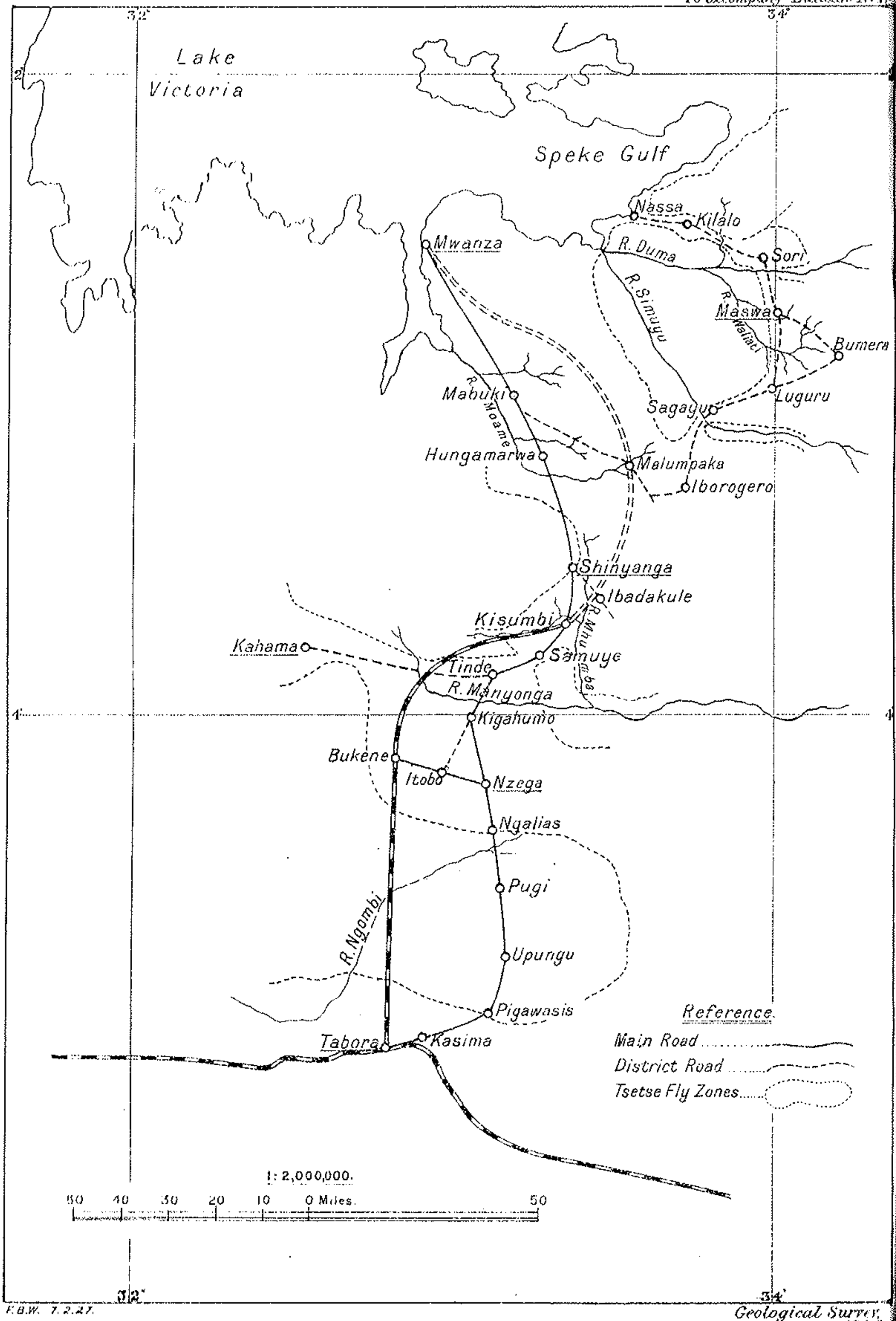
Water Supply Report on the region Northwards from Tabora to the Speke Gulf.

CONTENTS.

Frontispiece,
To accompany Bulletin No 1.



F.B.W. 7.2.27.

Geological Survey, 1926.

Water Supply Report on the region Northwards from Tabora to the Speke Gulf.

I.—INTRODUCTION.

Africa has ever been a land of contrasts. From the earliest times up to the present we have had existing side by side the most modern and the abjectly primitive. In early Egyptian times the highly developed skill that evolved the pyramids was to be found co-existing with primeval brutishness ; to-day, the seaplane and the dug-out canoe share the same waterways. Nature's gifts, too, are lavished in much the same spirit, years or seasons of plenty are contrasted with periods of famine and drought.

In this Territory the stabilising of these alternations of feast and famine might reasonably be said to be the aim of the Government's officers both administrative and technical. Food famines amongst the natives are the concern of the administrators of the natives and are counteracted by them to some extent by the creation of reserves of both food and money in times of plenty. The present notes will endeavour to demonstrate how the same basic principal must be applied to counteract the seasonal variations of the country's water supplies.

The region under consideration is one of the most thickly populated in the Territory and has a fairly generous rainfall. In general it is a much weathered plateau which has been planed down through the ages to what we find to-day, viz., rolling upland country very well drained and having a relatively small amount of soil overlying the higher parts of the undulations.

The density of the population creates a large demand for water, whilst the topography of the country, due to the excessive run off of rainfall, tends to reduce the supply unduly. These contending factors often produce acute shortage during the dry seasons and help to create a migratory people instead of the more desirable contented cultivator.

The consumers of water in this region may be divided up under four heads, arranged in diminishing order of local demand :—

(a) Railways.

(b) Townships.

(c) Trading Settlements.

(d) Native inhabitants (farmers and graziers).

Industrial undertakings, such as mines and ginneries, naturally establish themselves where water is to be found, and from their enterprise in developing the existing supplies much can be learned for application elsewhere.

II.—OUTLINE OF GEOLOGY OF THE REGION AND ITS RELATION TO WATER SUPPLIES.

The principal rock formation of this area is granite and allied rocks. This constitutes about 87 per cent. of the area traversed. The next important types of rock are those that can be broadly classified as Schists.

Both types have been subjected to strains due to various causes and fissures have resulted. In the granite these fissures are in the nature of joints, generally nearly at right angles to each other trending N.E.–S.W. and N.W.–S.E. In any one locality the one set may be better developed than the other and is then called the "major jointing." Sometimes the major jointing may even have resulted in relative displacement of the adjoining portions, and in such cases it is referred to as "minor faulting." Often the decay of the granite has been accelerated along the major jointing, resulting in valleys of roughly parallel trend with tributaries running nearly at right angles along the minor jointing.

This jointing in the granite has a mixed effect on water supplies. Theoretically, a well-jointed granite should store up underground a considerable amount of water in its jointing planes, but actually, in the region under review, it is the writer's belief that, owing to its great age, the joints have long since become sealed up with clay and secondary mineral salts so as to become ineffective as water reservoirs. Consequently, well sinking in granite country is too hazardous to be recommended.

Professor J. W. Gregory in his "Rift Valley and Geology of East Africa," p. 238, states that granite will absorb water to the extent of only 1 per cent. of its bulk, but that joints and fissures may hold considerable stores. On the whole, however, he considers well-sinking in the jointed granite to be unfavourable (p. 243) for the reason that the water-table has been lowered below the economic limit by the depths to which the joints and fissures extend.

The schists, however, are known to yield supplies of water at depth. From their nature they are more fissured than the granite, but their fissuring is generally in one direction only. In the areas traversed this direction is roughly N.E.–S.W. At the Tanganyika Diamond Mine, near Mabuki, water is encountered in the schists at about 30 feet below ground level. At the Buhemba Goldfields in Musoma a shaft in similar schist yields water plentifully at 50 feet below ground level.

The schists are found at lower elevations than the granite and, this being the case, it is possible that the water table is nearer the surface, and this, combined with the effect of the fissures, may be responsible for their better water-yielding abilities at depth. Unfortunately, the natives are not so thickly settled on the schist areas. This is possibly due to the fact that the lower lying schist zones become too swampy in the rains, and also, that the bush is generally thicker in the valleys than on the slopes. The thickness of the bush, of course, means greater prevalence of the tsetse fly, and, as the natives are cattle raisers as well as cultivators, they give the thicker bush a wide berth, preferring rather to cultivate the poorer granite soil for their own needs in order to preserve their cattle from infection by fly.

Younger rock formations derived from the two principal rocks mentioned above exist in various places, and in connection with water supply, it suffices to mention the principal one, known as Laterite or " murram." Laterite is found extensively overlying the granite and forms a capping to the low granite ridges. As a water carrier it is of great use in that it stores a certain amount of water within its bulk at places where the natives prefer to live, i.e., on the higher ground. Its function as a water conserver seems to be due to the fact that it acts as a lid or cover to the water underneath it and thus preserves it from evaporation by sun and wind. The laterite appears to yield water only when it has a clay layer between itself and the underlying granite, so that it may not be productive of water at every point where it is examined. Also, if water is found at its base, and the water hole be deepened so as to increase its capacity, it is possible that the clay lining may be pierced in turn, and the water will then leak into the underlying decayed granite and be lost. This fact must be guarded against when improving water supplies of this type.

It is well to understand how this laterite capping is disposed in relation to the granite. Being a capping, it naturally conforms to the sub-surface contours of the underlying granite; the granite weathers into hollows, and into troughs and crests. If the laterite be found overlying a hollow in the granite, and, if the necessary clay be present, the conditions are then most suitable for sub-surface water storage, though it is possible that the water may be hard or even brackish.

If the laterite overlies a trough and the clay be present between it and the granite, one should find at the lowest points of the trough a good supply of water. If the trough be tilted, and this is usually the case, there will be a slow flow of the water in the trough and naturally it will reach the surface at some lower point or run into the decayed granite and disappear. It seems to reach the surface only when it encounters an impermeable barrier in its lower reaches. The surface clay found in most shallow valleys usually provides such a barrier and the somewhat curious fact can be observed of water seepages along the upper margins of shallow valleys, whilst the lowest points of the valleys themselves are bone-dry.

Both the granite and schists are pierced in a few places by intrusions from below of wall-like masses, known as dykes, of different rock. The principal effect of these dykes is to cause local shattering of the rocks pierced and thus create additional storage for underground water. Occasionally intrusions of this sort are accompanied by deep-seated water under pressure and this rises to the surface and is to be found along the walls of the dykes. Springs of this type are sometimes valuable for their mineral content, but as no definite supplies of this type were encountered in the region under review, they need not be discussed further.

The soils of the region are broadly divisible into two types, sandy soil and clay. The sandy soil is to be found everywhere in the granite country and is cultivated extensively, yielding good crops of native grains, groundnuts and cotton. Clay also occurs in granite country in the valleys, forming, where drainage is slow, the well-known "black cotton-soil." This is a misnomer in this country, as it is not cultivated for cotton, nor any other useful commodity, and, whereas the sandy soil is a boon to mankind, this clay is a blight, its only redeeming point being the fact that it acts as a barrier to water seeping from more permeable media. The schists normally give rise to clayey soils, and black cotton soil is possibly more extensive in the valley bottoms in schist country. Where the schists are more quartzitic, a good loam is the result, and in places is eagerly cultivated, but always by non-cattle owning natives on account of fly. The Kisumbi Sultanate, where bush reclamation has been so successful, is an area of this type, and the natives are only too keen to return to the fertile lands from which they were driven by the tsetse fly encroachment. Red clayey soil is to be found principally where dykes occur. The two principal occurrences recorded are a small patch near Kisumbi, and a wider and more attractive area, agriculturally, situated between Sansui Hill and the Simiyu River at Sagayu.

III.—DESCRIPTION OF WATER SUPPLIES INVESTIGATED.

(a) Railway Requirements.

At Tabora the Railway Administration draw much of their water from deep bore holes driven into the granite, and, when the Kahama branch line was commenced, it was thought necessary to increase the supply, and, to this end a dam was contemplated near Kilo 4.5 on the Tabora-Kahama line. The site selected was a shallow sandy valley of considerable catchment area, but poorly suited for storage purposes. The plateau-like nature of the country precluded any better selection. The writer visited the dam site when preliminary test work was in progress, and, noting the absence of any extensive clay bed suitable for an impervious bottom and sides, and, realising that any water collected must of necessity be spread over a large area (the dam being a shallow one), he advised against the continuance of this scheme. As an alternative, nearer Tabora but on the eastern side of the branch line, an extensive laterite formation was observed, and near its lower margin a shallow spring was visited. Natives living near this source declared that the water was perennial. It was concluded that here possibly was the lower end of a sub-surface trough in the granite as described above, and so it was suggested that this spring should be developed by increasing its storage capacity, and at the same time minimising its wastage. This could be effected by a trench following the surface contours of the laterite to intersect any possible subsidiary or parallel troughs. This trench was then to be filled in with broken rock and the water collected in it was to be piped down to a storage tank alongside the permanent way. The engineer-in-charge gave orders to this effect and, on the writer's return, it was ascertained that a plentiful supply had resulted.

At Bukene Station a similar laterite formation has been tapped and a steam pump and 4-inch piping supplies the requirements of this stopping place.

At Kisumbi Station the water always to be found in the sandy bed of the Mhumbu River should suffice for all needs.

At Malumpaka, where the projected alignment of the Kisumbi-Mwanza section was crossed, the water in the sandy river bed there should suffice ; a suitable method of developing water under sand is discussed later on for Lubaga, near Kisumbi.

(b) Township Requirements.

Tabora.—The township water supply of Tabora has been developed by means of pumping plant, storage tanks and a reticulation system of pipes to consumers. The water bearing zone is at the head of a shallow valley and water slowly flows just under the ground surface down to the lower and wider parts of the valley where it is dissipated into the soil. The water seems to be due purely to rainfall stored by Nature at this point by some means not ascertainable without fairly close investigation by pit sinking and boring. No extensive laterite bed was noticed near by, and it is thought that possibly a set of fractures exists in the granite under the surface trending across the valley and continuing well over the side of the valley. In this way could the quantity of water available be accounted for, but no direct evidence was noted to substantiate this contention. Whatever its origin, it is clear that the water is slowly seeping down the valley, and consequently to tap this flow to the best advantage a series of inter-connected excavations suitably supported and covered, arranged athwart the flow, should have the desired effect. Sumps or underground chambers are already in existence and are pumped from in turn, but they appear to be aligned parallel to the flow instead of transversely. To increase the capacity of any one sump, without a great expenditure, the writer suggested to the Acting Executive Engineer that collecting trenches should be cut from the masonry sumps outwards across the valley and suitably graded so as to conduct the water they collect straight into the sump. The trenches should be filled with broken stone and embankments should be made on the upper sides to keep out storm water and the rubbish and mud generally borne by it. If this precaution is not taken, the storm water rushing down the valley will soon silt up the voids between the rock fragments and render useless the collecting trenches.

Nzega.—At present this is purely an Administrative Station, chosen in order to be centrally situated amongst the natives of this region, but, in view of the new railway being only 22 miles away, it is possible that it will grow into more of a trading settlement than a township. Possibly the railway station at Bukene will become, in time, the greater commercial centre. The water supplies of Nzega Post are not of a high order but are capable of being developed so as to be sufficient both for administrative needs and for a small trading settlement, the size of which will naturally depend on the capacity of the water supply when developed to its utmost. The accompanying sketch plan

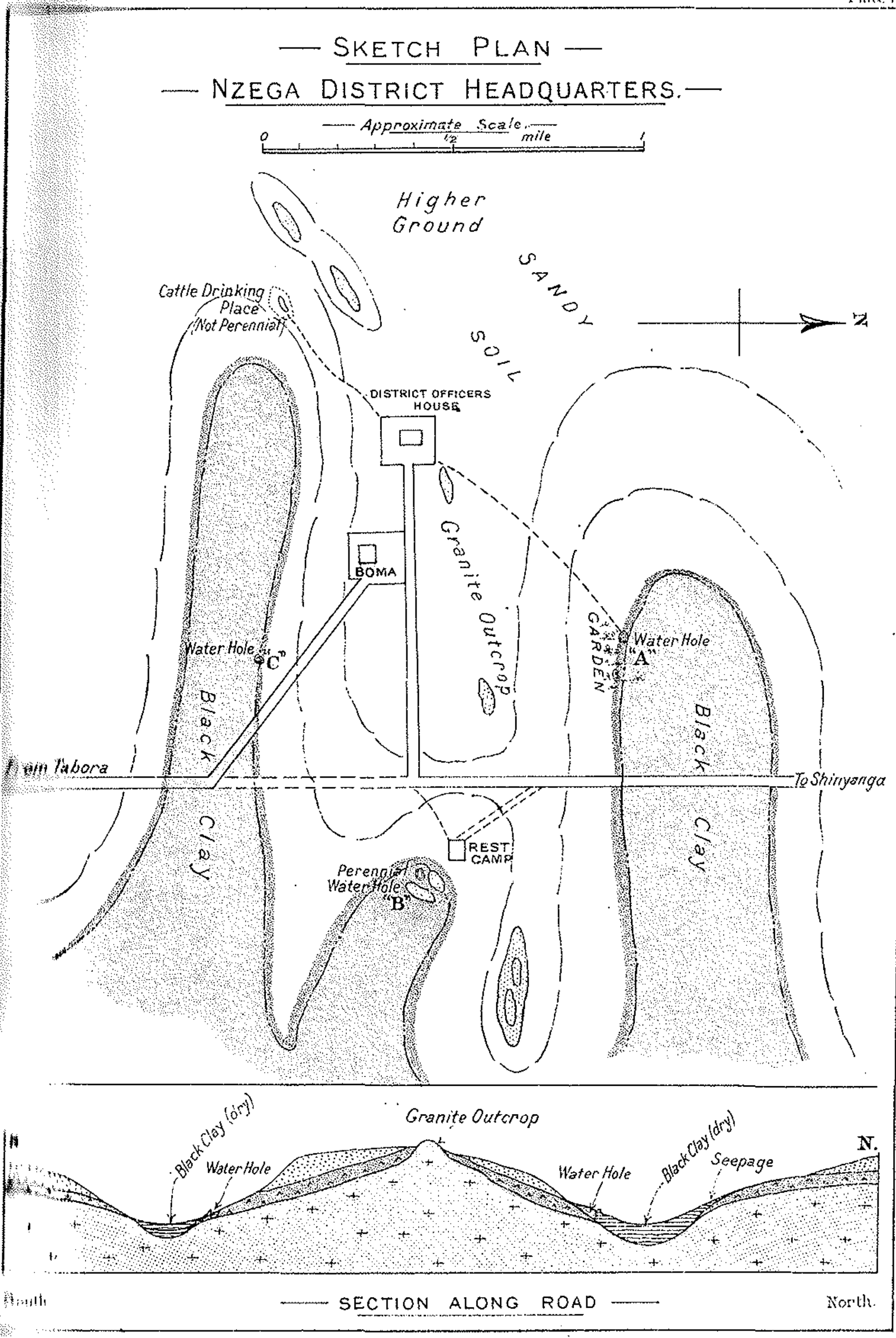
(Plate I) illustrates the nature of the topography in relation to the water supplies. Existing water holes are shown at points A, B and C, and it will be observed that all are situated on the sides of shallow valleys, A and C near the margin of the black clay in the valley bottom, and B associated with both a granite outcrop and clay. This water hole, B, is used principally by the natives living in the neighbourhood and by the visitors at the rest house, and is perennial. At the time when it was visited it contained too much water to admit of any conclusive opinion being formed as to its nature, but some laterite being noticed at a slightly higher elevation and none at the hole itself, it is thought that the fresh close-grained granite outcropping here is responsible for the welling up of the sub-surface water collected by the sandy soil and laterite on the higher ground.

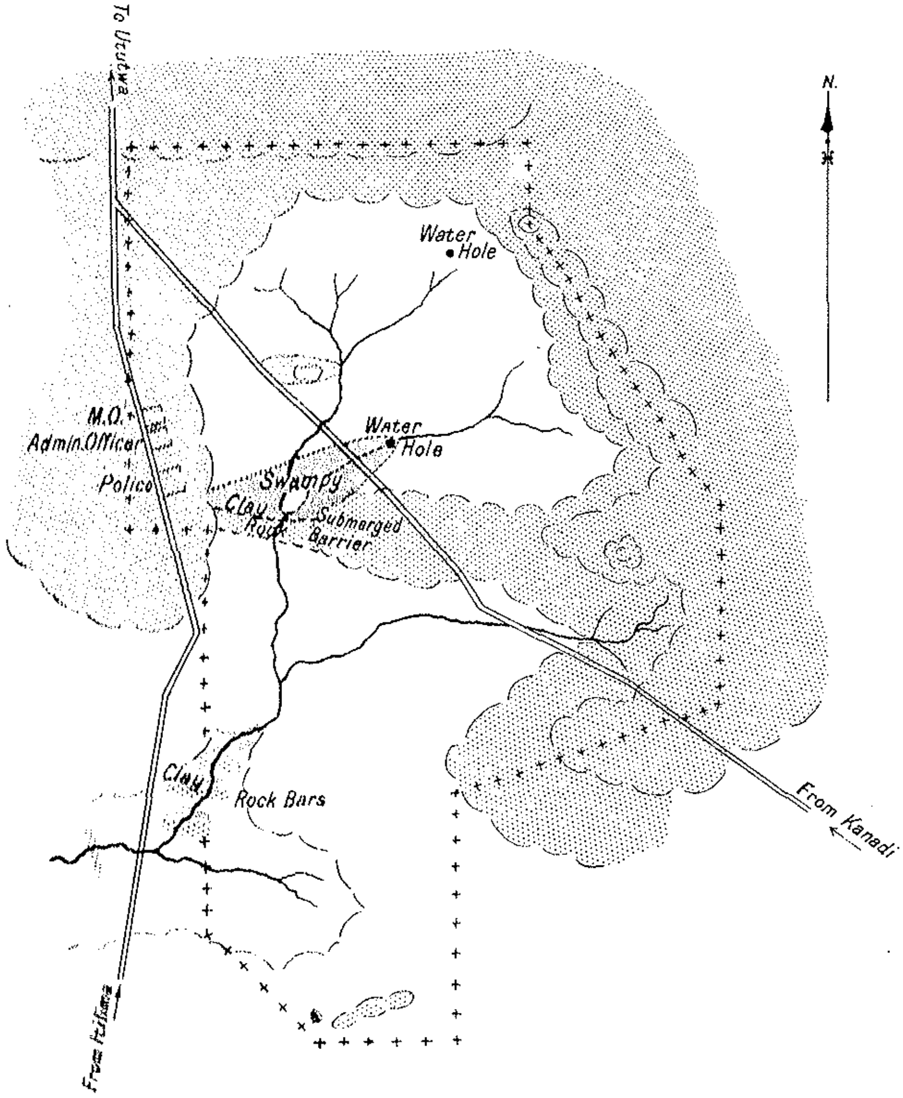
At the other two waterholes, the black clay forms the impermeable barrier which prevents the sub-surface water from running to waste down the natural drainage channels, i.e., the storm-water courses in the valleys. Other seepages were noted along the sides of the valleys and all roughly follow the same contour.

Referring to the probable cross-section shewn on the plan, the torrential rain in the wet season falls upon the sandy soil on the higher ground. It quickly sinks through the sandy soil into the porous laterite and commences its slow journey down to the lower levels, following the clay seam under the laterite on the close-grained, granite floor. On reaching an obstruction such as the black clay, it collects, wells up and finally oozes out at the surface. The more permanent of these seepages have naturally been converted into water holes by the natives, and in order to give a reserve sufficient for the needs of a small herd of cattle or goats the holes have been widened into small dams. In order now to develop these supplies to meet a greater demand, first of all the storage capacity must be made as perfect as possible to prevent waste from leakage, and then, more water must be collected and conducted into the watertight storage chambers or sumps.

The collection can be done by means of lateral trenches following roughly the contours of the slope, and filled in with broken rock, as described for Tabora. The sump can best be made as watertight as possible by masonry walling well rammed behind with black clay and resting on a similar impervious bottom. Black clay cores in dry stone walling are not recommended, as they are liable to be burrowed into by crabs and frogs; the water leaking out through these burrows completes the ruination of the storage capacity of the sump. Other forms of storage, such as galvanised iron tanks at the dwellings are to be advocated, and even pumping to these tanks either by hand or by wind power might advantageously follow. Trenches and sumps constructed continuously along the seepage contour will realise the development of the Nzega water to a maximum. In places the trenches may prove to be dry; this will be due to a sub-surface crest in the granite but the corresponding trough should yield enough water to make amends.

Kisumbi.—The new township site has been selected on account of the proximity of permanent water in both the Kidalu and Mhumbu Rivers, and


SKETCH PLAN
NZEGA DISTRICT HEADQUARTERS.
Approximate Scale.
0
1/2
1
mile
Higher Ground
SANDY SOIL
N
Cattle Drinking Place (Not Perennial)
DISTRICT OFFICERS HOUSE
BOMA
Granite Outcrop
GARDEN
Water Hole "A"
Water Hole "C"
Black Clay
Black Clay
From Tabora
To Shinyanga
REST CAMP
Perennial Water Hole "B"
Granite Outcrop
Black Clay (dry)
Water Hole
Water Hole
Black Clay (dry)
Seepage
N.
South
SECTION ALONG ROAD
North.



MASWA WATER SUPPLY.

Scale 1in. = ½ mile

Catchment Area + + + = 2½ sq. miles.
[shaded box] indicates granite outcropping or very near to the surface.

M.T. by F.B.W.

if suitable methods are employed no real shortage should be experienced when the township finally comes into being.

Maswa.—Maswa is a similar post to Nzega, having been chosen originally to gain close contact with the native. Now a township is mooted but suitable ground near the present Administrative site is not available for the standard township lay-out. At the time of the writer's visit nothing definite had been decided as to the new township site, so the water supply of the present location was investigated. Water for the Administrative officials, police and prisoners and a few natives, is drawn from the water hole shewn on plan (Plate II) due east of the Administrative buildings. Here a clayey soil deposit seems to be directly responsible for collecting the water in the crudely made earth sumps of the water hole. The clay deposit itself appears to have formed on the up-stream side of a submerged granite barrier, a sub-surface continuation of the ridge running east and west and indicated in the plan by form-lines. The actual existence of this sub-surface granite barrier was not proved by digging or boring, but lower down stream similar bars are visible with practically the same trend, and help to strengthen this assumption. In order to increase the water supply at this station, the existing main water hole above the clay should be dammed by means of a masonry wall built crescent shaped, having the horns of the crescent well embedded in the clay banks of the valley. The clay should be removed from the concave side of the crescent and a shallow dam created. Should this prove to be inadequate for the growing needs of the station, a dam wall should be constructed on the assumed submerged rock barrier, and the water impounded on the existing clay bottom. Before building such a dam, test pits or shallow bore holes should be sunk to determine the existence and extent of this sub-surface barrier and adequate provision made in the construction of the dam for sluicing out during the rains the accumulated silt from the dam bottom. Should the station finally develop into a township, the exposed rocky barriers lower down stream could each in turn be raised by masonry and the supply increased as required.

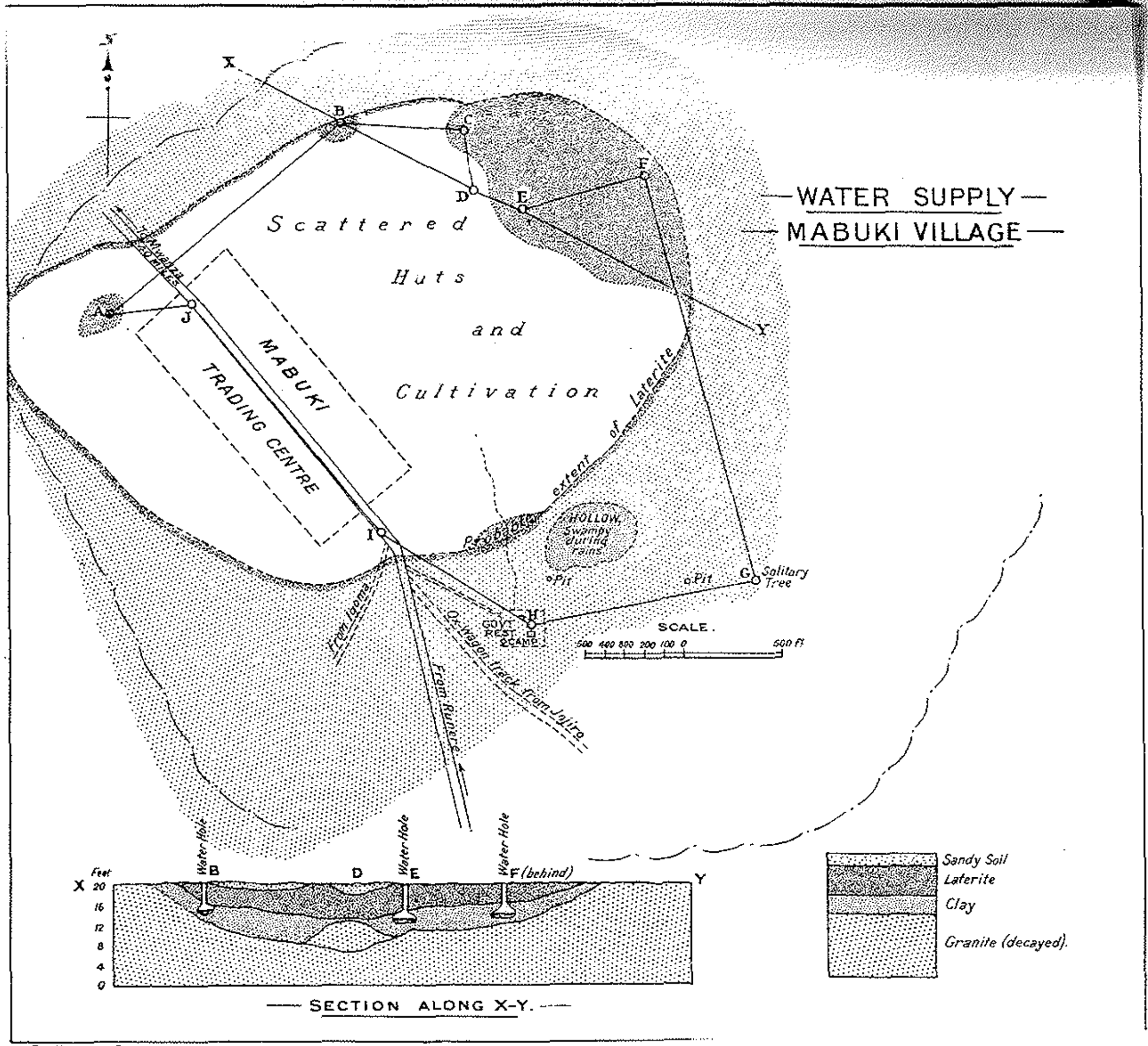
The cattle owned by the native farmers in the neighbourhood are watered in the muddy pools which form above these rock bars, and, whether the station develop into a township or not, one of the lowest rock bars might well be raised by masonry to create a larger water reserve for the present needs of the local cattle. Maswa seems to be favoured with rainfall such that the dry periods are not so long and unbroken as those of the regions nearer the central railways. Whilst the writer was in Maswa region, in September, copious rains fell, and the run-off was sufficient to cause the dry streams to flow for some days afterwards so that small dams in favourable positions should provide enough reserve water to prevent hardship during the shorter dry periods.

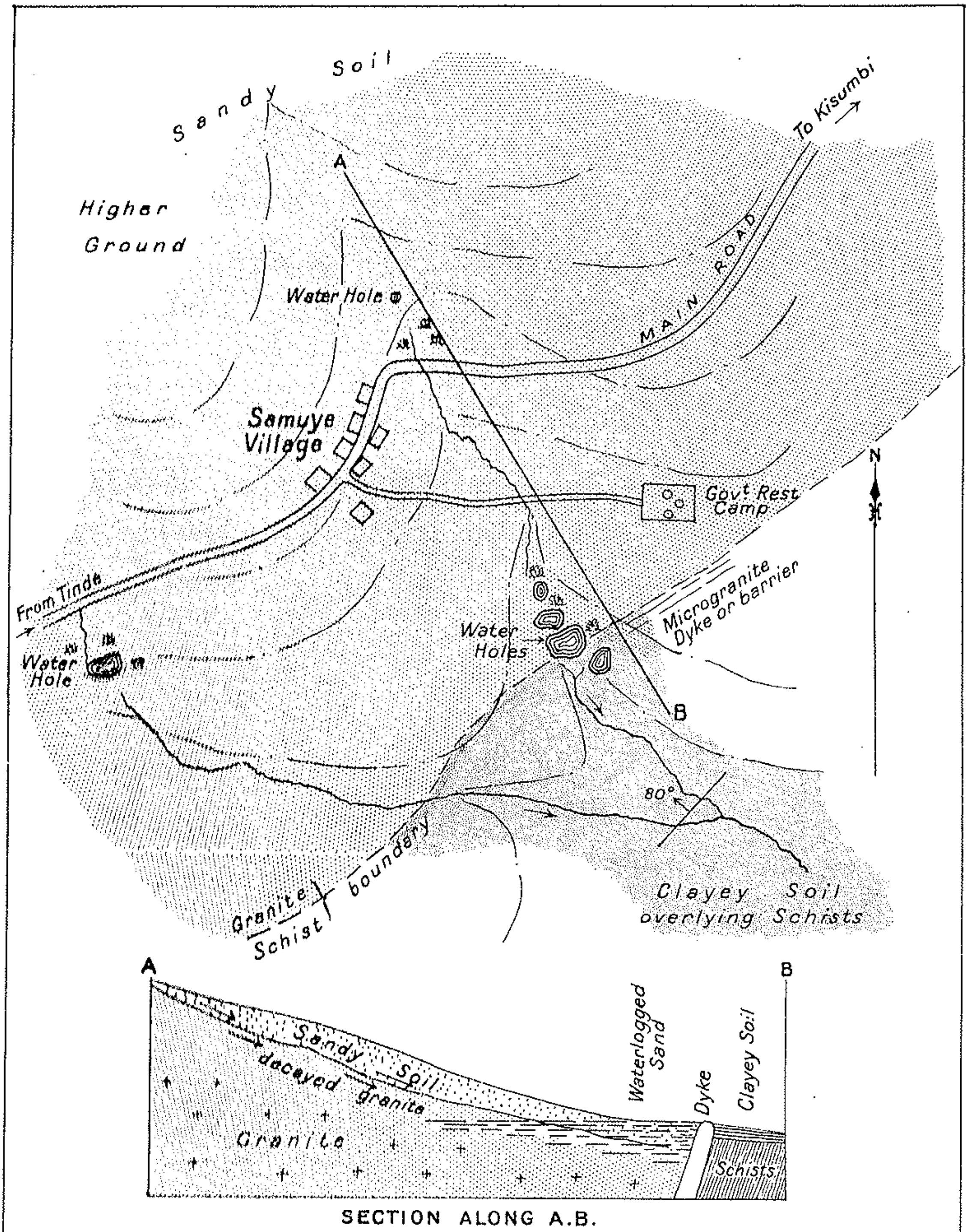
(c) Trading Settlement Requirements.

The water supplies of most of the trading settlements visited can be developed by the methods described above. The following settlements, however, require special discussion.

Mabuki.—This settlement is situated on the summit of a low, flattish dome of granite, in which there are small depressions. The dome is covered with a laterite deposit about a quarter of a square mile in area, which in turn is covered with sandy soil. For a greater part of the year the inhabitants draw water from holes made through the laterite, and water is encountered in cavities hollowed out under this rock, which forms a roof. In 1925, the then Provincial Commissioner authorised the sinking of a well at a selected point in order to assist the inhabitants during the dry season. The writer was privileged to visit this work on several occasions during the sinking, and from what was then observed, he was able to formulate a theory to explain the nature of the water supply and to evolve a scheme whereby the water could best be developed. The well in question is situated at the point A on accompanying plan (Plate III). The site was selected by the overseer because near by, in the laterite, there were holes from which women used to draw water for a greater part of the year. A circular well was sunk, and during the sinking an irregular bed of laterite, with a maximum thickness of 3 feet, was passed through. The bottom of this bed reached a maximum depth below the surface in the N.W. corner of the pit, and here water rushed out to such an extent that work was suspended until dry season conditions set in. Later on, the well was carried on down to a depth of 12 feet, or more. Below the laterite, a thin clay layer was to be observed, resting directly upon a coarse-grained decayed granite of such a nature that it was highly permeable by water. In August, 1926, when this well was revisited it was found that the flow from the laterite had long ceased, and that the granite pit was bone-dry. On the other hand, the native-made water hole in the laterite, 17 feet away and 11 feet below surface, was still water bearing. The explanation is that the laterite, and its accompanying clay base 17 feet away, occurred over a hollow in the underlying granite and the natives, more by good luck than design, had not pierced the clay layer and so the water failed to escape into the absorbent granite below.

Referring to the plan, the native-made water holes are to be found at "B," "E" and "F," and also at other points between the line X—Y and the settlement. Holes "B," "E" and "F" still yielded a supply of water in August, whilst "D" was dry. It was noted that the laterite at the wet holes formed a more or less horizontal roof to the cavities in the clay, whereas at the dry hole, "D," the laterite, 4 feet thick, and its underlying thin clay seam, were tilting towards the east. The inference is that "D" is situated near the rim of a hollow in the granite, or near the crest of a trough, whilst the wet holes are in the lower zones of hollows or troughs. Point "C" was where the laterite appeared at the surface, so the probability is that the line C—D defines a crest on the underlying surface of the granite. The laterite is also at or very near the ground surface between "E" and "F," but that indicates nothing in regard to its water possibilities; it is the sub-structure of the granite and its conforming clay and laterite that determine whether water will be struck or not.


WATER SUPPLY
MABUKI VILLAGE
Scattered Huts and Cultivation
MABUKI TRADING CENTRE
HOLLOW, Swampy during rains
Probable extent of Laterite
Pit
Pit
Solitary Tree
GOV'T REST CAMP
From Igoma
From Runere
Ox-wagon track from Jojiro
SCALE.
500 400 300 200 100 0
500 ft
Water Hole
Water Hole
Water Hole
F (behind)
Feet
Sandy Soil
Laterite
Clay
Granite (decayed).
SECTION ALONG X-Y.



SKETCH PLAN
SAMUYE WATER SUPPLY.

Approximate Scale

Yards 0 100 200 300 400 Yards

From Field Sketch by F. B. W.

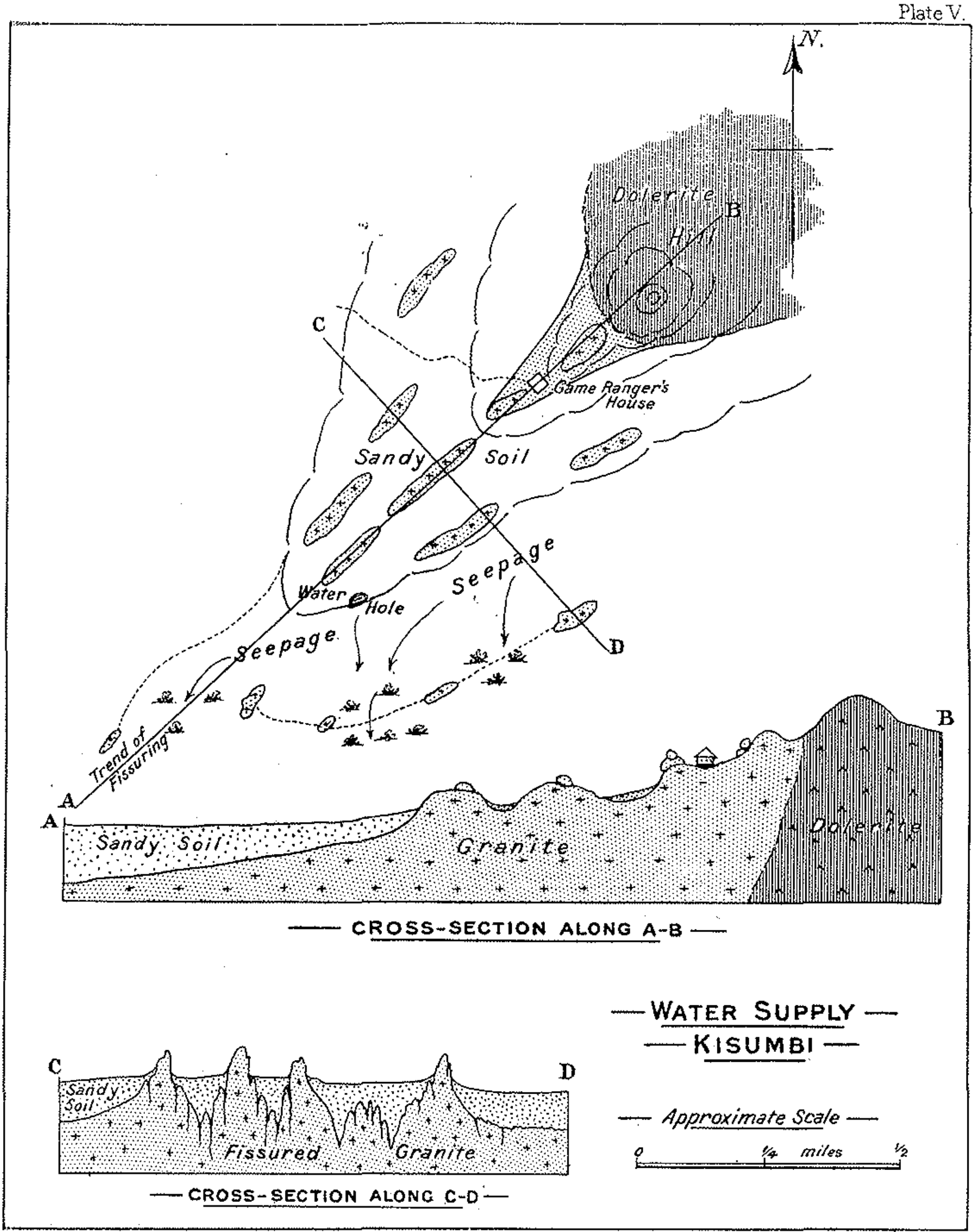
In order, then, to develop the existing supplies, the sub-structure should be determined. Shallow boring would give quickest results, but failing this, pits should be made through the laterite at as many places as possible, and, as the work proceeds, by correlating the information gained, such as thickness of the laterite, of the clay underneath, and, whether wet or dry, certain general conclusions may be reached to enable sites for water holes to be chosen successfully. Each wet hole should then be made as capacious as possible and the ground levels of the holes protected from pollution by the building of masonry curbing round them. In this way each family or household might possess its own water hole and hardship be avoided.

In regard to the watering of livestock here, the hollow shewn N.N.E. of the rest camp might well be developed. For many months in the year this is water-logged and cultivated as a rice paddy-field, but towards the end of the dry season it dries up completely, and then is revealed the fact that its bottom is composed of black clay. Evidently this clay conserves the water and creates a shallow pond, because pits sunk near the pond margin show decayed granite down to 20 feet. It is suggested that a pit be sunk in the middle of the pond, when dry, and the thickness of the clay determined. If the clay proves to be a reasonably thick deposit, then an excavation in it might be made and the sides supported by masonry and of dimensions capable of storing sufficient water to enable the local herds to be watered during the dry spell. Water could be drawn by pumping from this underground chamber into troughs on the higher ground, away from the pond itself. The suggested development depends entirely on the workable thickness of the clay. If the underground chamber be bedded on decayed granite, the storage possibilities of the undertaking will be negatived. The bottom must be impervious and the granite here has proved to be very absorbent and consequently useless for such a purpose.

Samuye.—The trading settlement at Samuye in the Shinyanga District has a water supply different from those already described. It is situated at the eastern extremity of the Tinde range of hills and is also on or very near to a geological boundary, viz., that between the granite and the schists. Water is at present drawn from three points, two of which are merely roughly made sumps to catch the normal run-off from the hills to the west. The third is situated on the boundary itself (*see* plan, Plate IV) and is in the writer's opinion worthy of development. Even at present in its undeveloped state it lasts the longest and yields the greatest volume, and consequently it is used mainly for the watering of cattle. The infrequent visitors at the rest camp also draw their supplies from this source. The water is slightly mineralised, but potable even at the end of the dry season. A glance at the probable section along A—B will show the following facts. The high ground is granite and the low is schist. The granite is covered by its weathering product, sandy soil, and the schist in turn by clayey soil. Conditions therefore are favourable, at their junction, for an arrest in the downward flow of the run-off of rainfall, the sandy soil being the conducting medium and the clayey soil the obstructing one. Consequently the collecting water wells up to the surface at this junction and gives rise to swampy ground during the rains. The water holes under discussion are even more favourably situated, as a dyke of microgranite forms an additional barrier to the downward flow of the waters. It is shewn on the plan and cross-section. On the surface it appears to be broken or discontinuous as it proceeds from N.E. to S.W., but there is every possibility that below the surface it continues right across the small valley and is responsible for the plentiful supply of water. If this supply is to be developed to a maximum, the line to follow would be to repair the breaks in this underground wall provided by Nature and, by so doing, increase the volume of water impounded by it.

The Game Preservation Headquarters, Kisumbi.—Whilst this is not a trading settlement, yet from considerations of demand it is placed in this category. Geologically it is interesting in that it is one of the few places where an intrusion of younger rock is recorded in the granite. The fact of this intrusion being much younger than the granite makes deeper-seated water in the granite fissures more likely, because the fissures have not had sufficient time to become useless as water reservoirs, as is held to be the case with the older fissures in the granite. The intruding rock is dolerite, and its effect has been to shatter the granite into fissures trending roughly N.E.-S.W. The topography in the immediate neighbourhood is a hill, the summit of which is of dolerite, the lower slopes of granite finally merging into a plain towards the S.W. The granite outcropping on the lower S.W. slopes takes the shape of towering monoliths, wall-like in shape, arranged roughly in parallel lines (*see* plan, Plate V). Cross-section A—B shews a diagrammatic section cut parallel to the granite " walls," and the cross-section C—D cuts the " walls " transversely. The forcible intrusion of the dolerite has caused these fissures along the original line of weakness, shattering and comminuting belts of rock between them ; these belts have been an easy prey to the agents of denudation, and have been completely eroded, whereas the unshattered rock has been left standing in the form of " walls." Subsequently the clefts have been largely infilled with sandy soil. The influence of this fissuring on water supply is to form a series of roughly parallel troughs of irregular shape, down which the annual rainfall percolates through the sandy soil. This percolation comes to the surface as the lower ground is reached and also tends to escape from between the confining walls, where the latter are broken transversely. The seepage direction is shown on the plan, and, for the present, if a greater supply be required, the scheme that suggests itself is to build sub-surface walls of masonry athwart the seepage flows, and to bed such construction on the underlying granite. Preliminary exploratory work, preferably by hand boring, should be undertaken first to determine whether the granite barriers exists underneath, and, if so, at what depth, in order to form a reliable estimate of the probable cost of such an undertaking. If such a wall, or walls, be built, the water may be drawn from sumps suitably situated within the impounded area.

Plate V.



From Field Sketch by F.B.W.

(d) Native Inhabitants' Requirements.

In tsetse-fly infested country it is assumed that it is more desirable to concentrate natives into farming communities than to have isolated hamlets and families scattered sporadically in the bush. It is also assumed that such communities should be on or adjacent to existing lines of communication so that their agricultural produce may be the more easily marketed. With this principle in view, the fly-belt lying between Tabora and Nzega, and traversed by the main motor road to the north, was investigated. Existing supplies were visited and will be discussed seriatim.

Kasima (6m.).—This centre seems to be plentifully supplied with water and the inhabitants are engaged principally in growing rice in the water-logged valleys. Mango trees, too, are plentiful and are, no doubt, a source of profit to their owners. From a technical point of view, no comment seems to be required on the water supplies, but from a hygienic point of view, precautions might well be taken to prevent pollution of the various water sources. At about 16 miles from Tabora a struggling hamlet, called after its headman, Maomba, is situated. The water supply here is situated in sandy ground, roughly where the hills merge into a valley bottom. This supply is said to be perennial and there seems to be no reason to the contrary. It supports only one family at present, but there is evidence in the bush of former more extensive cultivation. This source might well repay development, as it is well situated on the road and is not actually in the fly belt.

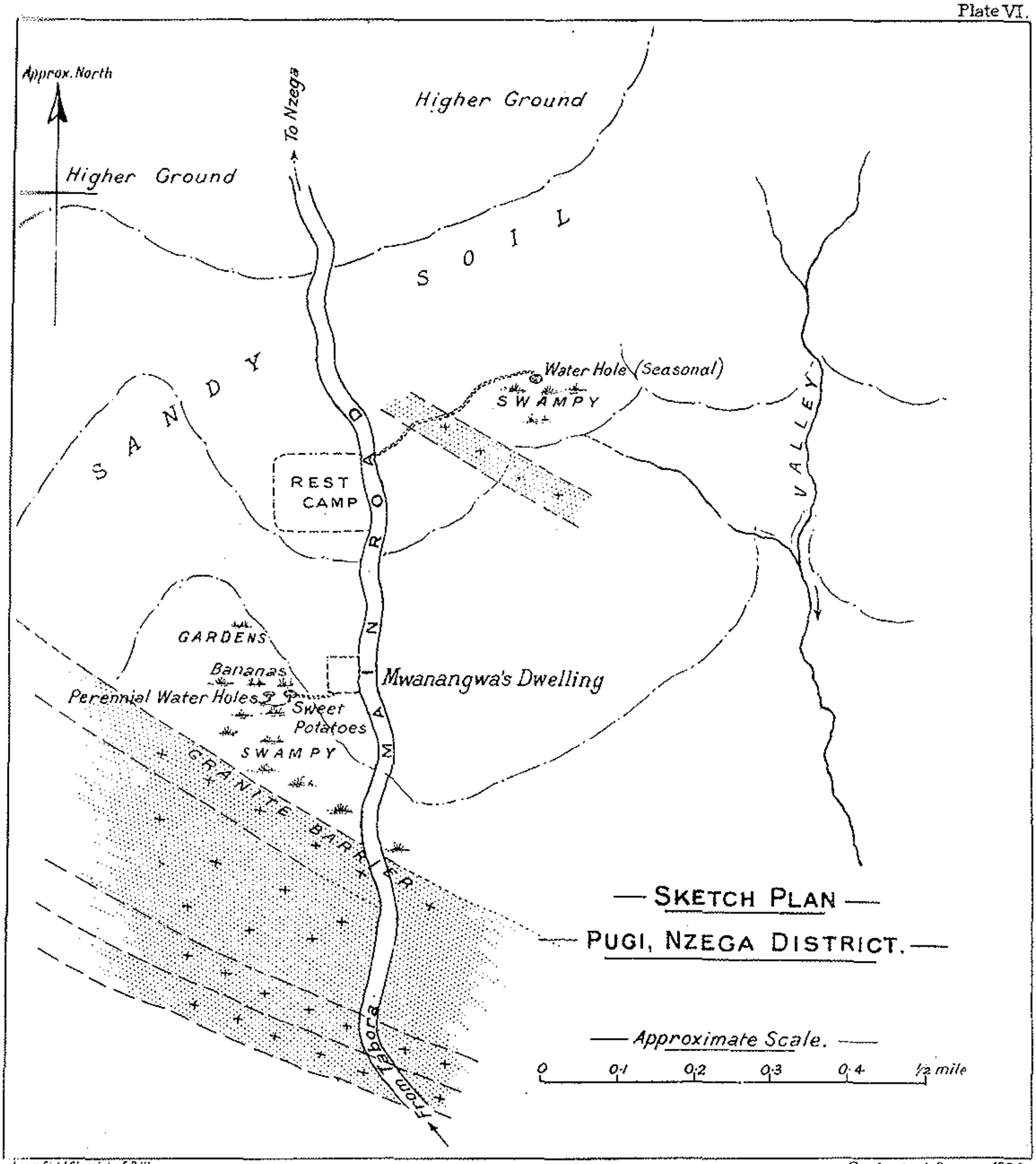
Pigawasi (22 m.).—This village is situated in a broad sandy valley having higher hills to the N.W. and north. The principal inhabitants seem to be relations and dependants of the local Sultan, who visits here occasionally. Some tsetse-fly is present, so this precludes the raising of cattle, but agriculturally, this valley should be very good. The Sultan was not present at the time of the writer's visit, but an elder furnished the information that the valley was very fertile but that more extensive cultivation was hampered by shortage of water and by raids from baboons.

The main water hole is situated to the north of the Sultan's house and is merely a large open excavation shaped like an inverted cone, no attempt having been made to support the sides. This hole is said to dry up towards the end of the dry season, and a hole further north nearer the hills is then resorted to until the rains occur. The hole was observed to bottom on laterite, and on being asked if the laterite had been pierced, the elder stated that this had been done at another point in the neighbourhood, but that the rains had filled it up. Evidently the shortage of water cannot be too acute, and, should this fertile valley be developed, the underlying laterite should be pierced and possibly it will yield at its base sufficient water to support an increased population.

At 24 miles along the main road in uninhabited bush, a seepage along the higher contours of the valley was noted. This might respond to the methods of development described under Nzega. At $25\frac{1}{2}$ miles a reedy hollow was noticed on the right of the road. This, too, might be worthy of attention. At 28 miles cultivation begins and nearby a shallow water hole in sandy soil resting on a calcareous cement bottom was noticed. This is most probably a seasonal supply, but further investigation nearby might give favourable results. At 30 miles a small swampy hollow similar to the one described at Mabuki was recorded. At 31 miles the village of Usagali is passed, and here similar conditions to those described at Nzega are recorded. At 35 miles the camp of Upungu is reached and water conditions are again similar. Between Upungu and the next camp, a swampy hollow is recorded at 40½ miles on the west of the road in uninhabited country. The water in this hollow covered an area of about 1½ acres on 11th July, 1926, and the hollow is simply a natural depression in the granite having no visible outlet. Pugi village at 49 miles has a water supply capable of supporting a fair number of natives, but the population in the neighbourhood was disappointingly small. This village, too, is a Sultan's alternative residence. Can it be that the natives prefer to live some distance away from their chiefs at the risk of experiencing hardship from water shortage?

Water is obtained from two places, one perennial and the other seasonal (*see* Plate VI), but both appear to be due to similar causes. A wall-like mass of granite trending N.W.–S.E. cuts across the main road and also traverses a small shallow valley obliquely. Rain water collects in the sandy soil covering the higher ground, and its slow progress down the valley is impeded by this oblique granite barrier, so that it stagnates and forms the swampy area to the S.W. of the Mwanangwa's house. The smaller supply to the N.E. of the rest camp is similar in every respect except quantity. The larger supply has been developed by the natives in a primitive way by digging holes and making small earth sumps in the swampy ground. The upper supply is as yet undeveloped even by the natives, but water for the rest camp was obtainable in July from the swamp itself. Should these supplies be developed, masonry walls athwart the present seepages, abutting at one end on to the granite barrier and embedded in clay at the other, and reaching down to the bedrock or to a good clay bed, should prove satisfactory.

Ngalia camp.—Ngalia camp at 59½ miles has two water holes, the one nearest to the camp derives its water from the base of a thick deposit of laterite, but is said to be seasonal only. When this fails the inhabitants draw from a supply about half-a-mile N.E. of the rest camp, where a natural rock-rimmed hollow is to be found. This hollow has a large catchment area of sandy soil on all sides. At the time when it was visited the water was very near the surface and its substructure was difficult to determine. Probably there is a bed of laterite conforming to the hollow in the granite underneath, and this is pierced, and at the driest time of the year water is drawn from its base. This was unable to be verified owing to the flooded state of the hollow at the time. Fly seems to be absent from this point onwards. At 62 miles the village of Utwigu is situated, and draws its water from a hollow similar to the one just described. From here onwards to Nzega at 71 miles the methods described earlier on for Nzega itself should be applied if an increase in supply is required.



From Field Sketch by F.B.W.

Geological Survey 1926.

Kigahumo.—Kigahumo, situated $13\frac{1}{2}$ miles from Nzega on the main road, is one of the first villages encountered on the schist zone. This zone is about 16 miles broad and stretches across the Manyonga valley up to the foothills of the Tinde Range. At Kigahumo, water is obtained from a spring in the sandy soil which the natives declare to be perennial. All this supply requires is the supporting of the sides of the excavation and protecting it from pollution by a masonry or concrete curb. From what was seen of the neighbourhood, it is thought that a greater part of the Mingoyu Sultanate is situated on the schist zone, and well-sinking on this formation should be productive of water at about 30 feet below the surface.

Itobo.—Itobo, situated about 12 miles from Nzega on the Bukene road, derives much of its water from a laterite deposit on the northern side of the village. Conservation of the existing supply should be undertaken on the lines suggested for Nzega post. A dam has been constructed on the southern side of the village in a rather shallow valley of considerable catchment. It was noted that the impounding wall built by natives was of mud mortar inside the wall, and faced with stone in a lime mortar outside. It had broken away in the centre during the rains of 1925-26, but had been repaired in portland cement and stone at the time it was visited, October 23rd, 1926. The new rains were imminent, and it was observed that, whilst there was a large spillway, no apron was provided to the dam wall itself on the down-stream side, nor were any means provided for sluicing out the accumulated silt during a spate. In the writer's opinion, the accumulated waters will again flow over the wall, as well as over the spillway, and having no apron, undercutting of the dam wall will ensue and render it unstable. At the most, this dam will be a paltry 9 ft. or 10 ft. deep, and during the dry season at least the upper four feet will be sacrificed to evaporation by wind and sun, so it is hoped that the remaining small volume will suffice for the needs of the local natives' stock.

Tinde—The portions of the Tinde Sultanate astride the main road are well supplied with water from the Tinde Range, and nothing further is required to be done here, except the usual preventive measures against pollution.

Lubaga.—Detailed investigations were carried out in the Kisumbi Sultanate at the request of C. F. Swynnerton, Esq., Director of Game Preservation, in order to locate, if possible, water at sites selected for their suitability in connection with the campaign against the tsetse fly encroachment in this Sultanate. Geologically, the area at present being attacked is situated in schist country, and, as the work proceeds westwards, the granite of the Mantine Hills will be approached. The present sites being on schist, well-sinking should yield water, though this possibility should be tested previously by boring. The sandy river known as Lubaga River was examined in detail and finally a site was selected for the construction of a sub-surface dam in the sands of this river. A small natural clay barrier was discovered by pits sunk in the dry river bed, and above it a rough scooped-out water hole in the sand yielded water. This black clay barrier rested on a yellow gritty clay, and the banks of the river were of suitable clay material to hold water. The scheme illustrated by the accompanying Plates Nos. VII and VIII was evolved to develop this site into a supply suitable for the support of a native farmstead. The idea was to prevent the downward flow of the water under the sandy bed and thus cause it to accumulate at a point when it could be put to use. The essentials of such a scheme are :—

(a) An impervious bottom.

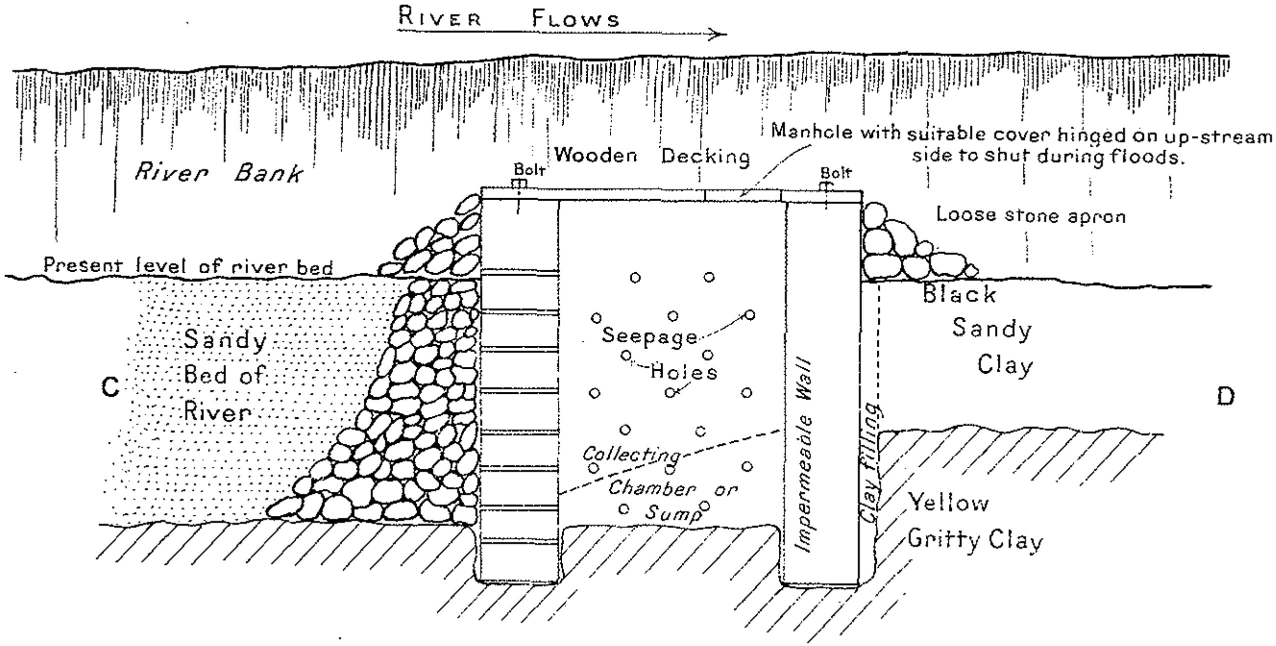
(b) Impervious sides.

(c) An impervious barrier transverse to the flow and rendered water-tight at its junction with the sides. Plate No. VII shews such a construction in cross-section. The impermeable wall may be of concrete or masonry and stretches across the river from bank to bank. It is shewn raised 2 feet above the existing river bed. The reason for this is to try and increase its capacity by encouraging more sand to be deposited on the up-stream side. The wall's function is purely to impound, under the sand, the water which sand normally contains. It has been found that sand will absorb 30 per cent. of its volume of water, but of this amount will not yield more than 1 per cent., but its important function is to act as a conducting medium for water from places higher up the river; in this way the water in the sand is under a small hydrostatic head and will seek the easiest path. Such a path is provided for it through the seepage holes into the collecting chamber or sump, in which it is readily accessible for consumption. It will be observed that the up-stream side of the impermeable wall is piled up with broken stone. This broken stone plays a very important part in the storage of the water, as broken stone contains from 40 per cent. to 45 per cent. of void spaces, which fill up with water, consequently the more broken stone in a dam of this sort the bigger will be its storage capacity.

It may be asked why a normal surface dam should not be constructed at this point instead of a sub-surface one. The answer is that a sub-surface dam has the minimum amount of loss through evaporation, which rises to formidable proportions in this country. Also, a sub-surface dam does not require to be emptied of accumulated silt so frequently, the only part where silting might occur is in the sump, and all the water entering the sump has been partially filtered by its passage through the sand. The wooden decking and manhole provided with a trap door are important items if the sump is to be kept free from excessive silting. During the flood or spate, if the manhole cover be shut, the storm waters with their mud and rubbish in suspension, will pass unchecked over the sump, and the amount that leaks in will be negligible. Referring to the plan (Plate VIII) the shape of the sump is shewn and also the quantity of broken stone. This type of sump is suggested as being more economical in masonry. It need not necessarily be in the middle of the dam wall, but its position should be at the deepest part of the stream bed. It may even be built some distance away from the wall, if a deeper hollow in the impervious bottom be discovered during exploratory work. If such a position be decided upon the sump should be circular in plan with seepage holes all round, but it must still be surrounded by as much broken

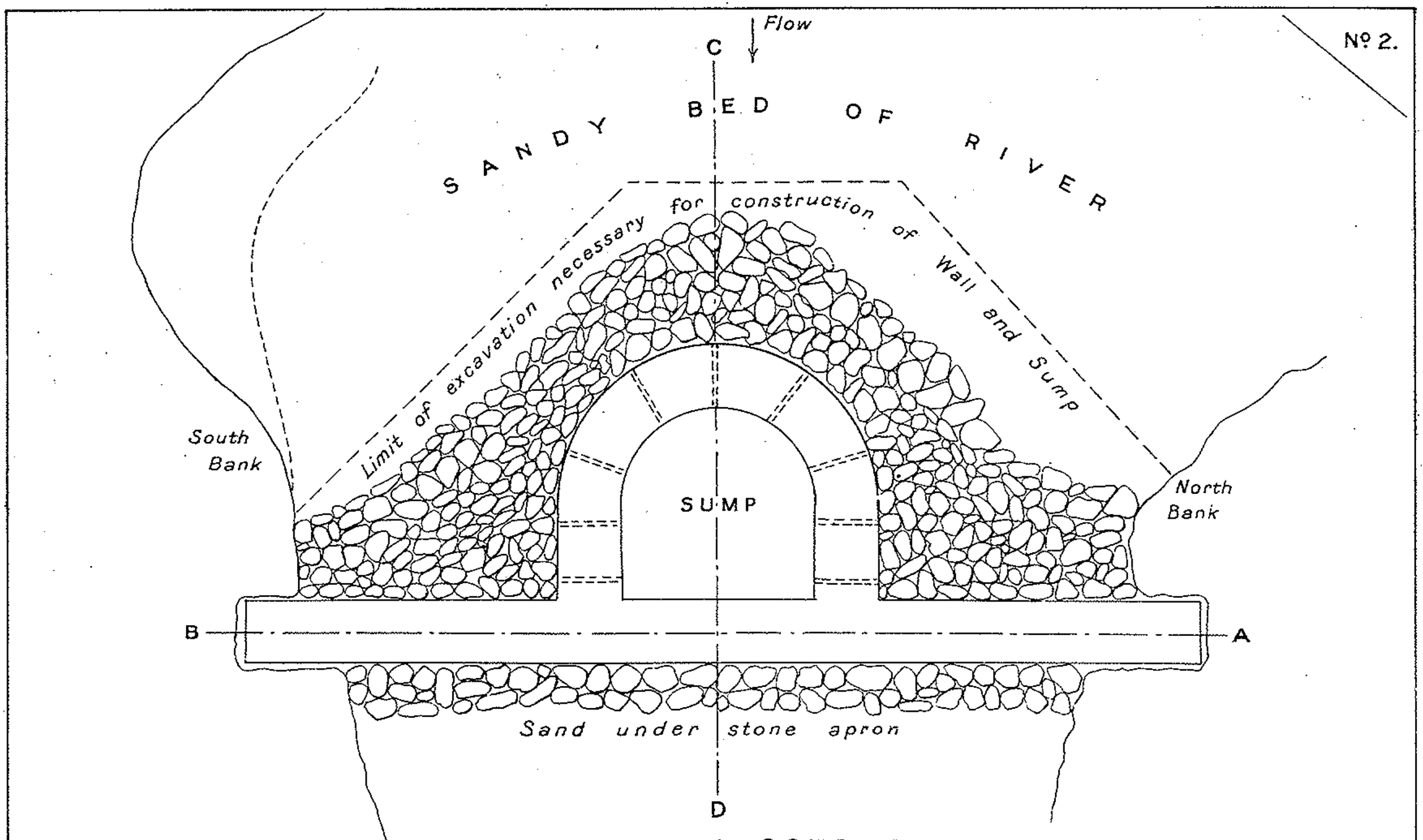
Plate VII.

No. 3.



— Cross-Section through C.-D. (plan No. 2.) —

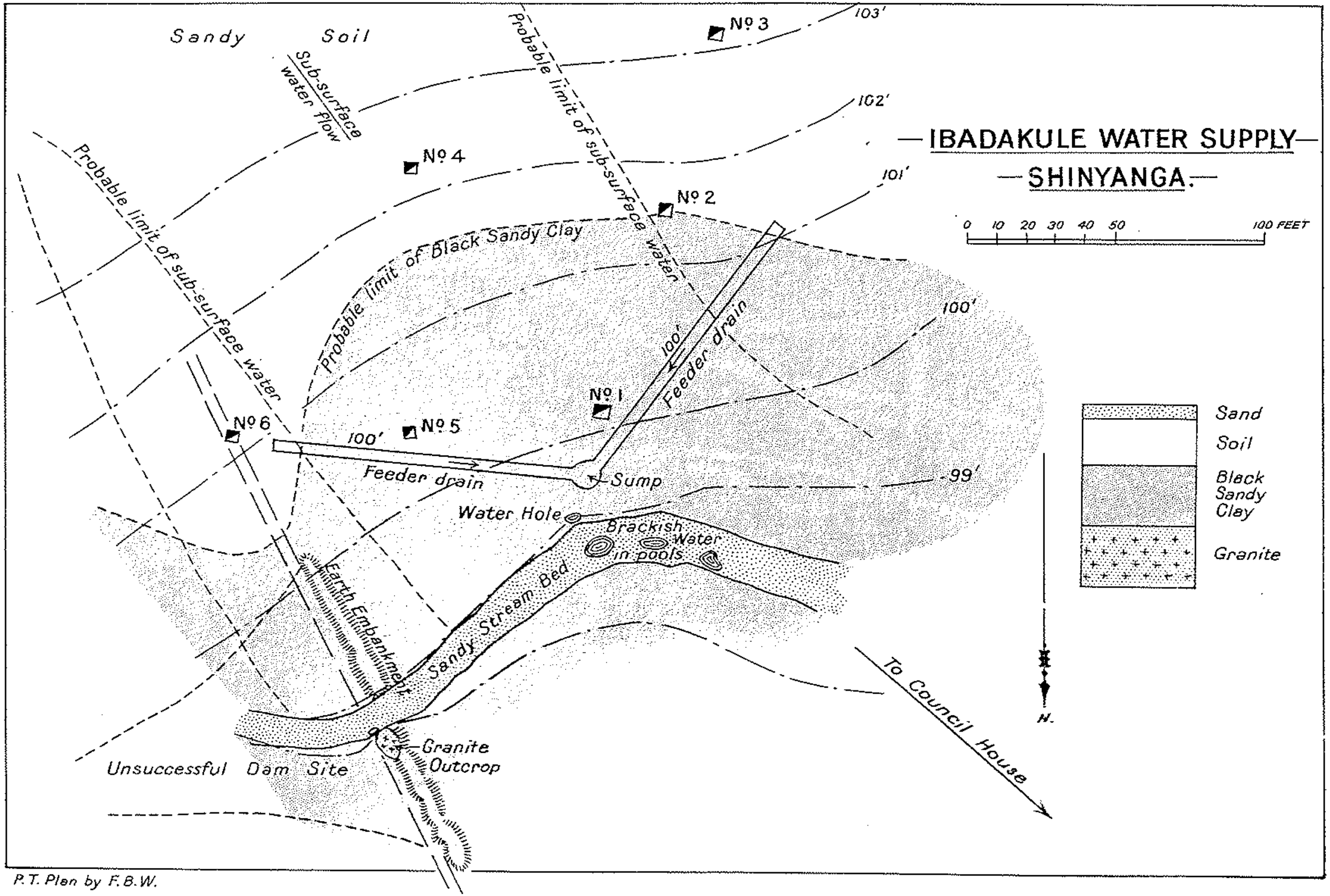
— Scale: 1 inch = 5 ft. —



—PLAN OF PROPOSED DAM—

—LUBAGA RIVER.—

— Scale 1 Inch=5 Ft. —


IBADAKULE WATER SUPPLY
SHINYANGA.
0 10 20 30 40 50 100 FEET
Sandy Soil
Sub-surface water flow
Probable limit of sub-surface water
Probable limit of Black Sandy Clay
No 1
No 2
No 3
No 4
No 5
No 6
103'
102'
101'
100'
99'
Feeder drain
Sump
Water Hole
Brackish Water in pools
Sandy Stream Bed
Earth Embankment
Granite Outcrop
Unsuccessful Dam Site
To Council House
N.
Sand
Soil
Black Sandy Clay
Granite
P.T. Plan by F.B.W.

stone as possible to give the best results. By October, the Game Preservation Department had commenced the building of this scheme, and possibly it will be in operation after the rains of 1926-1927, and results from this experiment are keenly awaited in order to know its limitations. If the scheme prove as successful as is expected, it will have a wide field of application in many parts of the Territory, where dry sandy rivers are the rule rather than the exception.

Ibadakule.—This new place is the capital of eight confederated sultanates, and is even now the centre to which the chiefs come from time to time to deliberate in the main council house. A central school is also in course of construction, and the Agricultural Department maintains an experimental seed farm in the vicinity. The area set aside for this native administrative centre is situated on a flattish ridge trending east and west, flanked on the north and south by shallow valleys draining slowly westwards into the River Mhumbu. The valley on the north side has a plentiful supply of water at a point N.E. from the Council House, but this water is used almost entirely by the natives for culinary purposes, whilst the valley to the south yields a smaller supply of water suitable for cattle.

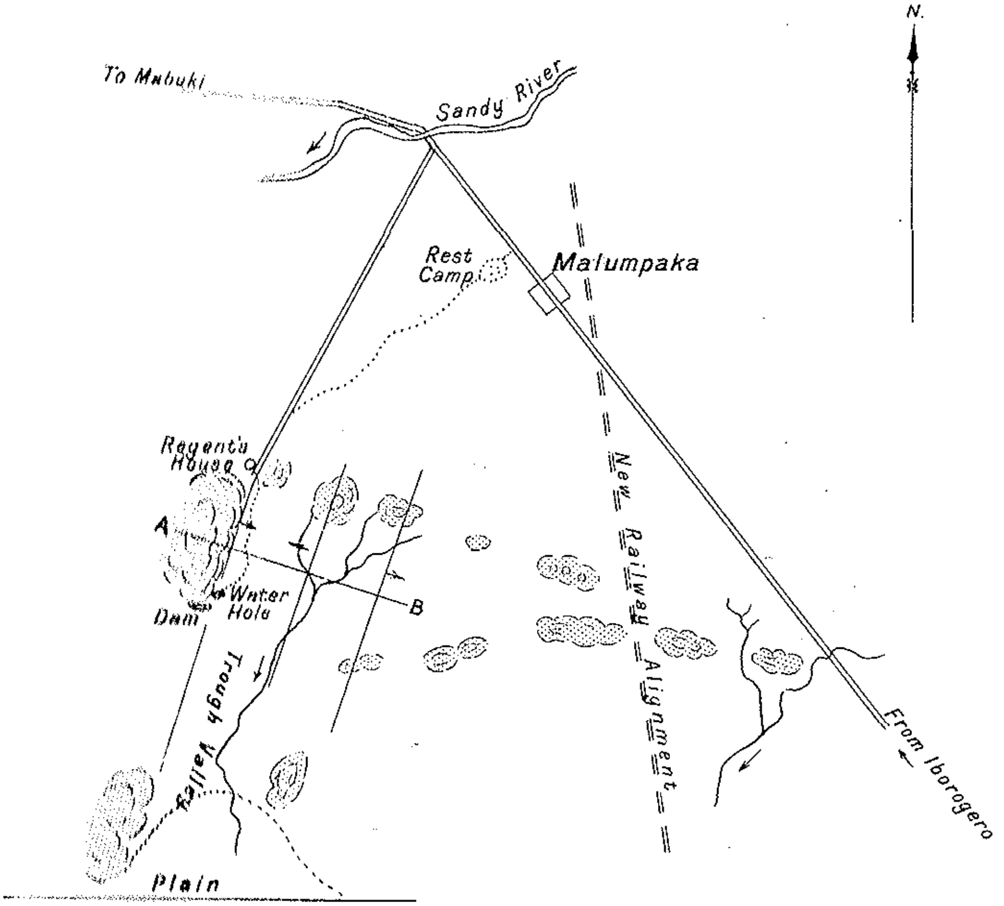
The supply in the north valley seems to be retained in its present area by some natural sub-surface barrier, probably a rock barrier reinforced by a clay bed, and requires developing merely to prevent pollution. Shallow wells with the sides supported by masonry containing seepage holes, and the masonry raised above ground level as a curbing, should meet the case. The water in this valley is tasteless but is always muddy in appearance due to fine clay of a colloidal nature in suspension.

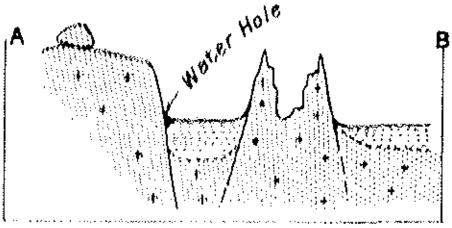
The water in the southern valley is of a different order. It is slightly mineralised but clear and is potable. The writer used it in preference to the sweet muddy variety mentioned above. Investigations in this valley showed that this water was slowly seeping down from the higher ground to the south-west (*see* plan, Plate IX). Test pits were sunk, shewn numbered 1 to 6 on plan. Nos. 1 and 5 reached water at about 4 feet down and No. 4 at about 6 feet. No. 4 shewed that the decayed granite under the black sandy clay was waterlogged as well. It is concluded that the water is kept back by the black sandy clay, which fills all the valley from this point right down to the Mhumbu River, and reaches the surface at or near the margins of this less permeable medium. Pits Nos. 2, 3, and 6 were sunk into the decayed granite and were bone dry. From this the lateral limits of the seepage were determined and, in order to collect as much of this seepage as possible, the scheme suggested was as follows :—A circular sump sunk down to near the base of the black sandy clay bed should be made and the sides lined with masonry. The masonry on the northern arc should be well cemented to make it watertight, and that on the southern arc need be of dry stone only, or of stone and mortar with seepage spaces provided. Radiating from this sump are two trenches, each 100 feet long, extending in the directions shewn. These should be dug down to near the clay-bed bottom and afterwards filled in with broken stone. Communication spaces must be provided to allow the collected water to flow into the sump. The lower reaches of the trenches adjoining the sump might conveniently be walled in order to minimise leakage as the level of the water in the sump rises, the black sandy clay not being too perfect as an impervious medium. This sump may be covered over to prevent pollution, and water raised from it by an ordinary suction pump or by bucket and chain. In order that the cattle may be watered economically, troughs should be provided at some point in the valley below the level of the sump and the water raised by pump or bucket should be conducted to the trough by a short length of piping. Similar seepages are to be found both to the east and west of the one discussed, and as the demand increases this scheme can be multiplied.

It is thought that if this mineralised water be mixed in a common reservoir with the muddy water from the northern valley, precipitation of the colloidal clay would follow and a clear potable water would result. For raising water in this locality, it occurred to the writer that windmills would be admirable, as the prevailing wind from the S.E. is very strong and persistent throughout the dry season. If the native council requires water laid on in order to save their women folk the labour of fetching it, water might be pumped from both valleys by windmills into a storage tank on the ridge, near the main settlement.

Hungamarwa.—This is an area of scattered native farms situated on an extensive laterite covered flattened ridge. The inhabitants draw their water from holes in the laterite and their cattle are watered in the sandy beds of the rivers Moamé to the south and west, and the Kaguasa on the north. The Veterinary Department maintain a Stock Inspector's post here, and this is supplied by water derived from the laterite and also from a well sunk into the decayed granite, but the latter yields brackish water only. Being brackish, and in porous decayed granite, seems to indicate a rock-rimmed basin in the more solid granite lower down, brackish water being usually found in places where water stagnates and thus the salts concentrate in the course of time.

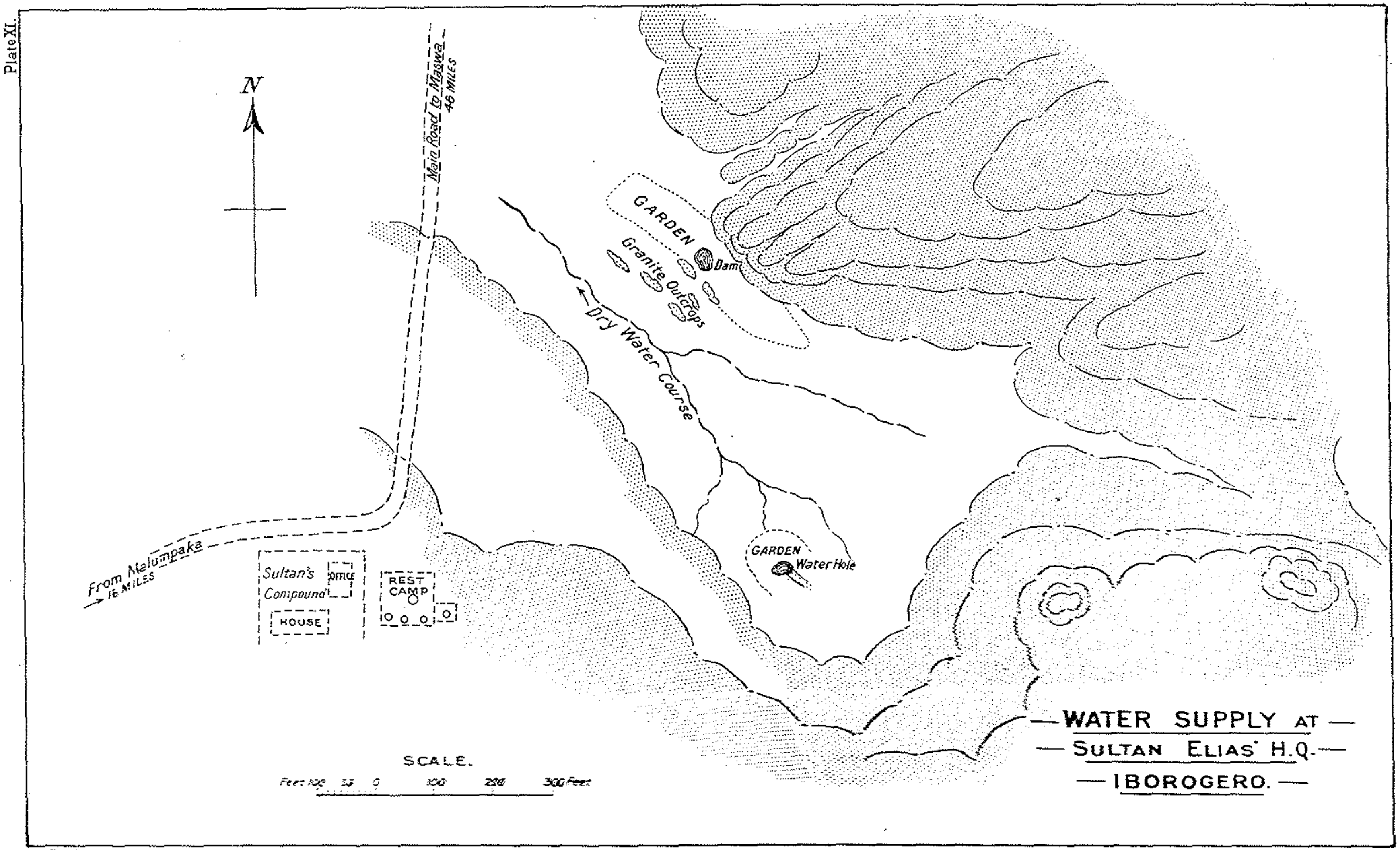
Region East of Main Road.—The following localities described are all on granite of a type which weathers into low domes, and in most cases it is simply the better run-off from these low domes and sloping pavements that yields water for the inhabitants of the region. Prof. Gregory, in his "Rift Valleys of E. Africa," p. 247, describes how, in Dalmatia, railway stations derive sufficient water from the run-off from an acre or two of suitable sloping rock, and points out that 20 inches of rainfall over an acre amounts to 450,000 gallons, so that even in the driest parts adequate water for native purposes can be obtained by the use of water collecting surfaces. Such water-collecting surfaces abound in the granite country under review. Moreover, the natives very frequently establish their homes at the foot of granite domes, generally plentifully studded with characteristic great balanced boulders. That they realise the benefits to be derived from the "run-off" is apparent, as it is quite common to see banana palms planted in the recesses in the granite where the boulders meet the soil level. They have made use of this principle for





MALUMPAKA WATER SUPPLY.

Plate XI.



N
Main Road to Maswa 46 MILES
GARDEN
Dam
Granite Outcrops
Dry Water Course
GARDEN
Water Hole
From Malumpaka 16 MILES
Sultan's Compound
OFFICE
HOUSE
REST CAMP
SCALE.
Feet 100 50 0 100 200 300 Feet
WATER SUPPLY AT
SULTAN ELIAS' H.Q.
IBOROGERO.

agricultural purposes, but, being Africans with no thought for the morrow, little or no effort has been made to conserve the plentiful run-off for their own domestic purposes. It is easier for their women to walk say 5 miles to a water hole or river pool, than for the male to exercise his ingenuity and muscles. Typical examples of water supplies of this sort are to be found at Malumpaka, Iborogea, Luguru (Itilima) and Bumera (Kanadi) all the headquarters of Sultans.

Malumpaka (*see* Plate X).—A series of rocky hills and pavements provide the run-off, and the storage here is assisted by Nature in that a succession of parallel minor faults have caused the formation of a small trough valley in the fallen-in parts of which the run-off water collects. The main water hole is situated in the clayey soil on the fault-plane itself and this plane undoubtedly assists the collection by acting as a long natural gutter which collects the run-off from the rocks to the west of it. For the purpose of watering their cattle a small earthen sump or shallow dam has been made by the natives, into which the cattle flounder. Troughs installed here would effect an economy in water consumption and cause the supply to last longer into the dry season.

Iborogero (*see* Plate XI).—The run-off from the granite hills to the N.E. of the Sultan's house is concentrated by the configuration of the ground to a point where a shallow dam stores a certain amount and renders it accessible to consumption. The configuration of the area is influenced largely by the well-developed jointing in the granite. Here there are two sets of joints, roughly at right angles. The valley itself is carved out along the major set, whilst the hills to the N.E. are weathered into channels which conduct rain-water to the sump. These latter channels follow the minor set of jointing. The sump seems to be situated where the two sets of joints meet, as elongated outcrops of granite trending N.W., are to be found just appearing above the surface of the clayey soil in the garden to the south-west of the sump or dam. A similar set of conditions but on a much smaller scale is observed at the small water hole immediately east of the rest camp. In this case the major joints, trending N.W., conduct the water from the higher ground into the crudely made collecting basin. Sultan Elias, who is responsible for the development of this water supply, deserves much credit, and, should the present sumps prove inadequate as time goes on, a good masonry sump should be constructed so as to fill in the gaps where the two sets of joints meet. This site is eminently suited for the conservation of a much larger supply as it is estimated that, with a 20-inch rainfall, the rock catchment area would provide 2½ million gallons. This Sultan puts to practical use the results of his early mission training, and besides possessing one of the few burnt-brick dwellings in the Province, he has quite a promising nursery garden of eucalyptus trees planted round his dam in order to break the wind and create shade and thus protect his supply from evaporation.

Sagayu.—This small settlement is situated at an important point from a tsetse-fly bush reclamation aspect, and, should it be desirable to increase the settlement, a well sunk at the present water hole in the Mwanangwa's village should yield a bigger supply. In order to do this, the use of explosive would be necessary. This is one of the few places where water was observed to emanate from joints in the underlying rock exposed in a water hole.

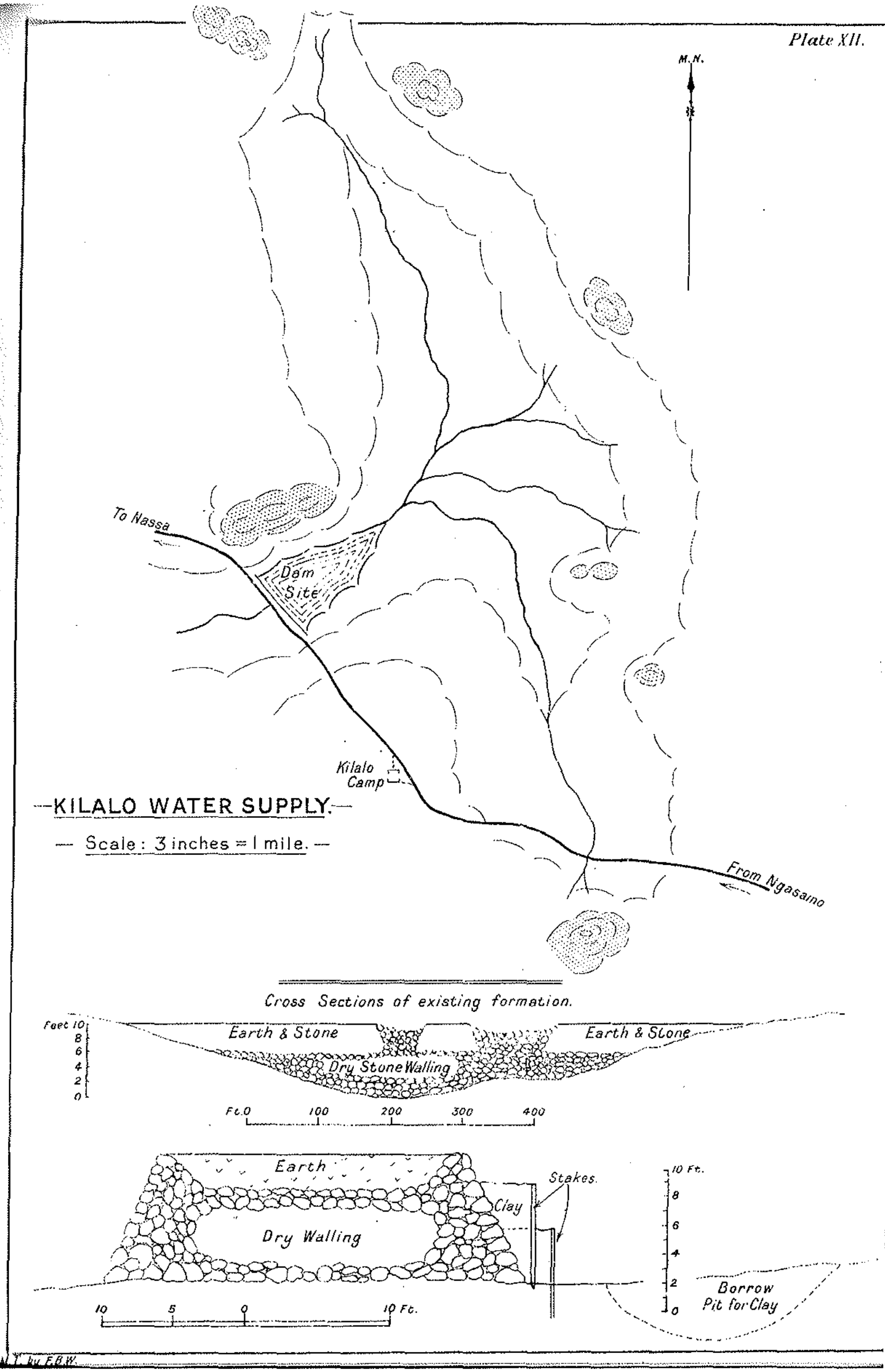
Luguru. Luguru is the head village of the Sultan of Itilima, and here the main water supply is derived from the run-off from the large flat dome of granite on or near which the village and rest camp are built. The sumps are mostly in granite embayments shut in by earth walls and are by no means watertight, so that should the rains be late, hardship will undoubtedly ensue. As it is, the water stored is not sufficient to provide for all the herds and flocks, so that as the dry season advances, only the oldest cattle and the calves are watered at the home ponds, the main herds being driven down to the valleys of the Wallati and Simiyu Rivers. This annual migration is not due to water shortage alone; grazing also is soon used up on the upland ridges and then the risk of nagana infection is faced in order to make use of the more succulent grass nearer the rivers. If drought-resisting crops such as spineless cactus and lucerne were introduced as winter feed possibly the wandering abroad in tsetse-fly infected valleys by both humans and cattle could be reduced to a minimum.

Bumera.—The principal village of the Kanadi Sultanate is in all respects similar to Luguru as far as water is concerned, though it is situated further away from tsetse-fly bush. The Simiyu valley to the south provides the cattle with both food and drink during the dry months.

Kilalo.—The natives of Maswa district appear to be fairly well off for water, due, no doubt, to the precipitation of some rain as early as September in the dry season, but at Kilalo, a village situated in the granite hills 30 miles N.W. from Maswa Administrative Post, some hardship is experienced. They have been in the habit of grazing their herds down to the Ngasamo River on one side and to the Duma River on the other, but, owing to sleeping sickness this custom is now discouraged and it is desirable that water should be procurable at some point within the fly-free area. The granite here does not seem to lend itself to the collection of run-off rainfall so readily as the areas described above, but on the other hand, being hilly country, deeper valleys are more common, and consequently topographical conditions for the construction of surface dams are more favourable.

The accompanying plan (Plate XII) shews a site that lends itself even more readily to dam construction in that a stone viaduct already exists across the valley at a very suitable point. This causeway was built in German times in connection with transport facilities to the Ngasamo Gold Mine and it would be foolish not to make use of it. The viaduct is approximately 900 feet long and built to carry a 20-foot road across it. Having been designed purely for transport purposes, it was constructed with dry stone in its lower courses, the voids between the boulders being thought sufficient to allow the flood waters to pass. Actually, these proved inadequate and the waters rushed over the top of this viaduct and partially breached it in two places

Plate XII.


M.N.
To Nassa
Dam Site
Kilalo Camp
KILALO WATER SUPPLY.
Scale: 3 inches = 1 mile.
From Ngasamo
Cross Sections of existing formation.
Feet 10
8
6
4
2
0
Earth & Stone
Dry Stone Walling
Earth & Stone
Ft. 0
100
200
300
400
Earth
Dry Walling
Clay
Stakes.
10 Ft.
8
6
4
2
0
Borrow Pit for Clay
10
5
0
10 Ft.
L. T. by F.B.W.

(*see* cross-section). At present it is not used even for a viaduct, the main road having been led along its down-stream side. The time has now come when this costly piece of work should be put to proper use, and be made to serve both purposes, viz., as a viaduct and a dam.

In order to make a dam wall of it, it must be rendered impervious. This might be done cheaply by banking up its up-stream side with clay as indicated in the lower section. The clay would need supporting, and this might be done by means of lines of driven stakes between which a basket-work of saplings is entwined. The latter are all procurable in the vicinity, and the work could be done by the local inhabitants, who are accustomed to build their dwellings on similar lines. The road could be carried over the breached portions of the structure by means of concrete or "armco" culverts, which in turn would serve as an overflow and spillway from the dam. The catchment area is considerable, and the dam should hold in the neighbourhood of 10 million gallons, and even allowing for evaporation it should yield some 700,000 gallons, enough to supply some three thousand cattle per day for six months.

IV.—SUMMARY.

During the traverse of some 360 miles water supplies have been investigated under four separate heads :—

(a) Railways.

(b) Townships.

(c) Trading Settlements.

(d) Native Inhabitants.

During the course of which, water supplies of many different localities have been investigated and discussed, and it may be said that for the region traversed, the seasonal rainfall must be looked to entirely as a source of water, and that shallow supplies derived from it will best repay development. In each case, having determined the nature of the supply, various methods of collecting it have been recommended and also different types of storage chambers discussed. In all cases masonry, i.e., roughly dressed stone set in lime mortar has been recommended rather than earth walls or embankments, and the principal reason for this has been to reduce wastage to a minimum. It is axiomatic that where the supply remains constant and the demand is likely to increase, wastage must be minimised at the inception of any scheme in order that the ultimate capacity of any supply may be arrived at, and if possible, the demand arranged accordingly.

In view of heavy evaporation losses, which can only be guessed at, most of the storage schemes recommended have been underground ones and covered in. Most of the collecting methods have been by trenching, in which broken stone plays an important part; and in the case of rivers, in which the sand in their beds is the collecting medium, a detailed scheme has been evolved and described whereby this water may be conserved and utilised. In general, wells have been recommended in schist country in preference to in granite country, and in particular the village of Sagayu is the one place where well-sinking would repay from the outset. Dams have been adversely criticised in places where conditions are unfavourable, and have been sparingly recommended in other places where conditions are most favourable.

V.—CONCLUSION.

The country traversed has a fairly generous rainfall, the direct effects of which are experienced for about 7 months of the year. The remainder of the year is provided for by the conservation which Nature affords in suitable places. The conservation is nearly always enough for the vegetable kingdom but not always enough for animal life. In the dry season wild animals can and do migrate to the spots where Nature's stores are most plentiful, and to a lesser degree the native inhabitants, through immemorial custom, do the same. In order to combat this primitive and undesirable custom, it is the duty of the leaders of the race to exercise their ingenuity towards removing the cause, and the line of action to achieve this end is summed up in the word *storage*. It has been shewn that whilst storage of water is an important desideratum, it is not *all* where cattle-raising natives are concerned ; reserves of dry-season cattle fodder must be created as well, and this subject, doubtless, is receiving the attention of those qualified to deal with it. Most of the schemes suggested will require a certain amount of muscular endeavour, a certain amount of expense on tools and imported material, and a small amount of guidance, and, where the interests of the native are directly concerned, it is assumed that their own communal labour and native funds will be called upon to provide the sinews of this campaign to make Nature's gifts more equally distributed and so to remove one of the principal hindrances to the advancement of their country.

VI.—APPENDIX I.—RAINFALL IN INCHES, 1925.

Meteorological Station.	Alt. Ft.	Lat. S.	Long. N.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	October.	November.	December.	Year's Total.
Tabora Station	3,930	5° 00′	32° 00′	5	5	7	0	1	0	0	0	0	2	23	8	51
Nzega	3,980	4° 15′	33° 08′	4½	2	8	1½	1¾	¼	0	0	0	1¼	14¼	3¼	36¾
Kahama	3,800	3° 35′	32° 33′	6	4½	11½	1½	1¾	1	0	0	0	2	8	5	41¼
Kola 'Ndota Mission Shinyanga District	3,860	3° 34′	33° 19′	4	3	5½	1¾	2	¾	0	0	0	0	8¾	5¾	31½
Mwanza	3,720	3° 32′	32° 53′	8	2	10	1	4	2	0	1	0	1	10	3½	42½
Singida	—	4° 45′	34° 45′	9¾	2½	4	0	0	0	0	0	0	1	5¼	6	28½
Dodoma	3,720	6° 15′	35° 45′	12¼	3½	1	½	0	0	0	0	0	0	2	4¼	23½

The writer is indebted to the Director of Agriculture and to the Provincial Commissioner of Central Province for the above rainfall records. The altitudes of various stations are based on figures supplied by the General Manager, Railways, for which acknowledgments are tendered.

It is regretted that no figures are available for Maswa and the eastern portion of the Mwanza Province The rainfall there seems to be of a somewhat different order, for a good downpour occurred in September, 1926, and reliable natives of that region stated that it was not unusual for some rain to fall during that month. This month was the driest of all in 1925 at other parts of the central plateau of the Territory.