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THE RECLAMATION OF SWAMP LANDS IN NORTH CAROLINA.

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A THESIS

BY

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TABLE OF CONTENTS.

INDEX OF MAPS AND DRAWINGS.

I. INTRODUCTION.

Prior to the Civil War, in the days when slavery flourished in the South, North Carolina had no drainage problems. Such drainage as was required to remove enough water to render the fields tillable was easily and cheaply accomplished by digging ditches with slave labor, and the vast areas which were too low or too great in extent to be reclaimed in this way were given over to the production of rice, which was at that time one of the largest crops. Many of the most magnificent of the old ante-bellum estates are found today in the midst of trackless swamps, in conditions which are travesties of their former grandeur, owing in a large measure to the failure of rice as a profitable crop. Forests of pine and hard-wood trees are now found growing where the ridges thrown up by the plow before the war are still visible.

In the re-adjustment following the state of paralysis in which the country found itself after the war, it was found imperative to abandon all but the most cheaply cultivated lands, and only in comparatively late years has the demand for farm land justified any effort to again bring this abandoned area under cultivation. The first efforts were very sporadic, done on a small scale by individual planters, and until 1909 there was no way in which concerted action could be taken and the reclaiming of the wet lands accomplished on a comprehensive basis. In 1909 the present drainage act was passed and became a law, and the actual work begun. North Carolina was the first Southern state to pass an adequate drainage law, and since that time has become the most active state in the drainage movement in the South.

II. GEOGRAPHICAL CONDITIONS.

The state of North Carolina may be divided geographically into three sections, merging more or less gradually into each other, but each section having distinct characteristics. On the east, along the coast, is the Coastal Plain section, low and flat with a gradual slope toward the sea and containing some of the richest land in the state. This section extends west as far as the"fall line", where begins the Piedmont section which occupies the center of the state. Here the rolling hills of red clay are the marking features. At the western end of the state is the Mountain section, where the highest mountains east of the Rockies are found.

The area of North Carolina is 31,194,600 acres, and of this approximately 2,400,000 acres, or 7.7 %, can be classed as reclaimable swamp. By far the major portion of this wet land lies in the coastal plain, and practically none in the mountain section. In the Piedmont section there are no large swampy areas, the wet lands being the bottoms contiguous to streams.

In the northeastern corner of the state lies the Dismal Swamp, partly in Virginia and partly in North Carolina. In Virginia the Dismal Swamp is largely under water, its liquid heart, Lake Drummond, lying wholly within that state, and furnishing the water-supply for the cities of Norfolk, Portsmouth and Berkley, Va. There is small probability of draining that submerged territory, at least in the near future, since the juniper, cypress and other swamp timber which grows to enormous size there is more profitable than farm crops. The southern end of the Dismal Swamp is out of water at most seasons of the year, and spreads out until it is lost among the chain of swamps along the sounds. South of the Dismal Swamp Albemarle Sound extends west into the state a considerable distance, and between Albemarle and Pamlico Sounds are several counties which are almost entirely swamp.

In the southeast corner of the state is another large wet area. Between this and Pamlico Sound there are occasional high ridges, but the swamps predominate.

The rivers along the coast are deep and sluggish, and there is very little erosion. Along the sounds the land is but little elevated above sea level, and is extremely difficult to drain, the capillary action of the soil often being sufficient to cause a swampy condition.

III. NORTH CAROLINA DRAINAGE LAW.

With the recent awaking of the South to its agricultural possibilities under scientific methods, came the demand for more land, and attention was again turned toward the rich wet lands. Following the example of the middle western states, North Carolina passed a drainage law in 1909 which enabled the land-owners to obtain relief from wet conditions by concerted effort.

This law provides for the formation of drainage districts, upon presentation to the Court of a petition signed by a majority of the land-owners, or the owners of three-fifths of the land effected. This petition describes approximately the boundaries of the proposed district, and approximately the improvements required. If the petition is favorably entertained by the court, a Board of Viewers is appointed to make a preliminary examination and report as to whether the proposed work is feasible or not. The Board of Viewers is composed of two citizens of the county or counties in which the district is located who do not own land in the proposed district, and a drainage engineer who must have the recommendation of the State Geologist. The engineer is given thirty days in which to make a preliminary survey and map, and at the end of that time he and the other two viewers submit their report in writing to the court. A meeting is then held at the court house where the report is heard, and any objections thereto are considered. If it appears to the court that the drainage is feasible, and that the expenses will not be more than the benefits to be derived, the Board of Viewers is instructed to make a complete survey of the district, to determine accurately the boundaries of the district and of each tract of land within it, to locate the proposed improvements plainly on the ground, to prepare maps, plans, profiles and specifications for the work, to classify each tract of land according to the benefits to be derived as a basis on which to levy the assessments, and to submit a Final Report embodying the results of their findings. This Final Report is submitted to the court at the end of sixty days, unless an extension of time is granted, another meeting held, and if the plan still appears feasible, after all objections are heard, the district is declared established and the Viewers discharged. The land-owners then elect three Drainage Commissioners from among their number, who are incorporated and have the power to administer the affairs of the District, to issue bonds and let contracts. They employ an engineer, who may or may not be the one who made the survey, who is called the Superintendent of Construction, and whose duties are the customary ones of a resident engineer on construction. The commissioners issue bonds to defray the expenses of the work, and all costs of the survey and preliminary work are taken from the first money received from the sale of the bonds. In case the Final Report of the Viewers is unfavorably decided upon and the proceedings dismissed, the costs are paid by the petitioners, who file a bond for that purpose with the court when the petition is first handed in.

The lands are assessed according to the classification of the Board of Viewers, and the money collected in the same manner as other taxes. Nothing is collected the first three years, giving the owners an opportunity to clear their land and raise crops, and at the end of the third year one-tenth of the principal and the interest is collected. This same amount is collected each succeeding year for ten years, until at the end of the twelfth year the assessment is paid in full and the bonds are retired. The bonds are issued in any denominations the Commissioners see fit, usually $100, and bear interest at the rate of 6 per cent.

IV. PRELIMINARY SURVEY.

The making of the preliminary survey is often a very cursory performance. Government maps, such as those of the Geological Survey, or the State Soil Survey, give information that is frequently sufficiently full and accurate for the purpose, or a hasty instrument survey is sometimes made, taking transit and level notes at the same time, and a rough sketch map drawn. There are times however, when the lay of the land is such that a complete survey must be made before the boundaries can be even approximated, or evan the nature of the improvements determined. In this event it is customary to do the work in such detail that it will not have to be done again at the time of the final survey.

V. SURVEYING PROBLEMS.

Without having recourse to words which may be subject to deletion by the censor, it may be said that field conditions for making drainage surveys in North Carolina are bad. The swamp land is mostly covered with a heavy growth of timber and underbrush, and where the timber has been removed by lumber companies, the ground is covered with the "tops" which are left after the saw-logs are removed, and which form a tough obstacle to be overcome. The cane-brakes and swamp grasses grow to eight or ten feet in height, and the woods are full of brier bushes and vines which are the bane of the drainage engineer. The soil in the swamps is mostly a loose peaty muck, composed of partially decomposed vegetable matter, and is very soft under foot. Where water covers the ground at most seasons, it is not uncommon to find depressions with a mat of vines and leaves over the surface of the water which supports a growth similar to that on land. This deceptive appearance leads to frequent trouble. Cold weather renders the work difficult and very disagreeable, for dry clothing is an impossibility. During warm weather the abundance of snakes and an occasional bear adds a touch of excitement, very likely to both parties.

In making a survey of this kind, there can be no hard and fast rules to go by. Each project has its own peculiar conditions, which have to be met in varying ways. The organization of the field party is the first move. In general, there must be at least one transit party and one level party. Where time is not pressing, one party can work alternately on level work and transit work, but it is generally less economical and as the two depend so largely one on the other, it is best to have a party at each working simultaneously. The transit party should consist of an instrument-man, two stadia rodmen who act as chainmen on location, sometimes a backflagman, and several axemen, their number depending on the nature of the country. The axemen are very important men on the party and on them depends largely the progress of the work, and they draw salaries in proportion. The level party should consist of the level-man, one or two rodmen, and if but one rodman, an axeman. Where time is of great importance two transit parties are sometimes used, one of which runs out property lines while the other is engaged in obtaining data on the topographical features. The camp cook completes the organization, and as always is its most important member. The writer is of the opinion that better and in the end cheaper work is obtained where the chief of party attempts no instrument work himself, but superintends the work of the others in the field, and does it in the field rather than from an office chair.

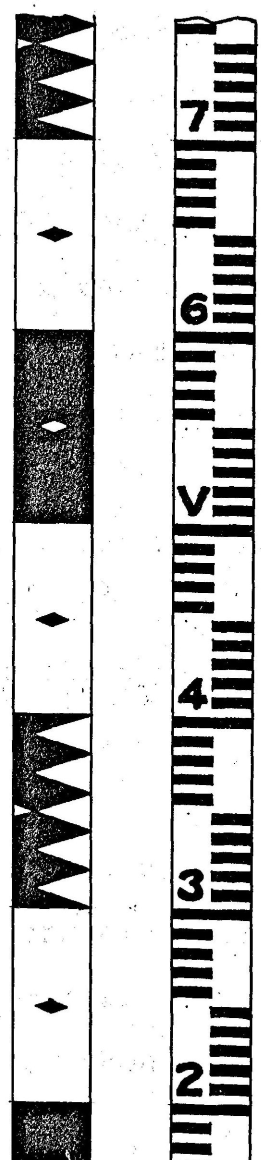
The location of the camp site is an important item. Owing to the inaccessibility of the territory to be covered, it must be pitched as far into the swamp as possible to avoid long walks to and from work, and at the same time must be close to a road for the carrying in of supplies, and also as it has to be moved as the work progresses. The question of transportation is a troublesome one, and the moving of a camp outfit for a dozen men is a big job in a country where a "team and wagon" generally means a mule and cart, even they being rather scarce.

A wholesome water supply must be considered, but in the swamps along the coast the ground water, which is never far below the surface, or even the surface water where cypress or juniper trees grow, is as good as can be obtained. This juniper water, although a deep reddish brown in color, is clear and very potable.

One of the first problems to be solved is that of what data it is necessary to obtain. It may be that the district boundaries can be determined only after numerous lines of levels have been run back and forth to locate the water-shed line, or it may be that a line of profile levels along the routes of the proposed canals will be sufficient. Property lines must be located, but frequently they can be plotted on the map from the deeds by reference to the roads, streams and other topographical points. Roads and water courses are always located by actual survey, but it is sometimes impossible to determine the location of the runs of the swamps, in which cases their edges are located.

Nearly all the transit work is done by stadia. For the making of maps of several thousand acres of land this system has been found to be nearly as accurate as the slower chain survey, which latter method could not well be used in meandering streams or the edges of swamps, where many side-shots are taken from one set-up. The writer has in mind several districts where canals were located at distances of exactly one mile apart by chain, and later checked up by stadia, the two agreeing very closely.

Two stadia rods are here illustrated which are in common use. The preference is generally for the rod no. 2. This rod was first used by the writer while with the U. S. Dept. of Agriculture, Drainage Investigations, and has been found very satisfactory. This rod has each foot graduated, and marked in large figures, which is very advantageous at times as the rod may be partly hidden behind trees or brush so that the intercept cannot be determined except by reading the top and bottom figures. These figures are legible except on extremely hot days for distances up to 1000 feet, and often much farther under favorable conditions. The



NO. 1 NO. 2

writer has plotted many shots over 2000 feet, and recalls one shot of 3200 feet. On shots of over 1000 feet, however, their accuracy cannot be guarranteed to be closer than the nearest 10 or 20 feet. These rods are most useful when made 15 or 16 feet long, for while the great majority of shots are less than 1000 feet, the bottom few feet on the rod is generally hidden by brush. They are made of straight 1/2" x 5" poplar or cypress, or are made 3/4" or 1" thick at the center of the rod, tapering off toward each end. As will be seen from the illustrations, rod no. 1 can be read direct to the nearest 10 feet, and rod no. 2 to the nearest 5 feet. Further accuracy is unnecessary, since the maps are seldom if ever plotted to a larger scale than 1 : 1000, and a distance of less than 5 feet could not be shown on that scale. In practice the rod is first faced toward the instrument-man for a "distance" reading, then on signal turned edge on for "line". Another advantage in using the no. 2 type of rod is that it can be used for rough work in leveling to supplement that of the level party.

The rest of the equipment of the field parties is what is commonly used on any other survey, except that the axemen are provided with machetes for cutting brush. These machetes are long slender knives similar to a corn knife but considerably heavier, and are made with leather scabbards by which they can be carried strapped around the waist and out of the way when not in use. It is used for cutting high grass and reeds, stakes and markers, and a good blow will cut down a tree two inches in diameter.

At the start of the survey, a base line is established, usually along some road near camp, at least 1000 feet long, its length measured carefully with the chain and substantial hubs set at each end. The instrument is set up over one of the hubs, the azimuth of the base line determined from an observation on Polaris or merely by dropping the magnetic needle, and the stadia work begun. Although the survey is frequently oriented by reference to the magnetic needle, the compass has been found too unreliable to use throughout the survey, and once the direction of the base line has been established all future work is done by azimuth.

A survey of the roads is first undertaken as a framework upon which to base future traverses. Although the canals are located by chain survey and theoretically should be the more accurate, it has been the practice of the writer to use the road traverses as the control for the survey and maps, as they have proved to be more reliable. If possible this road survey is made complete over the entire district, although no attempt is made to show features which are too small to show up on the map. Substantial hubs are used in marking points on the road traverses for future reference, one of the axemen keeping up with the head-rodman and preparing these stakes so that no time is lost. Another axeman usually acts as back-flagman, for there is little cutting to be done along the roads, and on the other work such as boundary and creek surveys where heavy cutting makes slow progress, the instrument-man sets his own "dead-man" for a back-sight. In the woods there is little danger of its being disturbed even by wind.

Starting form a point on the road traverse, a meander of the water courses is next run. Occasionally the edges of the swamp are run out and the creeks located by offsets from points on the edge. This is done by the rodman, who paces the distance over and calls it to the instrument-man. The accurate location of the natural water courses would be one of the most difficult operations, but fortunately great accuracy is rarely required since the runs are never deep and of little consequence in the location of canals. The growth is very dense along them and they are very crooked, necessitating short sights which increase the liability of error, both in field work and in plotting notes. This part of the work is done where it is impossible to see any distance ahead, and it is here that a good axeman and rodman make their presence felt.

In districts where the land is all flat it is necessary to run cross lines back and forth across the territory, and where there are no wagon roads or old lumber tram roads available these lines are run at regular untervals, generally one mile. It is sometimes possible to locate these preliminary lines so as to make use of them later as canal locations without re-running.

The writer has tried plotting notes both in the field and in the office, and is of the opinion that if night work can be avoided, field plotting is best, although much is to be said in favor of both methods. The advantage of having the map constantly at hand for reference and for planning work ahead cannot be discounted, but the practice of having the instrument-men keep up the map in addition to their field work, depending on rainy days and Sundays which seldom materialize when most needed, is bad. It usually means that the camp is kept working late into the nights at times when field work is heaviest and rest most needed, and the discontent and loss in efficiency is not to be disregarded. Unfortunately the great cry is always for keeping down costs and a draughtsman in camp is regarded as a luxury. Where the chief of party does no instrument work, he can very conveniently work on the map and keep it up to date.

Office plotting can be accomplished in two ways, neither of which offers many inducements. The entire map can be left until the field work is completed, in which case the mistakes that invariably creep into the best of work will not be discovered until too late, and the whole survey will have to be conducted more or less "in the dark". Another method which appears feasible enough on its face but which does not work so well in practice, is that of having each day's notes copied on blank forms for the purpose and mailed in each day to a draughtsman in the office, who can save much time by the use of a draughting machine and other conveniences, besides being able to devote much of his time to other work. This plan was tried by the writer on the survey of Columbus County Drainage District No. 2, and it was later supplemented when the need became apparent by having a tracing made of the office map, on tracing paper, which was mailed back and forth between office and camp for revision. The disadvantage of this plan proved to be the copying of notes, which as the field parties broke into their stride became more and more numerous, and the night work actually done in copying notes was more than would have been required to plot them in the field. Another drawback was that the sketch map was generally in the office when most needed on the work.

The level work in connection with a drainage survey must be done with more precision than the transit work. The differences in elevation are in many cases so slight that a few tenths may show the location of the boundary or a proposed canal, and an error of a few tenths may throw these lines several hundred feet off. The work is carefully done with an engineer's wye level and Philadelphia rod, not with the so-called "drainage level", and where there is any choice between instrument-men, the best man is given the level. The preliminary work consists of bench mark levels along all the main roads and along water courses which are likely to be used later as canal locations, establishing benches every half mile in convenient places. The limits of allowable error are usually taken as about 0.04 times the square root of the distance in miles, although lines which exceed this by no great amount are not re-run. All benches are checked at least once, and often several checks are obtained during the course of the survey.

The elevations of turning points and all ground elevations are plotted on the map by reference to transit points, the rodman pacing the distances. A "x" mark is made on the map , and the elevation set down under it. These points take the place of contours in obtaining a graphical idea of the country and are generally all that is required except for canal lines.

When the canals are located, profile levels are run taking center readings at each station and checking as often as possible on one of the bench marks. As the land is so uniformly flat, the reading on the center line is all that is taken and a one-level section is used in computing quantities.

All instrument work is extremely difficult in the swamps on account of the impossibility of getting a solid set-up. A very slight motion will throw the bubbles off so walking around the instrument is not to be thought of, and the ingenuity of the instrument-man is often severely taxed in planning his set-ups. Large tree stumps are used wherever available, three cypress "knees" often support the tripod, and where the tripod legs have to be forced into the ground, it requires elaborate contortions to preserve the stability of the instrument.

VI. ENGINEERING PROBLEMS.

The engineering problems connected with North Carolina drainage districts vary to a large extent with the locality. In the Piedmont section, surface water only need be provided for, while along the coast both surface and ground water must be taken into account. Often the ground water from territory at a considerable distance proves troublesome. This is especially true in the north-east corner of the state, where the flow of ground water at times attains great volume and velocity and is known as the "back-press". Its peculiarities have never been thoroughly investigated and in designing canals the very unsatisfactory method of obtaining information about it from local sources must be depended upon. The swampy condition of at least one district in this section can be attributed to this "back-press" alone, since its conformation is such that under ordinary conditions it should not be wet.

The precipitation along the coast of North Carolina is heavier than at any point along the Atlantic seaboard except Florida. Cape Hatteras has perhaps the most uniformly heavy rain-fall of any place in the country. The mean annual precipitation there for a period of 40 years is 60.2 inches, with no very marked rainy seasons. The average mean annual precipitation for the coast section is about 55 inches, July and August being the months of heaviest rainfall with from five to eight inches average. Severe stormy periods occurred in July in 1899 and 1908, precipitations of from 10 to 17 inches being recorded at many points. These exceptionally heavy rains are disregarded however in designing drainage works, only the mean of the heavy rains being taken. At points further back from the coast, the precipitation is much less, reaching a minimum in the center of the state and increasing again among the mountains.

However, while it is the individual storms which govern the sizes of canals required, it is not economical to design works of a size to take care of exceptionally large rains which occur only at long intervals, or even to immediately remove the water reaching the canals from such storms as are of frequent occurance. A system of canals which will remove the run-off from an ordinary storm in 24 hours has been found to be adequate in preventing overflow from such storms, and will generally remove the run-off from the big storms in from 36 to 48 hours without damage. Since running water is not injurious to crops if they are not too long or too deeply submerged, this is ample protection, and canals designed on this basis are seldom overflowed.

By the term "run-off" is meant that part of the rain-fall which reaches the canals or other water-ways as surface water. This factor depends upon so many conditions which cannot be reduced to figures that it can only be estimated. Besides the probable amount of precipitation, the run-off factor is influenced by the character of the soil, its degree of previous wetness and the slope and shape of the drainage area in respect to the water-way. Local conditions alone can be taken into account, but in general it may be said that the run-off is estimated to be from 1/4 to 3/4 inches per 24 hours. A run-off as low as 1/4 inch is too small to be used except for unusual sonditions of soil or slope or for very large areas, and 1/2 inch per 24 hours is perhaps more frequently used than any other figure, although 3/4 inch is not uncommon. A run-off greater than 3/4 inch is seldom used except for very small districts or individual farm systems.

In computing water-shed areas the topography sheets of the U. S. Geological Survey and the soil maps of the Dept. of Agriculture are very useful. These areas are figured only approximately, and are seldom actually surveyed. On the coastal plain the drainage area may be no larger than the drainage district, and is frequently the same, but where streams extend outside the boundaries of the district, the run-off from all the territory which they serve must be provided for.

The problem of establishing gradients for the canals is at times very troublesome, especially in large districts. The coastal plain slopes toward the sea at the rate of approximately one foot per mile, and it is sometimes impossible to obtain this slope for the canals in some of the larger districts. However a much greater fall can usually be attained without excessively deep canals by easing off the abrupt drop generally found where a small stream enters a large one and at many places along the coast. Often a large swampy area is found in a dish-shaped conformation, in which case the outlet must be cut through the rim, necessitating a very deep cut at the rim. In the Piedmont section the average fall per mile is approximately three feet, which is ample to secure good drainage except where the natural water courses are very crooked or become filled up. Grade-lines are laid so as to produce canals with an average cut of 7 or 8 feet, following as nearly as possible the general surface of the ground.

All the formulas for computing the size of water-ways are empirical. The data from which canals are computed is in so large a measure estimated, and the successful operation of the canals depends so largely upon uncertain climatological conditions, that these formulas are sufficiently accurate. All are based upon Kutter's formula, which is itself sometimes used although rather unwieldy, using as values of the coefficient "n", from .025 to .030. The use of this formula is very much simplified By the use of Church's Curves, where the velocity is read from curves for different values of "n", slope, and hydraulic radius. The writer uses a formula known as Elliot's Formula, devised by C. G. Elliot, former Chief of Drainage Investigations, U. S. Dept. of Agriculture, which gives results approximating those obtained by the use of Kutter's formula, and is satisfactory when applied to drainage canals as usually constructed. This formula is:

$$v = \sqrt{\frac{a}{p} \times 1.5\ f} \quad ;$$

where v = mean velocity in feet per second,

a = area of water-way, square feet,

p = wetted perimeter, in feet,

f = fall in feet per mile.

Having computed the velocity, the discharge is found by the formula: $Q = av$;

where Q = discharge in cubic feet per second, to which unit the run-off to be removed must be reduced.

In computing canal sizes, a factor of safety is sometimes introduced by assuming them to flow only 3/4 or 7/8 full under ordinary circumstances.

Another important item in the design of a canal is its section, depending largely on the character of the soil. A depth of from 5 to 8 feet has been found necessary to secure adequate outlet for the field ditches and this depth is used wherever possible. This is deep enough to provide for shrinkage of the soil which always occurrs when the water is removed, sometimes as much as 20 or 25 %, and will allow for the deposit of silt for several years before cleaning out is required. The main and outfall canals are more subject to silting up than the smaller laterals since their velocity is less, and are kept as deep as possible on this account. This settling out of the silt and suspended matter brought down during periods of rainfall is especially noticeable where the canals empty into salt water, which has a very marked clarifying action on muddy water.

The canal prism is given side-slopes which are as economical as possible with the nature of the soil in view. Trapezoidal sections with a hydraulic radius of .5 d are the most economical, but this ratio cannot always be obtained on account of the soil. Ordinarily slopes of 1/2 to 1 are specified, but where sand is encountered slopes of 1 to 1 or eben 2 to 1 are necessary to prevent caving of the banks. Where the material encountered is clay or blue marl which is found in some localities, the banks stand up with the slopes left by the dredge very well, but there is a great tendency to cave if there is sufficient sand to make the soil friable. Some specifications allow the ditch to be cut narrower and deeper than called for by the plans, so that when the caving has taken place the finished section will be of the required size. There is very little rock encountered in eastern North Carolina, but where it is found it proves as troublesome as in any other locality. The writer speaks from experience on this point.

In depositing the material excavated from the canal along the sides, a berm or clear space of from 4 to 10 feet is required to be left between the bank of the canal and the toe of the waste-bank. Openings are also left in this waste-bank to allow the surface water to reach the canals and for the construction of field laterals. These openings are ordinarily left where desired by the land-owners, at no regular intervals.

Secondary drainage, such as field ditches or tile drains to supplement the main outlet canals, is not provided for in the plans for a drainage district, even though the system is never complete without it. It is up to the owner of the land to take advantage of the outlet provided since he is the only person benefitted by the laterals. The use of tile drains in North Carolina is far from extensive as yet, although the price of land is becoming such as to render it expedient to fill up the old open ditches and make use of the territory now wasted in ditches and banks.

The classifying of the land according to the benefit to be derived is another problem which confronts the drainage engineer, together with the other two members of the Board of Viewers. It is provided by law that the land be placed in five classes, A, B, C, D and E, and assessed according to benefit in the ratio of 5, 4, 3, 2 and 1, respectively, Class A receiving the most benefit and paying the highest tax. In making the classification the present condition of the land, its degree of wetness and amount of natural drainage, value of the land, probable cost of improving it after the canals are constructed and the likelihood of its being improved, are points that must all be taken into consideration and given due weight in making the classification.

The most important factor influencing the classification of a tract of land is perhaps its proximity to one of the proposed canals, but where there is an existing water course, this natural drainage before the improvement must qualify the judgement. The length and number of field ditches which will be required to properly drain the land is a good criterion to go by. Since the engineer must work in conjunction with the other two members of the Board of Viewers in making this classification, it is sometimes hard to get results which are the outcome of unprejudiced observation. This is one of the most delicate matters in connection with the establishment of a drainage district, and no matter how carefully done, it will be open to criticism from some point of view, and rarely fails to receive it.

With the engineer's report must be an estimate of the cost of the improvements, and as the law provides that no bids for the work can be entertained for more than the engineer's estimate, the figures must be high enough to make the work attractive to contractors. In making this estimate, the engineer must have a knowledge of the work from the contractor's point of view, and of the prices for which similar work has been let, and be governed accordingly. Seven and one-half cents per cubic yard is about the average price received for earth excavation through timber, although in the writer's estimation this figure is too low to insure good work being done at a profit. Some specifications provide separate items for excavation and for clearing right of way, although many contracts are let where the price per cubic yard includes everything necessary to be done in the construction of the canals.

The engineering of a drainage district to a successful termination requires the exercise of a large amount of tact. The dealings of the engineer are almost entirely with farmers, and unless he gets their attitude and sees their point of view and deals with them accordingly there is bound to be friction, which is both costly and unnecessary. While strictly speaking the engineer's duties end when he complies with the requirements of the law, it has been the writer's experience that if the district is to be established it devolves upon the engineer to make sure that all legal papers are properly served, all required notices posted and affidavits made, to interpret the law to both farmers and lawyers, and also to smooth over misunderstandings and pacify those landowners who have grievances which are many times imaginary. The question of the cost of the work is generally the subject over which most disputes arise, especially the cost per acre, which is very commonly exaggerated by those opposed to the work, being placed even as high as $ 100 per acre. It actually seldom goes beyond $ 10, for Class A land. And the engineer is blamed for it all.

VII. ENGINEERING DURING CONSTRUCTION.

The engineer's duties as Superintendent of Construction are not very heavy. Except on very large districts or where there are several dredges at work it is not customary for the engineer to remain or keep an assistant on the job at all times, but to inspect the work once or twice a month only, and measure completed work for preparing the monthly estimate.

Although slope-stakes should be set for all work, this is seldom done unless by the contractor himself, and generally the center-stakes are all that are set. Owing to the more or less rough nature of the work, considerable lee-way is allowed the contractor and if the work is done in a workmanlike manner and in good faith it is not held up for minor infringements on the specifications. The most common cause for complaint is the caving of banks after the dredge has passed, and the washing back into the canal of stumps and roots. Clean-up work such as this is usually allowed to wait until the end of the job, unless it interferes with the operation of the canals, when it is done and the system turned over to the district in first class shape.

The monthly estimates are (by law) for 90 % of the completed work, the remaining 10 % being held back until the final completion and acceptance.

It is a regrettable fact that in many instances the Superintendent of Construction chosen by the Drainage Commissioners is not an engineer, but some land-owner or interested party. This practice is not only contrary to the theory that the engineer should be "neutral", impartial to both sides and acting as a buffer between them in cases of dispute, but is apt to prove very expensive to both the district and the contractor.

DESCRIPTIONS AND MAPS

OF VARIOUS NORTH CAROLINA

DRAINAGE DISTRICTS

EXPLANATION OF SYMBOLS ON MAPS

Drainage Canals.

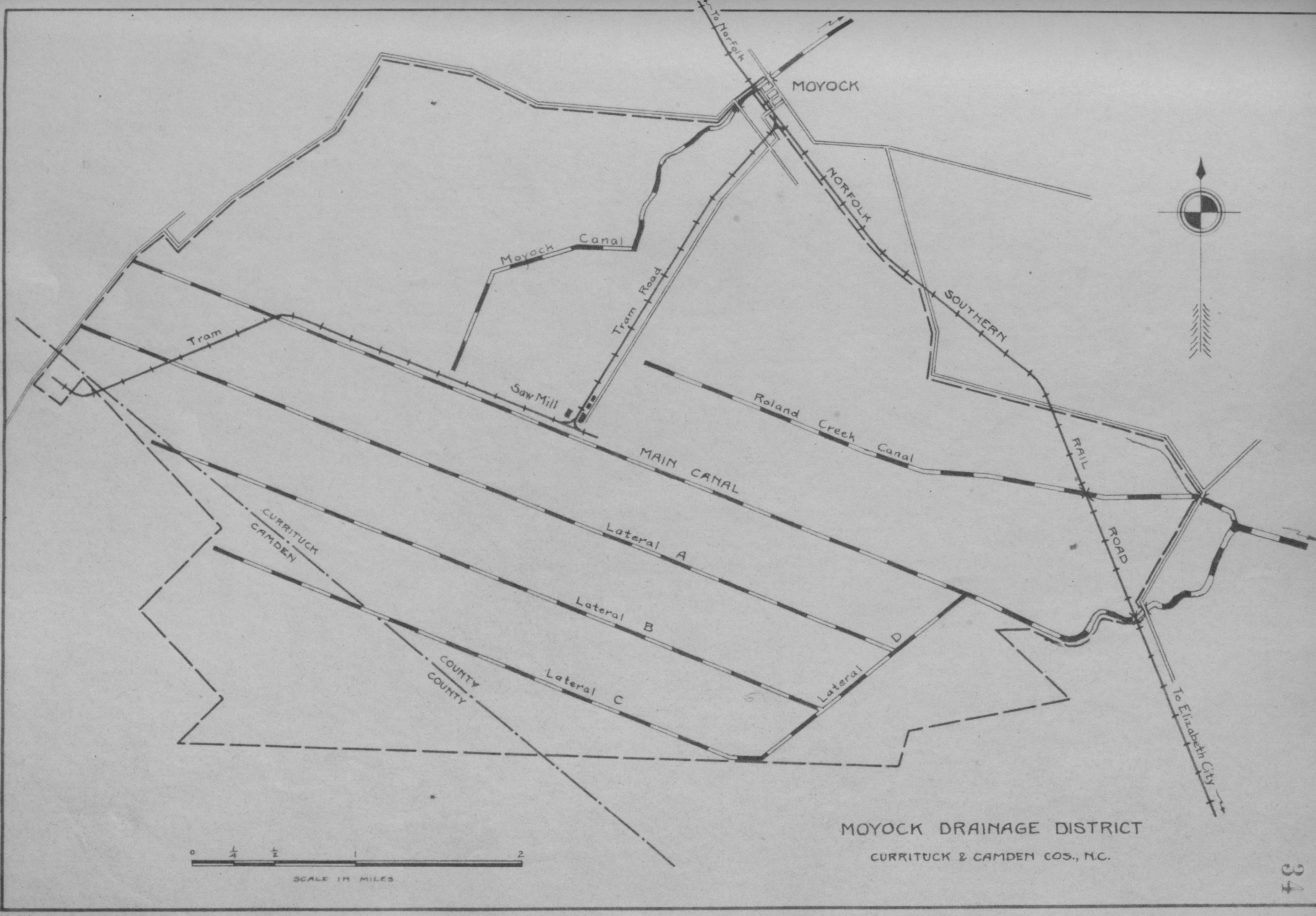
Levees.

District Boundaries.

Property Lines.

Wagon Roads.

Rail Roads.



To Norfolk
MOYOCK
NORFOLK
SOUTHERN
RAIL
ROAD
To Elizabeth City
Moyock Canal
Tram Road
Tram
Saw Mill
Roland Creek Canal
MAIN CANAL
Lateral A
Lateral B
Lateral C
Lateral D
CURRITUCK COUNTY
CAMDEN COUNTY
0 1/4 1/2 1 2
SCALE IN MILES
MOYOCK DRAINAGE DISTRICT
CURRITUCK & CAMDEN COS., N.C.

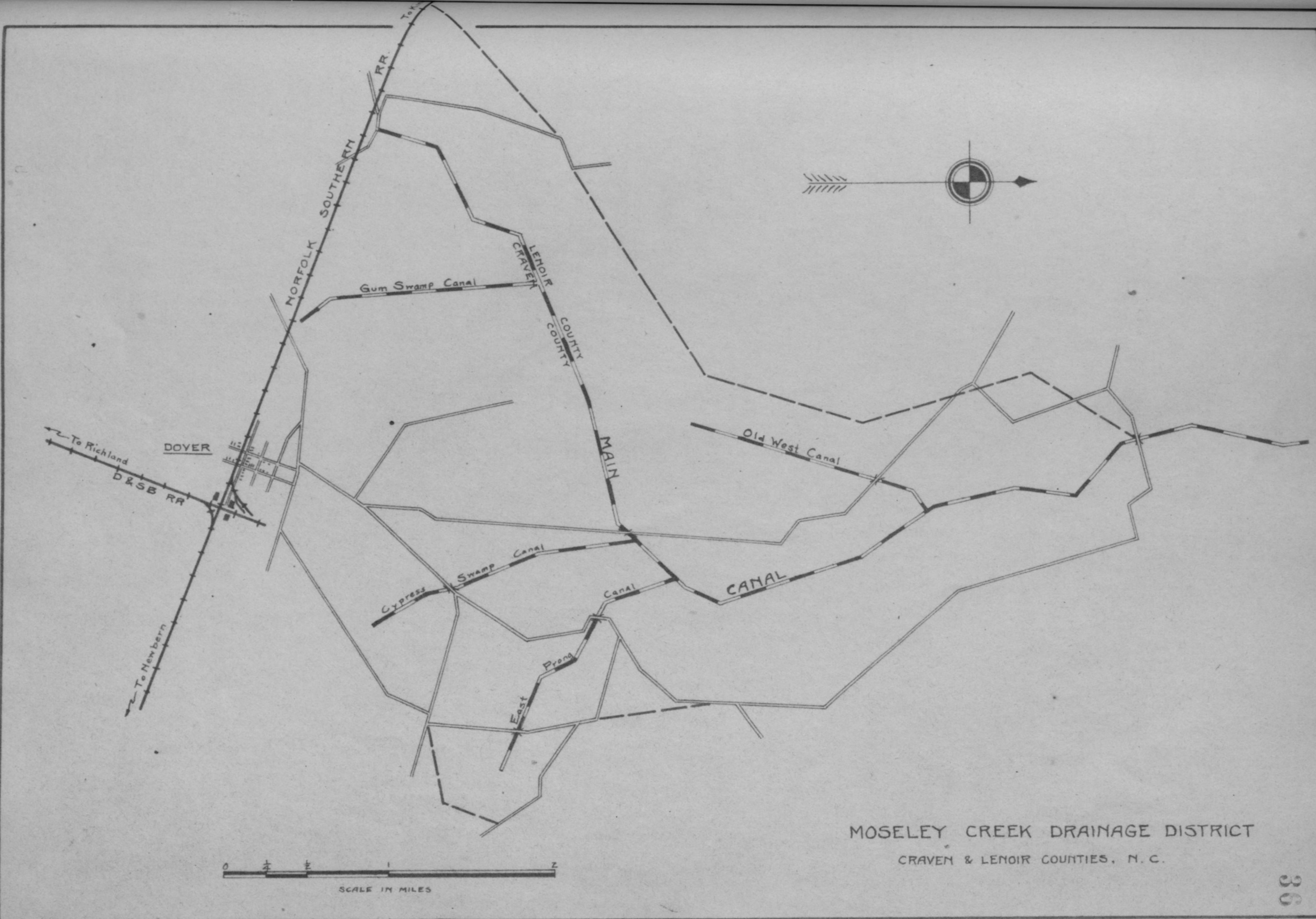
MOYOCK DRAINAGE DISTRICT.

This district is located on the edge of the Dismal Swamp and was the first to be organized after the passage of the drainage law. Most of the land was owned by a development company, who bought their own dredge and did the work themselves. The soil is a very rich black loam and was mostly covered with dense timber when the work was started.

Seven canals were designed and constructed, as follows:

Canal.	Length.	Yardage.	Cost.
Main Canal	7.5 m.	279,861	8.5 ¢
Lateral A	5.25 m.	121,360	8.5 ¢
" B	4.25 m.	85,213	8.5 ¢
" C	3.5 m.	66,500	8.5 ¢
" D	1.5 m.	36,208	8.5 ¢
Moyock Ditch	3.0 m.	56,854	10 ¢
Roland Creek Ditch	3.5 m.	87,122	10 ¢
Totals -	28.5 m.	733,118	

There are 12,418 acres in this district.



NORFOLK SOUTHERN RR
LENOIR COUNTY
CRAVEN COUNTY
Gum Swamp Canal
MAIN CANAL
Old West Canal
DOVER
To Richland
D&SB RR
To Newbern
Cypress Swamp Canal
East Prong Canal
0 ¼ ½ 1 2
SCALE IN MILES
MOSELEY CREEK DRAINAGE DISTRICT
CRAVEN & LENOIR COUNTIES, N. C.

MOSELEY CREEK DRAINAGE DISTRICT.

The canals in this district drain a territory contiguous to Moseley Creek, one of the tributaries of the Neuse River. There is but little difference in elevation between the high land and that in the swamps and when the swamps overflowed great damage was done to the crops. The district is thickly settled and well cultivated.

The survey was made in 1910 and the work done in 1912-13. The four canals are as follows:

Canal.	Length.	Yardage.	Cost.
Main Canal	10.0 m.	355,487	7.5 ¢
Gum Swamp	1.5 m.	15,232	21.0 ¢
Cypress Swamp	1.75 m.	12,506	16.5 ¢
East Prong	1.75 m.	11,760	18.5 ¢
Totals -	15.00 m.	394,985	

The bridges were built by the land-owners.

There are approximately 8000 acres in the district.

WAYNE COUNTY DRAINAGE DISTRICT NO. 1.

This district is located on the edge of the Piedmont section, the land reclaimed being the bottom land along Bear Creek and its tributaries. The soil along the creeks is very rich, much more so than the adjoining high lands. The bottoms vary from a quarter to a mile wide.

The survey was made in 1911-12 by a party of six men and cook, organized as follows:

(1) Level-man (chief of party) and rodman;

(2) Transitman, two stadia rodmen, and one axeman.

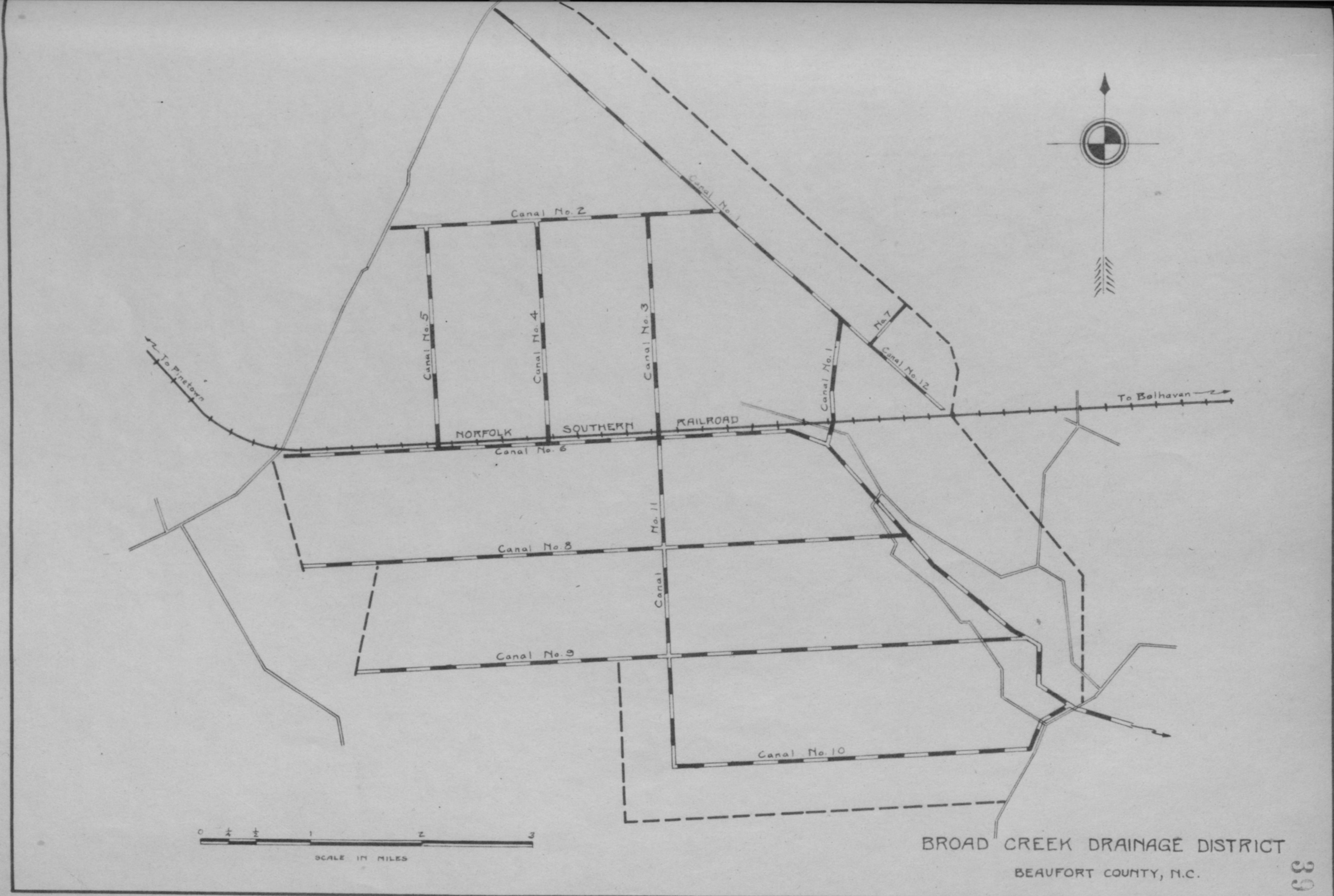
Very little timber was encountered except on the lower end of the creek, but the banks of all water courses were solid masses of briers.

One main canal and one lateral were designed:

Canal.	Length.	Yardage.
Main Canal.	10.25 m.	211,221.5
Northwest Prong.	4.0 m.	78,207.9
Totals -	14.25 m.	289,429.4

The engineer's estimate for the cost was 9 ¢ per cu. yd., but the contract price was 6.2 ¢. The nearest bid was 8.45 ¢. The Supt. of Constr. was not an engineer and the contractor was able to have enough "extras" allowed to require an additional bond issue.

There are 2691.3 acres in the district, mostly in Class A.



BROAD CREEK DRAINAGE DISTRICT

BEAUFORT COUNTY, N.C.

BROAD CREEK DRAINAGE DISTRICT.

This district was organized for the purpose of developing a large tract of land belonging to a company who did the work with their own dredges. The preliminary survey was made and the main canals laid out by the U. S. Dept. of Agriculture, Drainage Investigations, The laterals were later laid out as shown on the accompanying map, but no figures are obtainable as to their sizes or cost as they were constructed to suit the ideas of the land company. The district contains 20,514 acres, very little land being owned by individuals.

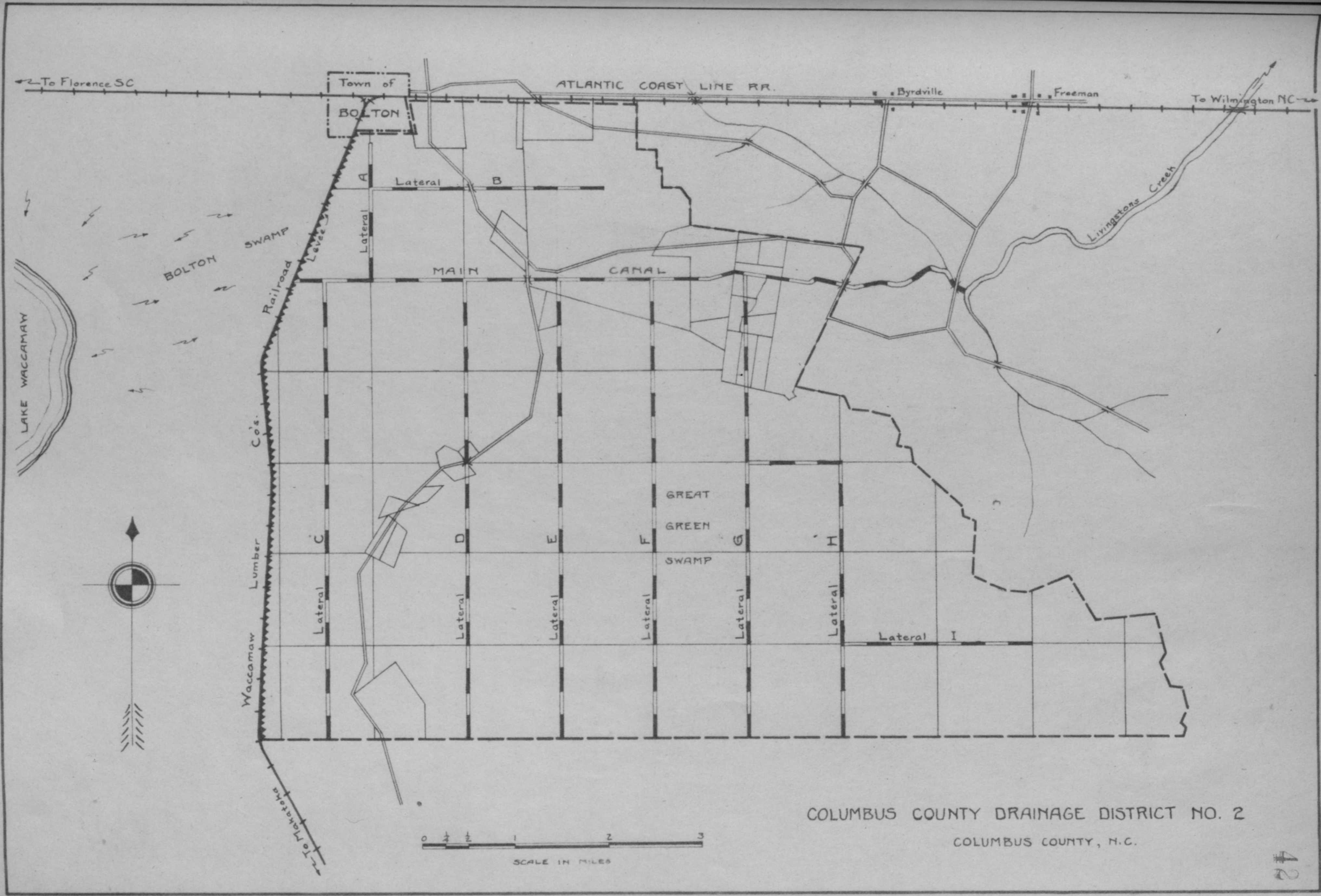
EDGECOMBE COUNTY DRAINAGE DISTRICT NO. 1.

This district comprises the bottom land along Deep Creek, is about ten miles long and over a mile wide in places. The survey was made in 1911 by a party of three; instrument-man and two rodmen, with two axemen employed for a part of the time. The survey occupied three months, but was very hastily done and some of the lines had to be re-run.

Shortly after the survey was completed, one of the banks at the county-seat failed with heavy losses to most of the land-owners, and the work has never been constructed.

One canal was designed, following in general the course of Deep Creek, 10.0 miles long, calling for the excavation of 417,816 cu. yds. of earth. The engineer's estimate for the cost of this is 8 ¢ per yard.

The district contains 6135.8 acres, including the town of Speed.



To Florence S C
Town of BOLTON
ATLANTIC COAST LINE RR.
Byrdville
Freeman
To Wilmington N C
Livingstons Creek
Lateral A
Lateral B
BOLTON SWAMP
Railroad Levee
LAKE WACCAMAW
MAIN CANAL
Waccamaw Lumber Co's. Railroad
GREAT GREEN SWAMP
Lateral C
Lateral D
Lateral E
Lateral F
Lateral G
Lateral H
Lateral I
To Makatoka
0 1/4 1/2 1 2 3
SCALE IN MILES
COLUMBUS COUNTY DRAINAGE DISTRICT NO. 2
COLUMBUS COUNTY, N.C.

COLUMBUS COUNTY DRAINAGE DISTRICT NO. 2.

This district is located in the north half of what is known as the Great Green Swamp, and includes another wet area known as Bolton Swamp. The Green Swamp soil is very similar to that in the Dismal Swamp, except that the timber is light and in some places the country is devoid of any growth but briers. The survey was made in the late winter and spring of 1914 by a party of 14:

(1) Chief of Party;

(2) Transit-man, one stadia rodman, two axemen;

(3) Transit-man, two stadia rodmen, two axemen;

(4) Level-man, two rodmen;

(5) Cook.

The direction of natural drainage was reversed on the west side of the district, in order to prevent overflow from Lake Waccamaw during times of high water in the lake, and to secure an outlet for the entire district through one main canal. The road-bed of the Waccamaw Lumber Cos. Railroad was designed to be filled in at all present trestles, to act as a levee against this overflow from the lake. In determining the best outlet for this district it was necessary to include the entire Green Swamp in the survey with all its natural outlets, which were few but widely separated.

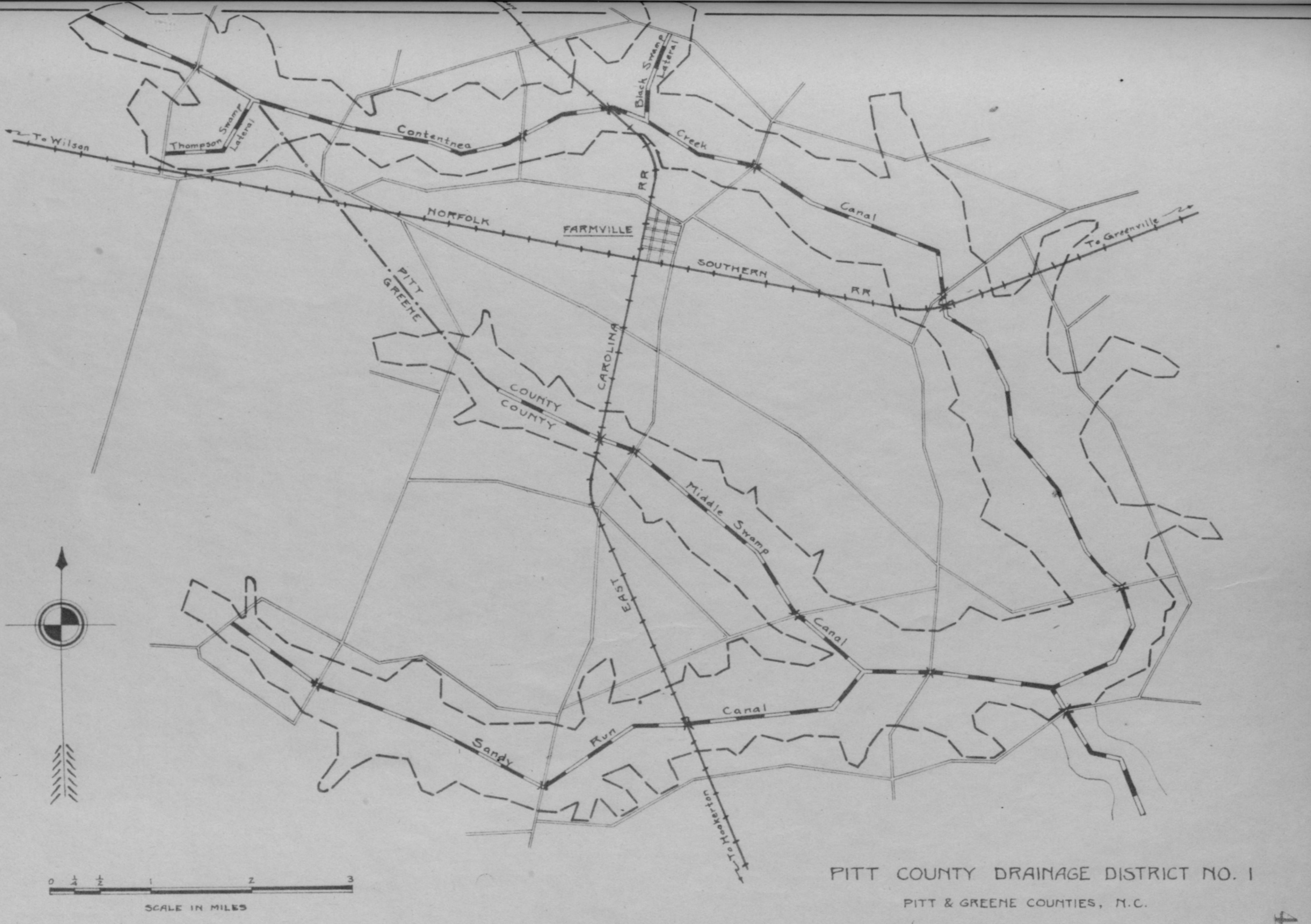
Ten canals were designed, as follows:

Canal.	Length.	Yardage.
Main Canal	7.75 m.	465,100.8
Lateral A	1.5 m.	46,476.8
" B	2.5 m.	64,578.6
" C	5.0 m.	170,814.5
" D	5.0 m.	144,561.4
" E	5.0 m.	155,308.9
" F	5.0 m.	144,687.2
" G	5.0 m.	165,912.9
" H	4.0 m.	121,465.8
" I	2.0 m.	52,669.1
Totals -	42.75 m.	1,531,676.0

This work has been let for 10 ¢ per cubic yard, which price includes clearing right of way and building a road on one side of each canal. In addition to the excavation, 14 wooden truss bridges are to be constructed:

3 bridges, 50 feet long, @ $ 600.
11 " , 30 " " , @ $ 300.

There are 26,824 acres in the district, of which over 90 % are owned by a development company.



PITT COUNTY DRAINAGE DISTRICT NO. 1

PITT & GREENE COUNTIES, N.C.

PITT COUNTY DRAINAGE DISTRICT NO. 1.

This district is typical of the work in the Piedmont section, although located on the edge of the coastal plain. The bottoms along Little Contentnea Creek and its tributaries have an average width of about one-half mile, and are mostly covered with a heavy growth of gum and pine timber. The creeks themselves are very crooked and shallow, being dry at some points during dry weather, but spreading over the bottoms after a storm.

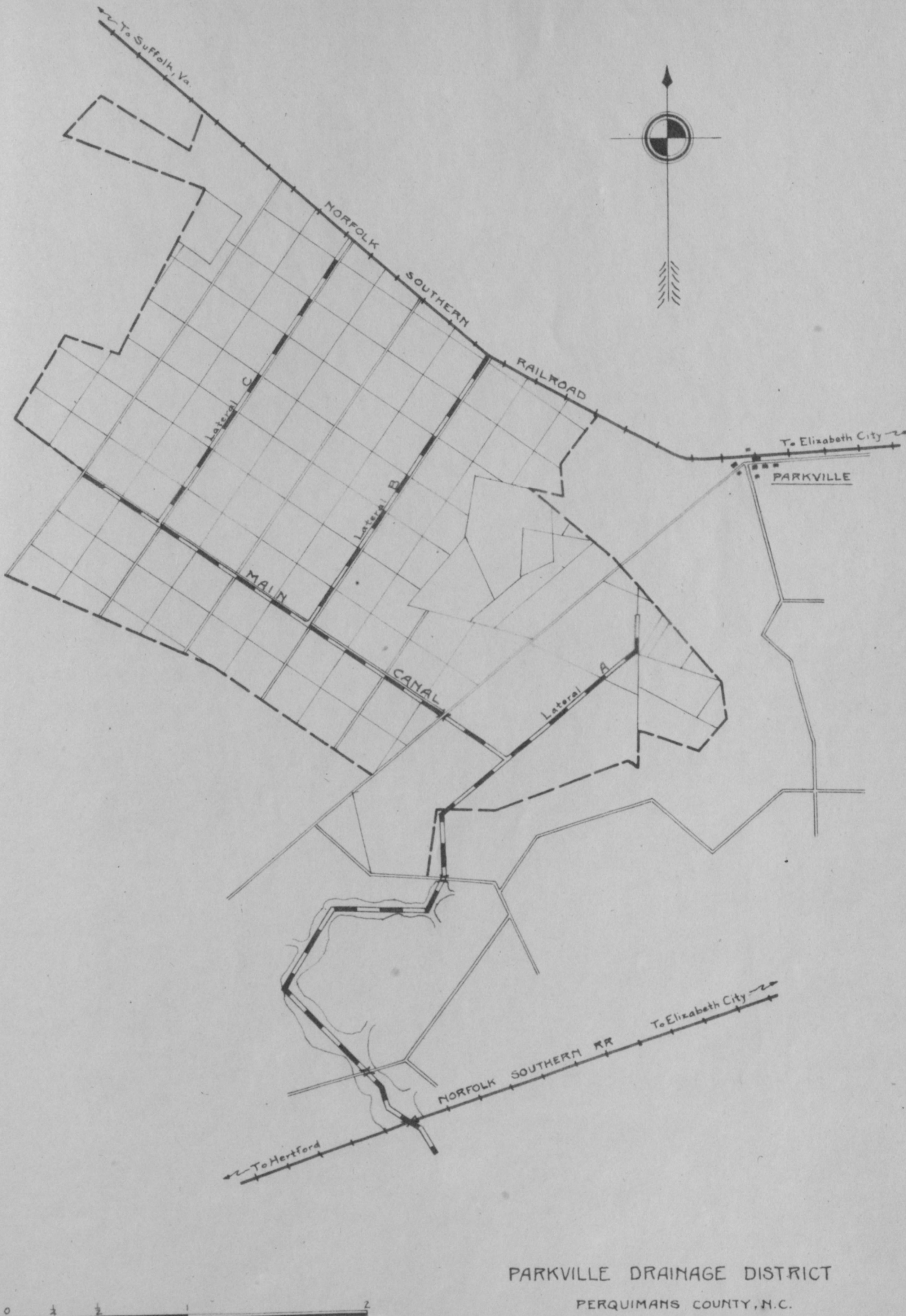
This survey was conducted by the same party used on Columbus County Drainage District No. 2, except that the chief of party was not in the field. The survey was made in the summer and fall of 1914, and the contract has not yet been awarded.

The following canals were designed:

Canal.	Length.	Yardage.
L. Contentnea Creek	16.48 m.	683,338.1
Thompson Swamp	1.40 m.	34,950.9
Black Swamp	0.61 m.	17,600.8
Sandy Run	9.94 m.	326,860.1
Middle Swamp	5.91 m.	161,017.7
Totals -	34.34 m.	1,223,767.6

The estimated cost of this work, including right of way, is 9 ¢ per yd. There are 15 bridges.

The total acreage is 11,125.8, all in individual farms.



PARKVILLE DRAINAGE DISTRICT

PERQUIMANS COUNTY, N.C.

PARKVILLE DRAINAGE DISTRICT.

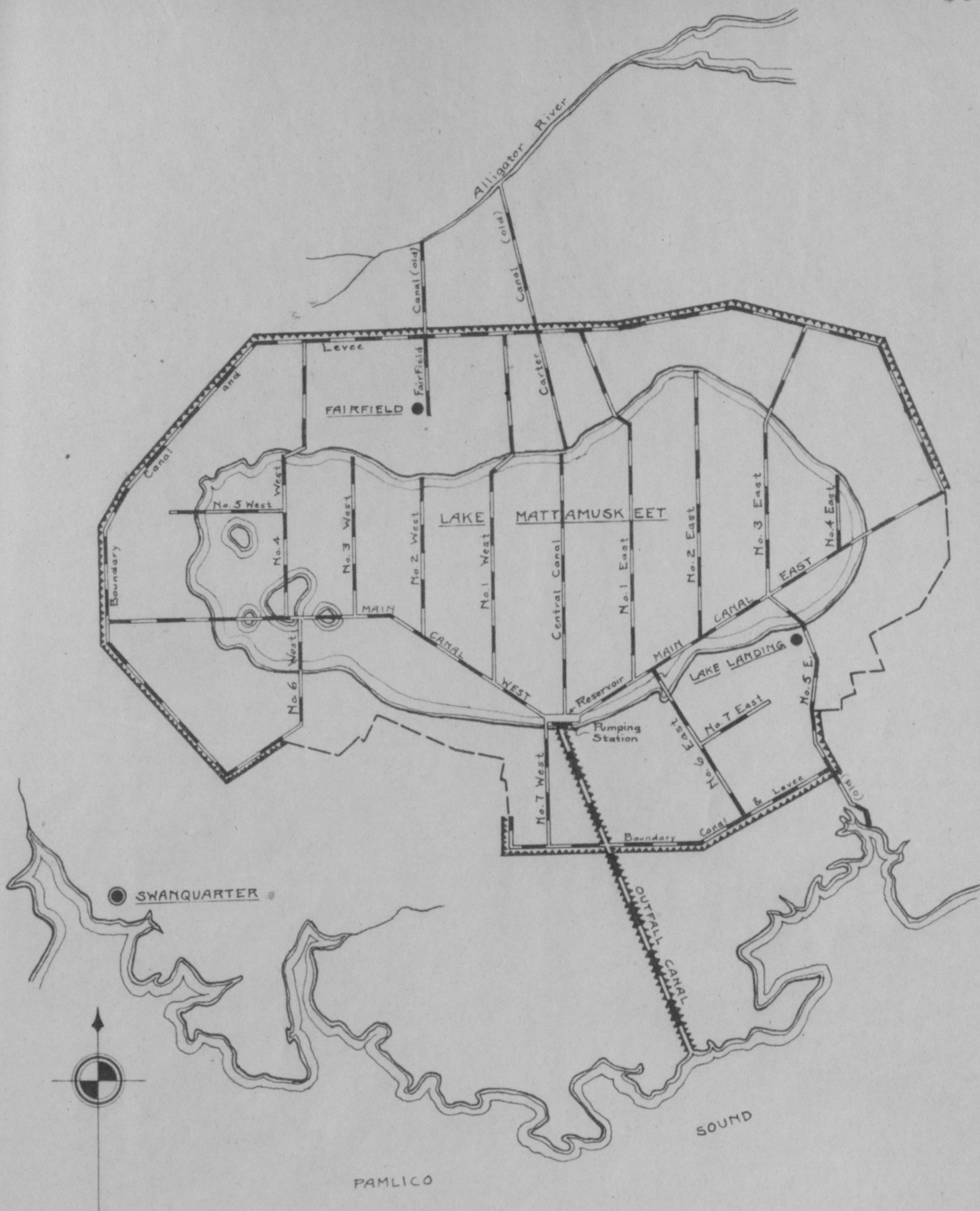
This district is a combination of the system where the canals are located to further the development of large tracts of land making them as attractive as possible to purchasers of the small farms into which they are subdivided, and the system where the natural water courses are followed. It is situated at the southern end of the Dismal Swamp. The soil is a very loose peat, but grows excellent crops when drained.

The survey was made in 1913 by a party of four, doing both transit and level work. Four canals comprise the system:

Canal.	Length.	Yardage.
Main Canal	5.75 m.	162,855.65
Lateral A	1.25 m.	27,130.04
" B	1.75 m.	39,068.76
" C	2.00 m.	32,923.90
Totals -	10.75 m.	261,978.35

The contract was awarded for 7.19 ¢ per cu. yd.

There are 5367 acres in the district.



MATTAMUSKEET DRAINAGE DISTRICT

HYDE COUNTY, N.C.

MATTAMUSKEET DRAINAGE DISTRICT.

This district occupies the center of Hyde County, contains approximately 80,000 acres, and is the largest pumping project attempted in this country. It is proposed to drain Lake Mattamuskeet and the surrounding territory through a system of gravity canals into a reservoir, from which centrifugal pumps will elevate the water into an outfall canal which will carry it to Pamlico Sound. The surface of the lake is at sea level and the surrounding land only a few feet above, although there is a higher ridge surrounding the lake which can be farmed, and nearly the entire population of the county resides along this ridge. The lake is 15 miles long by 7 miles wide, is from 3 to 7 feet deep, and contains about 50,000 acres. There are included in the district 30,000 acres of the surrounding country, around which a boundary canal and levee will be constructed, canal inside of levee, to cut off surface and seepage water.

The reservoir and pumping station are located on the south shore of what is now the lake, near the center. Two main canals lead into this reservoir, and 13 laterals feed the main canals, making a system of north-and-south canals spaced 1-1/2 miles apart across the lake, including a central canal and one other lateral which feed direct into the reservoir.

In the center of the reservoir is located the pumping plant, consisting of eight 60" centrifugal pumps direct connected to compound Corliss engines, 21x36x36, each engine driving two pumps. The pumps are arranged in four units so that after the lake-bed has once been uncovered the entire plant will not have to be operated to remove a small amount of water. The intakes will be 10-1/2 feet below sea level, and the specified duty of the plant is 1800 cu. ft. per sec. against a normal head of 10-1/2 feet with a maximum of 15 feet. The cost of operation at capacity is not to exceed $ 175 per 24 hours run, and it is claimed that the annual cost of pumping, exclusive of the initial draining of the lake, will not exceed 50 ¢ per acre per year.

The pumps discharge through concrete conduits under the power house and into a concrete-lined basin at the head of the outfall canal. This canal is 8 feet deep with a bottom width of 60 feet, and approximately 8 miles long. The outfall canal, with the three existing canals, the Fairfield, Carter and Lake Landing canals, will be diked off and used for navigation rather than drainage. There are no railroads in the county, which, in common with the other counties along the sounds, depends largely upon boats for transportation.

The original survey and plans were made by the Government. They were later revised several times and the contract was awarded on a yardage basis entirely different from that called for in the plans and specifications. A great deal of trouble has been caused by conflicts between different parts of the plans, profiles and specifications, and the actual cost will exceed the estimate by nearly half.

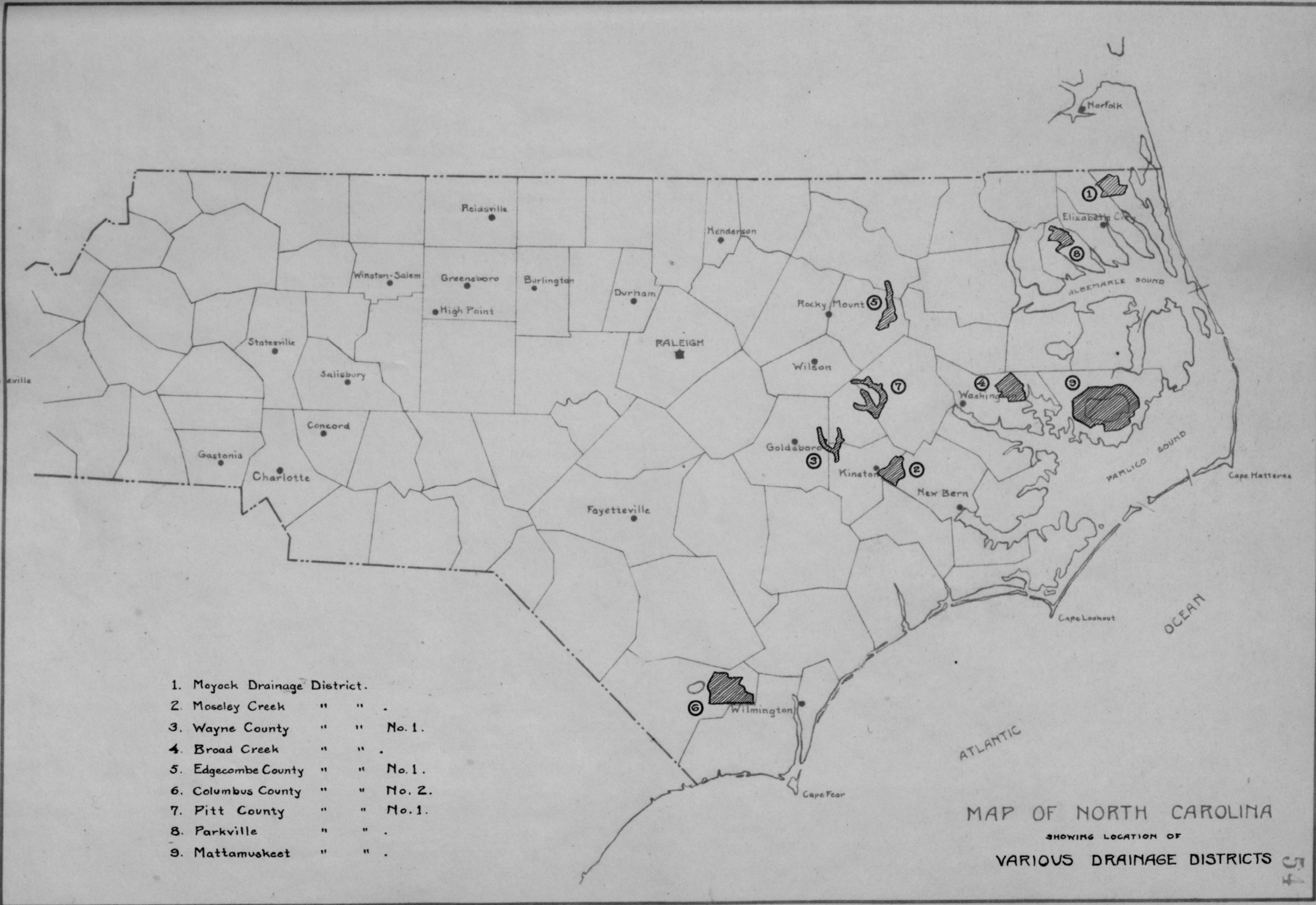
Following are the canals and yardages:

Canal.	Yardage.		Cost.
Outfall	939,609.7		.0694
Reservoir	105,622.2		.0694
Turning basin	10,362.6		.0694
Cut-around	5,366.0		.0694
East Main	539,081.1		.0694
West Main	541,045.8		.0694
Central	207,329.9		.08
No. 1 East	189,402.9		.08
" 2 "	118,202.1		.08
" 3 "	110,299.2		.08
" 4 "	41,437.5		.08
" 5 "	16,369.1		.10
" 6 "	78,028.2		.08
" 7 "	12,437.7		.10
No. 1 West	180,000.0	Estimated	.08
" 2 "	75,000.0		.08
" 3 "	110,000.0		.08
" 4 "	160,000.0		.08
" 5 "	24,000.0		.10
" 6 "	45,000.0		.08
" 7 "	29,744.0		.10
Boundary Levee, Sec. 1	44,495.5		

(Canal)	(Yardage)	(Cost)
Boundary Levee, Sec. 2	43,750.0	
" " " 3,4,5	225,000.0	(Estimated)
" " " 6	65,545.2	
" " " 7	85,235.7	
TOTAL YARDAGE-	4,002,364.4	(Latest estimate)

Cost of Excavation	$ 315,933.19
" " Pumping Plant	205,000.00
Incidentals	100,000.00
TOTAL COST-	$ 620,933,19

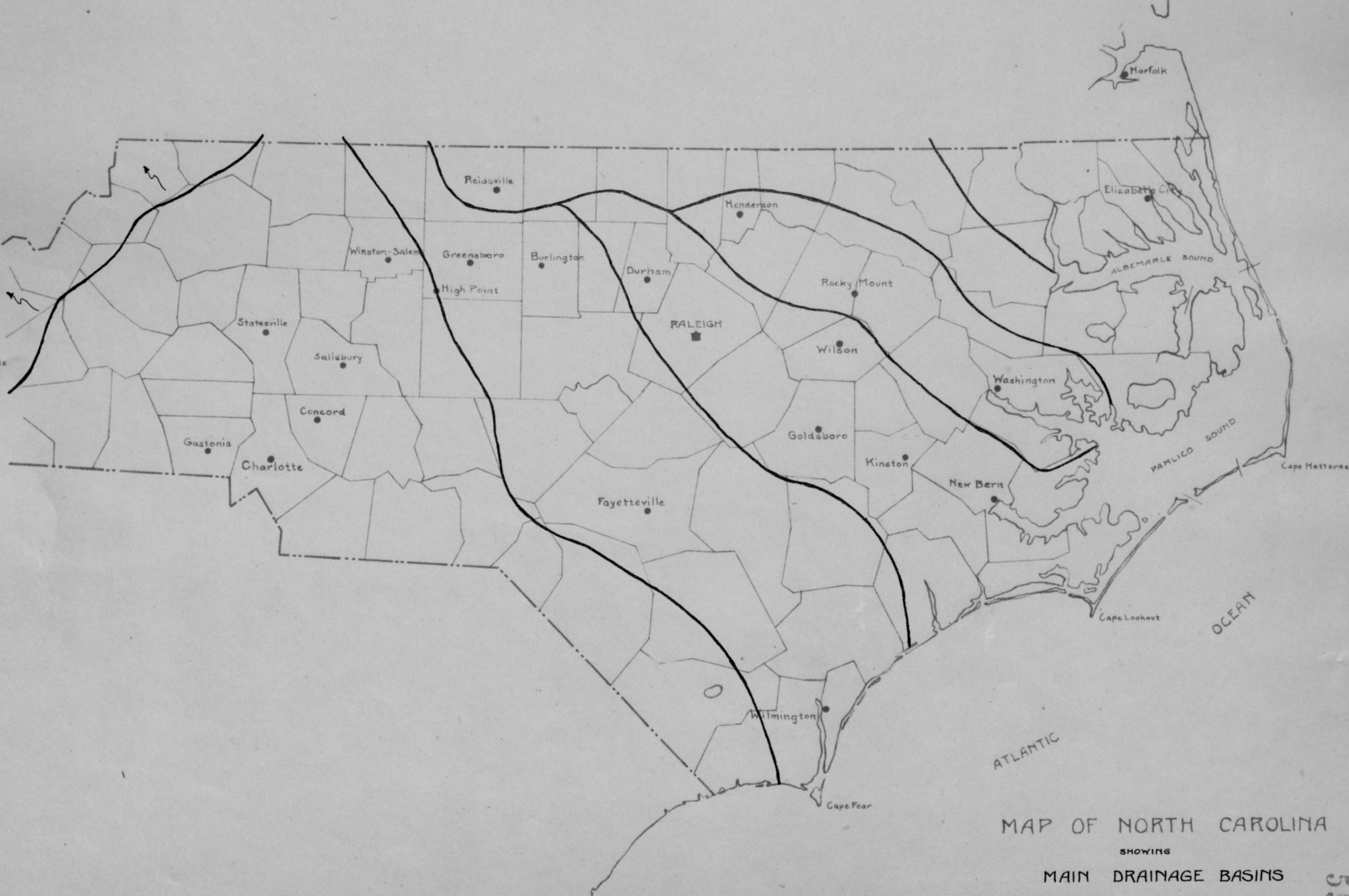
Work was begun on this project in the fall of 1913. The pumping station was begun in January, 1915, and it is expected to start the pumps in January, 1916.



MAP OF NORTH CAROLINA

SHOWING LOCATION OF

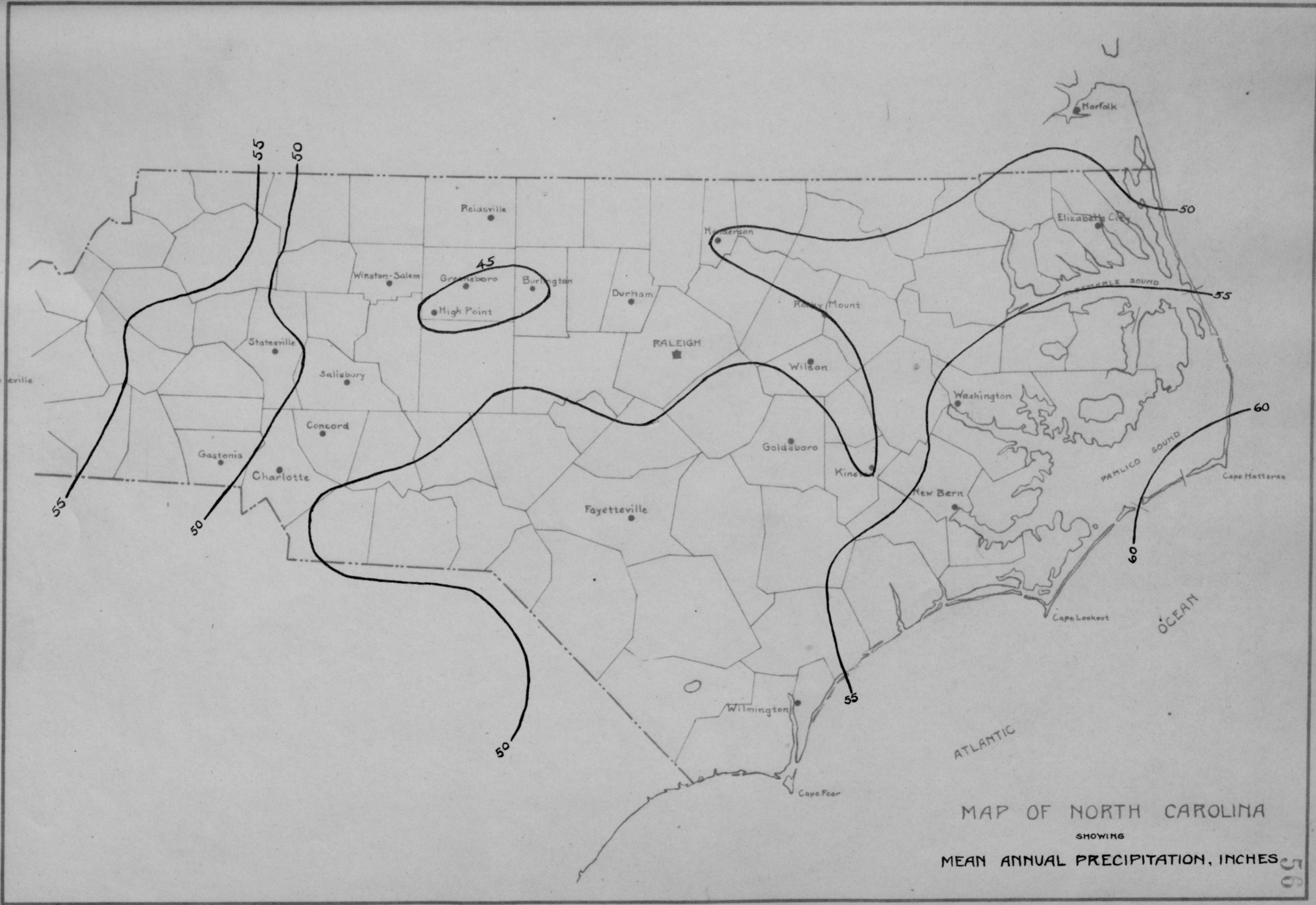
VARIOUS DRAINAGE DISTRICTS



MAP OF NORTH CAROLINA

SHOWING

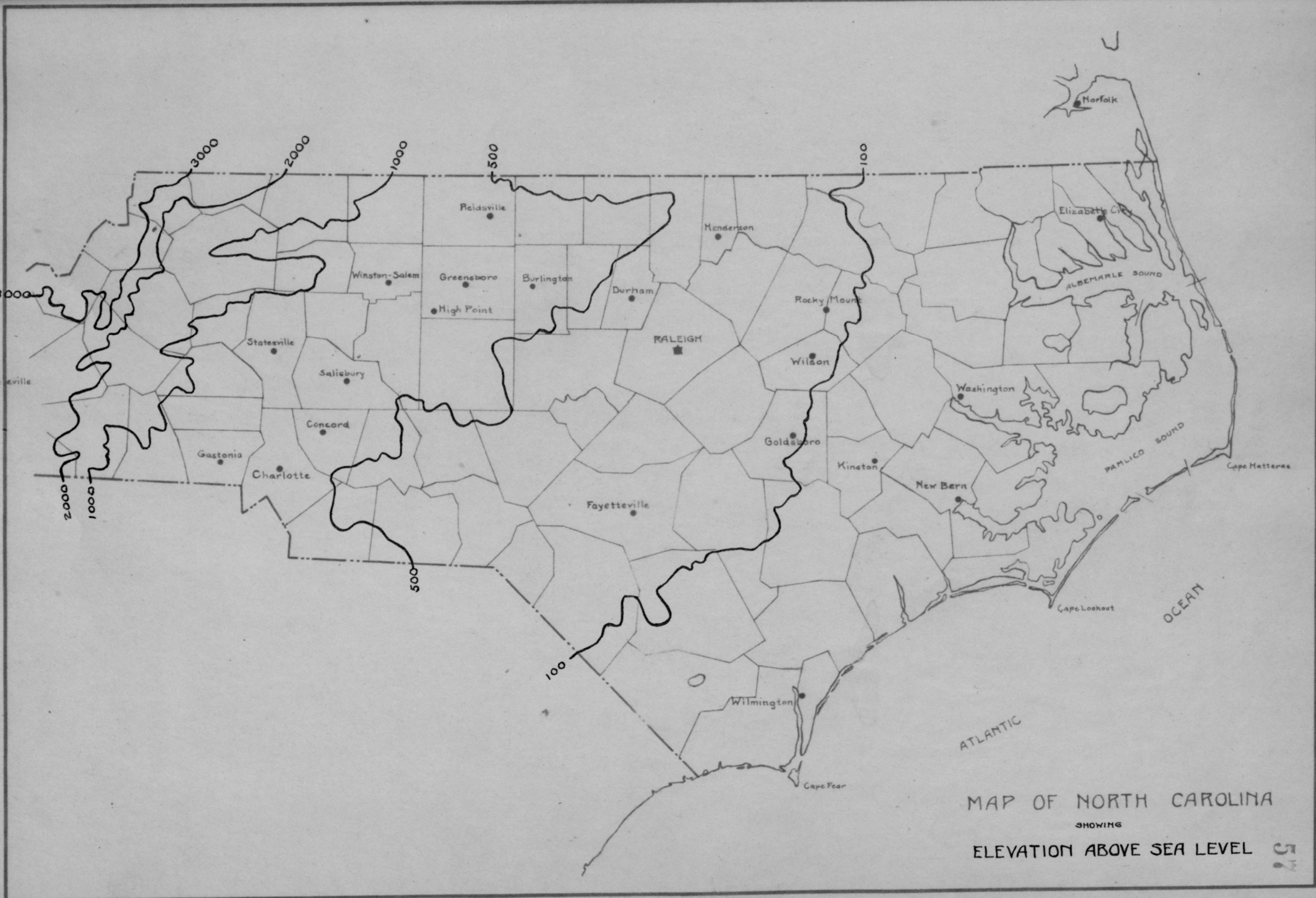
MAIN DRAINAGE BASINS



MAP OF NORTH CAROLINA

SHOWING

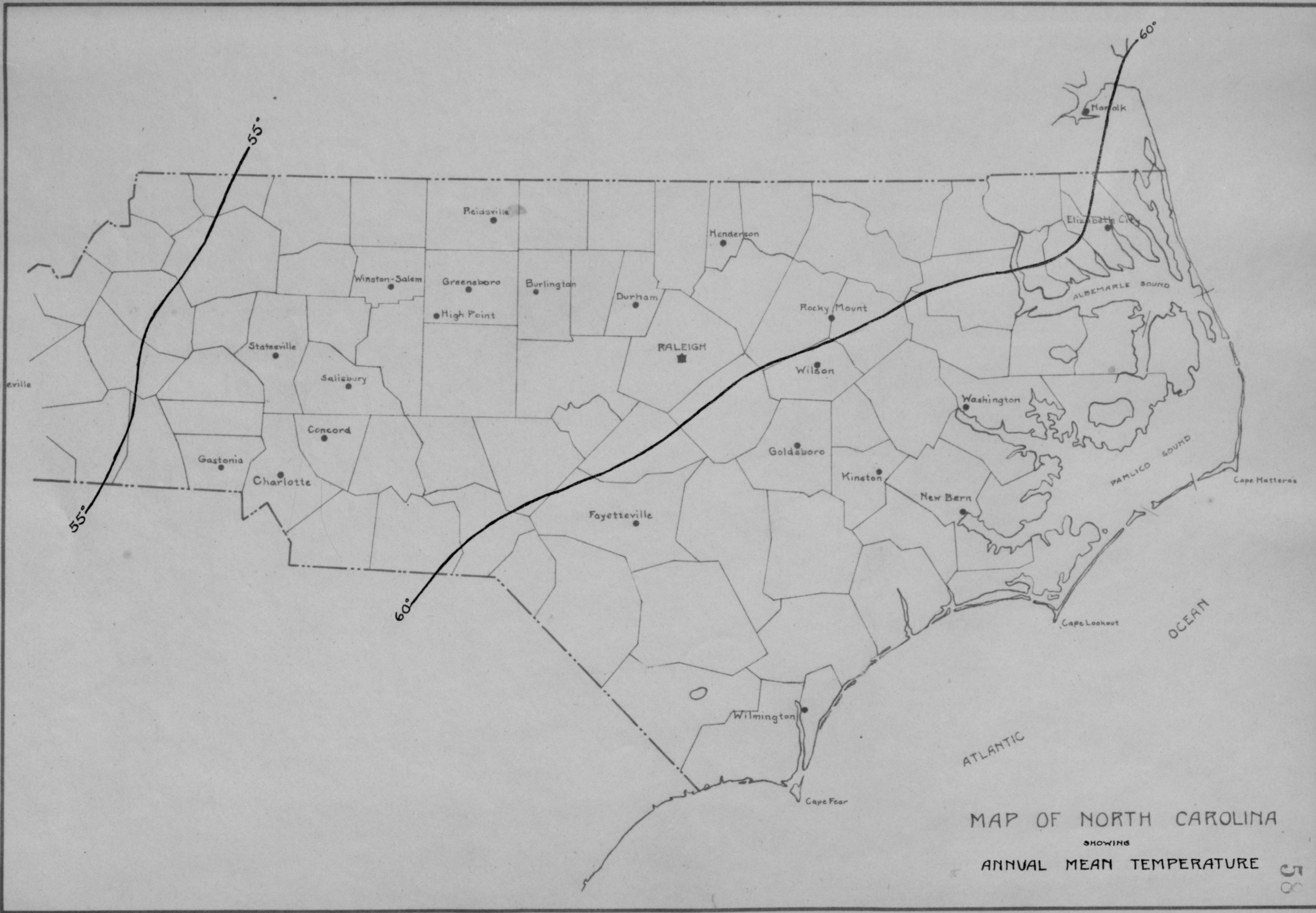
MEAN ANNUAL PRECIPITATION, INCHES



MAP OF NORTH CAROLINA

SHOWING

ELEVATION ABOVE SEA LEVEL



MAP OF NORTH CAROLINA
SHOWING
ANNUAL MEAN TEMPERATURE

TYPICAL CROSS SECTION OF DREDGE CANAL

Respectfully submitted,

Geo W March.

Wilson, North Carolina,

March 1st., 1 9 1 5.