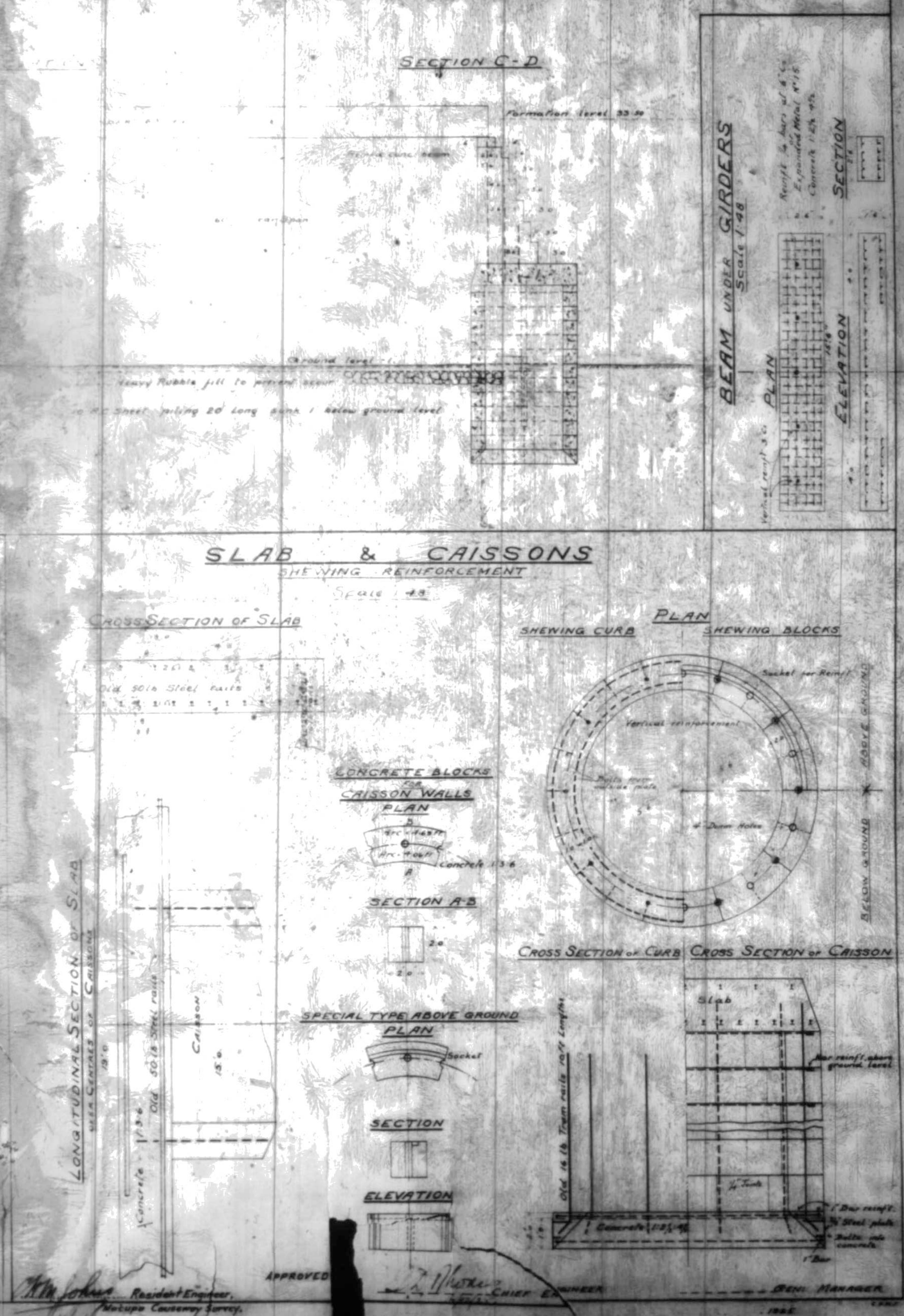
WAY —— BRIDGE ABUTMENT AND DETAILS —— SCA



Resident Engineer,
[illegible] Causeway Survey.

APPROVED

DETAILS — SCALE. 10 FEET TO AN INCH. No. 3.



W. M. Johns Resident Engineer,
Motupo Causeway Survey.

APPROVED [illegible] CHIEF ENGINEER

GENL MANAGER

1925

UGANDA RAILWAY.— MACUPA CAUSEWAY BRIDGE—GRAPHIC CALCUL

ABUTMENT ON

th Pressure = Area of A·B·C· = $\frac{11.66\times18}{2}$ = 104·94 □ Feet

5·41 Weight of A·B·C· = 104·94 × 100lbs = 10494 lbs + Temporary Load of 2240×3·2 = 7168. = 17662 lbs.

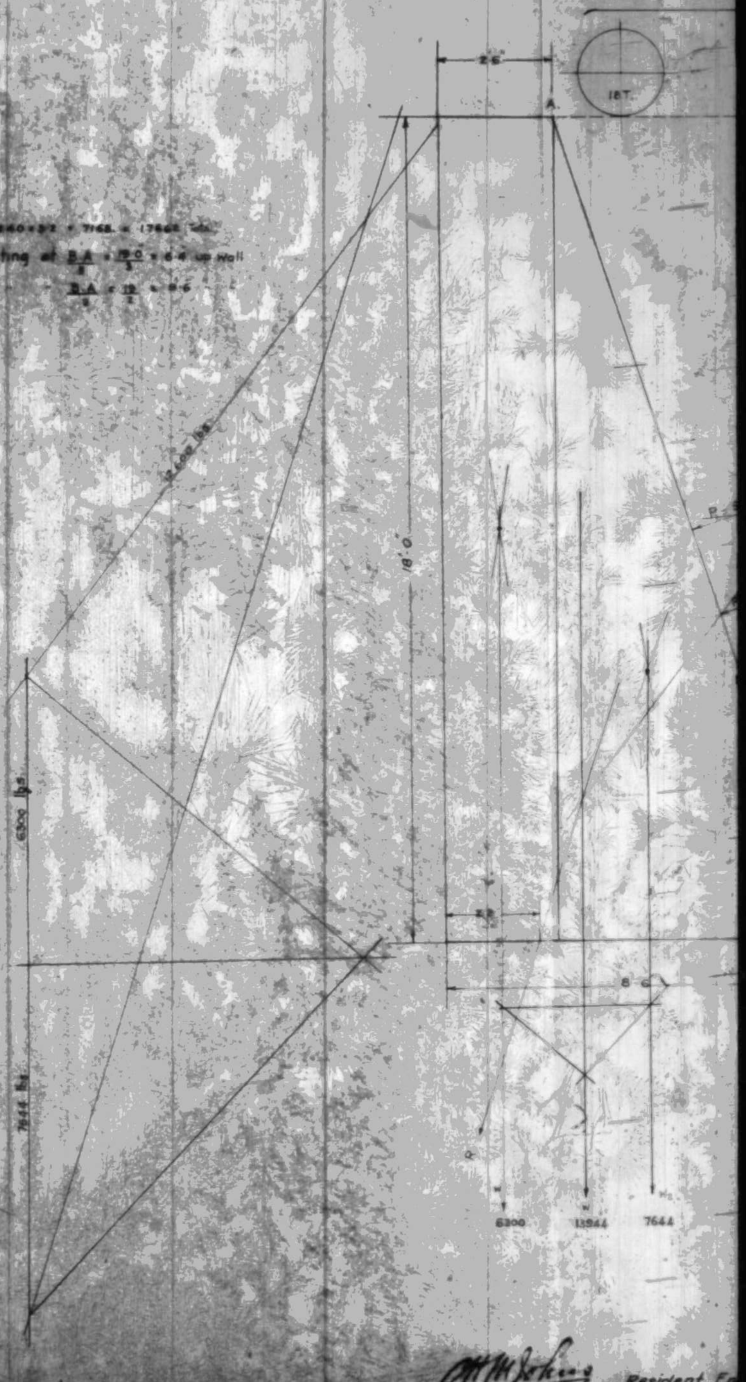
∴ From force Δ Earth Pressure = 7600 lb per ft run of wall acting at $\frac{B.A}{3} = \frac{19.0}{3}$ = 6·4 up wall

∴ From " " Temp. " = 5000 " " " " " " " " $\frac{B.A}{2} = \frac{19}{2}$ = 9·6 " "

Dead Weight W_1 = 18 × 2·5 × 140 = 6300 lbs

" " W_2 = $\frac{19.0\times5.8}{2}$ × 140 = 7644 lbs

13944 lbs

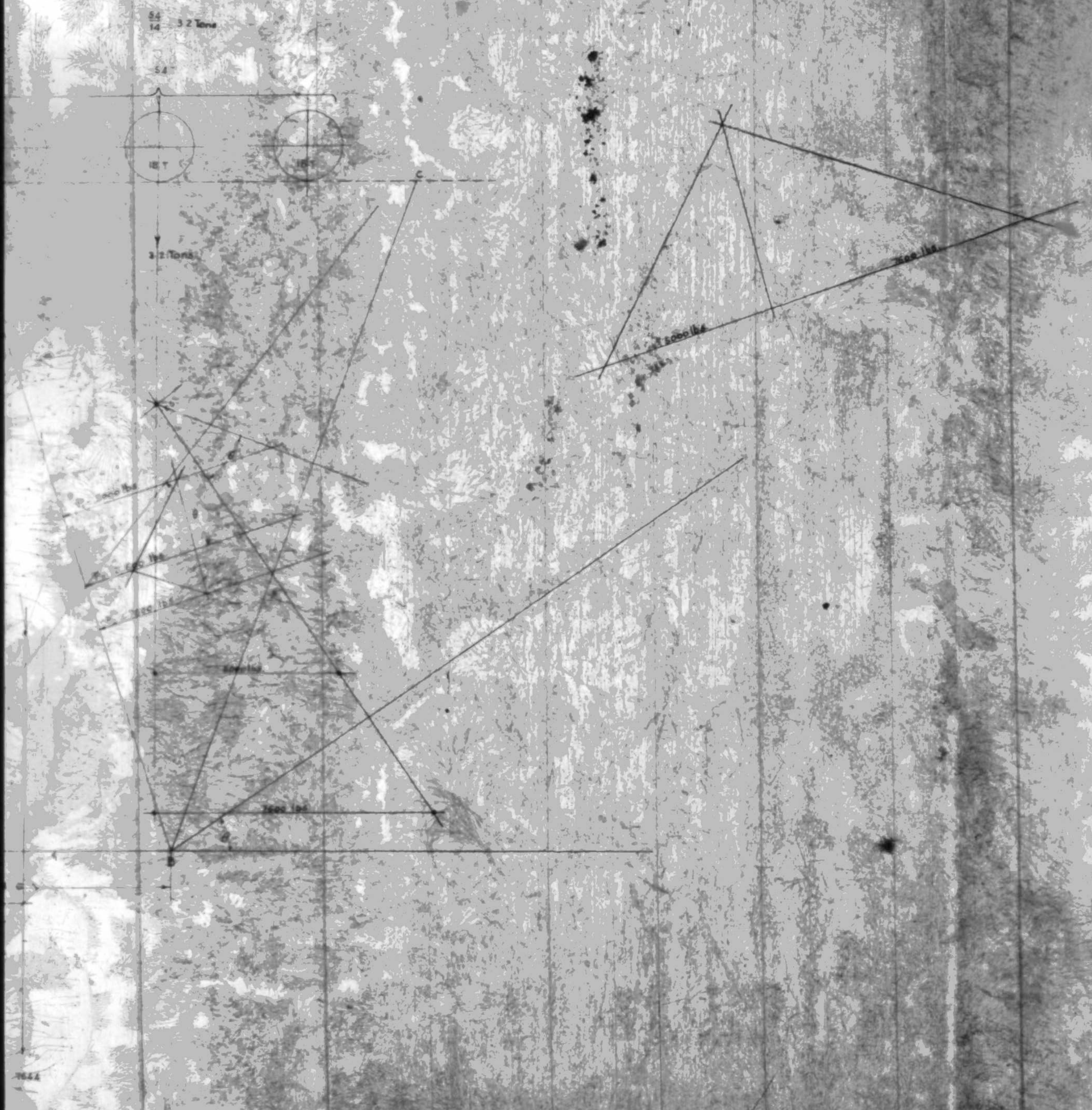


Resident En

16/10/25 Makupa Causew

No 4

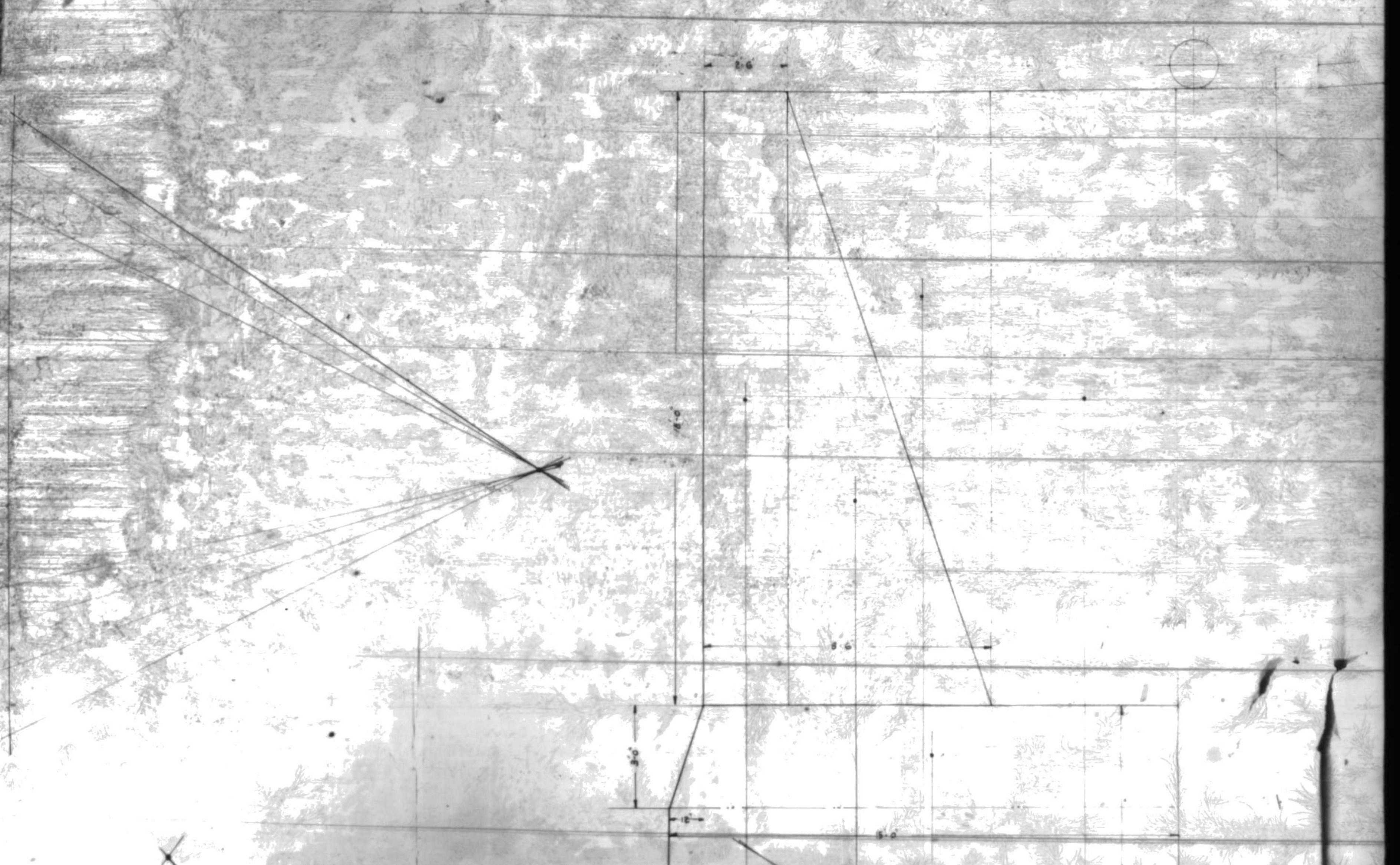
CALCULATION FOR OVERTURNING MOMENT OF BRICK ON CONCRETE SLAB —



esident Engineer,
upo Causeway Survey.

APPROVED ________ CHIEF ENGINEER ________ GENERAL MANAGER

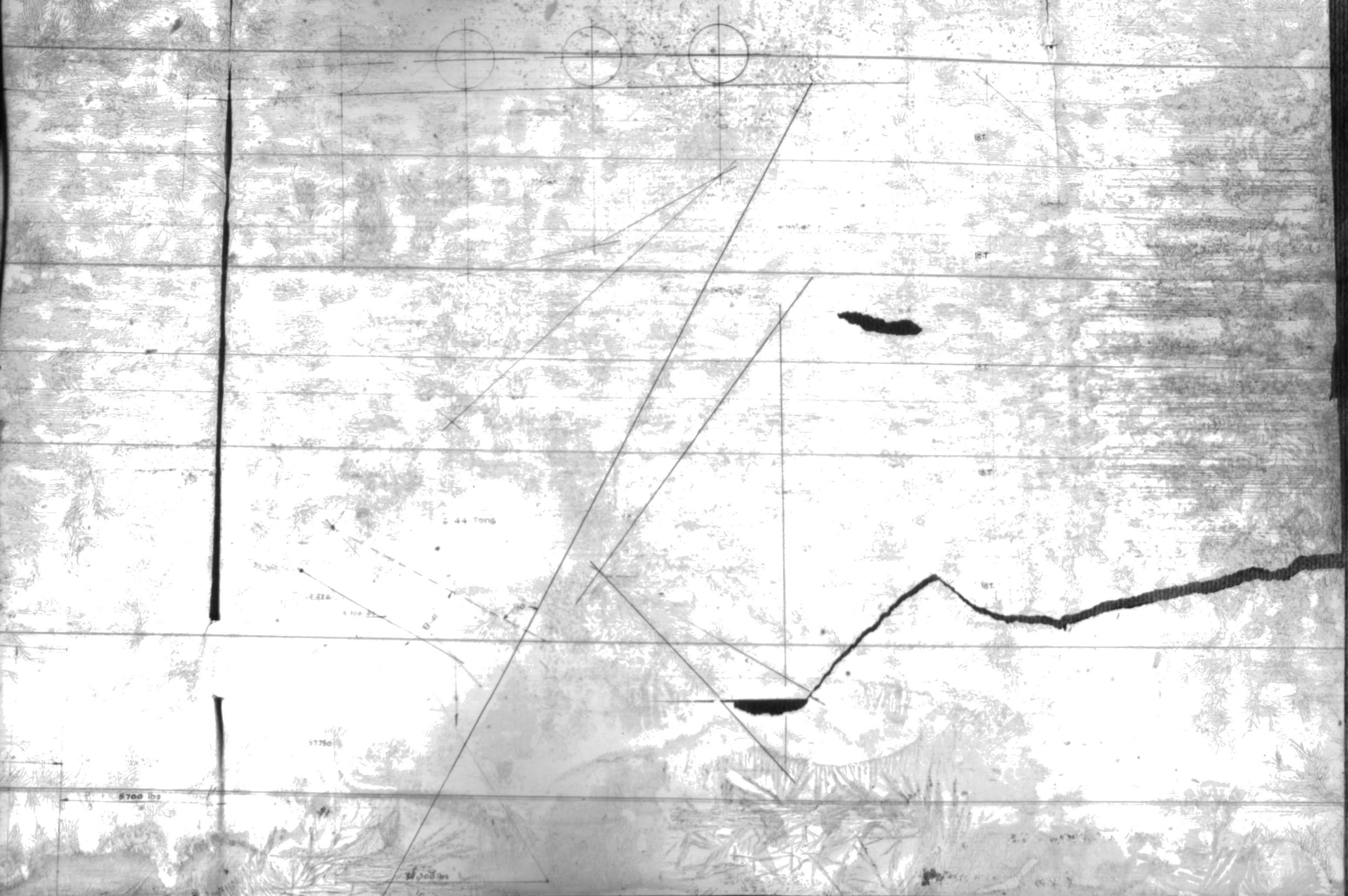
CANDA RAILWAY.—MACUPA CAUSEWAY BRIDGE—GRAPHIC CALCULATION FOR OVERTU[illegible] MO

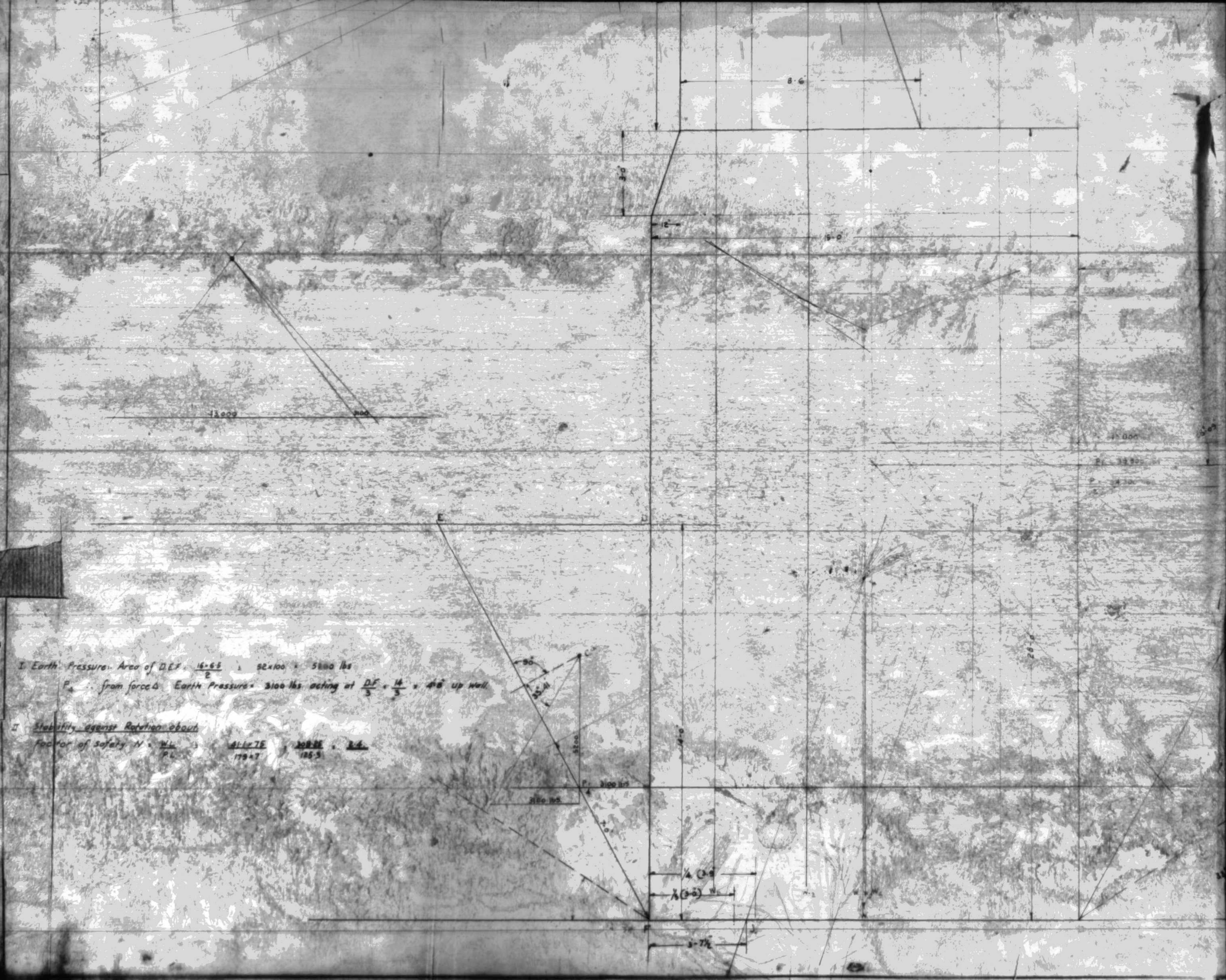


5

ON FOR OVERTU MOMENT OF ABUTMENT AT FOOT OF CAISSONS

Nº 5





I Earth Pressure. Area of D.E.F. = $\frac{16 \times 6.5}{2}$ = 52×100 = 5200 lbs

P_4 ∴ from force Δ Earth Pressure = 3100 lbs acting at $\frac{DF}{3} = \frac{14}{3} = 4'8''$ up wall.

II <u>Stability against Rotation about</u>

Factor of safety $N = \frac{WL}{PL} = \frac{41 \cdot 1 \times 7.5}{17.9 \times 7} = \frac{308 \cdot 25}{125 \cdot 3} = \underline{2 \cdot 4.}$

I Earth Pressure: Area of A.B.C = $\frac{52.5 \times 22}{2}$ = 577.5 □ ft. 57.750 / 14.426

Weight of A.B.C = 577.5 × 100 lbs = 57.750 + Temp Load (2240 × 6.44) = 14.426 = 72.176 lbs

P_2 from force Δ Earth Pressure = 34.300 lbs acting at $\frac{AB}{3}$ = $\frac{46}{3}$ = 15·4 up wall.

P_3 from force Δ Temporary Pressure = 8.700lbs acting at $\frac{AB}{2}$ $\frac{46}{2}$ = 23·0 up wall.

Concrete @ 150lbs per cft. Brickwork @ 140 lbs per cuft. Earth @ 100 lbs per cuft.

II. Dead Weight = W_1 = 18 × 2.5 × 140 = 6300 lbs

W_2 = $\frac{19 \times 5.75 \times 140}{2}$ = 7648 "

W_3 = 15 × 25 × 150 = 56.250 "

W_4 = $\frac{19 \times 5.75 \times 100}{2}$ = 5463 "

W_5 = 14.5 × 3 × 150 = 6525 "

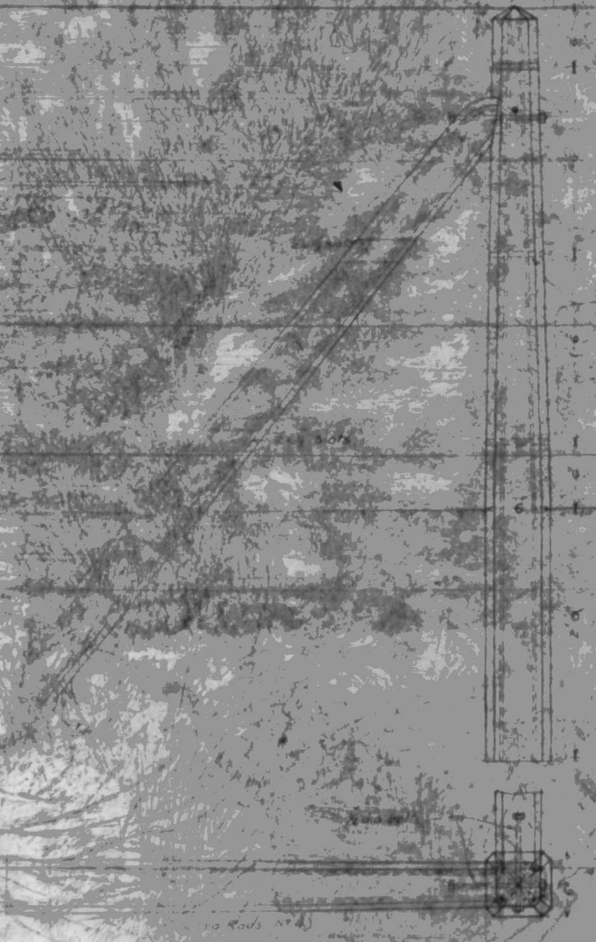
W_6 = 18 × 5.5 × 100 = 9900 "

92.086 lbs

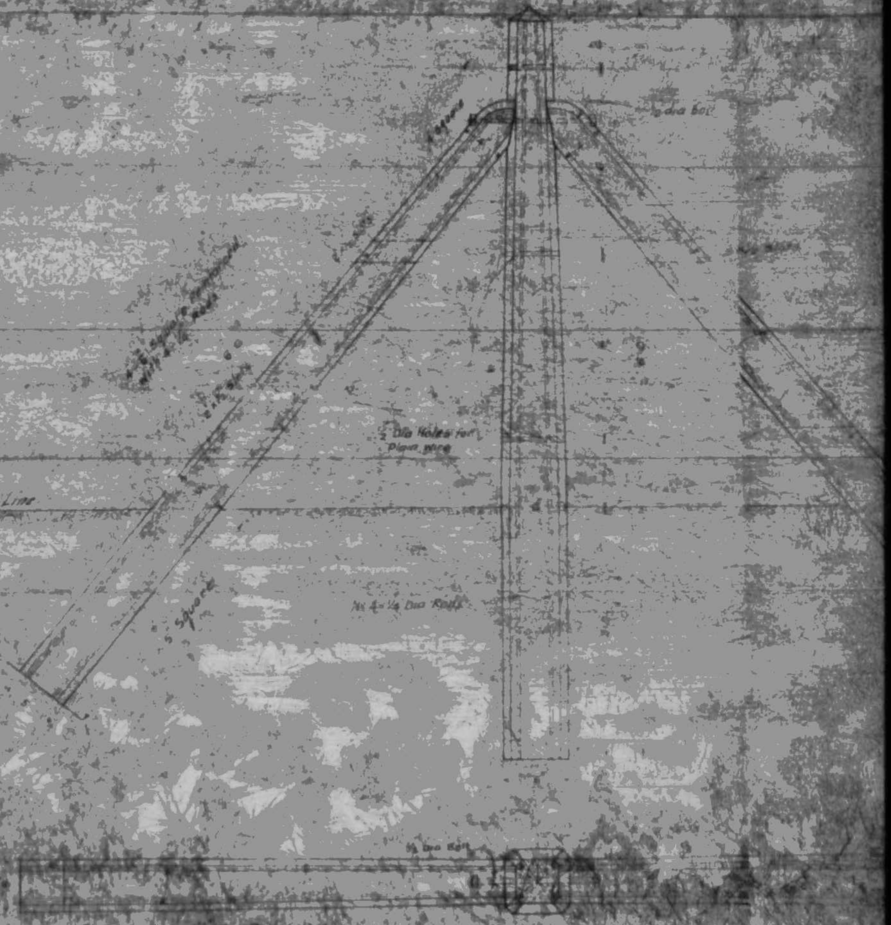
C.H.M. John Resident Engineer. CHIEF ENGINEER GENERAL MANAGER.

Enclosures of

UGANDA RAILWAY.— TYPE DRAWING OF CONCRETE FENCING

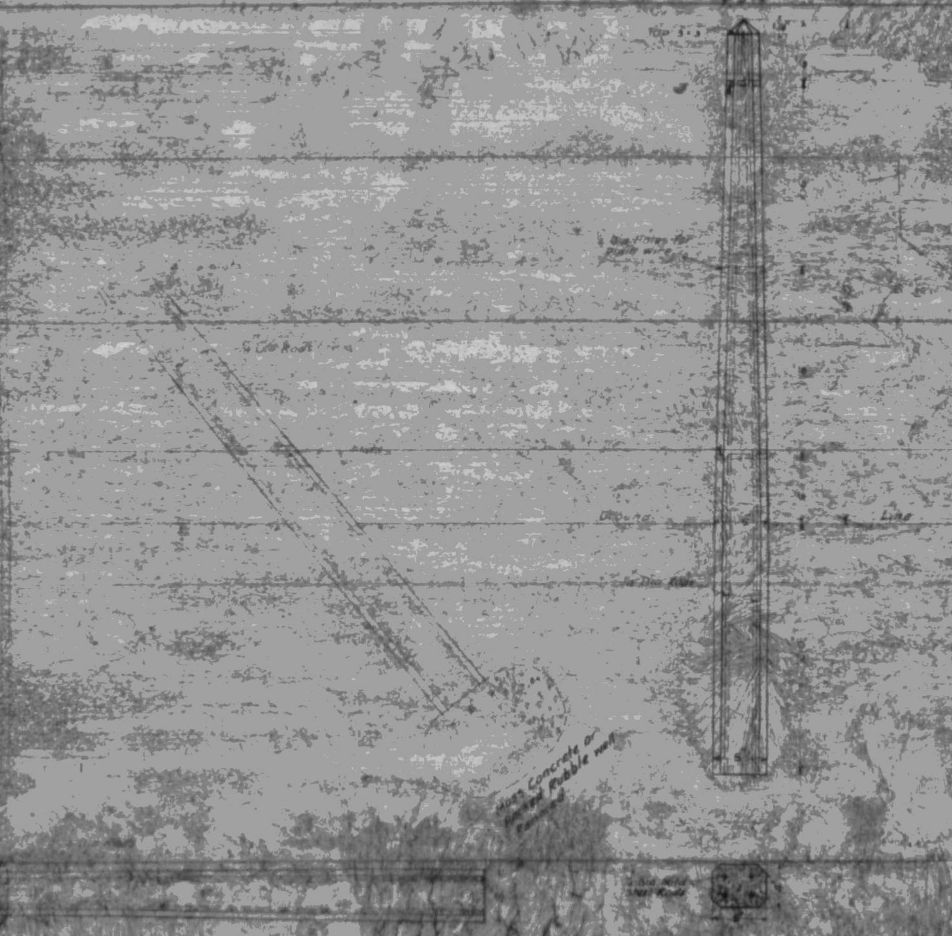


—CORNER POST—



STRAINING POST WITH TWO STRUTS
END POST WITH ONE STRUT ONLY

TE FENCING POSTS. SCALE 1½" TO A FOOT.



1 PART CEMENT
1½ " SAND
3½ " COARSE AGGREGATE

INTERMEDIATE POST

WITH TWO STRUTS

NE STRUT ONLY

DRAWING Nº 2419		
	SIGNATURE	DATE
DRAWN BY		5-11-25
TRACED BY		5-4-25
CHECKED BY		3-11-25
APPROVED BY	NAIROBI	1925
	CHIEF ENGINEER U.R.	

30/X

TE FENCING POSTS. SCALE 1½ TO A FOOT.

INTERMEDIATE POST

WITH TWO STRUTS

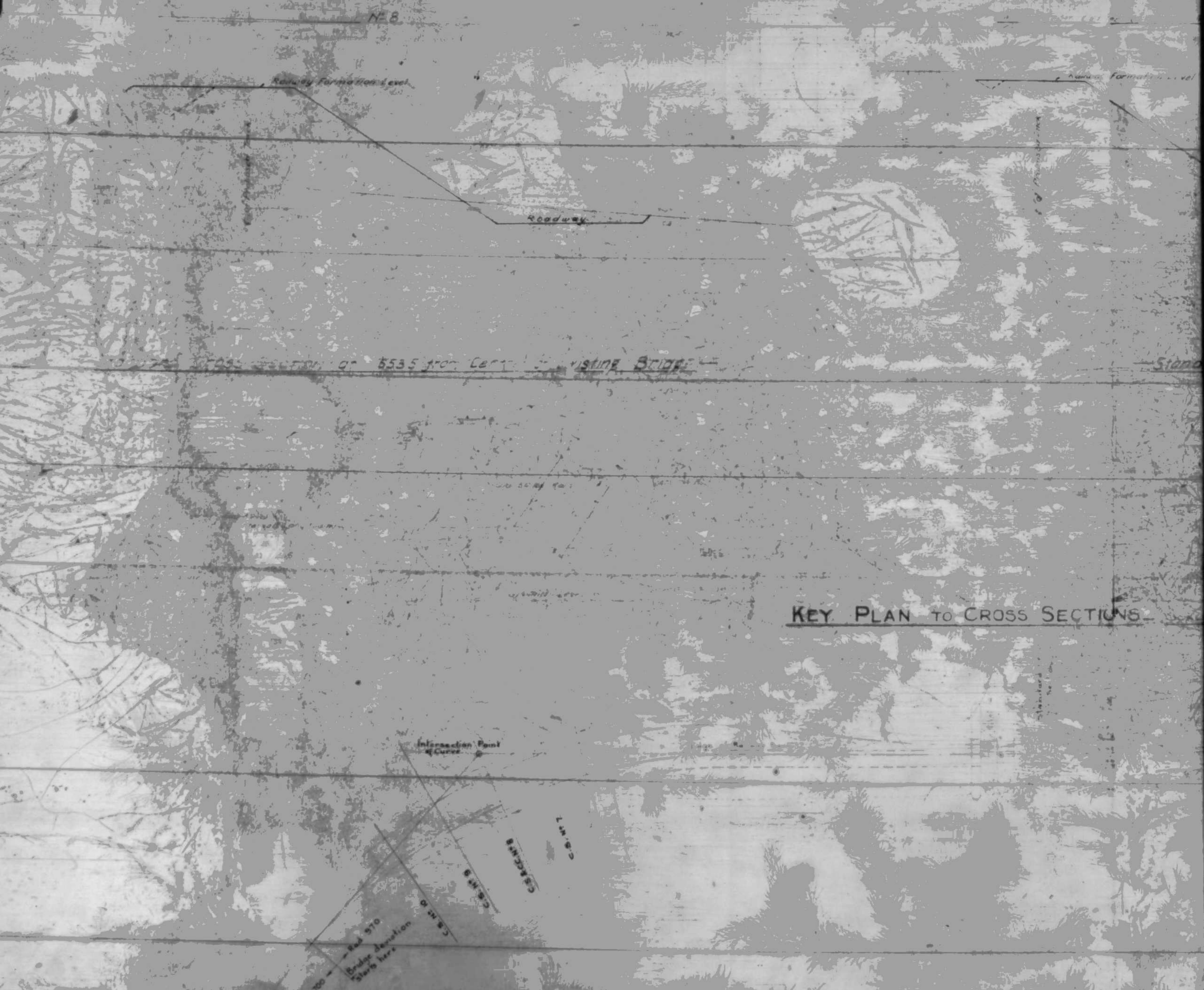
NE STRUT ONLY

DRAWING Nº 2419		
	SIGNATURE	DATE
DRAWN BY	Thom Kaw	5
TRACED BY	Thom Kaw	5
CHECKED BY		
APPROVED BY	NAIROBI	1925
	CHIEF ENGINEER U.R.	

30 K

UGANDA RAILWAY. — MAKUPA CAUSEWAY — CROSS SECTIO

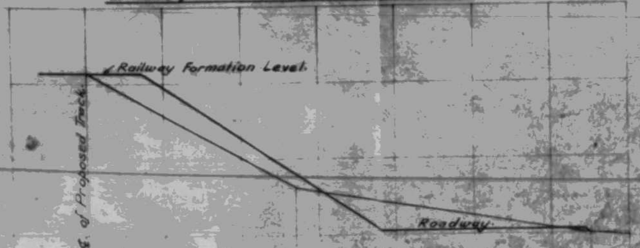
—SCALE 10 FEET TO 1 INCH—



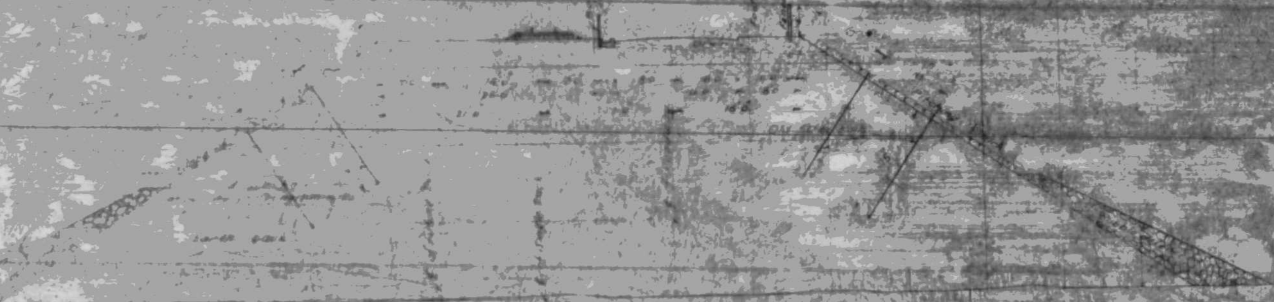
CROSS SECTIONS ON CURVES & STANDARD.— —SEE PLAN No 7.

No 9

At +200 from Centre of Curve, Main Land No 10



—Standard Cross Section at Bridge—



AN TO CROSS SECTIONS— SCALE 100 FEET TO INCH

—UGANDA RAILWAY — KEY PLAN TO SURVEY, LOCATION &

Nº 8

PLAN TO SURVEY, LOCATION & BORINGS — SCALE 200 FT – 1 INCH —

DETAILS OF WATER JET BORES SHEWN THUS ●

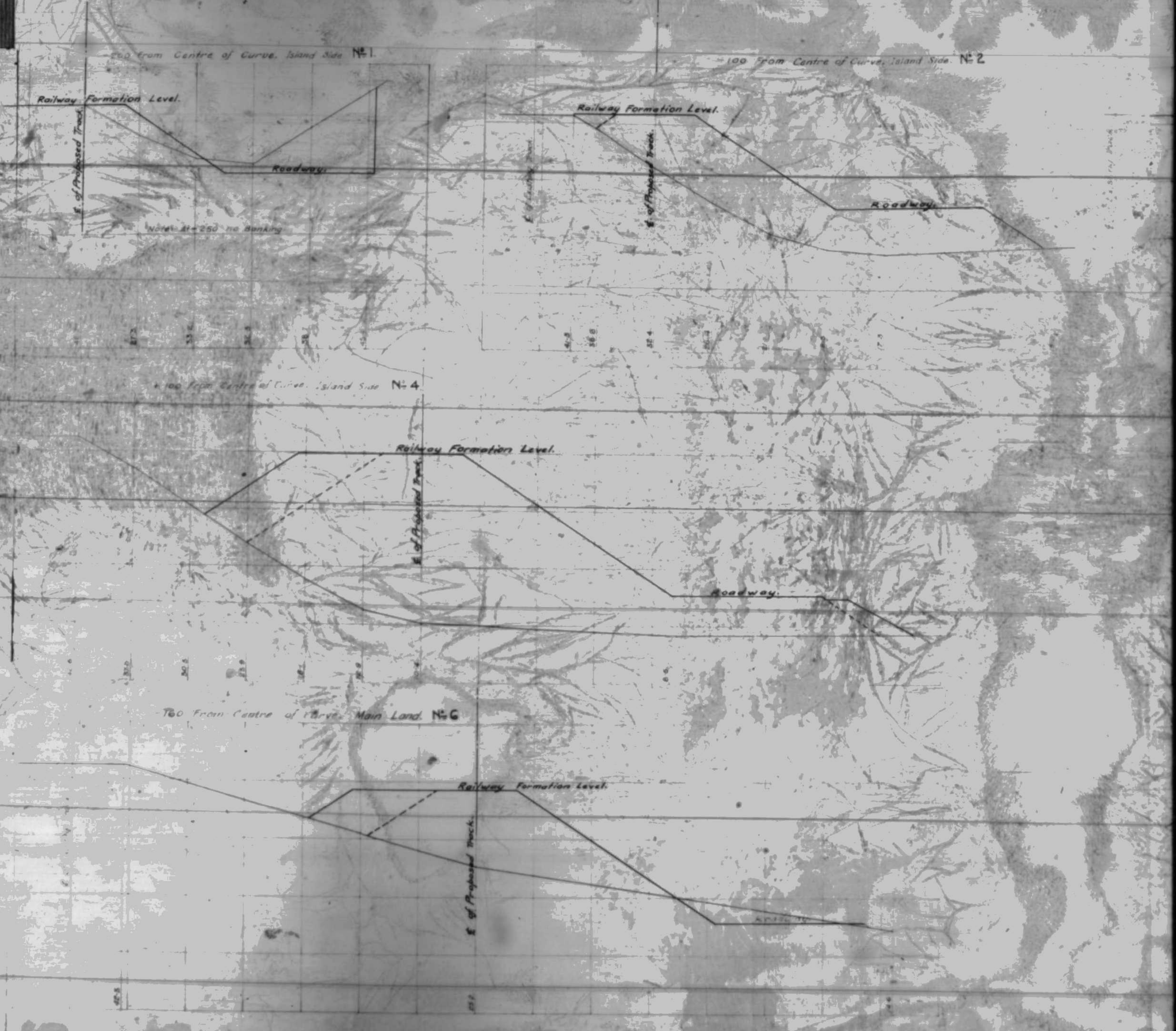
No A - 14 FEET TO HARD ROCK
B - 12 id id id id
C - 11 id id id id
D - 26 id id SOFT SEMI CORAL FORMATION
E - 24 id id id id
F - 33.8 id NO ROCK ENCOUNTERED
G - 26 id TO HARD ROCK

DETAIL OF CUTTING SHEWN THUS ▬

No AT 3 FEET EARTH & CLAY FORMATION
" 7 " CLAY
" 12 " HARD CLAY

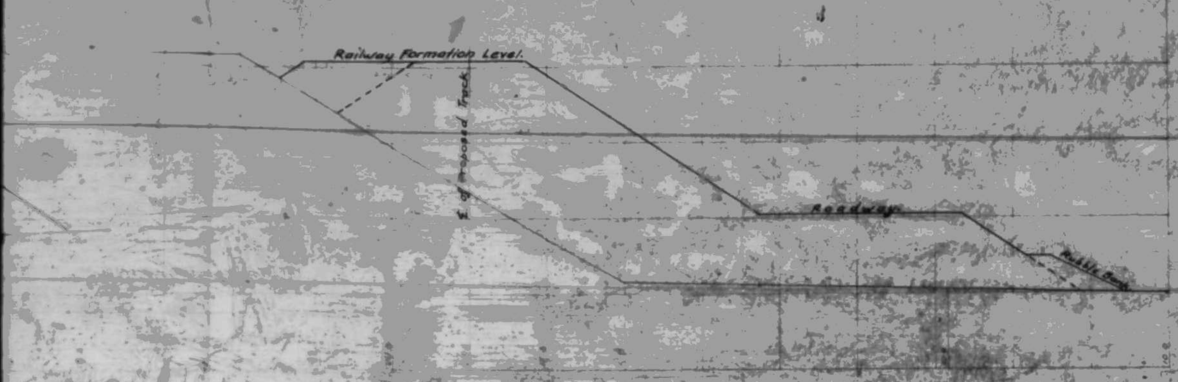
APPROVED CHIEF ENGINEER GENERAL MANAGER

UGANDA RAILWAY. —MAKUPA CAUSEWAY— —CROSS S

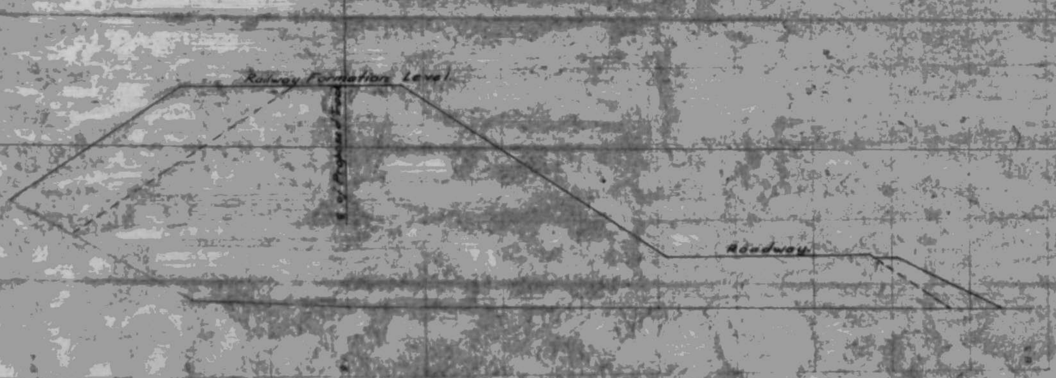


CROSS SECTIONS ON CURVES — SCALE 10 FEET TO 1 INCH — SEE PLAN Nº 6.

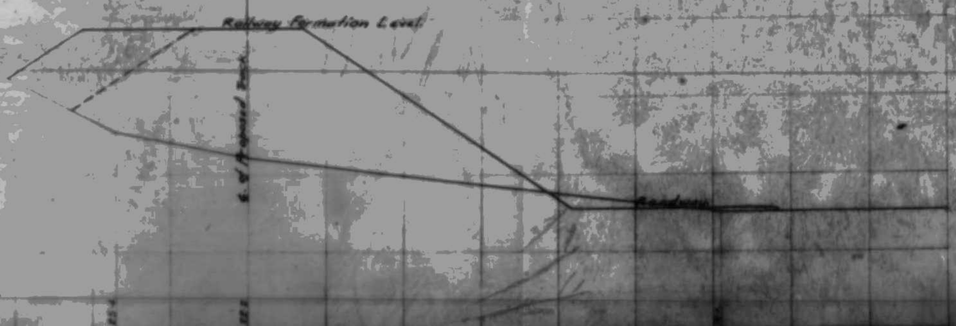
Centre of Curve, Island Side Nº 3



[illegible] from Centre of Curve, Main Land Nº 5



[illegible] Main Land Nº 7



№ 10.

UGANDA RAILWAY

MACUPA CAUSEWAY.

TYPE ROAD DRAIN.

Scale 1 Inch to a Foot.

TYPE. H.