Tennessee Valley Authority
Division of Water Control Planning
Geologic Branch

PRELIMINARY GEOLOGICAL INVESTIGATIONS

FOR EASTERN AREA STEAM PLANT

Charles P. Ennsiger
John M. Zellberg

Knoxville, Tennessee
February 1951

CONTENTS

ILLUSTRATIONS

Exhibits		
1	Alternate Steam Plant Sites	G MS 453A613 RD
2	Geologic Sections Ranges A, B, and Section 12+00	G GE 1 822K1068
3	Geologic Sections Ranges C, D, and E	G GE 1 822K1070
4	Geologic Sections Sections 8+00, 10+00, and 15+00	G GE 1 822K1069
5	Geologic Sections Ranges C, G, and E	W GE 1 822K1087
6	Geologic Sections Ranges L and J	W GE 1 822K1088
7	Geologic Sections Sections 10+00 and 12+00	W GE 1 822K1085
8	Geologic Sections Sections 14+00 and 16+00	W GE 1 822K1086
9	Ranges EE, A, and C	36 GE 1 822K1091
10	Ranges E and G	36 GE 1 822K1092
11	Ranges J and L Sections 18+00 and 20+00	36 GE 1 822K1093
12	Geologic Section Exploratory Trench	36 GE 1 822K1090

Appendix B

PRELIMINARY GEOLOGICAL INVESTIGATIONS FOR EASTERN AREA STEAM PLANT

Charles P. Ennsiger
John E. Gallberg

INTRODUCTION

Location and Scope of the Investigation

Six sites were investigated for the proposed Eastern Area Steam Plant. Three of the sites were explored by diamond drilling, while the other three were the subjects of brief reconnaissance studies. Preliminary exploratory drilling began at the Yellow Creek (Watts Bar No 2) site, two miles downstream from Watts Bar Dam, on the right bank of Chickamauga Reservoir at river mile 528.0; next was the Concord site on the right bank of Fort Loudoun Reservoir at river mile 615.0, two miles due south of the railroad station of Concord, Tennessee; the third is the Kingston site, 1.5 miles due north of the town of Kingston, Tennessee, on the right bank of the Clinch River arm of the Watts Bar Reservoir at mile 2.6 on the Clinch River (exhibit 1). Three other sites were investigated but rejected more for economic reasons than for any anticipated foundation defects. The three sites are all on the left bank of the Fort Loudoun Reservoir. The Louisville site is at river mile 623.0 (622.0), just upstream from the abandoned Lowes Ferry; a site at river mile 626.0, and a site at river mile 628.0. The latter two sites are located on Jackson Bend.

Eight ranges were laid out at Yellow Creek, roughly normal to the bank of the reservoir. Twenty holes, predominantly fishtailing, were drilled, totaling 578.7 feet (exhibit K). At Concord, twenty-two diamond drill holes, totaling 1,695.8 feet, were spaced on a rectangular grid, with the ranges and the sections parallel and normal to the river, in that order. The holes were spaced 200 feet apart (exhibit J). An irregular pattern of holes was drilled at the Kingston site since the areas on which information was sought was fairly well bounded by the space limitations before the drilling commenced. A total of forty-one holes was drilled, partly by fishtail methods and partly by diamond bits recovering core. A total of 1775.0 feet of rock was drilled at this site before drilling operations were suspended (exhibit L).

Scope of the Report

As the sites vary in details with reference to bedrock conditions, topography, and location, they will be considered separately in this report. The Louisville site and the Jackson Bend sites will not be treated under one heading because they were under consideration for such a short time and have since been rejected.

The exploratory investigations were limited to comparatively shallow holes on widely spaced centers; therefore, it was not possible to obtain all the desired information as to depth of weathering, amount of solution, detailed geologic structure, or correlation of the rock strata encountered in the holes. The results put forth in this report must of necessity be considered tentative and subject to revision on the basis of further geologic investigation.

General Physiography and Geology

Since all the proposed sites for the Eastern Area Steam Plant are located in the same physiographic and geologic provinces, certain basic facts apply to all the sites under consideration. Therefore, a general discussion of the applicable primary knowledge of the area is presented.

General Physiography

All the sites are located in the Valley and Ridge province of the Appalachian Highlands. This province extends from New York to Alabama and varies in width from 20 to 75 miles. It is bounded on the east by the steep slopes of the Blue Ridge front, and on the west by the abrupt escarpment of the Cumberland Plateau. The Appalachian Valley sub-region, confined largely to East Tennessee, but occupying small portions of Alabama and Virginia, extends northeastward across the Tennessee Basin. It has an area of slightly more than 11,000 square miles.

Physiographically, this sub-region is characterized by long narrow ridges and somewhat broader intervening valleys with a northeast-southwest trend. The ridges are parallel and fairly even topped. They are held up by the resistant sandstones and the less soluble limestones and dolomites. The valleys are excavated on the easily weathered shales and the more soluble limestones.

Elevation of the ridge summits and valley floors decrease progressively from the northeast to the southwest. In the extreme northeastern portion of the valley region the valleys are narrow and

gorge-like, ranging in elevation from 2000 to 2500 feet for the valley floors to 4000 to 4500 feet for the summits of the ridges. In the vicinity of Knoxville, the master streams, on or near which all the sites are located, flow at an elevation of approximately 800 feet, while the tributary valley floors range in elevation from 850 to 1100 feet. Comparative elevations become progressively lower to the southwest.[1]

General Geology

The Appalachian Valley is a region of highly deformed but unmetamorphosed sedimentary rocks of Paleozoic age. The rocks consist mostly of limestones, dolomites, and calcareous shales, but arenaceous and argillaceous shales and sandstones are present. They range in age from earliest Cambrian to Pennsylvanian, but Cambrian and Ordovician rocks are by far the most abundant.

The various formations in the valley outcrop at the surface in relatively narrow, linear belts of northeast-southwest trend, each formation being repeated at the surface several times from the southeast to the northwest. This outcrop pattern is the result of the folding and faulting of originally nearly horizontal strata followed by removal, by erosion, of the upper portion of the resulting structures. Apparently the strata were folded and faulted by compressive forces acting from the southeast. Individual folds were compressed tightly, then overturned toward the northwest and finally broken by faults

---

1. Fenneman, N. M.: "Physiography of Eastern United States," 1938.

along their axial planes. The structure of the valley, therefore, is characterized very largely by a series of overlapping linear fault blocks which dip to the southeast. The topographic expression of their structural phenomenon is very marked, and any deviation from it is a clue to variations in the normal structure or the formational sequence.

Joints are abundantly developed in the rocks of the valley. These minor structures are controlled by the major systems of faulting and folding, but they occur in sets and systems, and may be classified generally as strike joints, dips joints, and oblique joints.

PART I - ~~YELLOW CREEK SITE~~ WATTS BAR No. 2

Site Topography and Detailed Physiography

The ~~Yellow Creek~~ Watts Bar site is located on the right bank of the Chickamauga Reservoir, approximately two miles downstream from Watts Bar Dam, at river mile 528.0. It is located on a narrow floodplain and terrace formed by the present and past channels of the Tennessee River. The floodplain, composed predominantly of river alluvium, extends the whole length of the site parallel to the river and averages 10 to 25 feet higher in elevation than the headwaters of Chickamauga Reservoir. It varies from 200 to 1000 feet in width, widening downstream. Back of this floodplain, old river terraces are present, averaging 40 to 60 feet above the floodplain. The old terraces are presently being dissected by tributary streams, but the river edge is a fairly abrupt slope. Away from the river and northwest of the terrace line, the topography is fairly even.

DETAILED GEOLOGY

Stratigraphy

Three geologic formations are present at or near the surface at the Watts Bar Yellow Creek site. These consist of recent deposits of river alluvium; older terraces; and the bedrock formation, the Conasauga shale. The Rome formation to the northwest is overlain by the younger Conasauga series of shales and sandstones while it is in turn overlain to the southeast by the still younger Knox group. The Rome formation and the Knox group are not involved in the foundation of the plant and will not be described. The three formations found at the site are described in detail.

Alluvium and Terrace—The unconsolidated deposits overlying the bedrock are composed of a mixture of water-laid alluvium and terrace materials deposited by the Tennessee River on its past and present floodplains. The alluvium is composed of fine-grained, finely sorted, silts and clays, with micaceous sand and some quartz gravels. The thickness of this formation is questionable, since the drilling did not penetrate its greatest depth. It thins out against the southeast slope of the terrace deposits. Included in the alluvial material are some fairly well defined beds of tough, blue-grey clay, containing carbonized fragments of wood, which are interpreted as old slough fillings. The wood fragments prove that the formation is a comparatively recent one, geologically speaking.

The terrace deposits are older and are marked by a topographic bench from 200 to 1000 feet northwest of the present channel. These

deposits are not as well sorted as the recent alluvium, containing silt, sand, clay, gravels, and good-sized cobbles of quartz and quartzitic sandstone. In the terrace deposits, however, were found several sharply defined lenses of clean, fine-grained micaceous sand which seemed to have the long axes of the lens parallel to the present channel. Probably they are the remnants of old buried shorelines of the ancient river. In practically all the holes drilled in the terrace material, near the bottom of the hole the lens of sand up to 15 feet in thickness, was encountered, then a layer of coarse gravels and pebbles, then the weathered upper surface of the bedrock. Usually the thin gravel bed, averaging less than a foot in thickness, was present. The terrace deposits varied from 4.4 feet in thickness to more than 50.0 feet, and had an average depth of 23.6 feet.

Conasauga Shale--Practically all the drilling was done with a fishtail bit, with only a few feet of rock being cored. The main information sought was on the amount of overburden and the depth of the weathered portion of the shale, since the information on the foundation of the present Watts Bar Steam Plant, on the same strike belt and only a mile upstream, was applicable to the foundation of the Yellow Creek No. 2 site. Thus, statements made as to the soundness of the bedrock are based on the construction experience gained at the Watts Bar Steam Plant and are, therefore, tentative. Generally speaking, the foundation problems of the Watts Bar site will be the foundation problems of the ~~Yellow Creek site.~~ New Site.

Unweathered, the Conasauga shale consists of dark gray to black, irregularly bedded, sandy, fissile, hard to soft, sheared and

contorted shale, with numerous thin interstratified layers of dense quartzitic, hard, brittle, gray sandstone. The beds of sandstone seldom exceed two inches in thickness, but occasionally a six to ten-inch layer of impure argillaceous sandstone does occur. The thin layers of sandstone thicken and thin greatly along the line of strike and may disappear altogether in a few feet, a new lens appearing at a slightly higher or lower horizon. The sandstone is so well cemented with silica and calcareous material that the fine grains of sand are only dimly visible. It is easily taken for limestone by the layman. The sandstone comprises from 10 to 25 percent of the rock mass, with the remaining 75 to 90 percent being composed of sandy and fissile shales. There is no sharp contact between the sandy shale and the fissile shale, one grading gradually into the other. The sandy shales are harder, less sheared, and the best foundation rock present in the area. The fissile shale is very slightly sandy, being mostly argillaceous. It suffered the most during the period of structural deformation, losing any of the primary structures it may have possessed prior to the regional and local upheavals. Numerous parallel and intersecting shear planes or slickensides have produced in the fissile shale small thin flakes or scales. When unconfined, these scales part easily, and offer little resistance to grinding but beyond a certain stage they do not easily break down into clay when wet and dried, but they do offer little resistance to grinding.

The earlier geologic mapping of the area by Hayes placed the rocks in the Yellow Creek area and on the Watts Bar Steam Plant in the Rome formation, due to the fact that there were no satisfactory surface

exposures in the area.[2] Such outcrops as existed were badly weathered and indistinguishable from the Rome outcrops and most of the bedrock was covered with a thick mantle of overburden. When the foundation of the Watts Bar Steam Plant was excavated, Fox found fossils which were diagnostic of the Conasauga formation, which is younger than the Rome. Fox divided the Conasauga into its component units on the basis of lithology and faunal content, but the preliminary drilling program at ~~the Yellow Creek~~ this site does not allow such division.[3]

Structure—The geologist is confronted with the same dilemma regarding structure at the ~~Yellow Creek~~ Watts Bar site as was posed by the problem of stratigraphy. The exploratory drilling program did not allow much conjecture regarding the degree, type, and extent of any deformation present. However, it is highly probable that the general details uncovered in the foundation of Watts Bar Dam and Steam Plant will anticipate any that are present in the bedrock of the ~~Yellow Creek~~ Watts Bar No. 2 site.

In general, the ~~Yellow Creek~~ site rests on the southeast limb of a rather large anticline or the northwest limb of a large syncline. No details are known, but actually there is a very complex system of folds and faults existing in the area. Many dip and strike readings taken on fresh foundation exposures less than a mile upstream show an average dip to the southeast of 35° and the strike N 55° E. Many small, sharp folds were noted in the exposures, some being recumbent, or partially overturned, so that the limbs of the folds were horizontal. The structures wax and wane along the strike, dying out and being

---

2. Hayes, C. W.: Kingston Folio, "Geologic Atlas of the United States," 1894.

3. Fox, P. P.: Watts Bar Steam Plant, "Exploration and Geology of Foundation," April 1942.

replaced by others slightly higher or lower in the section. These folds have little influence on the bearing strength of the rock. Small faults of minor displacement occur at the site but they too are unimportant. In the over-all view, even the variety of structures exhibit a degree of homogeneity which may be relied on as a basis for the foundation geology (exhibits 2, 3, and 4).

Foundation Conditions--Although details of structure and stratigraphy remain obscure due to scarcity of factual data available, an approximation of foundation conditions expected to be encountered can be safely assumed. The drilling program was based on the theory that the fishtail bits could penetrate the overburden and weathered rock to the top of the sound rock. The depth at which the bit was unable to penetrate further was regarded as the top of sound rock. The overburden averaged 23.6 feet in thickness, while the weathered shale and sandstone ranged from 1.0 to 17.5 feet thick and averaged 4.7 feet thick. Below this shallow zone of weathered rock, the shale is firm and sound and is capable of adequately supporting any anticipated load.

Physical Character of the Rocks--No tests were made on any rocks at the ~~Yellow Creek~~ site, but an approximation of their physical characteristics can be taken from the results of tests made at the Watts Bar Steam Plant.

When completely dry, the shale has a specific gravity of 2.72. The interbedded sandstone has a specific gravity of 2.46, and a compressive strength of 36,000 pounds per square inch normal to the bedding, which is unusually high for a sandstone.

PART II - CONCORD SITE

Site Topography and Detailed Physiography

The Concord site is located on the right bank of the Fort Loudoun Reservoir at river mile 615.0, two miles due south of the railroad station at Concord, Tennessee. The site proper is an alluvial floodplain and terrace, the slip-off slope of an unnamed bend of the Tennessee River. The bedrock is covered by the river terrace and alluvium, and practically the entire floodplain of the river is now covered by the backwaters of the reservoir, which reach to the edge of the older terrace deposits. Wave-cut benches at the present lake level reveal the residuum which underlies the terrace deposits, and some of the more resistant bedrock formations appear at the surface on the benches. The site has numerous sinkholes, attesting to the amount of solution in the bedrock, but otherwise rises with a fairly even slope from the reservoir level of approximately 815.0 to an elevation of approximately 880.0 on the knob northwest of the range lines. As far as could be determined in a cursory investigation, the terrace deposits extend to the top of this knob. The sinkholes are roughly elliptical depressions with the long axis along the line of strike, and are not very deep. The bottoms of the sinks range from 2.0 to 6.0 feet below the tops of the basin divides, and vary from a diameter of 100 to 400 feet in length, measured by the long axes.

DETAILED GEOLOGY

Stratigraphy

Three geological formations are involved in the foundation of the Concord site. These are the river terrace and alluvium; the

residuum from the weathering of the Knox dolomite; and the bedrock consisting of the Copper Ridge formation of the Knox group. Two other formations are found in the vicinity, but are not directly involved in the plant foundation. The Copper Ridge is faulted over the younger Sevier shale to the northwest, and the Copper Ridge is in turn overlain by the younger member of the Knox group, the Beekmantown formation, to the southeast. The fault, which trends northeast-southwest and outcrops 1000 feet northwest of range L, is of the thrust type and shows a stratigraphic throw of at least 1500 feet. This is a major fault, and all geologic structures in the plant area are directly related to it.[4]

Alluvium and Terrace--The entire site is covered with a layer of terrace composed of sand, silt, clay, gravels, and cobbles. Under the terrace and overlying the bedrock is a layer of residuum, composed of clay with residual chert. The combination of these two types of deposits which comprise the overburden varies in thickness from 20.0 feet to 75.0 and averaged 50.5 in depth in the 22 holes drilled. The recent deposits of alluvial material are now mostly below the reservoir level and have little bearing on foundation conditions.

Copper Ridge Dolomite--The Copper Ridge formation of the Knox dolomite group is the bedrock at the site. It is upper Cambrian in age, the upper contact between the Copper Ridge and the overlying Beekmantown being the dividing line between the Cambrian and Ordovician. The Copper Ridge formation is approximately 1000 feet thick in this part of the

---

4. Memorandum, "Geologic Reconnaissance of Possible Steam Plant Sites in Fort Loudoun Reservoir," John M. Mellberg and Charles P. Bensiger, September 18, 1950.

Tennessee Valley, although it was not measured at the site since one of the contacts is a fault surface and the upper contact with the Beckmantown is not visible in this belt, at least on the right bank of the reservoir. The rock is light gray or white to medium gray to black, fine-grained to medium crystalline, cherty, vuggy, and contains layers of dolomitic sandstone, one of which is the upper limit of the formation. The bedrock is almost always massive, with only a few thin partings of shale. The only beds outcropping in the site area are beds of weathered sandstone on the northeast and southwest sides of the site, exposed on the wave-cut benches.

Structure—The controlling feature of the detailed structure at the Concord site is the fault northwest of the area. The dips close to the fault approach the vertical, but to the southeast they flatten out and average 15° to 20°. The strike of the rock is N 35° E. Thus, the foundation area rests on a southeast dipping slope of a large fault block. Details of structure are not known, but small structures are apparent from the inspection of the cores. These structures were not correlated, due to the wide spacing of the drill holes and the inadequate outcrops. One general feature which was controlled by the major structure is evident however. The river at an earlier stage flowed much higher on the slope than at the present. When the region was elevated, and the river began its job of down-cutting to grade, it naturally cut into the face of the rocks and down the dip slope. The result of this erosion is a deeply weathered bedrock, with serious weathering to great depths.

In practically all the rocks of this type and degree of structural deformation, joints are evident. The larger series and

systems, when present, are seriously weathered and were logged as open and filled cavities. Smaller systems of joints were noted in the cores, but these are recemented with calcite and quartz, proving that no great deformation has taken place recently, as geologic time is counted.

Foundation Conditions--Foundation conditions are to a large degree dependent on the structure and lithology of the rocks concerned. The Copper Ridge dolomite is very soluble, and the structure of the bedrock forms ideal channels for the movement of the water to effect maximum solution. The most prominent cavities are those which are excavated along the bedding planes, and they continue down the dip to unknown depths. They range from a tenth of a foot to many feet in depth, and as mentioned before, seem to be controlled by the structure. The overburden encountered, both the terrace and residuum, seemed to be unusually "tight" for this type of formation. It averaged approximately 50.0 feet in depth, from a minimum of 20.0 to a maximum of 75.0 feet. In most of the holes drilled, even after the top of rock was encountered, much solution was evident, one hole stopping in a cavity at elevation 744.0, some 70.0 feet below present lake level. This particular cavity was entered at elevation 773.0, and the bottom was not reached.

Although the bedrock at the site could be treated to get a satisfactory foundation for the proposed structure, it is believed that the cost of such a program would render it prohibitive (exhibits 5, 6, 7, and 8).

Physical Character of the Rocks--No tests were made on any of the rocks at the Concord site or on the overburden. Similar rocks from

the foundation of Norris Dam were subjected to exhaustive tests. The compressive strength determinations show the Copper Ridge at that location to have a value of 28,150 pounds per square inch. The unweathered rock at the Concord site will compare favorably with the Norris foundation rocks.[5]

PART III - KINGSTON SITE

Site Topography and Detailed Physiography

The Kingston site is located on the right bank of the Clinch River arm of the Watts Bar Reservoir at mile 2.6 on the Clinch River. The area is the neck of a rather large peninsula, bounded by Swan Pond (a large embayment on the Emory River) on the northeast, by Pine Ridge on the northwest, by the Clinch River on the southwest, and by the head of the peninsula, which rises 150 feet above the neck, to the southeast and east. The neck of the peninsula varies in elevation from 741.0, which is normal pool level, to approximately 800.0 in its higher parts. The surface is rolling, with gentle slopes to the beds of the streams which dissect its surface. One of the most noteworthy features is a large sinkhole, the active end of which is at the contact of the Knox dolomite and the Conasauga shale. The sinkhole drains into the dolomite, but a shallow basin has been excavated in the shale to the northwest and the sink includes a sizeable drainage area at the present. It is not known whether or not the sink is still active, since the reservoir level

---

5. Technical Report No. 22, "Geology and Foundation Treatment," Tennessee Valley Authority, 1946.

is above the bottom of the hole, and in addition, a ditch for malaria control purposes has been excavated from the sink to the main body of the reservoir. However, it is practically certain that if the lake level was dropped to the same elevation as before the construction of the dam, the sink would again become active in a short while.

DETAILED GEOLOGY

Stratigraphy

Only one geologic formation is present at the site and involved in the present proposed construction program. This is the Conasauga shale, the same bedrock which exists at the ~~Tellow Creek site~~ Watts Bar and in the foundation of the Watts Bar Steam Plant. Some small amounts of alluvium are found in the sink area but are very thin. Residuum or soils are almost entirely lacking, being present only in small scattered patches. No terrace deposits were noted.

The Conasauga shale overlies the Rome formation, which is found in the southeast slopes of Pine Ridge to the northwest, and the Conasauga is, in turn, overlain by the Copper Ridge formation of the Knox group to the southwest. The contact with the Rome is obscure, partly because the outcrops are weathered in the known vicinity of the contact, but mainly because both the formations are for the most part composed of shales, and the relationships, even in areas where the exposures are fresh, tend to be obscure. The contact between the Conasauga and the Knox is fairly well delimited, however, and can be placed more accurately. The Rome shales and sandstones composing

the Ridge, and the Knox [illegible]

Pine Ridge, and the Knox dolomite composing the enlarged head of the peninsula, are not involved in any present plans of construction of the plant proper.

The Conasauga shale at the Kingston site is composed of blue-gray shale with lenses of siltstone, limestone, and a few conglomerates. The amount of calcareous rocks in the formation increases to the southeast, or in other words, in the younger parts. The major part of the drilling was done between ranges C and J, inclusive, and between Sections 12+00 and 22+00, inclusive. The ratio of shale to limestone in this selected area is approximately 4:1, or about 80 percent shale. The lenses of limestone vary in thickness from an inch to several feet, but, in contrast to the same formation at Watts Bar, the individual beds exhibit more continuity. This continuity is shown in the road-cut just northwest of the highway bridge over the Clinch River on U. S. Highway #70. The rocks in this road-cut are relatively undisturbed, being only slightly tilted from the original horizontal position, but they illustrate the type of stratigraphy which is present at the site. Sandstones, which are prevalent at the Watts Bar Steam Plant, are in the minority at Kingston. After the shales the major group of rocks is the medium to coarse crystalline, light to dark gray limestones, with a sprinkling of glauconite and what appears to be oolites. The next most abundant formation is the conglomerates, the limestone pebbles of which seem to be well rounded, the sandstone pebbles being reddish brown in color and angular in shape. Glauconite is well represented in the cement. The siltstones are the least abundant of the rocks. They are medium gray in color, fine-grained, and stand up well under weathering. At present, due to the wide

spacing of the drill holes, the shallow depths to which they were drilled, and the degree of dip encountered, no correlation of individual strata has been attempted.

Structure—The over-all structure of the bedrock at the Kingston site is simple. Dips to the southeast averaging 45° are found throughout the Knox, Conasauga, and Rome formations. The Rome belt to the northwest, along with the overlying Conasauga and Knox formations, was pushed over the next Knox belt to the northwest in a large thrust fault block. This is the controlling structural feature of the region. When this huge block was pushed from the southeast over the next block to the northwest, the incompetent shales in the Conasauga and Rome formations were contorted and sheared. This shows especially well in the Rome road cuts, where it becomes next to impossible to get an average dip. The Conasauga seemed to fare somewhat better and in the only exposure where some structure is exposed in the site area, in cuts along the road leading east along the peninsula, the dips appear to be fairly regular, with little variation. However, dips in cores taken with the diamond drill varied from vertical to 10° and 15°, with the average being 45° to 50°, showing the presence of at least minor fluctuations in the bedrock, and perhaps the presence of small faults. At no place except in the above-mentioned road cut does enough rock outcrop to give one an idea of the structure present. It is presumed, on the basis of experience with the formation in the Watts Bar area, to be very similar to that locality and to pose approximately the same problems.

Foundation Conditions—Only an approximation of the expected foundation conditions can be given on the basis of the present drilling

program. The drilling penetrated through the weathered zone in most holes, being doubtful only in the cases where limestones were encountered. The top of rock, as denoted on the sections, is somewhat higher than the top of sound rock, due to the fact that the shale is very susceptible to weathering. After the shale is weathered to a depth ranging from 5.0 feet to 33.0 feet, the weathered material is protected from further weathering, with the exception of the limestone zones. Where the limestone beds are practically vertical in dip, weathering may extend to great depths along the bedding. The average depth of the weathered shale is approximately 15.0 feet. The shale, even in an unweathered state, is adaptable to excavation by power machinery. The erratic beds of harder rocks offer the only real resistance to this type of excavation, and some drilling and shooting may be necessary in these strata.

Before any final recommendations can be made as to depths to which weathering has penetrated or amount of rock that it would be necessary to remove during construction could be made, additional intensive geological exploration, consisting of holes drilled on closer centers or of trenches excavated to the top of sound, unweathered rock, should be made (exhibits 9, 10, 11, and 12).

Physical Character of the Rocks--No compressive strength determinations have been made on rocks taken from this site. The strength of the shales is comparable to that of the shale at the Watts Bar Steam Plant site. Any of the rocks at the Kingston site, where fresh and unweathered, are capable of supporting any contemplated load.

Construction Materials--No surveys of the availability of rip-rap and aggregate have been made. The Copper Ridge formation of

the Knox group outcrops in belts to the northwest-southeast, and quarry sites are available in these belts. Mississippian limestones are abundant in the edge of the Cumberland escarpment several miles to the northwest.

Break Part IV

PART IV - LOUISVILLE AND JACKSON BEND SITES

The Louisville site and the two sites on Jackson Bend are on the left bank of the Fort Loudoun Reservoir. The Louisville site is just upstream from the abandoned Lowes Ferry at river mile 625.0. It is located on an old terrace, which is approximately 25 feet above lake level. The terrace is slightly rolling and varies in elevation from 825 to 900 feet above sea level in the site area proper. The underlying bedrock is the Lenoir formation of Ordovician age. Due to the fact that only a hasty reconnaissance was made of the site, no assumptions can be made as to depth of overburden, amount of weathering in the bedrock, or foundation conditions in general.

Two sites were investigated on Jackson Bend. One was at river mile 626.5 on the downstream end of the bend. The site was located on a floodplain and terrace and the bedrock consisted of the Lenoir formation and the Beckmantown formation of the Knox group. The other site was at river mile 628.0 on the upstream end of Jackson Bend. This site was located on terrace and floodplain deposits, but the Lenoir and Knox formations, forming the bedrock, were fairly close to the surface, outcropping in bluffs along the river and on the surface of the site area. Since no drilling was done at any of these sites no attempt is

made to give details of geology, foundation conditions, or other pertinent facts.[6]

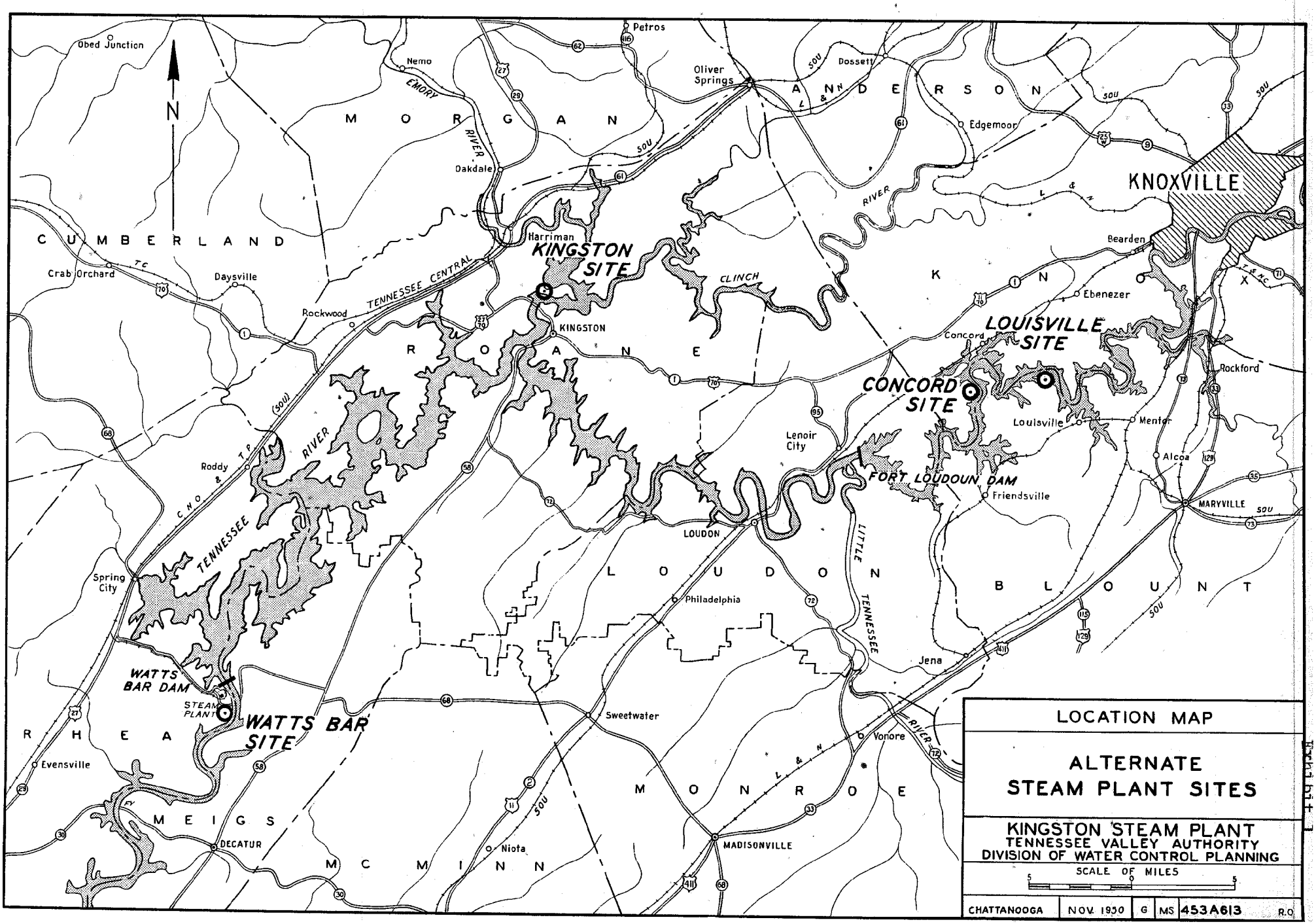
CONCLUSIONS

The comparison of sites is between the ~~Yellow Creek~~ Watts Bar, Concord, and Kingston areas, since the sites on the left bank were not drilled. Of the three sites on the right bank, the ~~Yellow Creek~~ Watts Bar and the Kingston sites appear to show the best foundation conditions. The Concord site, geologically speaking, has limitations. The depth of overburden and the unknown depth of weathered rock would involve extensive and intensive foundation excavation and treatment. The ~~Yellow Creek~~ Watts Bar and Kingston sites, being located on the same geologic formations, will pose approximately the same problems as were encountered in the Watts Bar Steam Plant. There is not much to choose between ~~Yellow Creek and~~ Watts Bar and Kingston in a geological sense, the major factor hinging more on the location.

---

6. Memorandum, "Geologic Reconnaissance of Possible Steam Plant Sites in Fort Loudoun Reservoir," John M. Kellberg and Charles P. Denziger, September 18, 1950.

EXHIBIT



LOCATION MAP

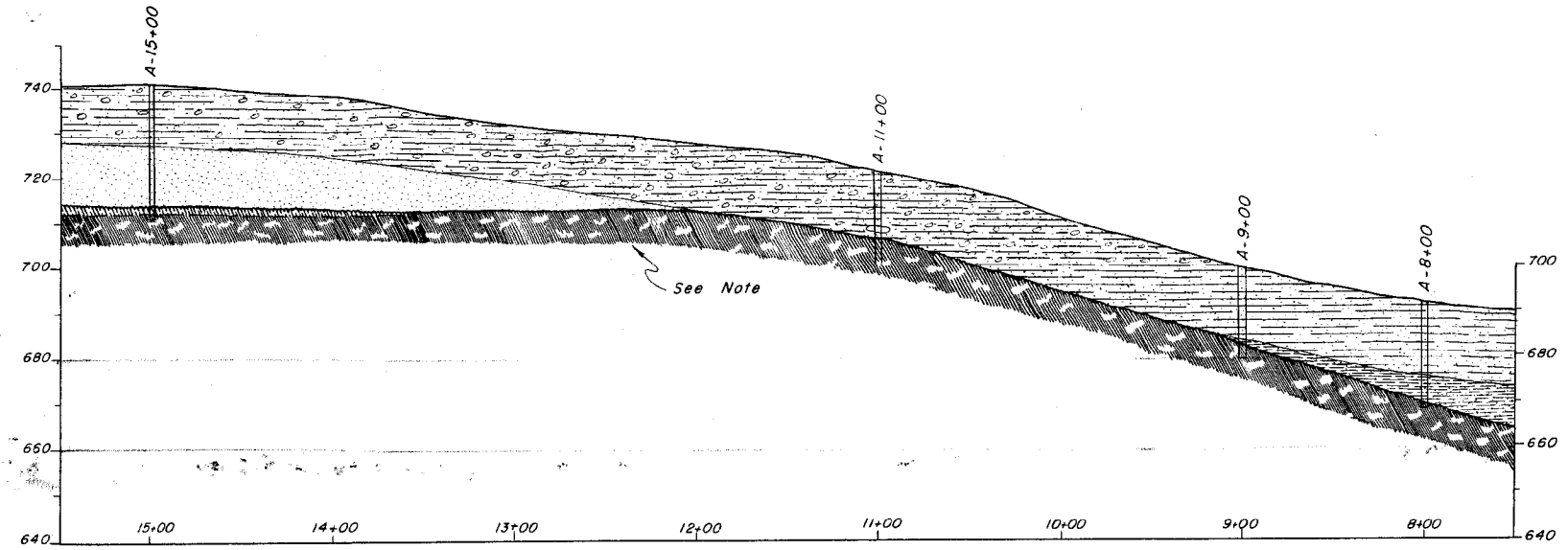
ALTERNATE STEAM PLANT SITES

KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING

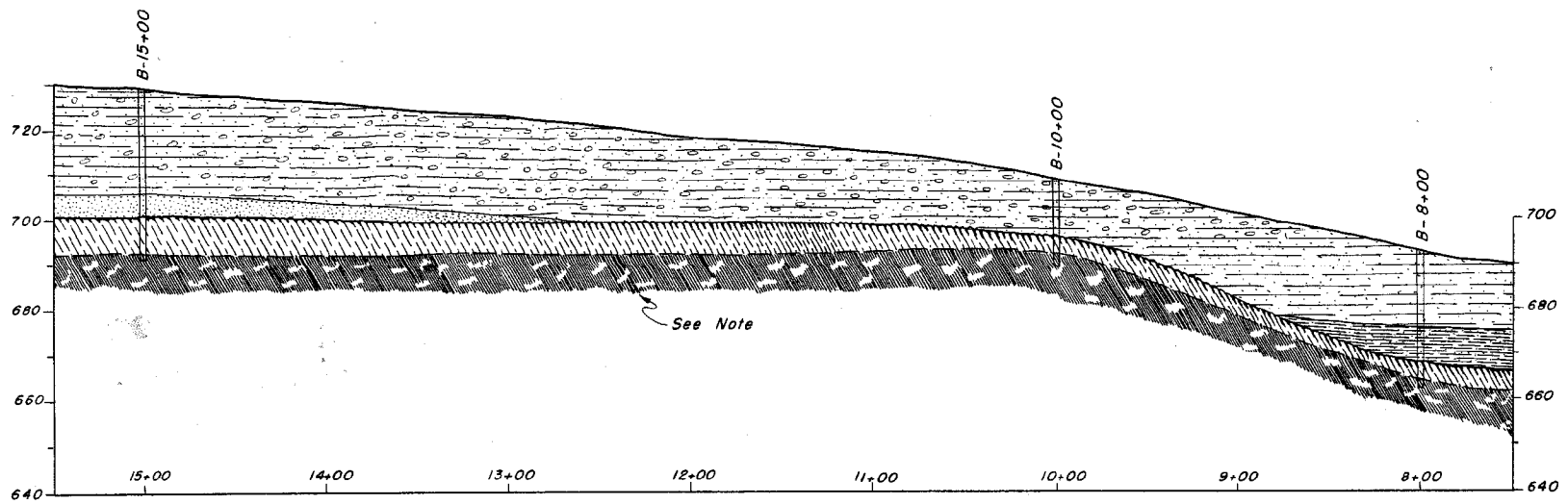
SCALE OF MILES 5 0 5

CHATTANOOGA	NOV. 1950	G	MS	453A613	R.O.

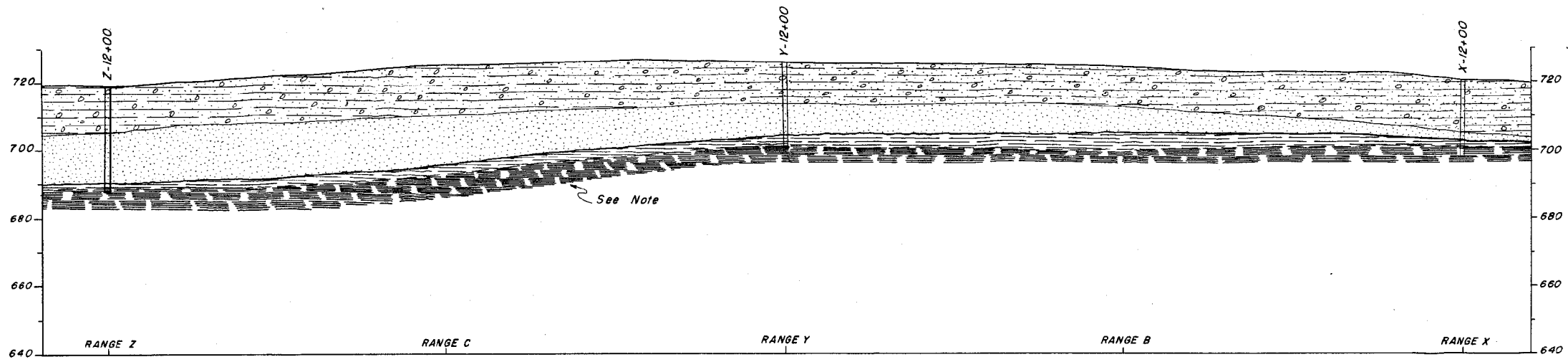
Exhibit 1



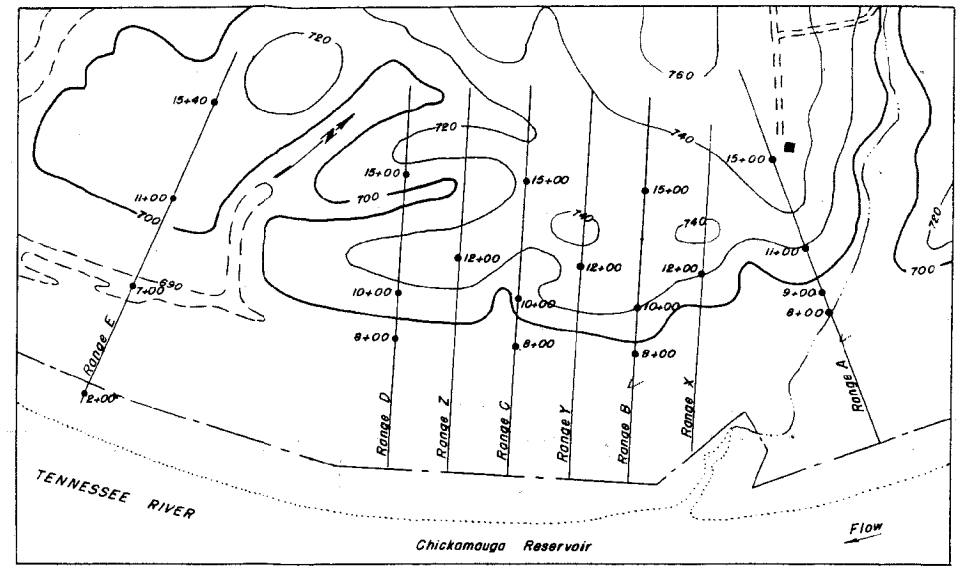
RANGE A



RANGE B



SECTION 12+00



LOCATION PLAN

400 0 400 Feet

LEGEND:

Terrace and Alluvium

- Clay, sand, silt, and gravel.
- Fine-grained, micaceous sand.
- Dark gray, organic clay - Slough filling.

Conasauga Formation

- Thin-bedded, fissile, vari-colored shale with a few thin beds of limestone and sandstone. — Sound.
- Shale, as above — Weathered.

NOTE:

The details of the geologic structure in this area are not known. The general dip is 60° to 70° to the southeast, however the strata are intricately folded and contorted.

SCALE:

20 0 20 40 Feet
VERTICAL

50 0 50 100 Feet
HORIZONTAL

REV NO.	DATE	MADE	CHKD	SUPV	INSP
DRWN		COMPUTED			
TRCD		ENGINEER			
CHKD					

FOUNDATION EXPLORATION

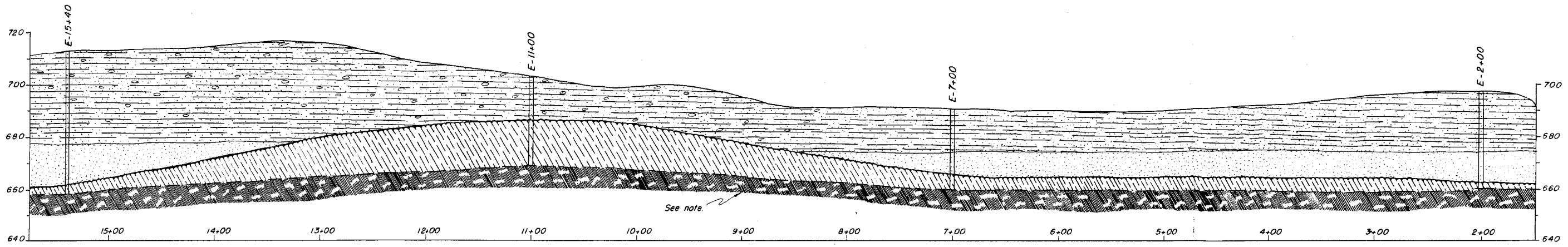
GEOLOGIC SECTIONS
RANGES A, B, AND SECTION 12+00

WATTS BAR AREA - YELLOW CREEK SITE

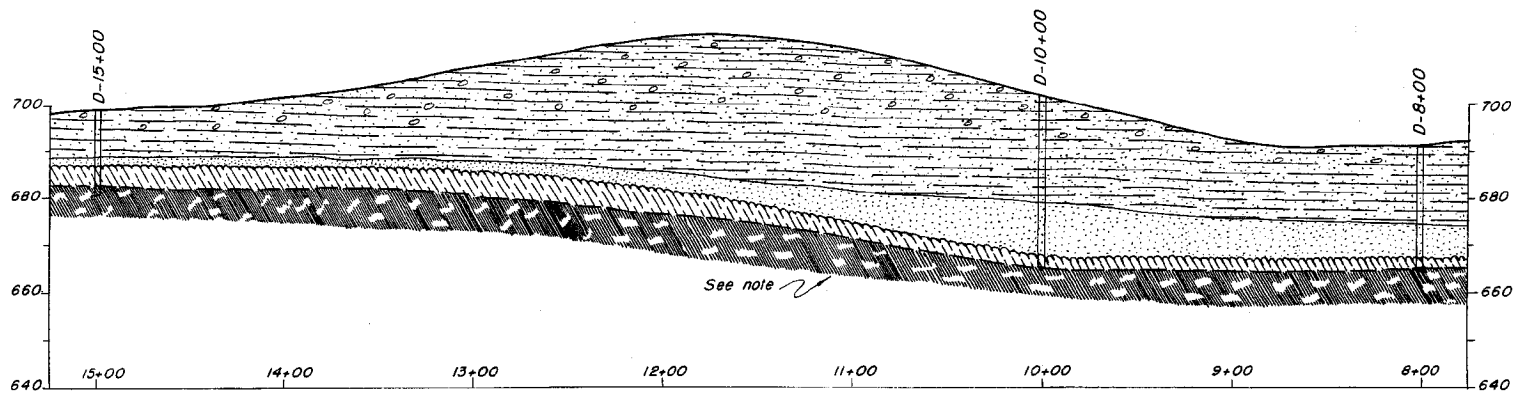
SYSTEM INVESTIGATIONS
TENNESSEE VALLEY AUTHORITY
WATER CONTROL PLANNING DEPARTMENT

SUBMITTED	RECOMMENDED	APPROVED
John M. Gallagher		Beverly E. Mayne

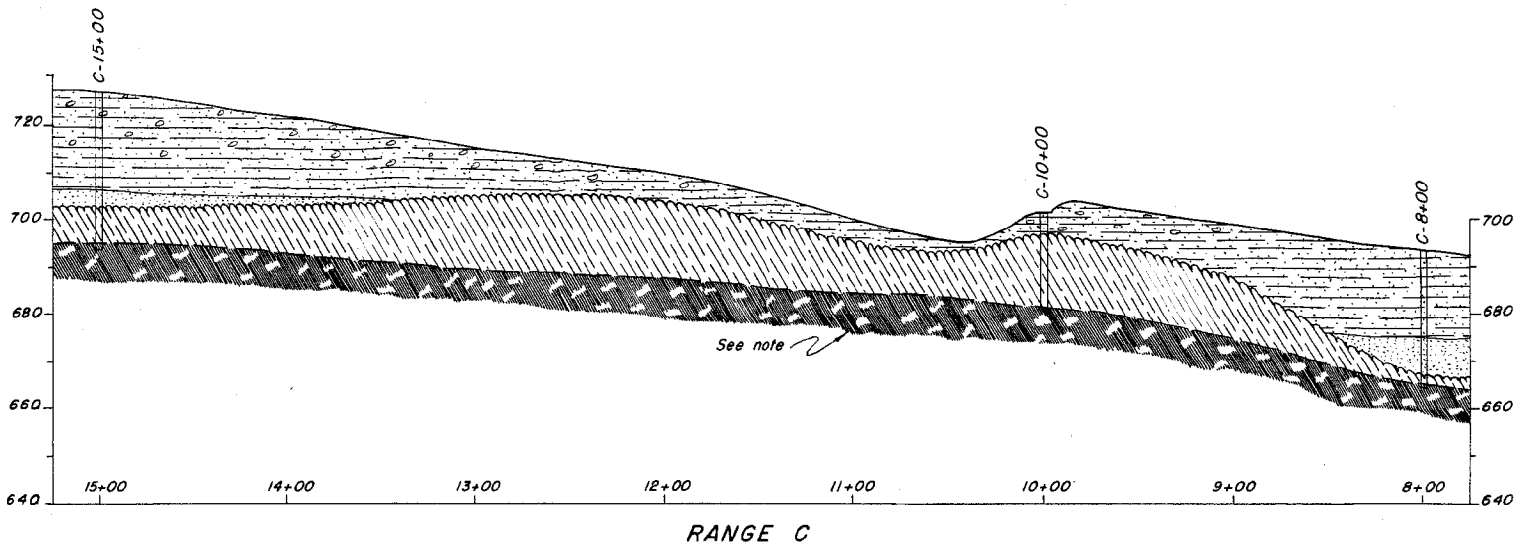
KNOXVILLE	8-30-50	G	GE	1	822K1068



RANGE E



RANGE D



RANGE C

LEGEND:

Terrace and Alluvium

- Clay, sand, silt, and gravel.
- Fine-grained, micaceous sand.
- Dark gray, organic clay - Slough filling.

Conasauga Formation

Thin-bedded, fissile, vari-colored shale with a few thin beds of limestone and sandstone. — Sound.

- Shale, as above — Weathered.

NOTES:

The details of the geologic structure in this area are not known. The general dip is 60° to 70° to the southeast, however the strata are intricately folded and contorted.

For location of sections see drawing G GE I 822K1068.

SCALE:

20 0 20 40 Feet
VERTICAL

50 0 50 100 Feet
HORIZONTAL

REV NO.	DATE	MADE	CHKD	SUPV	INSP
DRWN		COMPUTED			
TRCD		ENGINEER			
CHKD					

FOUNDATION EXPLORATION

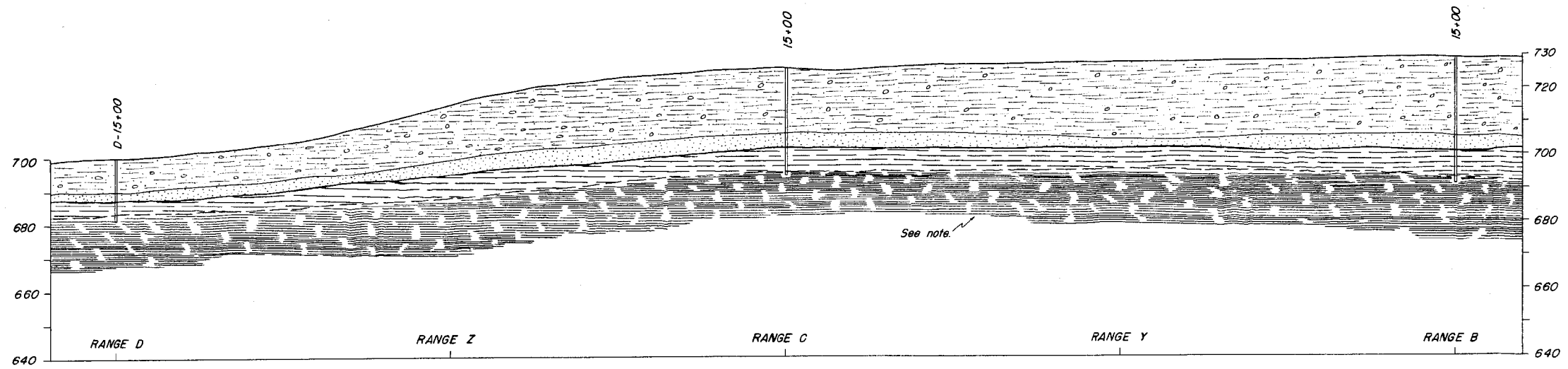
GEOLOGIC SECTIONS
RANGES C, D, AND E

WATTS BAR AREA-YELLOW CREEK SITE

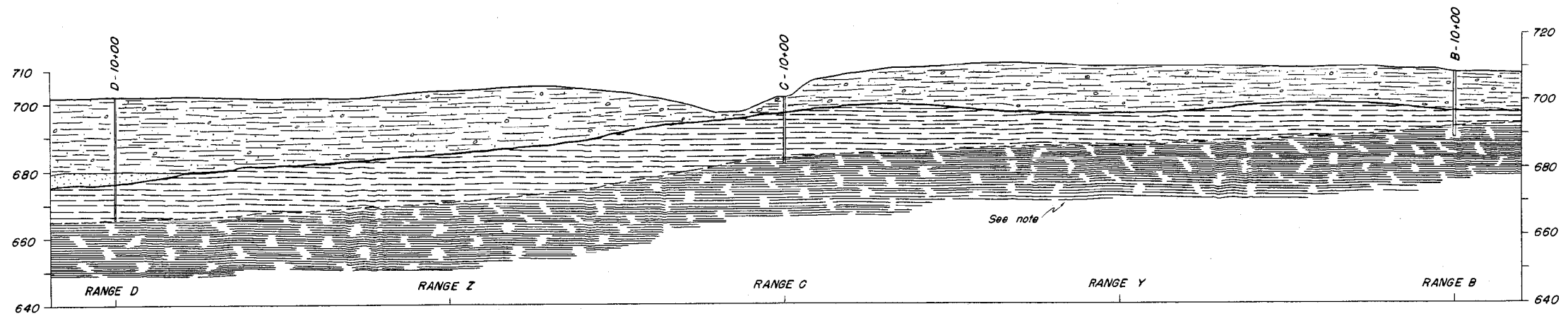
SYSTEM INVESTIGATIONS
TENNESSEE VALLEY AUTHORITY
WATER CONTROL PLANNING DEPARTMENT

SUBMITTED	RECOMMENDED	APPROVED
Wm. M. Kellberg		Berlin E. Mongomery

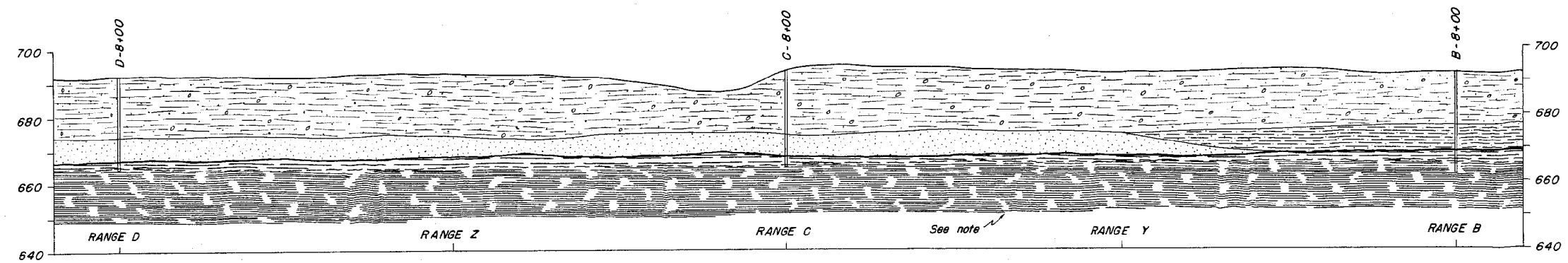
KNOXVILLE	8-30-50	G	GE	I	822 K 1070



SECTION 15+00



SECTION 10+00



SECTION 8+00

LEGEND

Terrace and alluvium

Clay, sand, silt and gravel.

Fine grained, micaceous sand.

Dark gray organic clay - Slough filling.

Conasauga Formation

Thin bedded, fissile, vari-colored shale, with a few thin beds of limestone and sandstone. Sound.

Shale as above. Weathered.

NOTES

For location plan, see drawing G-GE-1-822K1068

The details of geologic structure in this area are not known. The general dip is 60° to 70° to the southeast, however the strata are intricately folded and faulted.

SCALE:

Horizontal 50 0 50 100 Feet

Vertical 20 0 20 40 Feet

REV NO.	DATE	MADE	CHKD	SUPV	INSP
DRWN		COMPUTED			
TRCD		ENGINEER			
CHKD					

FOUNDATION EXPLORATION

GEOLOGIC SECTIONS

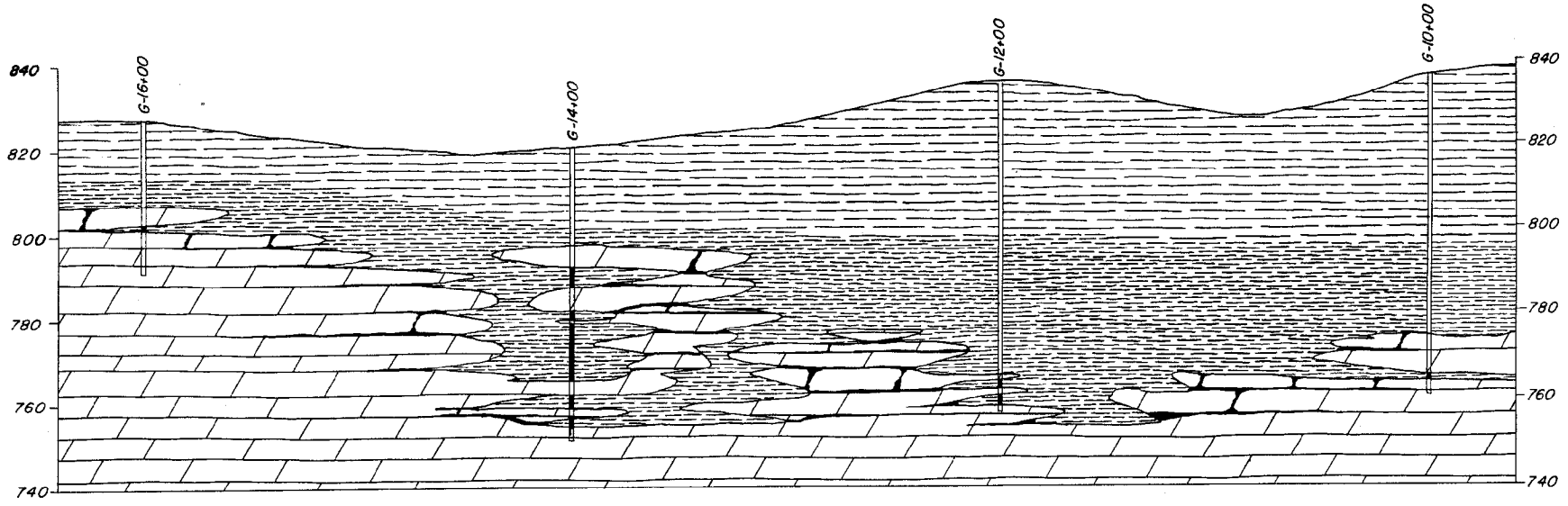
SECTIONS 8+00, 10+00, AND 15+00

WATTS BAR AREA - YELLOW CREEK SITE

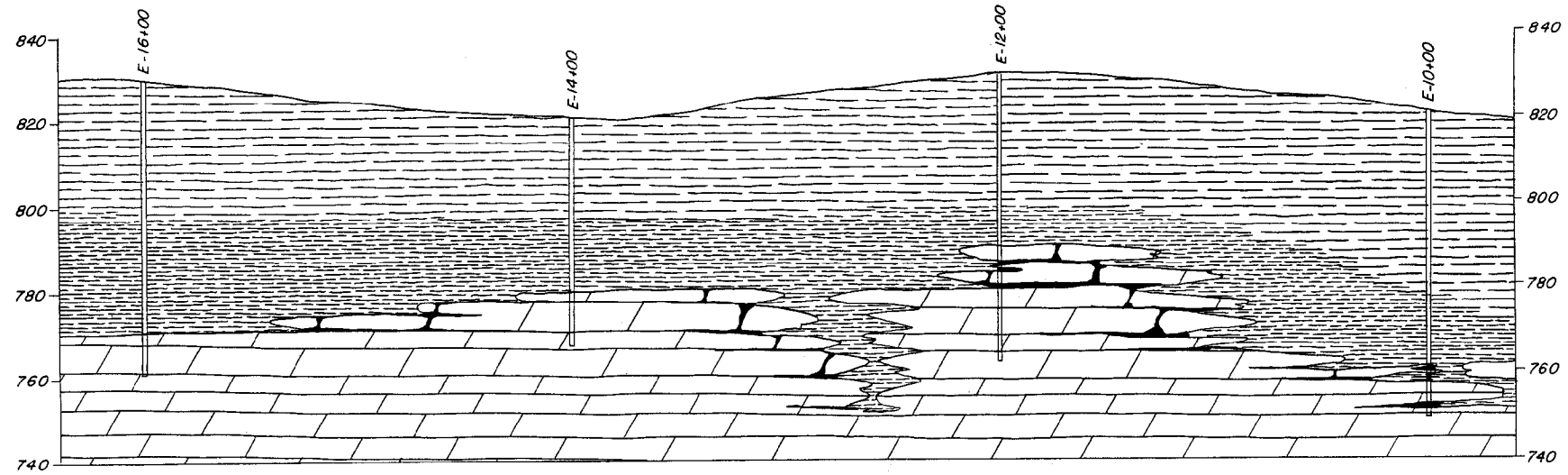
SYSTEM INVESTIGATIONS
TENNESSEE VALLEY AUTHORITY
WATER CONTROL PLANNING DEPARTMENT

SUBMITTED	RECOMMENDED	APPROVED
Charles P. Young Jr.		Robert L. Montgomery

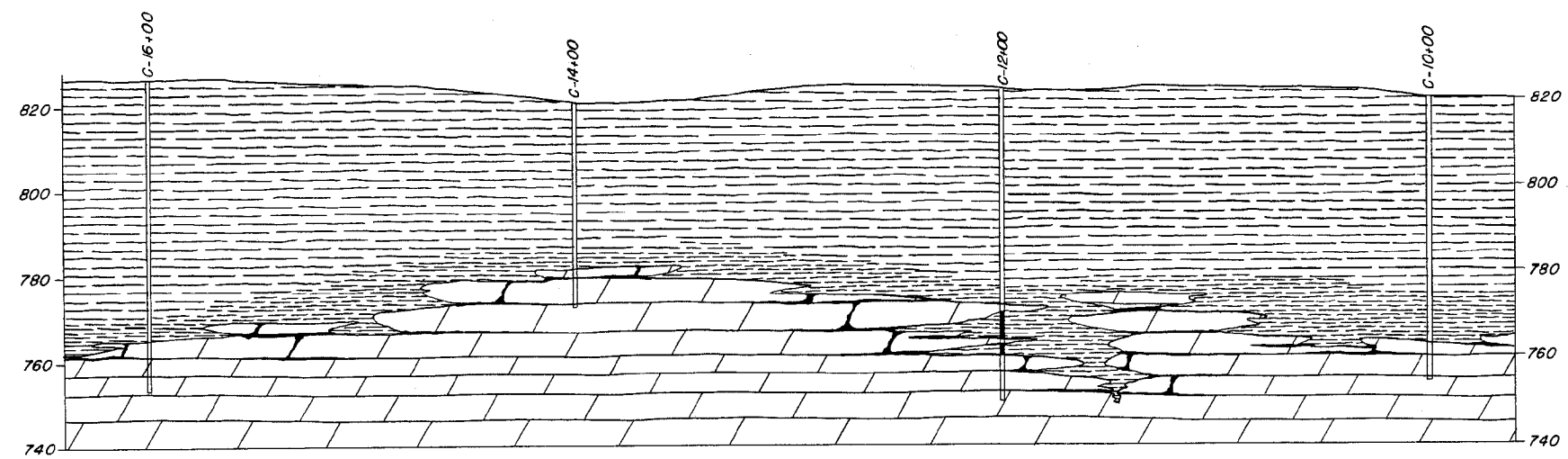
KNOXVILLE	8-31-50	G	GE	1	822K1069



RANGE G



RANGE E



RANGE C

LEGEND

Overburden

Terrace and alluvium – Clay, silt, sand, and gravels, well compacted.

Residuum – Chert pebbles and cobbles, red to yellow compact clay, with sandy zones.

Knox formation – Copper Ridge - Light to dark gray, sandy to fine grained, brecciated, recemented, cherty, dolomite.

NOTES

Sections drawn looking northwest.

For location plan, see drawing W-GE-1-822K1085.

SCALE: Horizontal 40 0 40 80 Feet

Vertical 20 0 20 40 Feet

REV NO	DATE	MADE	CHKD	SUPV	INSP

DRWN ..... COMPUTED

TRCD ..... ENGINEER

CHKD .....

FOUNDATION EXPLORATION

GEOLOGIC SECTIONS

RANGES C, G, AND E

CONCORD SITE

SYSTEM INVESTIGATIONS

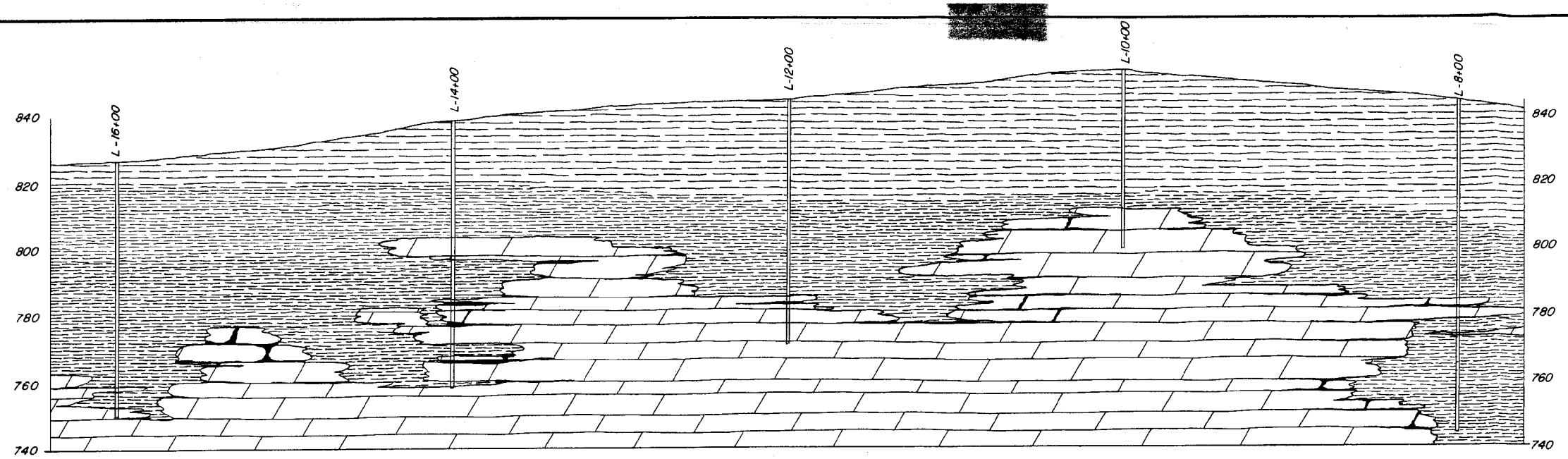
TENNESSEE VALLEY AUTHORITY

WATER CONTROL PLANNING DEPARTMENT

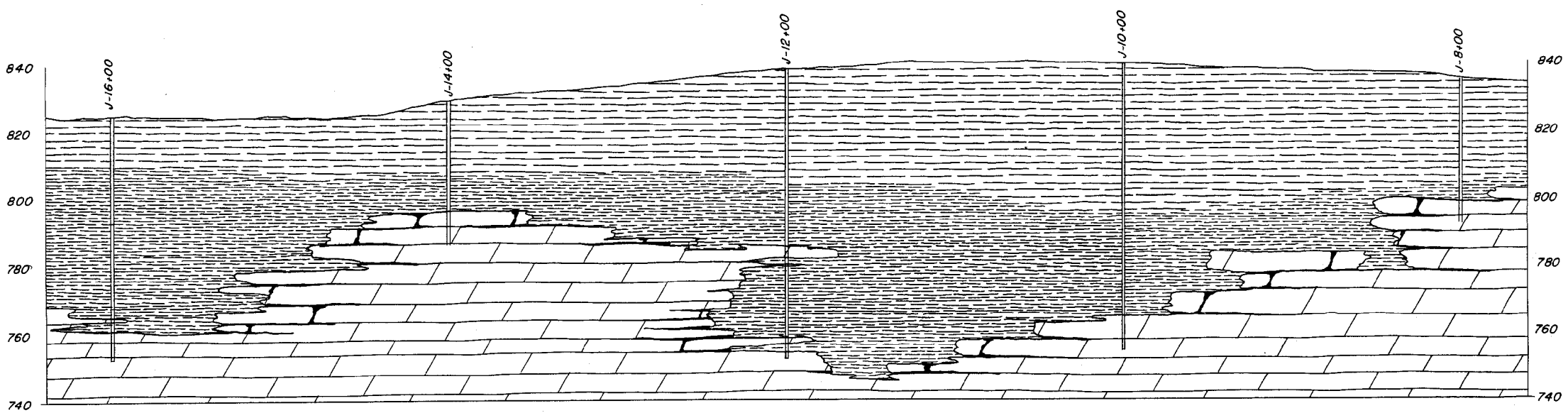
SUBMITTED	RECOMMENDED	APPROVED
Charles F. Ringgold		Reuben E. Montgomery

KNOXVILLE	1-17-51	W	GE	1	822K1087

EXHIBIT C



RANGE L



RANGE J

LEGEND

Overburden

Terrace and alluvium- Clay, silt, sand, and gravels, well compacted.

Residuum- Chert pebbles and cobbles, red to yellow compact clay, with sandy zones.

Knox formation- Copper Ridge - Light to dark gray, sandy to fine grained, brecciated, recemented, cherty dolomite.

NOTES

Sections drawn looking northwest.

For location plan, see drawing W-GE-1-822K1065.

SCALE: Horizontal 40 0 40 80 Feet

Vertical 20 0 20 40 Feet

REV NO.	DATE	MADE	CHKD	SUPV	INSP

DRWN ..... COMPUTED

TRCD ..... ENGINEER

CHKD .....

FOUNDATION EXPLORATION

GEOLOGIC SECTIONS

RANGES L AND J

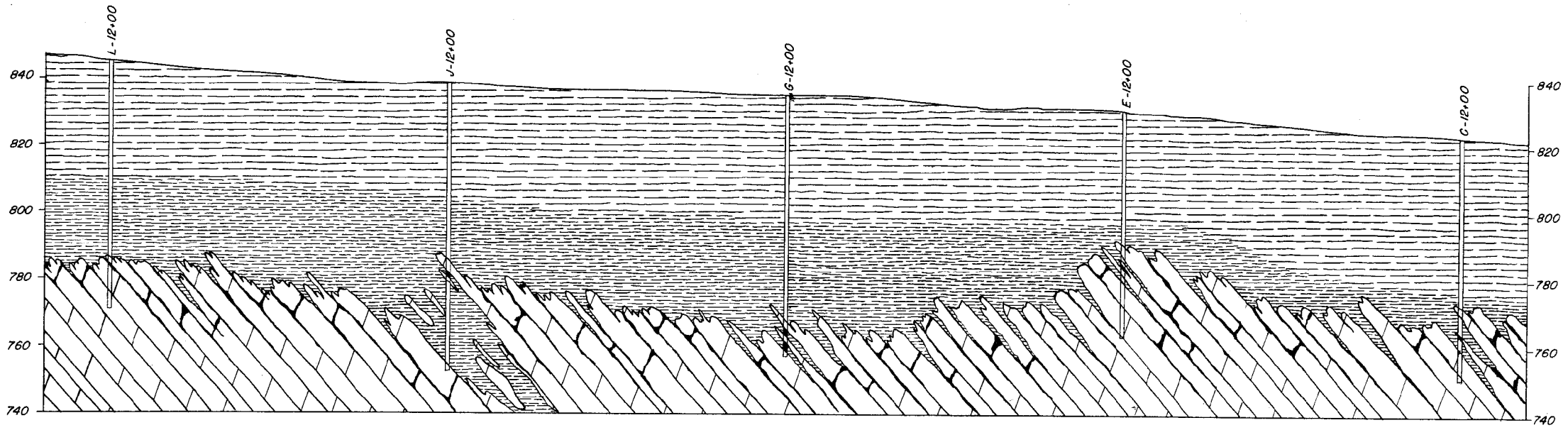
CONCORD SITE

SYSTEM INVESTIGATIONS
TENNESSEE VALLEY AUTHORITY
WATER CONTROL PLANNING DEPARTMENT

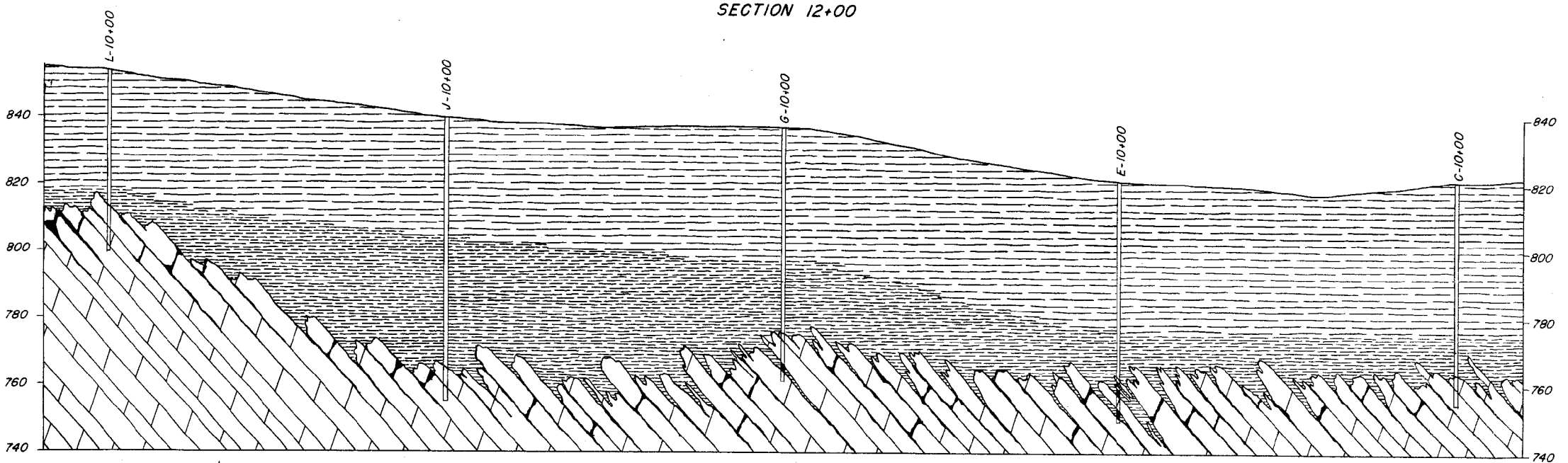
SUBMITTED	RECOMMENDED	APPROVED
Charles F. Bingaman		Reuben E. Montgomery

KNOXVILLE	1-17-51	W	GE	1	822K1088

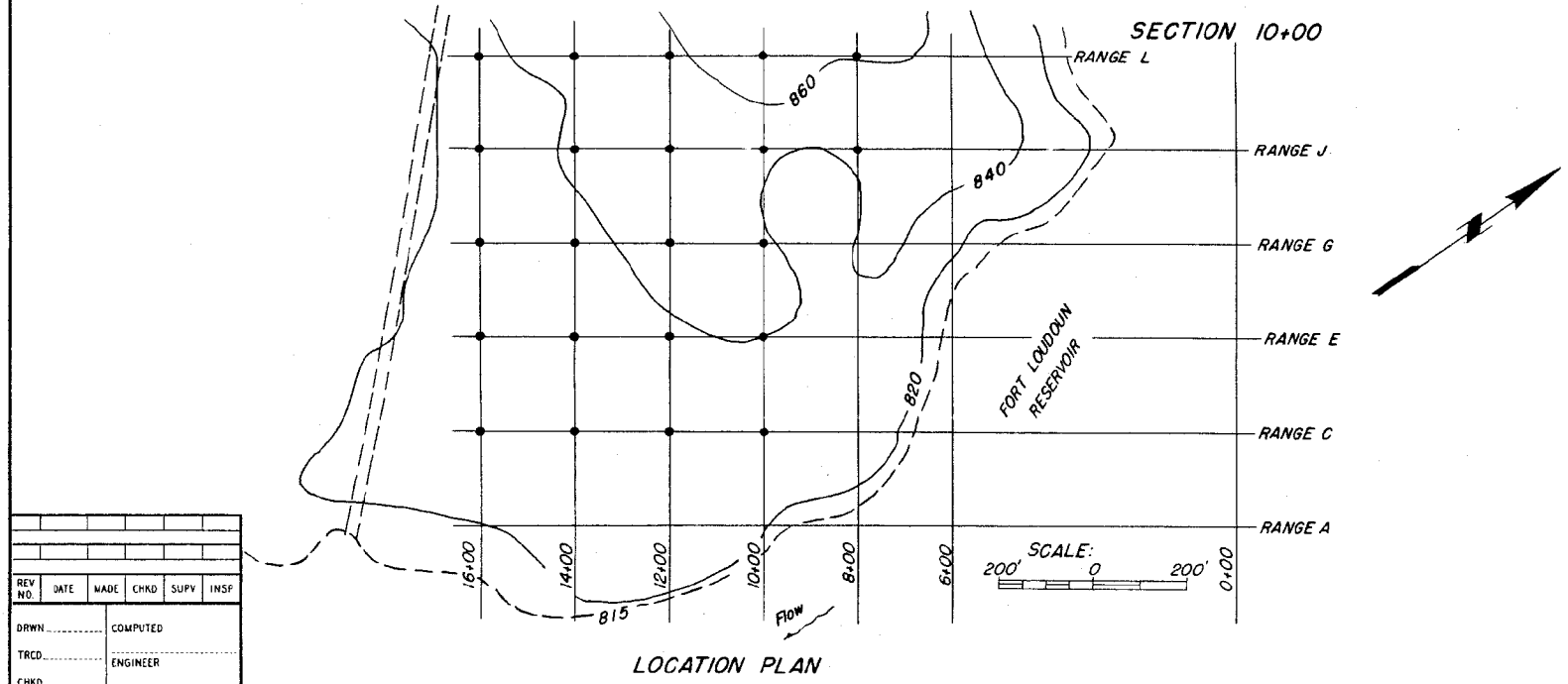
Exhibit 7



SECTION 12+00



SECTION 10+00



LOCATION PLAN

LEGEND

Overburden

Terrace and alluvium - Clay, silt, sand, and gravels, well compacted.

Residuum - Chert pebbles and cobbles, red to yellow compact clay, with sandy zones.

Knox formation - Copper Ridge - Light to dark gray, sandy to fine grained, brecciated, recemented, cherty dolomite.

NOTES

All sections drawn looking upstream.

Dip of rock exaggerated to compensate for exaggeration of scale. True dip averages 25° to 30°.

SCALE: Horizontal 40 0 40 80 Feet

Vertical 20 0 20 40 Feet

REV NO.	DATE	MADE	CHKD	SUPV	INSP
DRWN		COMPUTED			
TRCD		ENGINEER			
CHKD					

FOUNDATION EXPLORATION

GEOLOGIC SECTIONS

SECTIONS 10+00 AND 12+00

CONCORD SITE

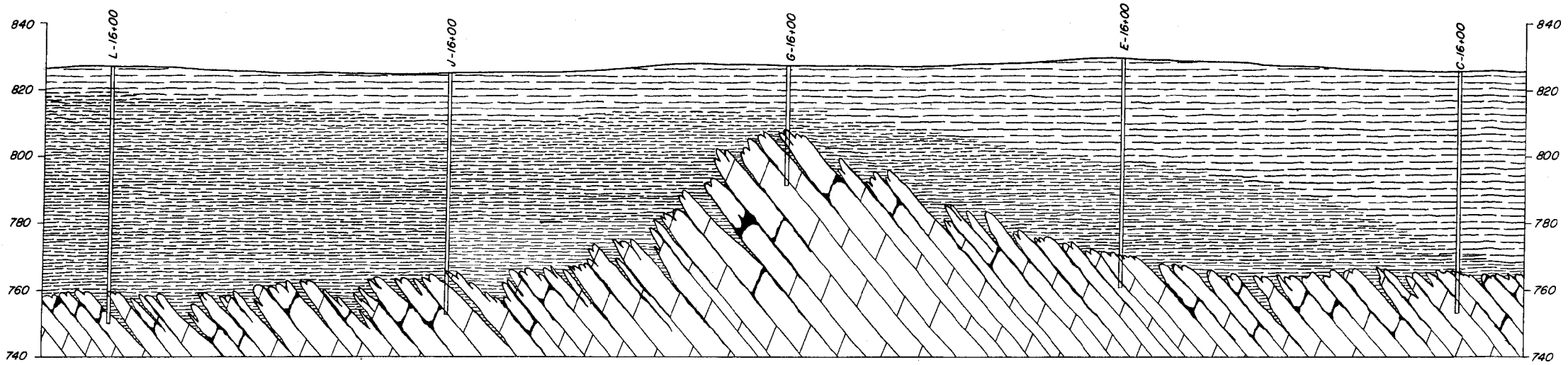
SYSTEM INVESTIGATIONS

TENNESSEE VALLEY AUTHORITY

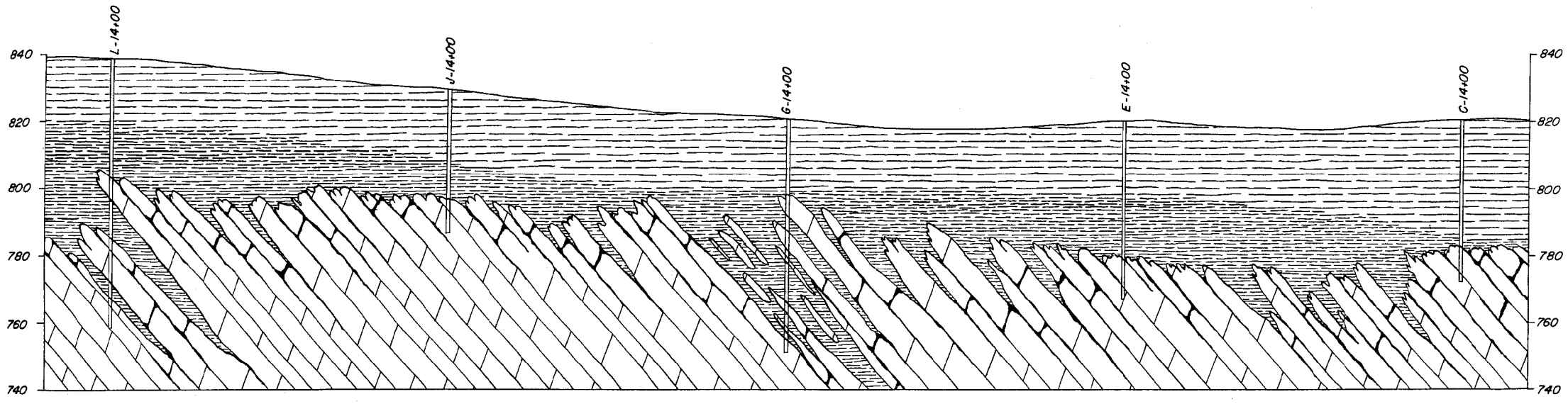
WATER CONTROL PLANNING DEPARTMENT

SUBMITTED	RECOMMENDED	APPROVED
Charles F. Berry		Reuben E. Montgomery

KNOXVILLE	1-17-51	W	GE	1	822K1085



SECTION 16+00



SECTION 14+00

LEGEND

Overburden

Terrace and alluvium- Clay, silt, sand, and gravels, well compacted.

Residuum- Chert pebbles and cobbles, red to yellow compact clay, with sandy zones.

Knox formation- Copper Ridge- Light to dark gray, sandy to fine grained, brecciated, recemented, cherty dolomite.

NOTES

Sections drawn looking upstream.

For location plan, see companion drawing W-GE-1-822K1085.

Dip of rock exaggerated to compensate for exaggeration of scale. True dip averages 25° to 30°

SCALE: Horizontal 40 0 40 80 Feet

Vertical 20 0 20 40 Feet

REV NO.	DATE	MADE	CHKD	SUPV	INSP

DRWN _____ COMPUTED

TRCD _____ ENGINEER

CHKD _____

FOUNDATION EXPLORATION

GEOLOGIC SECTIONS

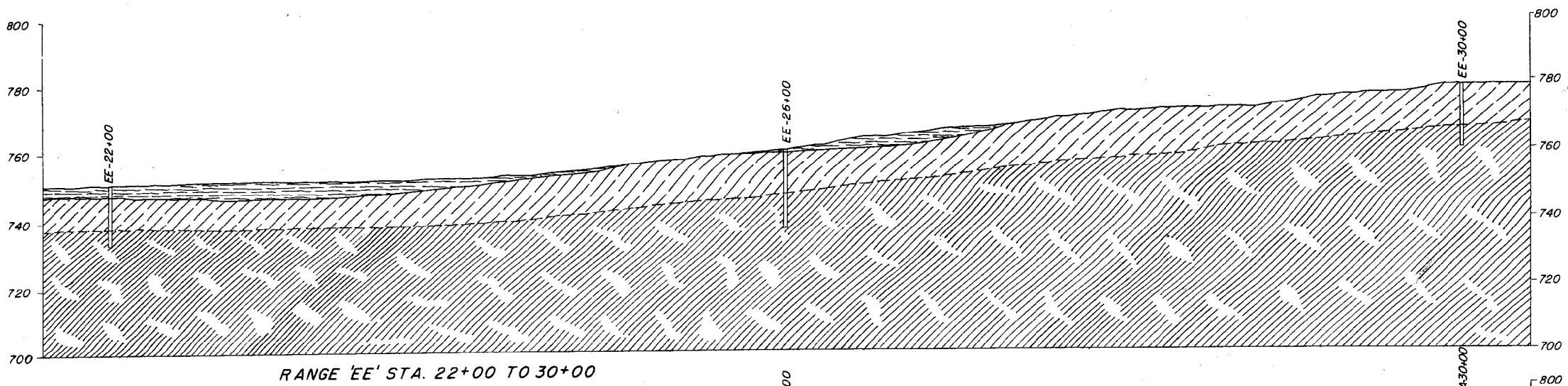
SECTIONS 14+00 AND 16+00

CONCORD SITE

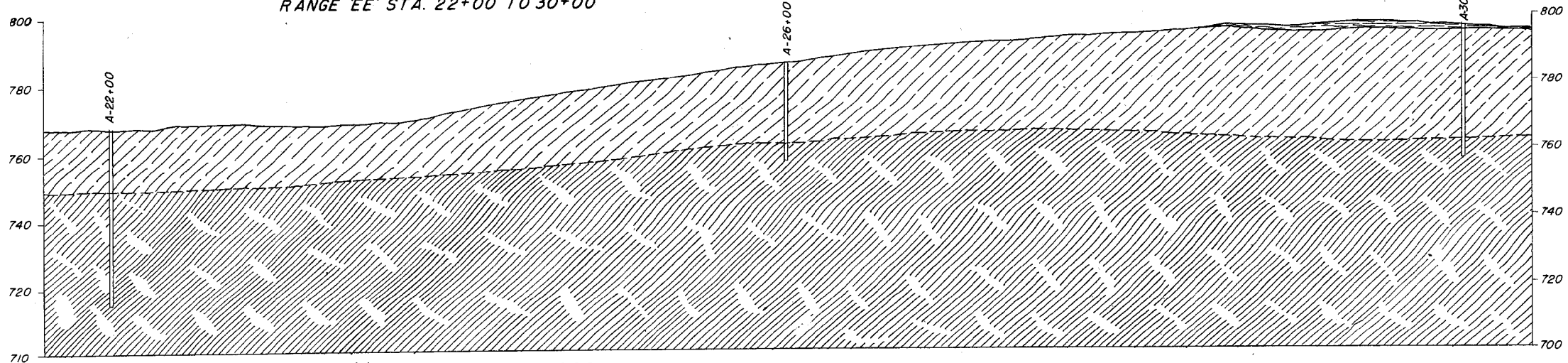
SYSTEM INVESTIGATIONS
TENNESSEE VALLEY AUTHORITY
WATER CONTROL PLANNING DEPARTMENT

SUBMITTED	RECOMMENDED	APPROVED
Charles P. Barclay Jr		Reuben E. Montgomery

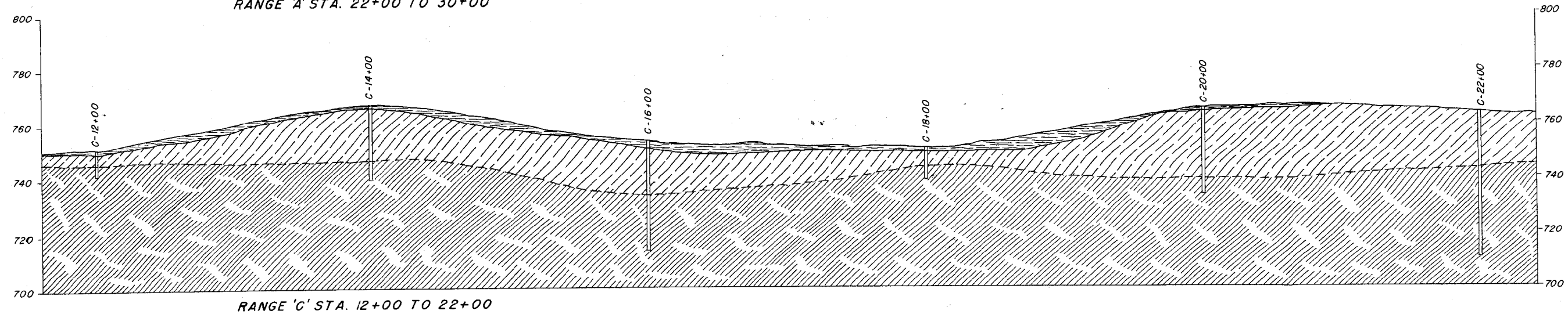
KNOXVILLE	1-17-51	W	GE	1	822K1086



RANGE 'EE' STA. 22+00 TO 30+00



RANGE 'A' STA. 22+00 TO 30+00



RANGE 'C' STA. 12+00 TO 22+00

LEGEND

OVERBURDEN

- Yellow clay - residuum.

CONASAUGA FORMATION

- Thin bedded, fissile, dark gray to blue shale, with numerous thin beds of limestone and siltstone scattered throughout the formation. Sound rock.
- Shale, as above, weathered.

NOTES

No attempt was made to correlate individual beds, due to the overall homogeneity of lithology and the wide spacing of the drill holes.

The sound rock consists of interbedded shales and calcareous rocks, limestones, siltstones and limestone conglomerates. The percentage of resistant beds increases to the southeast, toward the contact with the overlying Knox group. The incompetent beds between the layers of harder, calcareous rock, are intricately folded and faulted.

Near the surface, the more soluble limestones have been dissolved, enabling the processes of decomposition to act on the less vulnerable shales. The foundation grade will correspond fairly close to the top of sound rock as shown in the sections.

For location of sections, see companion drawing 36-GE-1-822K1093

REV NO.	DATE	MADE	CHKD	SUPV	INSP

DRWN ..... COMPUTED

TRCD ..... ENGINEER

CHKD .....

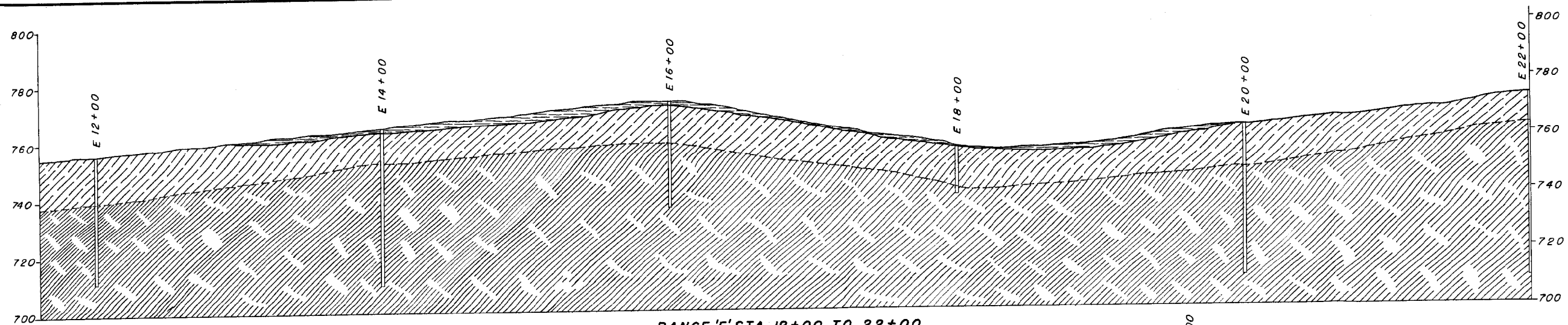
FOUNDATION EXPLORATION

RANGES EE, A, AND C

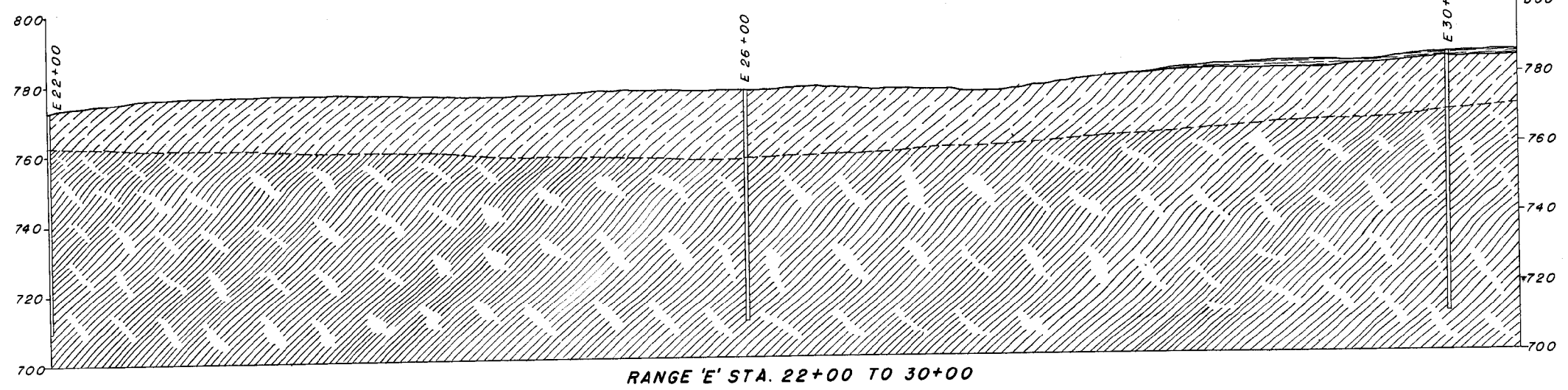
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
WATER CONTROL PLANNING DEPARTMENT

SUBMITTED	RECOMMENDED	APPROVED
Charles P. Bongiorno		Braden C. Manning

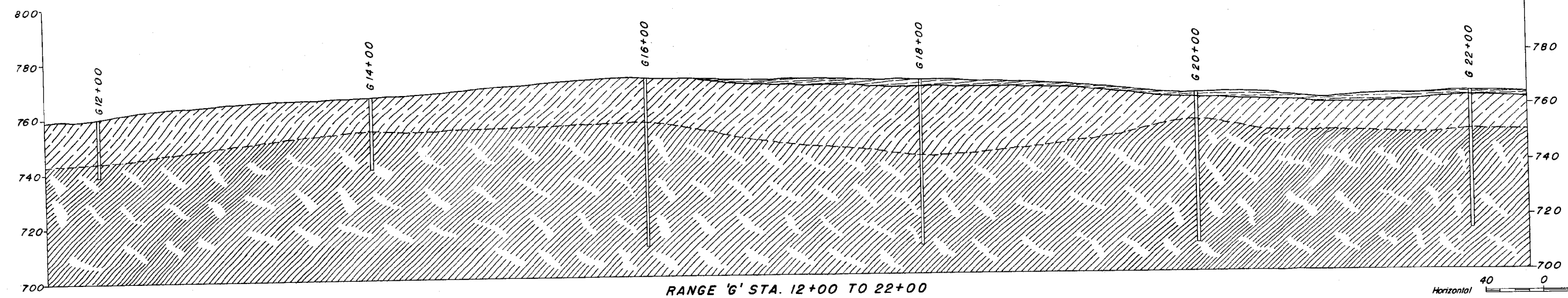
KNOXVILLE	2-2-51	36	GE	1	822K1091



RANGE 'E' STA. 12+00 TO 22+00



RANGE 'E' STA. 22+00 TO 30+00



RANGE 'G' STA. 12+00 TO 22+00

LEGEND

OVERBURDEN

- Yellow clay - residuum.

CONASAUGA FORMATION

Thin bedded, fissile, dark gray to blue shale, with numerous thin to massive beds of limestone and siltstone scattered throughout the formation. Sound rock.

- Shale, as above, weathered.

Horizontal 40 0 40 80

Vertical 20 0 20 40

NOTES

No attempt was made to correlate individual beds, due to the overall homogeneity of lithology and the wide spacing of the drill holes.

The sound rock consists of interbedded shales and calcareous rocks; limestones, siltstones and limestone conglomerates. The percentage of resistant beds increases to the southeast, toward the contact with the overlying Knox group. The incompetent beds between the layers of harder, calcareous rock, are intricately folded and faulted.

Near the surface, the more soluble limestones have been dissolved, enabling the processes of decomposition to act on the less vulnerable shales. The foundation grade will correspond fairly close to the top of sound rock as shown in the sections.

For location of sections, see companion drawing 36-GE-1-822K1093

REV NO.	DATE	MADE	CHKD	SUPV	INSP
DRWN		COMPUTED			
TRCD		ENGINEER			

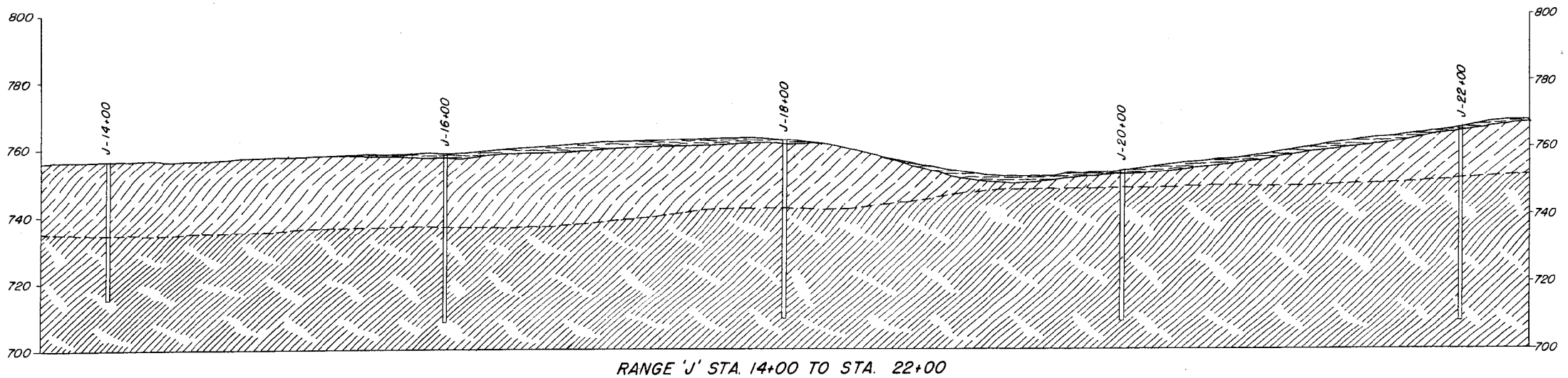
FOUNDATION EXPLORATION

RANGES E AND G

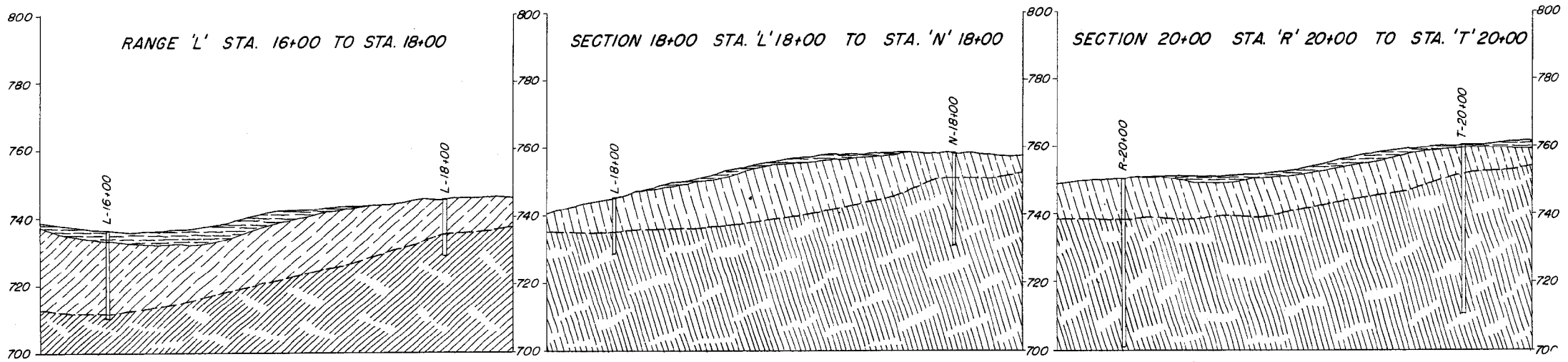
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
WATER CONTROL PLANNING DEPARTMENT

SUBMITTED	RECOMMENDED	APPROVED
Charles P. Bingham		B.C. Montgomery

KNOXVILLE	2-2-51	36	GE	1	822K1092



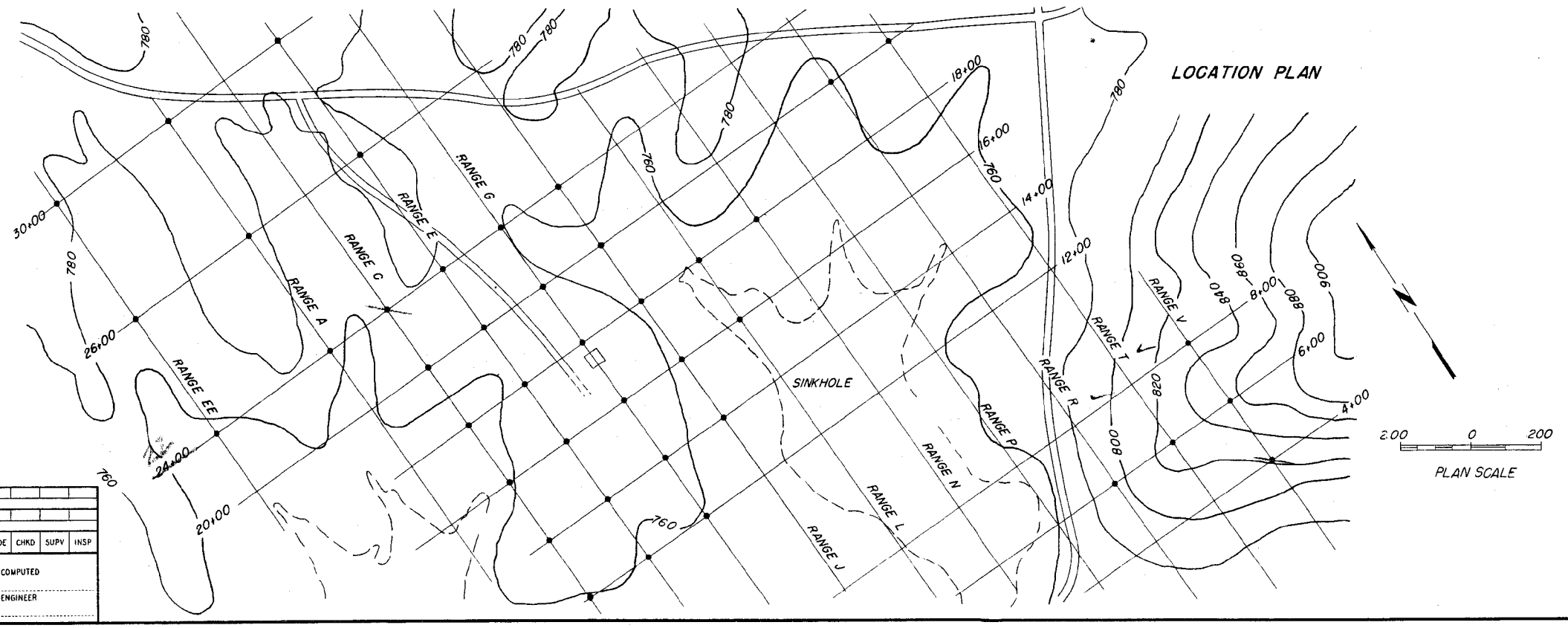
RANGE 'J' STA. 14+00 TO STA. 22+00



RANGE 'L' STA. 16+00 TO STA. 18+00

SECTION 18+00 STA. 'L' 18+00 TO STA. 'N' 18+00

SECTION 20+00 STA. 'R' 20+00 TO STA. 'T' 20+00



LEGEND

OVERBURDEN

- Yellow clay - residuum.

CONASAUGA FORMATION

Thin bedded, fissile, dark gray to blue shale, with numerous thin beds of limestone and siltstone scattered throughout the formation. Sound rock.

Shale as above, weathered.

NOTES

No attempt was made to correlate individual beds, due to the overall homogeneity of lithology and the wide spacing of the drill holes.

The sound rock consists of interbedded shales and calcareous rocks; limestones, siltstones, and limestone conglomerates. The percentage of resistant beds increases to the southeast, toward the contact with the overlying Knox group. The incompetent beds between the layers of harder, more calcareous rocks, are intricately folded and faulted.
Near the surface, the more soluble limestones have been dissolved, enabling the processes of decomposition to act on the less vulnerable shale. The foundation grade will correspond fairly close to top of rock as shown in the sections.

SCALE:

Horizontal 40 20 0 40 80 Feet

Vertical 20 0 20 40 Feet

REV NO.	DATE	MADE	CHKD	SUPV	INSP
DRWN.		COMPUTED			
TRCD.		ENGINEER			
CHKD.					

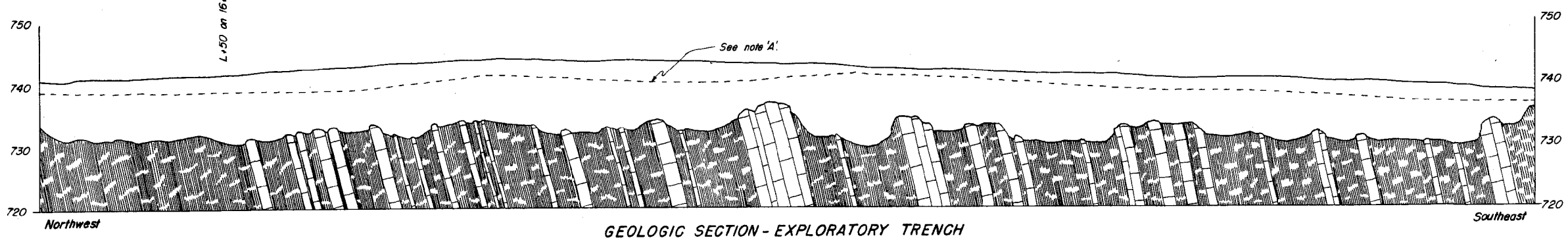
FOUNDATION EXPLORATION

RANGES J AND L SECTIONS 18+00 AND 20+00

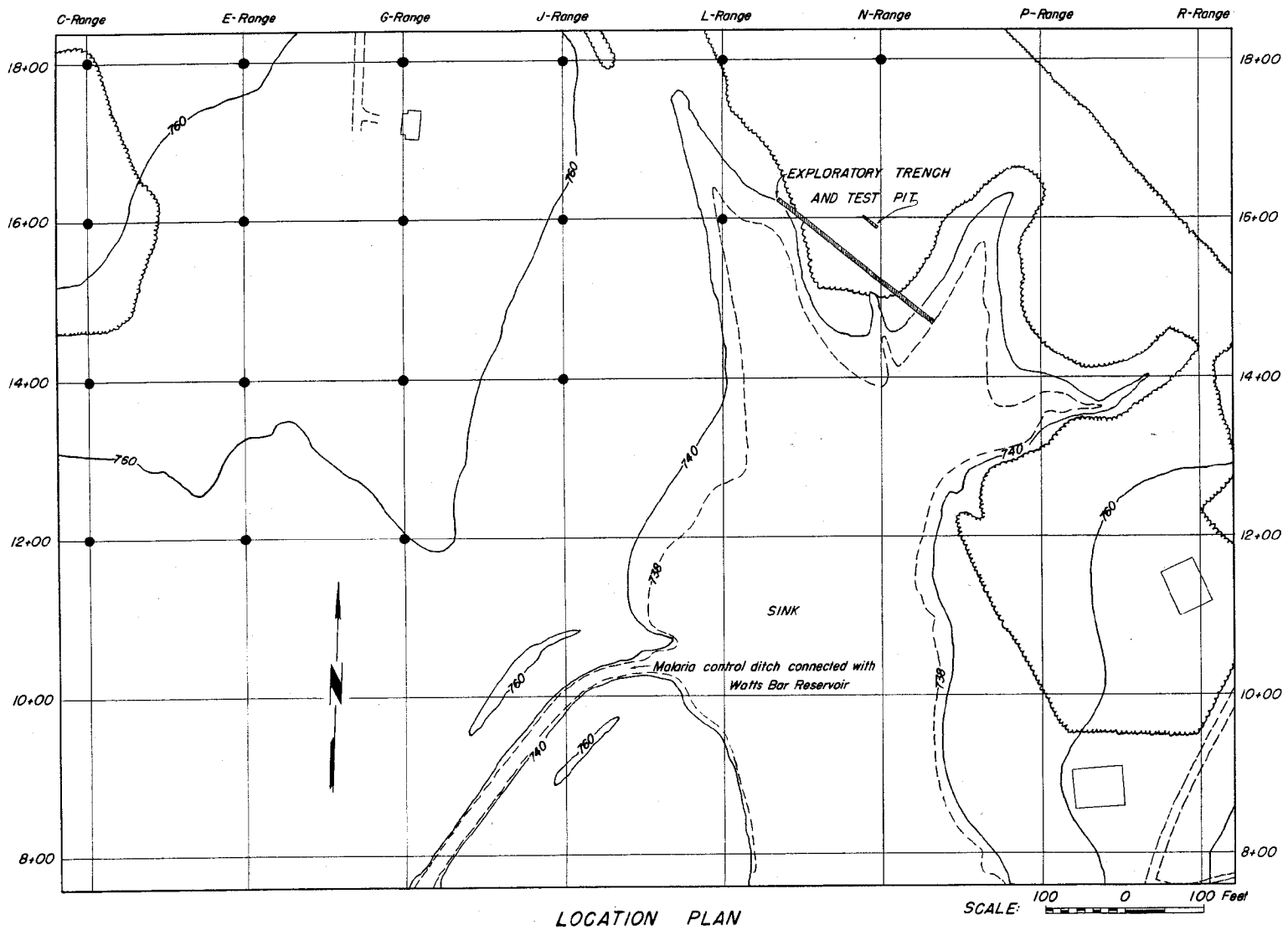
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
WATER CONTROL PLANNING DEPARTMENT

SUBMITTED	RECOMMENDED	APPROVED
Charles P. Bingham		B. C. Montgomery

KNOXVILLE | 2-2-51 | 36 GE 1 | 822K1093



GEOLOGIC SECTION - EXPLORATORY TRENCH



LOCATION PLAN

LEGEND

Conasauga Group

Pink, light to dark gray limestone and limestone conglomerate, with some beds of siltstone; thin bedded to massive, fine to medium crystalline.

Blue-gray shale, argillaceous and arenaceous, fine grained, extremely contorted, folded, and faulted. When weathered, the beds of shale show yellow, brown, gray, green, and reddish zones.

● Hole drilled by T.V.A., 1950.

NOTES

Note A- The dashed line denotes the top of rock. The material above this line consists of a sandy, yellow clay, residuum from the weathering of the interbedded shale and limestone.

Note B- The incompetent shale beds between the more competent beds of limestone are intricately folded and faulted, making impractical the delineation of detailed structure. Complete folds occur in the shale between massive beds of limestone which are only a few inches apart. Complete reversals of dip in the space of a few inches are common. The thinner bedded limestones are involved in the structural deformation in several places in the exploratory trench, however, the more massive beds are not folded in small scale structures which are visible in a short section.

Note C- The limestone beds are completely weathered to an approximate elevation of 730.0, appearing above this elevation only as a yellow clay residuum. The shales, due to the effects of the deformational processes, break up easily on exposure. The shales are badly weathered to a depth of 10 to 15 feet. Although the structure is still recognizable, the material is easily excavated by hand methods.

SCALE: 10 0 10 20 Feet

REV NO.	DATE	MADE	CHKD	SUPV	INSP

DRWN ..... COMPUTED

TRCD ..... ENGINEER

CHKD .....

FOUNDATION EXPLORATION

GEOLOGIC SECTION EXPLORATORY TRENCH

KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
WATER CONTROL PLANNING DEPARTMENT

SUBMITTED	RECOMMENDED	APPROVED
Charles P. Ringgold		Orden L. Montgomery

KNOXVILLE	1-30-51	36	GE	1	822K1090