# CHAPTER 5

# LONG-TERM STORAGE CAPACITY OF CONTAINMENT AREAS

## 5-1. Factors Affecting Long-Term Storage Capacity.

a. General.

(1) In order that the maximum benefits can be derived from areas constructed for the confined disposal of dredged material, the design and operation plan must accurately account for the long-term increase in storage capacity in containment areas resulting from decreases in the height of dredged fill deposited. The height of the dredged fill decreases by three natural processes: sedimentation, consolidation, and desiccation. Sedimentation is a relatively short-term process, whereas consolidation and desiccation are long-term processes. Design of containment areas for effective sedimentation was discussed in Chapter 4. This chapter presents guidelines for estimating long-term containment area storage capacity, considering both dredged material consolidation and dewatering (evaporative drying). The storage capacity is defined as the total volume available to hold additional dredged material and is equal to the total unoccupied volume minus the volume associated with ponding requirements and freeboard requirements. The estimation of long-term storage capacity is an important consideration for long-term planning and design of new containment areas or evaluation of the remaining service life of existing sites.

(2) After dredged material is placed within a containment area, it undergoes sedimentation and self-weight consolidation, resulting in gains in storage capacity. The placement of dredged material also imposes a loading on the containment area foundation; therefore, additional settlement may result from consolidation of compressible foundation soils. Settlement due to consolidation is therefore a major factor in the estimation of long-term storage capacity. Since the consolidation process is slow, especially in the case of fine-grained materials, it is likely that total settlement will not have taken place before the containment area is required for additional placement of dredged material. Settlement of the containing dikes may also significantly affect the available storage capacity and should be considered. Once a given active dredging operation ends, the ponded surface water required for settling is decanted, exposing the dredged material surface to desiccation (evaporative drying). This process can further add to long-term storage capacity and is a time-dependent and climate-dependent process. Active dewatering operations such as surface trenching can speed the natural dewatering process. A conceptual diagram illustrating these processes is shown in Figure 5-1.

(3) Guidelines for estimation of gains in long-term capacity due to settlement within the containment area are based on the fundamental principles of consolidation theory modified to consider the self-weight consolidation behavior of newly placed dredged material. The guidelines are presented in the following paragraphs; illustrative examples are found in Appendix F.

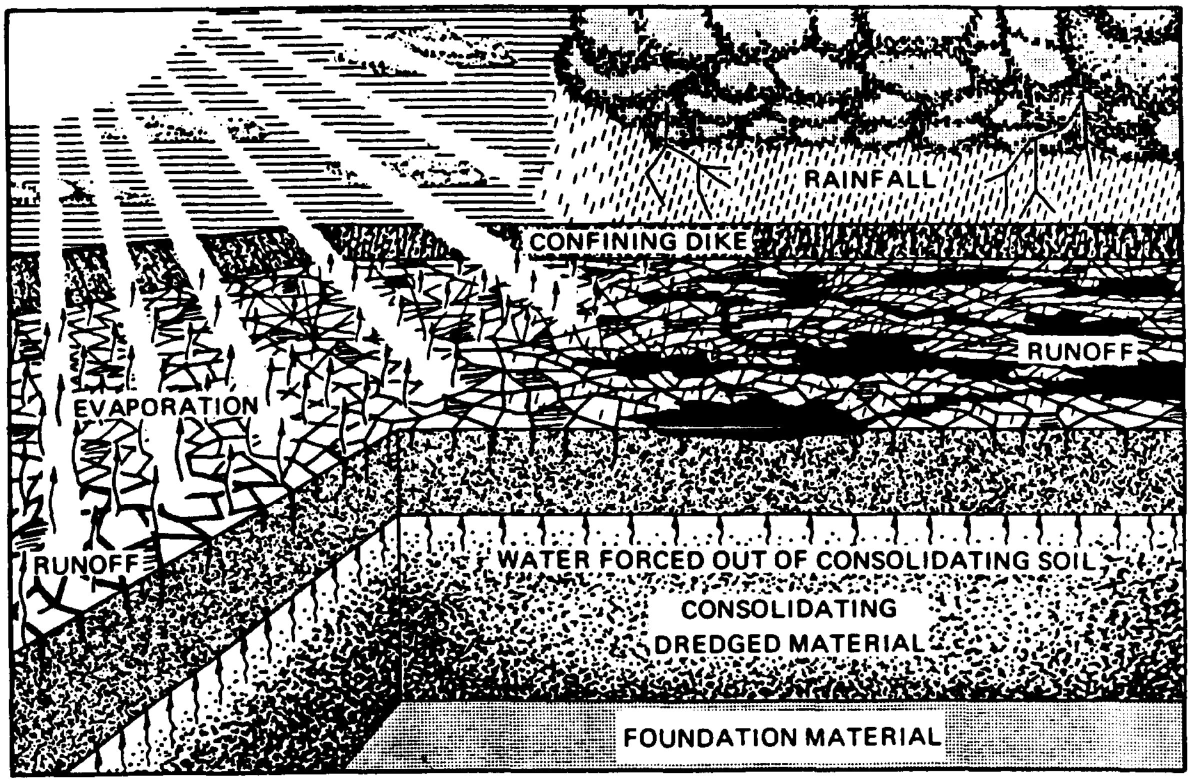

Figure 5-1. Conceptual diagram of dredged material consolidation and dewatering processes.

b. Dredged Material Consolidation. Three types of consolidation may occur in dredged material containment areas. These are primary consolidation, secondary consolidation, and consolidation resulting from desiccation.

(1) Primary consolidation. The Terzaghi standard theory of one-dimensional consolidation has received widespread use among geotechnical engineers and continues to be the first choice for estimation of settlements. The Terzaghi or "small strain theory" has received widespread application for consolidation problems in which the magnitude of settlement is small in comparison to the thickness of the consolidating layer. In contrast to the small strain theory, a "finite strain theory" for one-dimensional consolidation is better suited for describing the large settlements common to the primary consolidation of soft fine-grained dredged material. Calculation techniques are discussed in 5-2.

(2) Secondary consolidation. The process of secondary consolidation or "creep" refers to the rearrangement of soil grains under load following completion of primary consolidation. This process is not normally considered in settlement analyses and is not considered in this manual.

(3) Desiccation consolidation. There are basically two phenomena that control the amount of consolidation caused by desiccation of fine-grained dredged material. The first is the evaporation of water from the upper

sections of the dredged material. The resulting reduction in its moisture content causes a reduction in void ratio or volume occupied due to the negative pore water pressure induced by the drying. This can be referred to as the dewatering process and is discussed in 5-1.c.

(4) Consolidation in underlying material. An additional process influencing settlement involves the primary consolidation in underlying material when the free water surface is lowered. As the water surface moves downward, the unit weight acting on lower material changes from buoyant unit weight to effective unit weight. The material below the new water level is therefore subjected to an additional surcharge.

c. Dredged Material Dewatering Processes.

(1) General process description.

(a) Desiccation of dredged material is basically removal of water by evaporation and transpiration. In this report, plant transpiration is considered insignificant due to the recurrent deposition of dredged fill and is therefore disregarded. Evaporation is mainly controlled by such variables as radiation heating from the sun, convective heating from the earth, air temperature, ground temperature, relative humidity, and wind speed.

(b) However, other factors must also be taken into account. For instance, the evaporation efficiency is normally not a constant but some function of depth to which the layer has been desiccated and also is dependent on the amount of water available for evaporation.

(c) It is practical to make desiccation calculations on a monthly basis because of the availability of long-term monthly average rainfall and pan evaporation data. Rainfall and pan evaporation data have been tabulated and published in climatic summaries by the US Weather Bureau for many areas of this country. Tables of average monthly rainfall for select stations are available from the National Oceanic and Atmospheric Administration (NOAA) (item 25). Maps of monthly pan evaporation are presented in Appendix H. In the absence of more site-specific data, these sources can be used for specification of climatic data.

(2) Evaporative stages.

(a) Evaporative drying of dredged material leading to the formation of a desiccated crust is a two-stage process. The removal of water occurs at differing rates during the two stages as shown in Figure 5-2. The first stage begins when all free water has been decanted or drained from the dredged material surface. The void ratio at this point $e_{oo}$ corresponds to zero-effective stress as determined by laboratory sedimentation and consolidation testing. This initial void ratio has been empirically determined to be at a water content of approximately 2.5 times the Atterberg liquid limits (LL) of the material.

(b) First-stage drying ends and second stage begins at a void ratio that may be called the "decant point or saturation limit" $e_{SL}$ . The $e_{SL}$ of

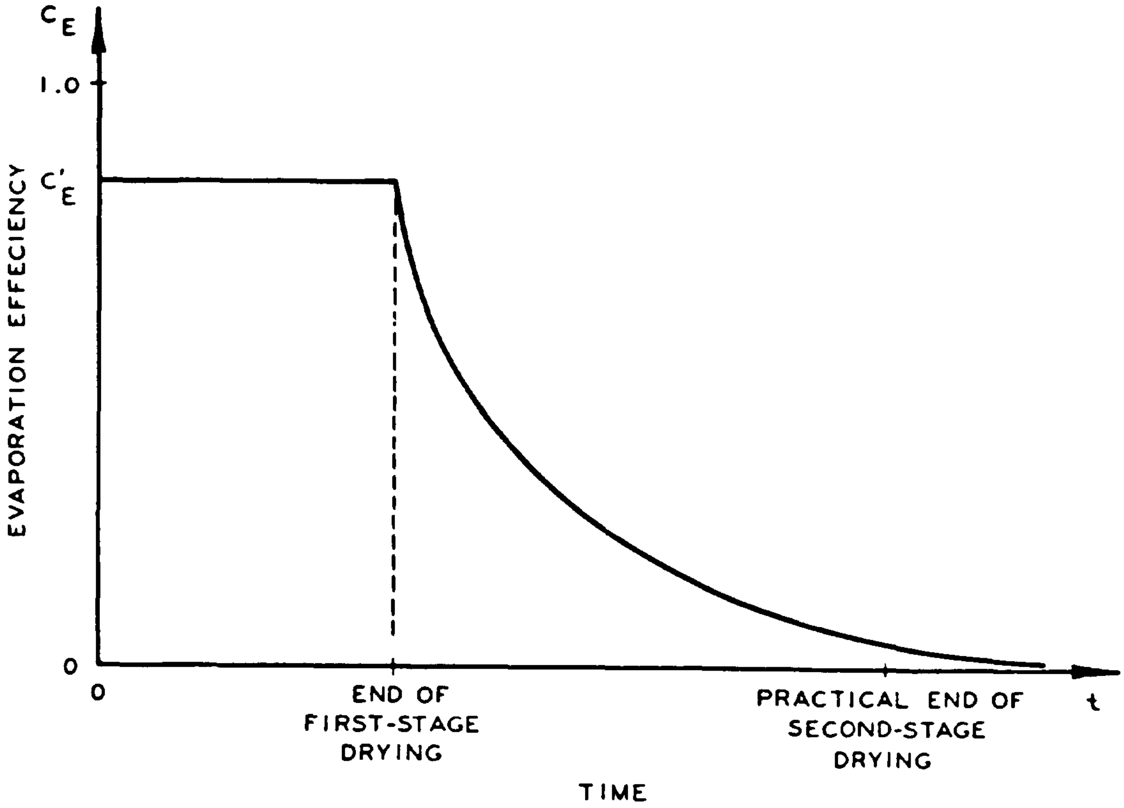

Figure 5-2. Dredged material evaporative efficiency as a function of time

typical dredged material has been empirically determined to be at a water content of approximately 1.8 LL.

(c) Second-stage drying will be an effective process until the material reaches a void ratio that may be called the "desiccation limit" or $e_{DL}$ . When the $e_{DL}$ reaches a limiting depth, evaporation of additional water from the dredged material will effectively cease. Any additional evaporation will be limited to excess moisture from undrained rainfall and that water forced out of the material as a result of consolidation of material below the crust. The $e_{DL}$ of typical dredged material may roughly correspond to a water content of 1.2 plastic limit (PL). Also associated with the $e_{DL}$ of a material is a particular percentage of saturation that probably varies from 100 percent to something slightly less, depending on the material.

5-2. Estimation of Long-Term Storage Capacity.

a. Data Requirements. The data required to estimate long-term storage capacity include the consolidation and desiccation properties of the fine-grained dredged material, the consolidation properties of compressible foundation soils, and project data. Any system of units is permissible as long as the dimensions are consistent. For example, if layer thickness is in feet and time is in days, then permeability must be in feet per day. The data required are as follows:

(1) Compressible foundation characteristics.

(a) Specific gravity of the soil solids.

(b) Initial thickness of the compressible foundation.

(c) Relationship between the void ratio and the effective stress.

(d) Relationship between the void ratio and the permeability.

(2) Fine-grained dredged material characteristics.

(a) Specific gravity of the soil solids.

(b) Thickness of the initial material deposit.

(c) Initial void ratio of the deposit.

(d) Unit weight of water.

(e) Relationship between the void ratio and the effective stress.

(f) Relationship between the void ratio and the permeability.

(g) Filling sequence, including average thickness of deposit, time of disposal, and estimated time until the material is exposed to evaporative drying.

(h) Elevation of a permanent water table.

(i) Void ratio corresponding to the end of maximum evaporation.

(j) Void ratio at the end of effective material drying.

(k) Efficiency of surface runoff drainage in the area.

(l) Monthly average pan evaporation values.

(m) Monthly average rainfall values.

(n) Average pan-to-field evaporation coefficient.

(o) Percent saturation of the material when dried to the desiccation limit, including the desiccation crack volume.

(p) Maximum thickness of the dried crust.

(3) Incompressible foundation characteristics.

(a) Void ratio at the upper surface.

(b) Permeability at the upper surface.

(c) Drainage path length.

(d) Elevation of the upper surface.

b. Storage Capacity-Time Relationship.

(1) The estimated time-settlements due to dredged material consolidation and dewatering and foundation consolidation may be combined to yield a time-total settlement relationship for a single lift as shown in Figure 5-3.

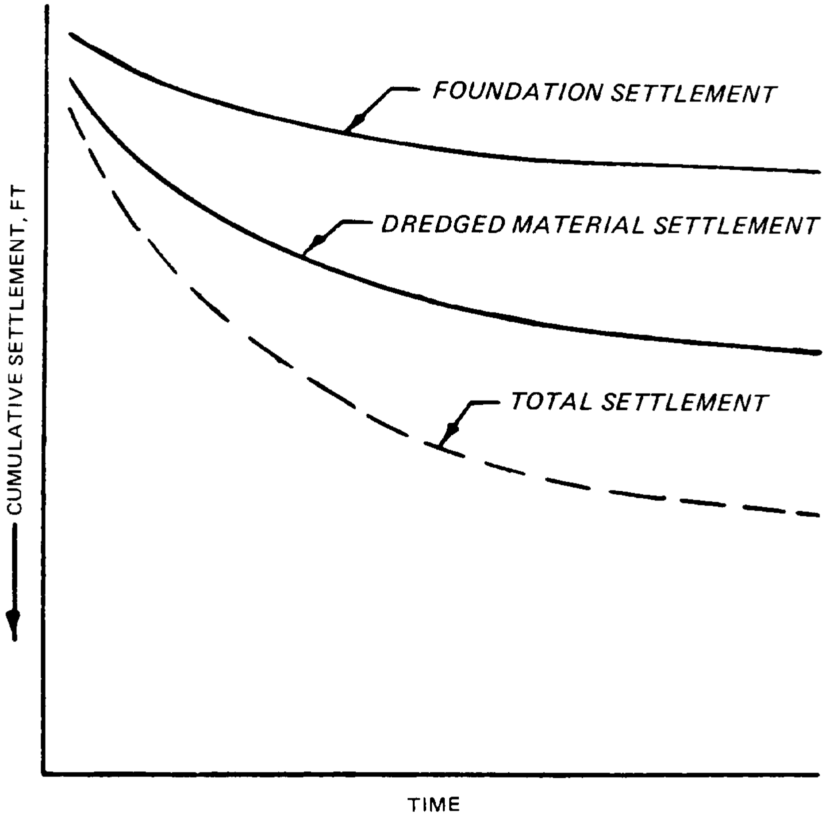

Figure 5-3. Illustrative time-consolidation relationships

These data are sufficient for estimation of the remaining capacity in the short term. However, if the containment area is to be used for long-term placement of subsequent lifts, a projected plot of dredged material surface height versus time should be developed. This plot can be developed using time-settlement relationships for sequential lifts combined as shown in

Figure 5-4. Such data may be used for preliminary estimates of the long-term service life of the containment area.

(2) The maximum dike height as determined by foundation conditions or other constraints and the containment surface area will dictate the maximum available storage volume. The increases in dredged material surface height during the dredging phases and the decreases during settlement phases correspond to respective decreases and increases in remaining containment storage capacity, shown in Figure 5-5. Projecting the relationships for surface height or for remaining capacity to the point of maximum allowable height or exhaustion of remaining capacity, respectively, will yield an estimate of the containment area service life. Gains in capacity due to anticipated dewatering or material removal should also be considered in making the projections.

(3) The complex nature of the consolidation and desiccation relationships for multiple lifts of compressible dredged material and the changing nature of the resulting loads imposed on compressible foundation soils may result in errors in projections of remaining storage capacity over long time periods. Accuracy can be greatly improved by updating the estimates every few years using data from newly collected samples and laboratory tests. Observed field behavior should also be routinely recorded and used to refine the projections.

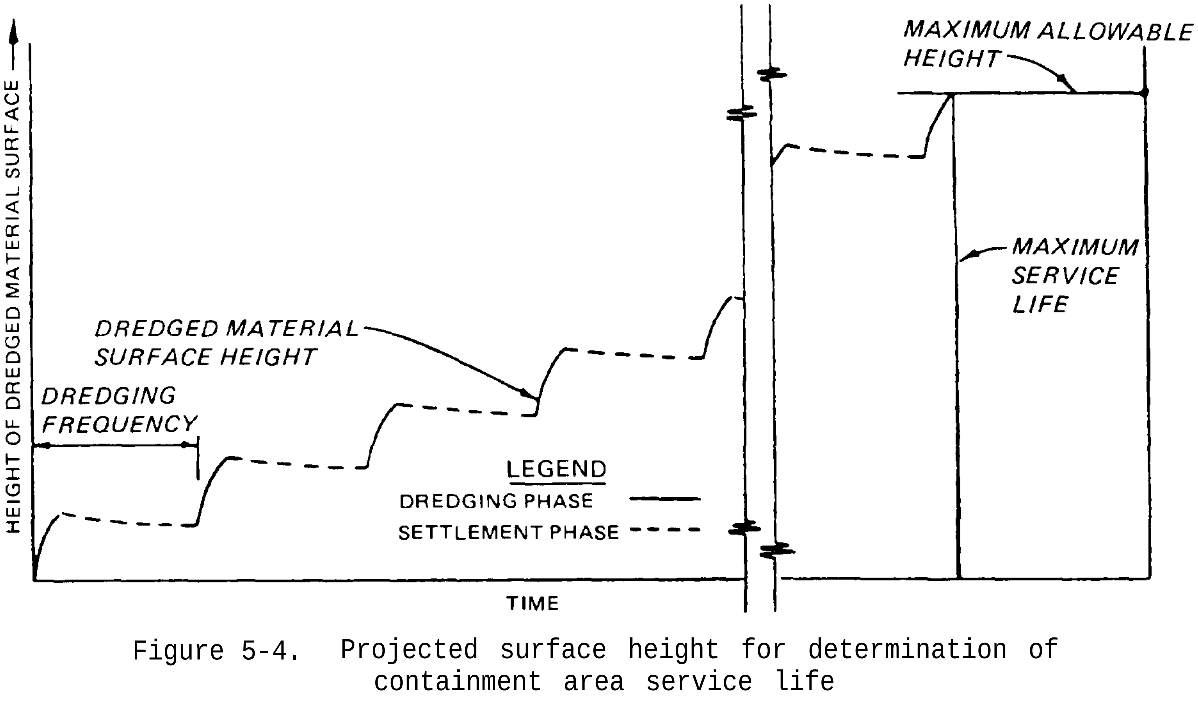

Figure 5-4. Projected surface height for determination of containment area service life

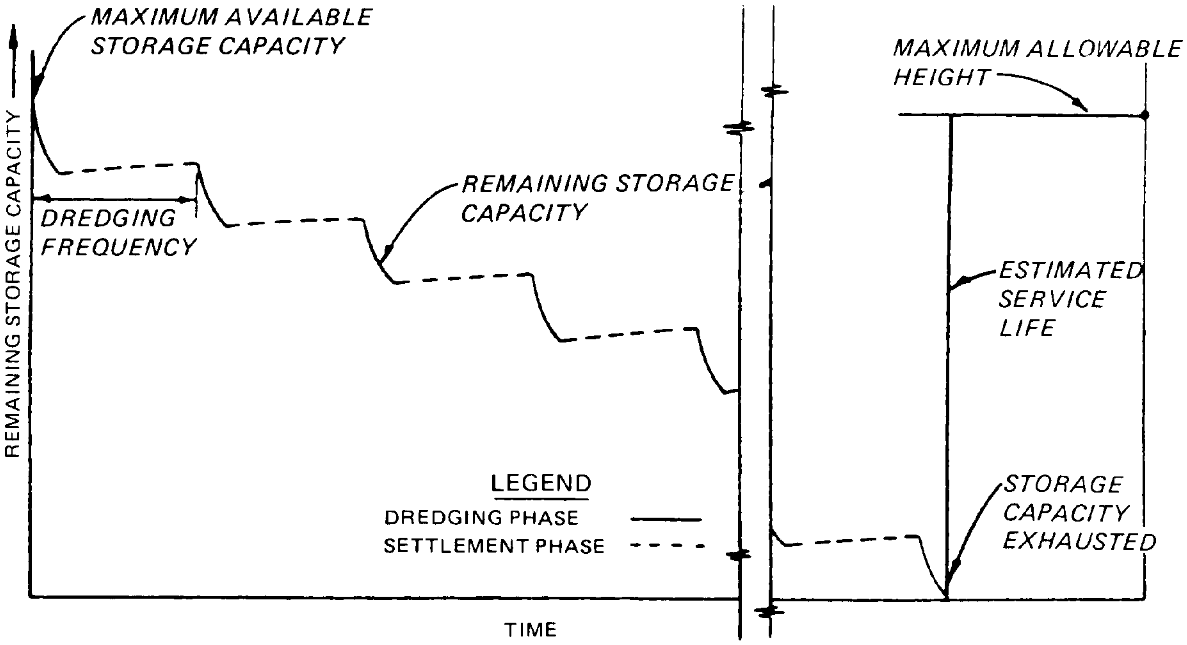

Figure 5-5. Projected storage capacity for determination of containment area service life

c. Overview of Estimation Techniques.

(1) Small strain versus finite strain consolidation.

(a) The most applicable procedure for estimating consolidation in soft dredged material is the finite strain consolidation theory. The magnitude of consolidation as determined by small strain techniques is equivalent to that determined by the finite strain technique. However, the time rate of consolidation is overly conservative for small strain in that the rate of consolidation as predicted is slow when compared to field behavior. Details on the theoretical background for the finite strain theory are given in WES TR D-83-1 and TR D-85-4 (items 5 and 6).

(b) The advantages of using the finite strain technique for the estimation of dredged material consolidation settlement are summarized in Table 5-1. The technique accounts for the nonlinearity of the void ratio, permeability, and coefficient of consolidation relationships that must be considered when large settlements of a layer are involved. Hand calculations using the finite strain approach have been developed and are presented in this manual. However, the technique is more easily applied using a computer program.

(2) Empirical methods for estimating desiccation behavior. Empirical equations for estimating the settlement of a dredged material layer due to desiccation and the thickness of dried crust were developed for the purpose of determining feasibility and benefits of active dewatering operations (item 14). The empirical relationships have been refined (Item 6) to consider the two stage process of desiccation and the overall water balance

Table 5-1

Comparison of Small Strain and Finite Strain Consolidation Techniques

| Consideration | Finite strain | Small strain |
|---|---|---|
| Range of void ratios | Very large | Very small |
| Self-weight | Included | Not included |
| Void ratio/effective stress relationship | Nonlinear | Linear |
| Void ratio/permeability relationship | Variable | Constant |

relationships that exist within a dredged material disposal area. The interaction of the desiccation process with dredged material consolidation due to self-weight has been incorporated in computer programs for estimating long-term storage capacity. The refined empirical relationships can be easily applied in determining the benefits of dewatering programs and provide increased accuracy in storage capacity evaluations.

(3) Hand calculation versus computer solution.

(a) The use of computer models can greatly facilitate the estimation of storage capacity for containment areas. Although the computations for simple cases can be easily and quickly done by hand, the analyses often require computations for a multiyear service life with variable disposal operations and possibly material removal or dewatering operations occurring intermittently throughout the service life. These complex computations can be done more efficiently using a computer model.

(b) The use of computer models holds added advantage when considering the additional settlements that occur as the result of dredged material desiccation (dewatering). The estimation of desiccation behavior can also be done by means of hand calculations; however, the interaction between desiccation and consolidation cannot be handled by direct hand computation, but instead would require cumbersome iterative calculations. A computer program is well suited to handle the calculations of both consolidation and desiccation and the interaction between the two processes.

(c) Methods of hand calculation for finite strain consolidation and desiccation are presented in Appendix F. These calculations are manageable for estimation of settlements in one dredged material layer. However, if storage capacity estimates must be made for multiple disposal operations, the use of computer programs is recommended.

d. Computer Solutions for Consolidation and Desiccation.

(1) The recommended computer model for use in predicting the long term capacity of disposal areas is documented in the Automated Dredging and Disposal Alternatives Management System (ADDAMS) described in Chapter 8 of this manual. The program is entitled "Primary Consolidation and Desiccation of Dredged Fill (PCDDF)" and incorporates the concepts described in this chapter. Theoretical documentation, description of solution techniques, and a user guide are available (item 6). An expanded user guide with plotting routines for results is found in the ADDAMS instruction report (item 19).

(2) Examples of the results obtained using the PCDDF model are shown in Figures 5-6 and 5-7. These are plots of dredged material surface elevation versus time for several cases including multiple layers deposited at varying times. Field data collected at the respective sites are also shown for comparison.

## 5-3. Dredged Material Dewatering Operations.

a. General.

(1) Surface trenching for improved drainage and use of underdrains are the only technically feasible and economically justifiable dewatering techniques for dredged material containment areas. The use of underdrains has been successfully applied on a small scale; however, their use in large disposal areas has not been proven economical as compared with surface drainage techniques. Accordingly, this section describes only techniques recommended for improvement of surface drainage through trenching. Guidance for application of underdrains is found in WES Technical Report DS-78-11 (item 14).

(2) Four major reasons exist for dewatering fine-grained dredged material placed in confined disposal areas:

(a) Promotion of shrinkage and consolidation, leading to creation of more volume in the existing disposal site for additional dredged material.

(b) Reclamation of the dredged material into more stable soil form for removal and use in dike raising, other engineered construction, or other productive uses, again creating more available volume in the existing disposal site.

(c) Creation of stable fast land at a known final elevation and with predictable geotechnical properties.

(d) Benefits for control of mosquito breeding.

b. Conceptual Basis for Dewatering by Progressive Trenching. The following mechanisms were found to control evaporative dewatering of fine-grained dredged material placed in confined disposal areas:

(1) Establishment of good surface drainage allows evaporative forces to dry the dredged material from the surface downward, even at disposal area locations where precipitation exceeds evaporation (negative net evaporation).

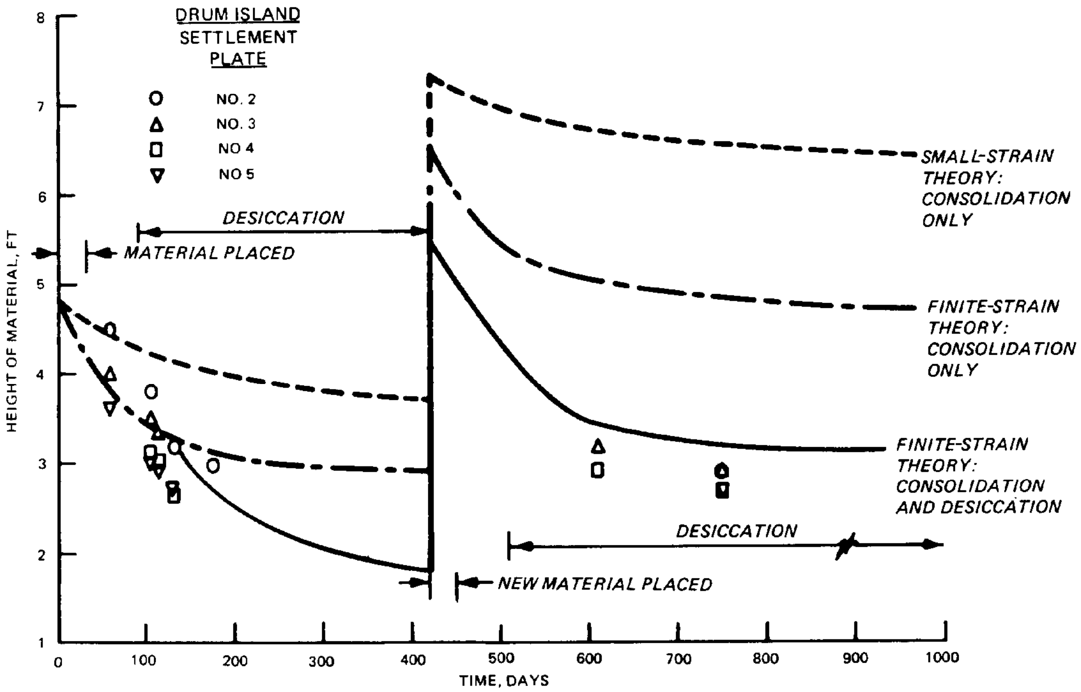

Figure 5-6. Measured and predicted material heights at Drum Island

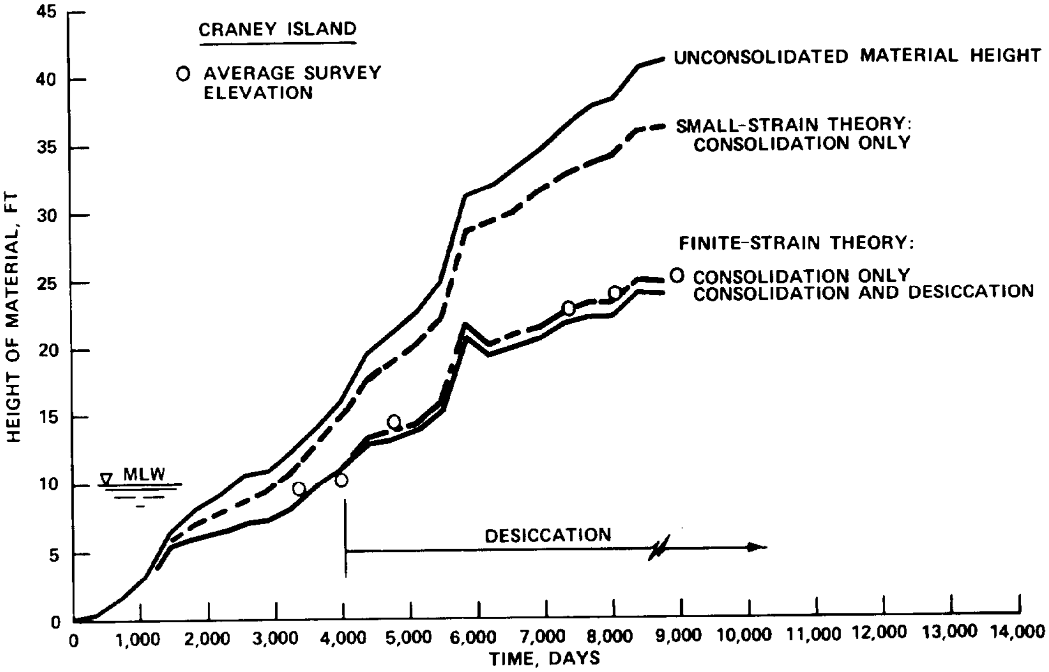

Figure 5-7. Measured and predicted material heights at Craney Island

(2) The most practical mechanism for precipitation removal is by runoff through crust desiccation cracks to surface drainage trenches and off the site through outlet weirs.

(3) To maintain effective drainage, the flow-line elevation of any surface drainage trench must always be lower than the base of crust desiccation cracks; otherwise, ponding will occur in the cracks. As drying occurs, the cracks will become progressively deeper.

(4) Below the desiccation crust, the fine-grained subcrust material may be expected to exist at water contents at or above the liquid limit (LL). Thus, it will be difficult to physically construct trenches much deeper than the bottom of the adjacent desiccation crust.

(5) To promote continuing surface drainage as drying occurs, it is necessary to progressively deepen site drainage trenches as the water table falls and the surface crust becomes thicker; thus, the name "progressive trenching" was developed for the concept.

(6) During conduct of a progressive trenching program, the elevation difference between the internal water table and the flow line of any drainage trench will be relatively small. When the relatively low permeability of fine-grained dredged material is combined with the small hydraulic gradient likely under these circumstances, it appears doubtful that appreciable water can be drained from the dredged material by gravity seepage. Thus, criteria for trench location and spacing should be based on site topography so that precipitation is rapidly removed and ponding is prevented, rather than to achieve marked drawdown from seepage.

c. Effects of Dewatering. The net observable effects of implementing any program of dewatering by improved surface drainage will be as follows:

(1) Disappearance of ponded surface water.

(2) Runoff of the majority of precipitation from the site within a few hours.

(3) Gradual drying of the dredged material to more stable soil form.

(4) Vertical settlement of the surface of the disposal area.

(5) Ability to work within the disposal area with conventional equipment.

d. Initial Dewatering (Passive Phase).

(1) Once the disposal operation is completed, dredged material usually undergoes hindered sedimentation and self-weight consolidation (called the "decant phase"), and water will be brought to the surface of the consolidating material at a faster rate than can normally be evaporated, During this phase, it is extremely important that continued drainage of decant water and/or precipitation through outlet weirs be facilitated. Weir flow-line elevations may have to be lowered periodically as the surface of the newly placed dredged

material subsides. Guidelines for appropriate disposal site operation during this passive dewatering phase, to maximize decant and precipitation water release while maintaining appropriate water quality standards, are described in Chapter 7.

(2) Once the fine-grained dredged material approaches the decant point water content, or saturation limit as described previously, the rate at which water is brought to the surface will gradually drop below the climatic evaporative demand. If precipitation runoff through site outflow weirs is facilitated, a thin drying crust or skin will form on the newly deposited dredged material. The thin skin may be only several hundredths of a foot thick, but its presence may be observed by noting small desiccation cracks that begin to form at 3- to 6-foot intervals, as shown in Figure 5-8. Once the dredged material has reached this consistency, active dewatering operations may be initiated.

e. Dewatering by Progressive Trenching.

(1) Three procedures have been found viable to initiate active dredged material dewatering by improved surface drainage, once the material has achieved consistency conditions shown in Figure 5-8: periodic perimeter

Figure 5-8. Surface of fine-grained dredged material at the earliest time when surface trenching should be attempted; initial cracks are spaced at 3- to 6-foot intervals, and the surface water content approaches 1.8 x LL

trenching by dragline, with draglines working initially from perimeter dikes and subsequently from berms established inside the perimeter dikes; periodic interior site trenching; or a combination of these two methods. This section presents information necessary to properly conduct dewatering operations by these procedures. Only the last two procedures will result in total site dewatering at the maximum rates. The first procedure would have, in many instances, an effective interior dewatering rate considerably less than the predicted maximum rate, though the exact lower rate would be highly site-specific.

(2) Perimeter dragline trenching operations.

(a) Construction of trenches around the inside perimeter of confined disposal sites is a procedure that has been used for many years to dewater and/or reclaim fine-grained dredged material. In many instances, the purpose of dewatering has been to obtain convenient borrow for use in perimeter dike raising activities. Draglines and backhoes have been found to be adaptable to certain activities because of their relatively long boom length and/or method of operation and control. The perimeter trenching scheme should be planned carefully so as not to interfere with operations necessary for later dewatering or other management activities.

(b) When initiating dragline trenching operations, the largest size, longest boom length dragline that can be transported efficiently to the disposal site and can operate efficiently on top of disposal site dikes should be obtained. Operations should begin at an outflow weir location, where the dragline, operating from the perimeter dike, should dig a sump around the weir extending into the disposal area to maximum boom and bucket reach. The very wet excavated material is cast against the interior side of the adjacent perimeter dike. It may be necessary to board up the weir to prevent the very wet dredged material from falling into the weir box during the sump-digging operation. A localized low spot some 1 or 2 inches in elevation below the surrounding dredged material can be formed. Once the sump has been completed, weir boards should be removed to the level of the dredged material, and, if necessary, handwork should be conducted to ensure that any water flowing into the sump depression will exit through the outflow weir.

(c) Once the sump has been completed, the dragline should operate along the perimeter dike, casting its bucket the maximum practicable distance into the disposal area, dragging material back in a wide shallow arc to be cast on the inside of the perimeter dike. A wide shallow depression 1 to 2 inches lower than the surrounding dredged material will be formed. The cast material will stand on only an extremely shallow (1 vertical on 10 horizontal or less) slope. A small dragline should be able to accomplish between 200 and 400 linear feet of trenching per working day.

(d) Dredged material near the ditch edge will tend to dry slightly faster than material located farther out in the disposal site, with resulting dredged material shrinkage giving a slight elevation gradient from the site interior toward the perimeter trenches, also facilitating drainage (Figure 5-9). In addition, desiccation crack formation will be more pronounced near the drainage trenches, facilitating precipitation runoff through the cracks to the perimeter trenches.

Figure 5-9. Shallow initial perimeter trench constructed by dragline operating from perimeter dike

(e) Once appreciable desiccation drying has occurred in the dredged material adjacent to the perimeter trench and the material cast on the interior slope of the perimeter dike has dried, the perimeter trenches and weir sumps should be deepened. The exact time between initial and secondary trench deepening will vary according to the engineering properties of the dredged material and existing climatological conditions, ranging from 2 or 3 weeks during hot, dry summer months up to 8 or 10 weeks in colder, wetter portions of the year. Inspection of the existing trenches is the most reliable guideline for initiating new trench work, since desiccation cracks 1 or 2 inches deep should be observed in the bottom of existing trenches before additional trenching is begun. Depending on the size of the disposal area, relative costs of mobilization and demobilization of dragline equipment, and the relative priority and/or need for dewatering, it may prove convenient to employ one or more draglines continuously over an interval of several months to periodically work the site. A second trenching cycle should be started upon completion of an initial cycle, a third cycle upon completion of the second cycle, etc., as needed.

(f) During the second trenching, wide shallow trenches with a maximum depth of 2 to 6 inches below the surface of adjacent dredged material can be constructed, and sumps can be dug to approximately 8 to 12 inches below surrounding dredged material. These deeper trenches will again facilitate more rapid dewatering of dredged material adjacent to their edges, with resulting shrinkage and deeper desiccation cracks providing a still steeper drainage flow gradient from the site Interior to the perimeter trenches.

(g) After two or perhaps three complete periodic perimeter dragline trenching cycles, the next phase of the trenching operation may be initiated. In this phase, the dragline takes the now dry material placed on the interior of the perimeter dike and spreads it to form a low berm adjacent to the dike inside the disposal area. The dragline then moves onto this berm, using single or double mats if required and using the increased digging reach now available, and widens and extends the ditch into the disposal site interior, as shown in Figure 5-10. The interior side of the ditch is composed of material previously dried, and a ditch 12 to 18 inches deep may be constructed, as shown in Figure 5-11. Material excavated from this trench is again cast on the interior slope of the perimeter dike to dry and be used either for raising the perimeter dike or for subsequent berming farther into the disposal area.

(h) After two or more additional periodic trench deepenings, working from the berm inside the disposal area, trenches up to 3 to 5 feet deep may be completed. Trenches of this depth will cause accelerated drying of the dredged material adjacent to the trench and produce desiccation cracks extending almost the entire thickness of the adjacent dredged material, as shown in Figure 5-12. A well-developed perimeter trench network leading to outflow weirs is now possible, as shown in Figure 5-13, and precipitation runoff is facilitated through gradual development of a network of desiccation cracks which extend from the perimeter trenches to the interior of the site.

(i) Once a perimeter trench system such as that shown in Figure 5-13 is established, progressive deepening operations should be conducted at less frequent intervals, and major activity should be changed from deepening perimeter trenches and weir sumps to that of continued inspection to make sure that the ditches and sumps remain open and facilitate free drainage. As a desiccation crack network develops with the cracks becoming wider and deeper, precipitation runoff rate will be increased and precipitation ponding in the site interior will be reduced. As such ponding is reduced, more and more evaporative drying will occur, and the desiccation crack network will propagate toward the

Figure 5-10. Small dragline on mats working on berm deepens shallow perimeter drainage trench

Figure 5-11. Construction of ditch 12 to 18 inches deep with excavated material cast on interior slope of perimeter dike

Figure 5-12. Desiccation crust adjacent to perimeter 3- to 5-foot-deep drainage trench

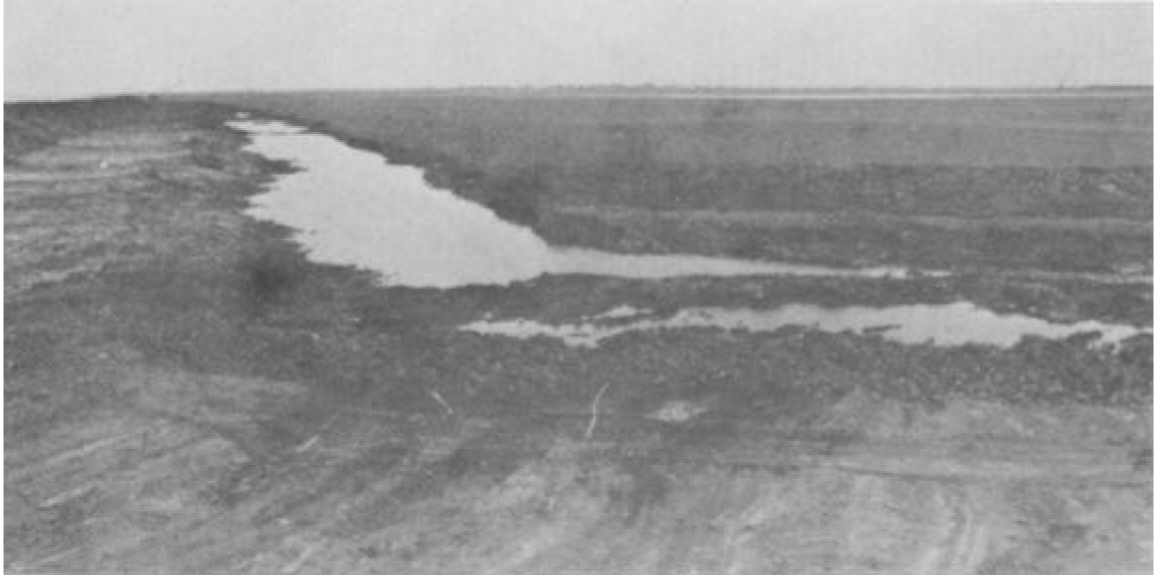

Figure 5-13. A well-developed perimeter trenching system, Morris Island Disposal Site, Charleston District

disposal area interior. Figure 5-13 is a view of the 500-acre Morris Island Disposal Site of the Charleston District, where a 3-foot lift of dredged material was dewatered down to approximately a 1.7-foot thickness at the perimeter over a 12-month period by an aggressive program, undertaken by the District, of site drainage improvement with dragline perimeter trenching. Figure 5-14 shows the 12-inch desiccation crust achieved at a location approximately 200 yards from the disposal area perimeter. The dredged material was a CH clay with an LL over 100. However, despite the marked success with perimeter trenching, a close inspection of Figure 5-13 shows that ponded water still exists in the site interior.

(3) Interior trenching.

(a) Riverine utility craft. The high water content of dredged material during the initial dewatering stages requires the use of some type of amphibious or low-ground-pressure equipment for construction of trenches in the site interior. The Riverine Utility Craft (RUC), an amphibious vehicle using twin screws for propulsion and flotation, can successfully construct shallow trenches in fine-grained dredged material shortly after formation of a thin surface crust. It can also be effective in working with other equipment in constructing sump areas around outflow weirs for collection of surface water. The RUC was initially developed in the 1960's as a reconnaissance vehicle for military applications and was used on an experimental basis for trenching operations. RUC vehicles have since been successfully applied in dewatering operations in the Mobile, Charleston, and Norfolk Districts for both trenching and surveying/sampling applications. Even though this vehicle is perhaps the only tool that can be used to construct shallow trenches in dredged material

Figure 5-14. Desiccation crust achieved in highly plastic clay dredged material 200 yards into disposal area by perimeter trenching over 12-month period

with little or no developed surface crust, its potential use in dewatering operations is limited. The RUC is susceptible to maintenance problems because of the nature of the drive train and frame, which were not designed for heavy use in trenching operations on a production basis. The nonavailability of RUC vehicles limits their potential widespread use for routine dewatering operations. Only two vehicles are available Corps-wide. Also, field experience has shown that the early stages of evaporative dewatering and crust development occur at acceptable rates considering only the natural drying processes, perhaps aided by perimeter trenching as described previously. Once a surface crust of 4 to 6 inches has developed, more productive trenching equipment as described in the following paragraphs can be used.

(b) Rotary trenchers. The use of trenching equipment with continuously operating rotary excavation devices and low-ground-pressure chassis is recommended for routine dewatering operations. This type of equipment has been used successfully in dewatering operations in the Savannah District and in the other numerous locations along the Atlantic Coast for mosquito control. The Charleston, Norfolk, and Philadelphia Districts have also used this equipment for dewatering operations. The major features of the equipment include a mechanical excavation implement with cutting wheel or wheels used to cut a trench up to 3 feet deep. The low-ground-pressure chassis may be tracked or rubber tired. The major advantage of rotary trenchers is their ability to continuously excavate while slowly moving within the containment area. This allows them to construct trenches in areas where the use of dragline or backhoe equipment would cause mobility problems. Photographs of tracked and rubber-tired trenchers are shown in Figures 5-15 and 5-16. The excavating wheels can be arranged in configurations that create hemispherical or trapazodial trench cross sections and can throw material to one or both sides of the trench. The material is spread in a thin layer by the throwing action, which allows it to dry quickly and prevents the creation of a windrow which might block drainage to the trench. Photographs of the excavating devices, ongoing trenching operations, and configuration of constructed trenches are shown in Figures 5-17 through 5-22. Based on past experience, an initial crust thickness of 4 to 6 inches is required for effective mobility of the equipment. This crust thickness can be easily formed within the first year of dewatering effort if surface water is effectively drained from the area, assisted by perimeter trenches constructed by draglines operating from the dikes. A suggested scheme for perimeter and interior trenching using a combination of draglines and a rotary trencher or other suitable equipment is shown in Figure 5-23.

(c) Trench spacing. The minimum number of trenches necessary to prevent precipitation ponding on the disposal area surface should be constructed. These trenches should extend directly to low spots containing ponded water. However, the greater the number of trenches per unit of disposal site area, the shorter the distance that precipitation runoff will have to drain through desiccation cracks before encountering a drainage trench. Thus, closely spaced trenches should produce more rapid precipitation runoff and may slightly increase the rate of evaporative dewatering. Conversely, the greater the number of trenches constructed per unit of disposal site area, the greater the cost of dewatering operations and the greater their impact on subsequent dike raising or other borrowing operations. However, the rotary trenchers have a relatively high operational speed, and it is therefore recommended that the maximum number of drainage trenches be placed consistent with the specific trenching plan selected. Trench spacings of 100 to 200 feet have normally been used. If topographic data are available for the disposal site interior, they may be used as the basis for preliminary planning of the trenching plan.

(d) Parallel trenching. The most common trench pattern would employ parallel trenching. A complete circuit of the disposal area with a perimeter trench is joined with parallel trenches cut back and forth across the disposal area, ending in the perimeter trench. Spacing between parallel trenches can be varied as described above. A parallel pattern is illustrated in Figure 5-22. A schematic of a parallel trenching pattern with radial combinations is shown in Figure 5-23.

(e) Radial trenching pattern. Small disposal areas or irregularly-shaped disposal areas may be well suited for a radial trenching pattern for effective drainage of water to the weir structures. The radial patterns should run parallel to the direction of the surface slopes existing within the area. Radial trenching patterns can also be used to provide drainage from localized low spots to the main drainage trench pattern. When the disposal area is extremely large in areal extent or when interior cross dikes or other obstructions exist within the disposal area, sequential sets of radial trenches may be constructed, with the sets farthest into the disposal area

Figure 5-15. Rubber-tired rotary trencher

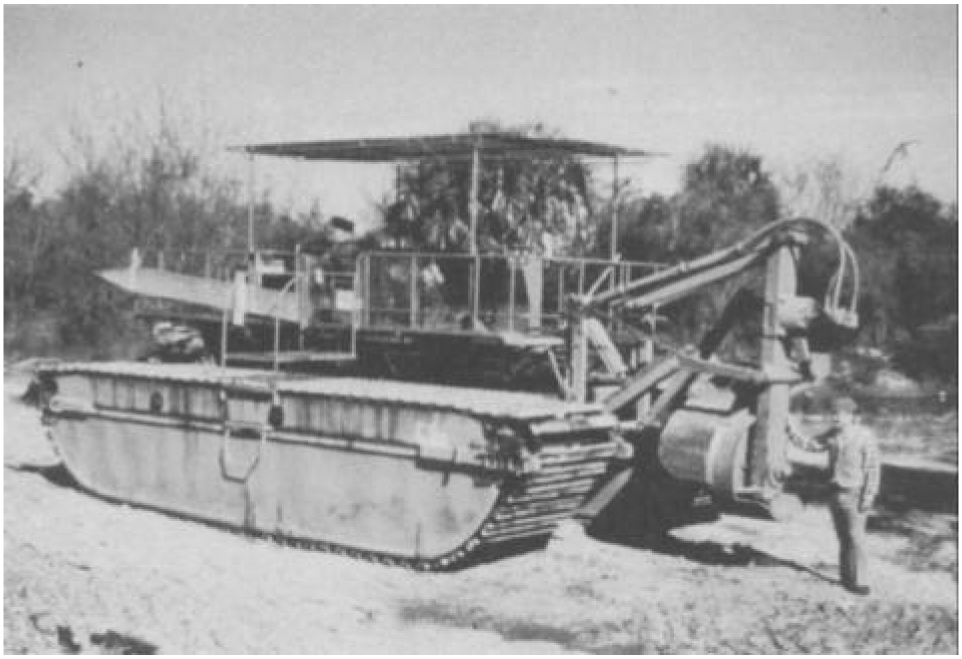

Figure 5-16. Track-mounted rotary trencher used in mosquito control activities

Figure 5-17. View of hemispherical rotary trenching implement

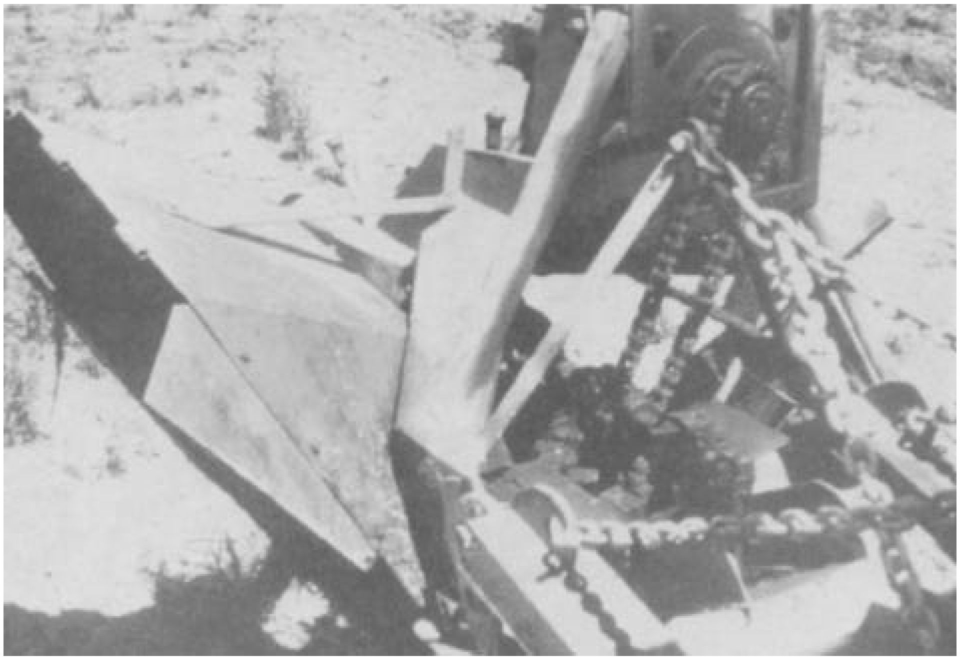

Figure 5-18. View of the trapazodial rotary trenching implement

Figure 5-19. View of rotary trenching device in operation

Figure 5-20. General view of trenches formed by rotary trencher

Figure 5-21. Closeup view of trenches formed by rotary trencher

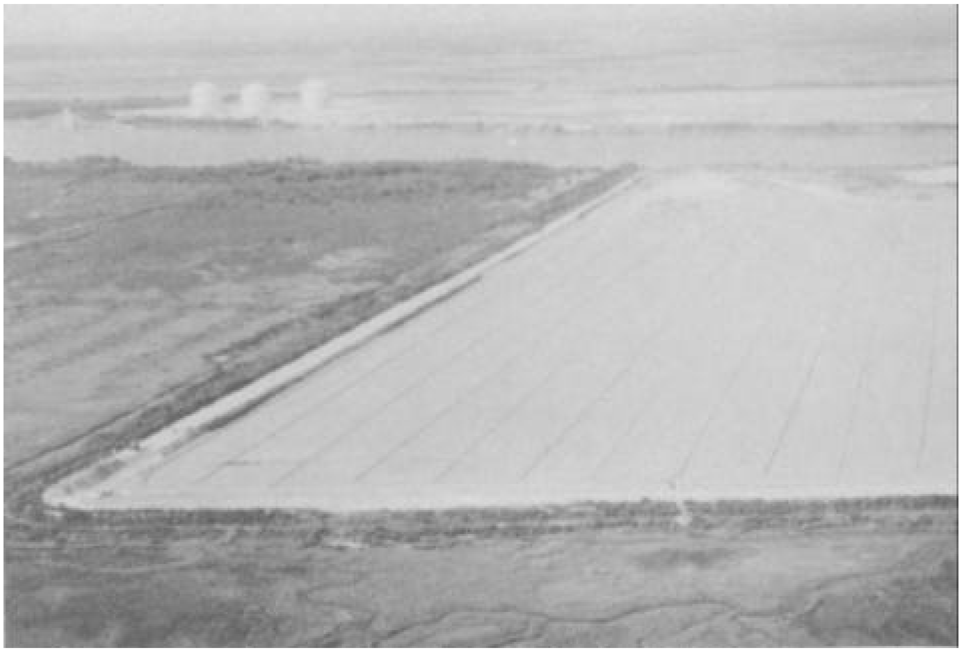

Figure 5-22. General view of confined disposal area showing parallel trenches in place

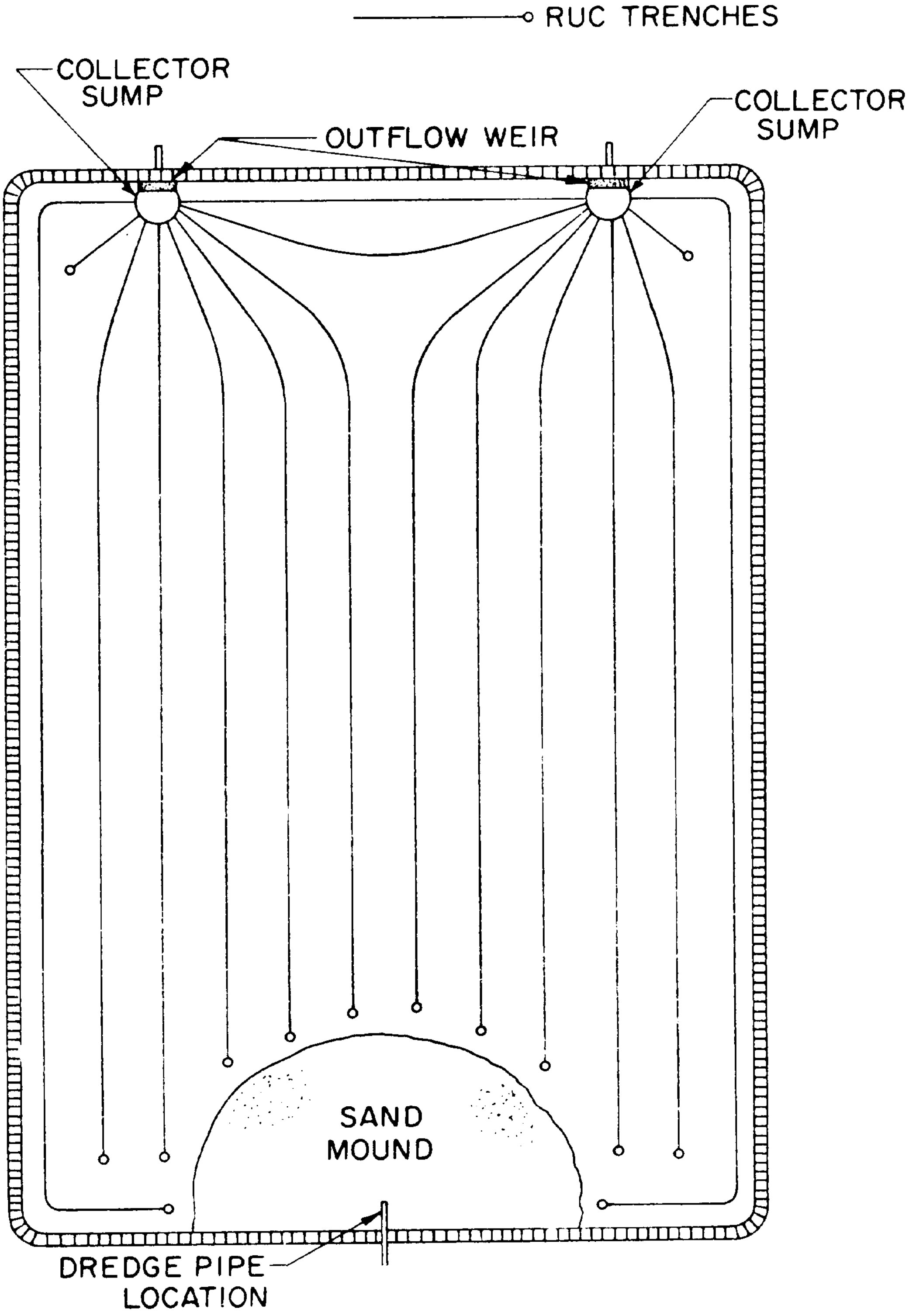

Figure 5-23. Combination radial-parallel trenching scheme

interior acting as collectors funneling into one of the radial trenches extending from the outflow weir.  This sequential radial trenching procedure is shown in Figure 5-24, as constructed in the South Blakely Island Disposal Site of the Mobile District.

Figure 5-24. Aerial view of sequential radial trenching procedure used when interior cross dikes are encountered, South Blakely Island Disposal Site of the Mobile District