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REFERENCE

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Open File Report 14

Status of Phosphatic Clay Waste Disposal

by

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Status of Phosphatic Clay Waste Disposal

The Department of Natural Resources has the responsibility, under Chapter 211, Part II, Florida Statutes, for administering the reclamation of certain lands mined for solid minerals in Florida. Currently, these minerals include phosphate, clay, and heavy minerals. However, only phosphate will be discussed as the purpose of this report is to present information on the present conventional method for reclaiming phosphate clay waste storage areas and research relating to clay waste disposal.

GEOLOGY

Phosphate occurs in Florida as a sedimentary rock in the form of calcium phosphate. There are several kinds of phosphate deposits in Florida, but those known as the land pebble phosphate are the most important commercially. The land pebble phosphate deposits, also known as the Bone Valley Formation, were formed during the Miocene and Pliocene geologic epochs. Commercial deposits of land pebble phosphate occur in Polk, Hillsborough, Hardee, Manatee, and DeSoto counties in central Florida, and in Columbia and Hamilton counties in northern Florida. (Figure 1). As shown in figure 2, the phosphate ore zone, five to fifty feet thick, is overlain by the 0 to ten foot thick leach zone, ten to thirty feet of overburden, and top soil. (Florida Bureau of Geology, Phosphate Land Reclamation Study Commission Report, 1978, 32 p.)

MINING

Before mining, a program of extensive drilling is conducted to explore for and determine the economic potential of the deposit. If an area is determined to contain commercial deposits and is to be mined, the vegetation is removed. Phosphate mining is done by the open-pit method using large, electrically-operated, walking draglines. Mining is conducted in adjacent cuts 200-300 feet wide and up to several thousand feet long. As the first mine cut is made the overburden is removed and placed on top of the natural ground adjacent to the

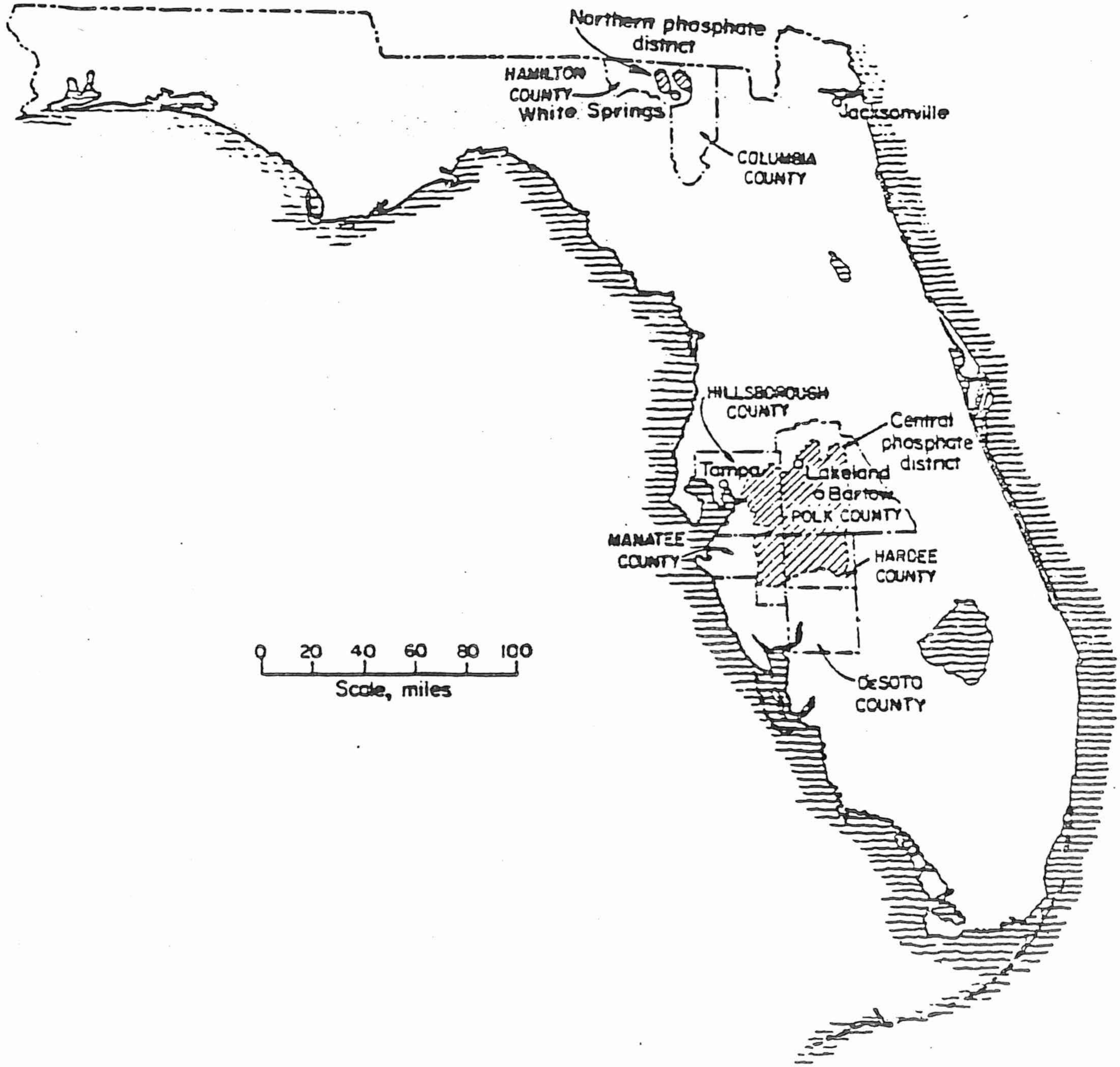


FIGURE 1 - Map of phosphate-producing counties.
USBM, p. 17, 1983.

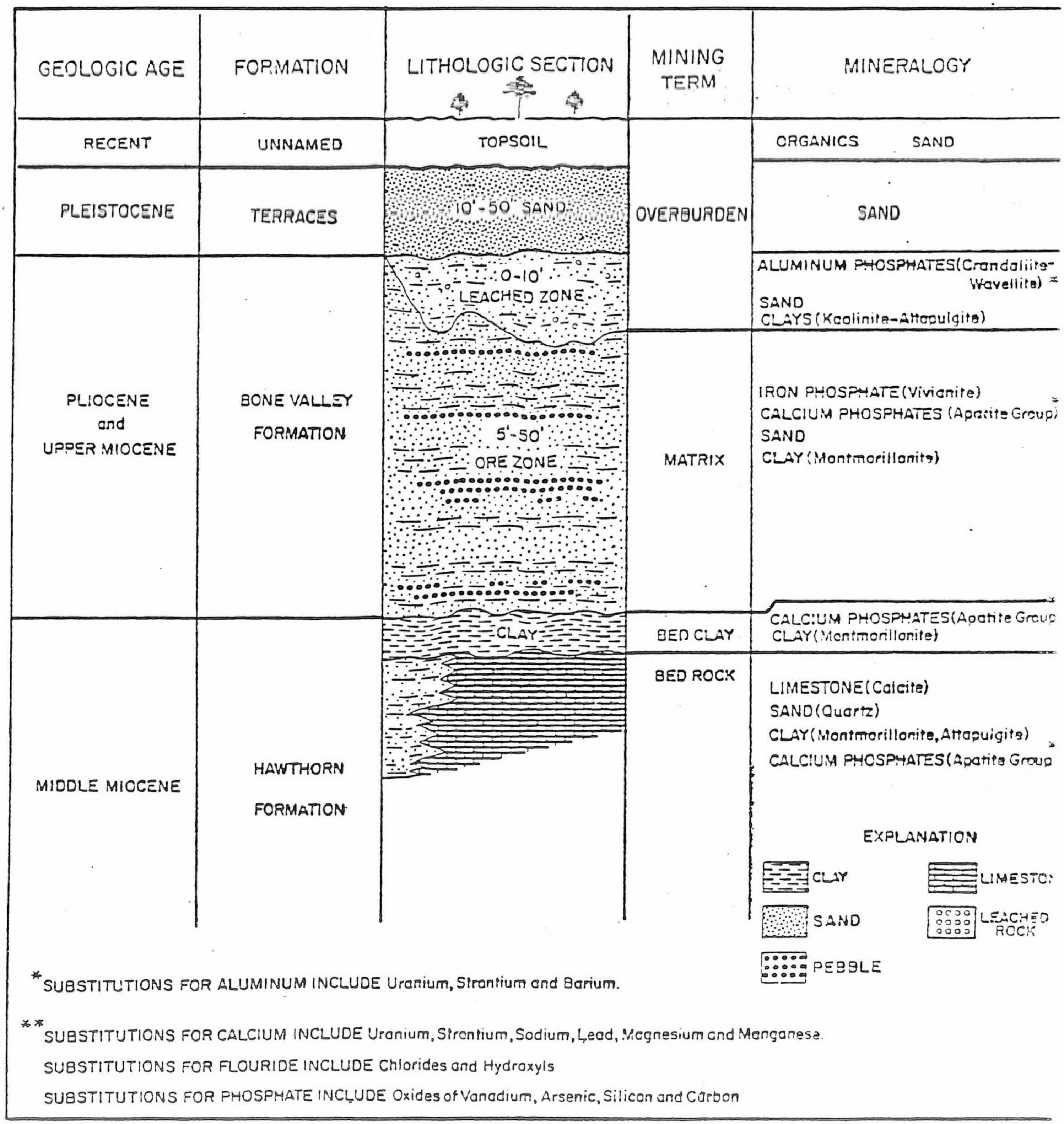


FIGURE 2 - Columnar Section of the Central Florida Phosphate District, Phosphate Land Reclamation Study Commission Report, p. 4, 1978.

mining operation. When mining progresses beyond the initial cut, the overburden removed to make the phosphate ore accessible is cast back into the preceding mined-out cut. The phosphate matrix is then removed by the dragline, slurried with water under high pressures, and hydraulically transported by pipeline to a washer plant where the pebble phosphate is removed from the sand and clay associated with it.

BENEFICIATION

The process of separating the phosphate rock from the matrix is known as beneficiation and produces two waste products, quartz sand and phosphatic clay. The quartz sand is disposed of by pumping it back to mined-out cuts left during the mining process. The phosphatic waste clay is near collodial size material, 0.002 mm in particle size, and has a tendency to remain in suspension for long periods of time when mixed with water. As the clay wastes mixed with water leave the beneficiation plant, the slurry is about three percent solids by weight. The clay wastes are composed of montmorillonite(smectite), attapulgite (palygorskite), kaolinite, illite, phosphate minerals, and silt size material. All of the above clay minerals occur in a complex combination in the natural state and causes numerous varation in settling characteristics of phosphatic clays (USBM, p. 17, 1983). The USBM (p. 17, 1983) states that the phosphatic clays containing greater amounts of attapulgite settle much slower than those clays which contain lesser amounts of this particular clay mineral.

CONVENTIONAL STORAGE AND RECLAMATION OF CLAY WASTE PONDS

As shown in figure 3, phosphatic clay wastes are placed in conventional storage areas which are surrounded by dams of varying heights. Although most of the settling areas have holding capacities of approximately two years and are used alternately with other settling areas to permit periods of natural

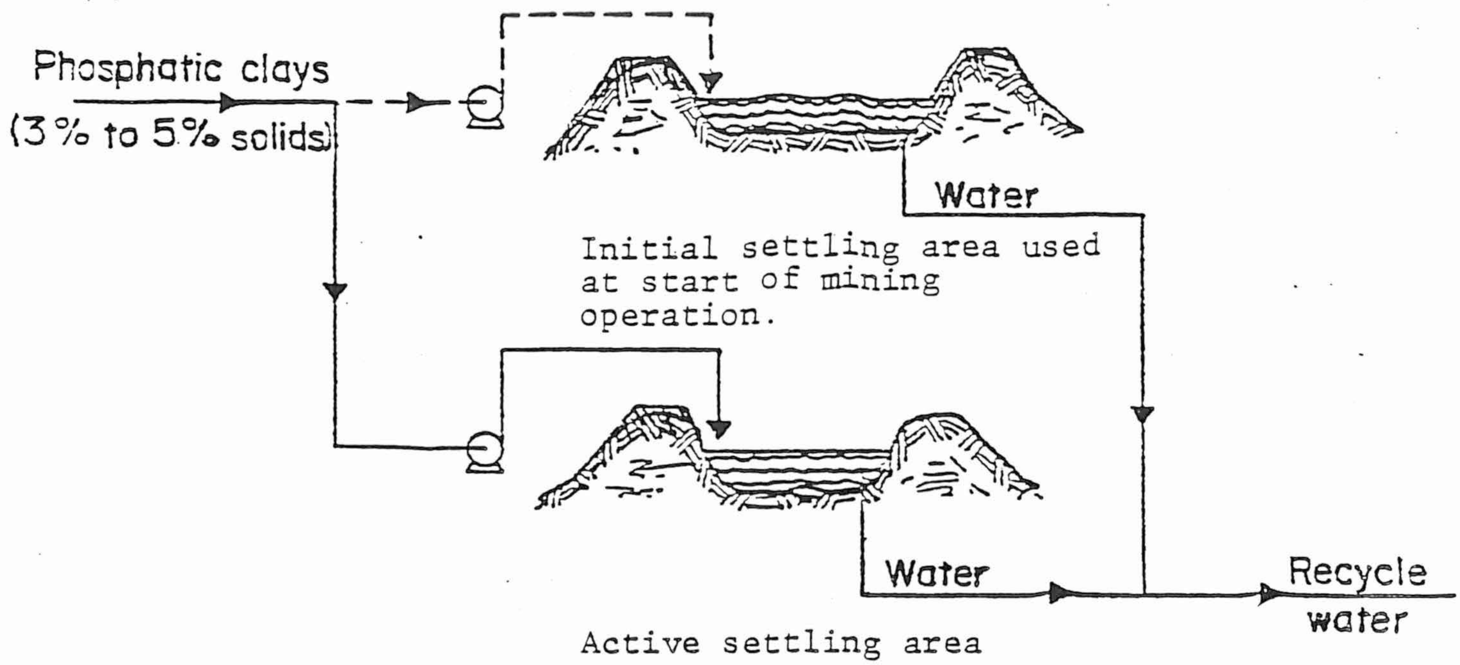


FIGURE 3 - Conventional clay disposal process. (modified USBM, p. 22, 1983.

settling (USBM, p. 21, 1983), they may remain in service for the life of the mine as a water reservior. Once a storage area is filled with clay and no longer used as a water reservior, it is taken out of service and reclamation can begin.

The reclamation of waste clay settling ponds is a time consuming process because of the water retention properties of the clay materials. The two most frequently used methods to reclaim a settling pond by the phosphate industry are dewatering by decanting and by capping the clays, i.e., pumping sand tailings onto the semi-liquid clays.

The decanting process begins by removing surface water as fast as possible through water control structures. As soon as dewatering of the surface area is feasible, perimeter drainage ditches are dug inside the dams and into the interior of the settling ponds to further enhance the drying of the clays. Continual maintenance and deepening of these channels is required to maintain the dewatering process. As the clay dries, a crust forms which is capable of supporting light farm machinery for cultivating the area. Due to the instability of the substrate, conventional settling ponds are usually reclaimed for pasture.

Sand tailings often are pumped into settling ponds, capping the clays which speeds up the process of dewatering. However, if the sand is added to the clay before a sufficient surface crust has been formed, "mud waves" often develop as the clays are pushed ahead of the sand.

CLAY WASTE RESEARCH

The phosphate industry, because of the environmental concern of government and the phosphate industry over the traditional method of storing waste clays, was encouraged to condust research for accelerating the consolidation of clays and improve land stability and minimize above ground storage.

Since 1972, the USBM, the phosphate industry, and others have conducted numerous studies related to the phosphatic waste clay problem. In 1975, the

USBM, in their publication, "The Florida Phosphate Slimes Problem--A Review and Bibliography" (USBM IC 8668, 1975, 41p.) lists the research conducted on phosphate slimes. The list below is comprised of methods cited in the USMB publication and some other methods used for dewatering waste clays:

1. Filtration
2. Centrifugation
3. Freezing
4. Drying
5. Electrical Dewatering
6. Bacteriological Dewatering
7. Mechanical Thickeners
8. Chemical Flocculation and Addition of Sand Tailings
9. Mixing with Sand Tailings
10. Dredge and Mix with Sand Tailings
11. Rotary Trommel and Flocculation
12. Reverse Osmosis
13. Pre-thickening of clay and cap with sand and/or overburden.

Of the above methods, mixing with sand tailings, dredge and mix with sand tailings, chemical flocculants, and capping of pre-thickened clays in mine cuts appear to be the most promising. For convenience, these processes are combined into two broad categories, 1)physical settling and 2) chemical settling, and are reviewed in the discussion that follows:

PHYSICAL SETTLING

Physical settling enhances the dewatering of phosphatic clays by mixing sand with the clay or capping pre-thickened clay with sand and/or overburden. Sand-clay mix has been developed to the extent that the process is now an operational technique for at least two operators.

Sand Spray Process:

In early 1972, Brewster Phosphates began experimenting with the sand spray method of mixing sand with clay (Figure 4). Clay slurries of three to five percent solids were placed in mined-out cuts and allowed to settle to 15 percent solids. Subsequently, sand tailings were sprayed over the clays from spray nozzles attached to a floating pipeline. As the sand settled through the clay,

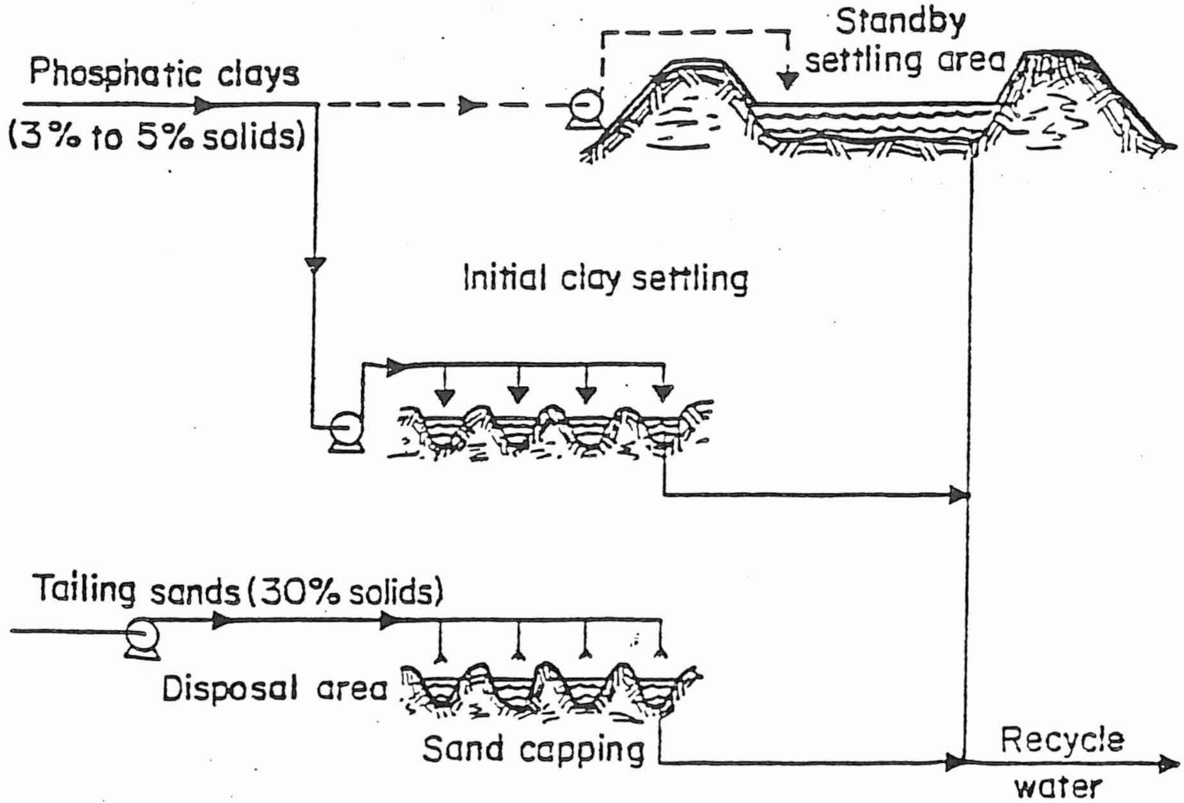


FIGURE 4 - Sand-spraying process for clay disposal.
USBM, p. 25, 1983.

the water trapped within the clay was released. After the initial sand-clay mix, more clay was introduced into the mine cuts and a second sand tailing spraying was conducted to produce a clay solids content in excess of 35 percent.

Brewster Phosphates is presently using a sand-clay mixing technique which is significantly different from the sand-spray process described above. Clays at three to five percent solids are placed in mine cuts and upon consolidating to 15 percent solids in three to four months slurried sands are discharged into the mine cuts containing the clay from several points. The discharge points are such that only one unit is discharging at a given time. As the sand interacts with the clay, movement of the clay may take place. To counteract this movement, the discharge of sand is stopped at that point and changed to another unit placed along the bank of the mine cut. (B. Sapp pers. comm., 1983). Approximately two years after filling the mine cuts, the clays begin to consolidate to 35 to 50 percent solids and available overburden peaks are used to cover the sand-clay material. (B. Sapp pers. comm., 1983).

Dredge Mix:

CF Industries in Hardee County is presently experimenting with a dredge-mix technique for disposal of phosphatic clay wastes and ensuing reclamation of mined-out lands (Figure 5). The dredge mix method involves placing clays in a holding pond and allowing them to settle to approximately 15-18 percent solids. Then the clays are dredged out and mixed in a hopper with sand tailings before being placed in mined-out cuts. The mix is pumped at approximately 30-32 percent total solids content and can be placed above or below the water level. After the ini tial fill, with the sand-clay mix, the material is allowed to settle and the process is repeated until the mine cut is filled. Ardaman and Associates, Inc., under the sponsorship of Florida Institute of Phosphate Research monitored and collected data during the filling of a 110-acre sand-clay

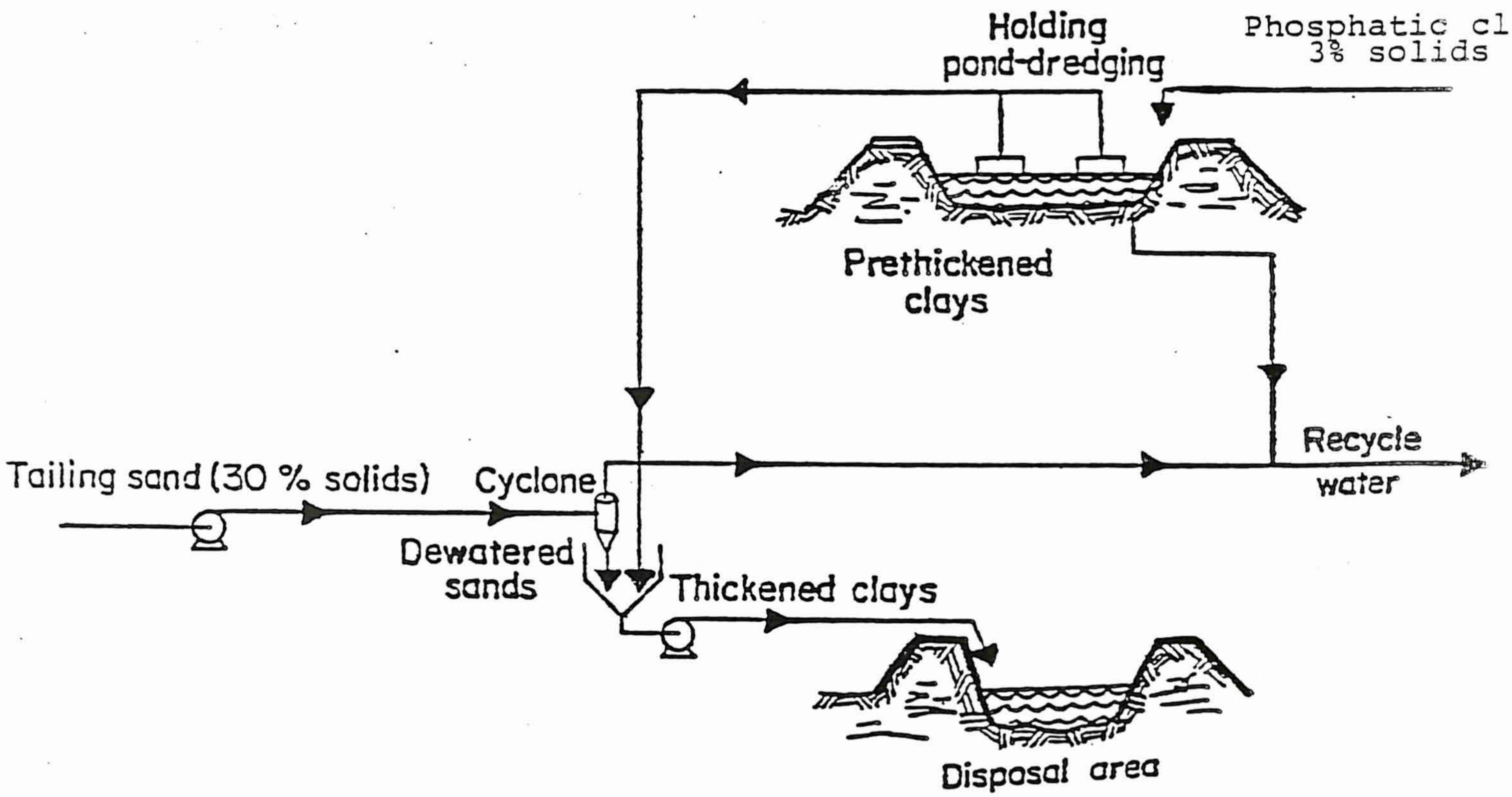


Figure 5 - CF Industries, Inc. process for clay disposal.
(modified USBM, p. 25, 1983)

mix site at CF Industries, Hardee County Mine. In a final report on the area, Ardaman and Associates (1982, p. 6-1) reported that at the end of a two year study period the sand-clay mix averaged 34 percent clay solids. They (Ardaman and Assoc., Inc., 1982, p. 6-1) also stated that reclamation can begin in the area within one to two years after filling is complete, provided the site is kept well drained.

Capping Process:

International Minerals and Chemical Corporation, Agrico, and Mobil Chemical Company are experimenting with the technique of placing prethickened clays from an initial settling pond in mine cuts surrounded by dikes (Lawver, 1982, p. 141), (Figure 6). After the mine cuts are filled above ground with prethickened 18 percent clay solids, a one and one-half foot cap of sand clay mix is placed over the clays. At this point the clays are permitted to further consolidate for one year before final capping with an additional seven foot layer of sand tailings or overburden.

Five years after the final filling of the pits, the clays will consolidate to 36 percent and that the ultimate clay consolidation will reach approximately 42 percent (Lawver, pers. comm., 1983).

CHEMICAL SETTLING

Over a period of several years the USBM has experimented with chemical flocculants as a means for rapidly dewatering phosphatic clays. They state that, (USBM, p. 27, 1983)

> "Flocculation is a technique in which discrete, colloidal-sized particles are agglomerated by an appropriate reagent and, as a result, settle out of suspension. Hundreds of commercial flocculating reagents have been tested singly or in combination with others, in an effort to select a flocculant that will result in the formation of stable flocs that will not reslurry readily and that will cause rapid

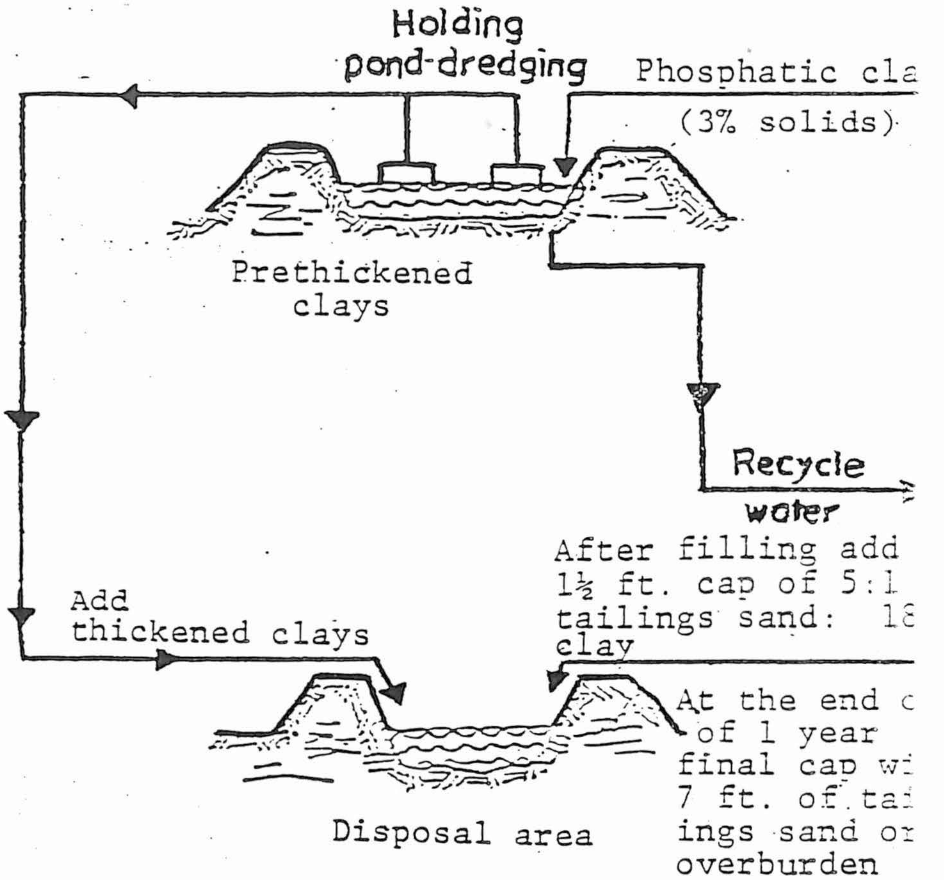


FIGURE 6 - International Minerals and Chemicals Corp. process for clay disposal. (modified USBM, p. 26, 1982)

settling and dewatering of phosphatic clays. Frequently, successful flocculating reagents evaluated in the laboratory on a specific clay proved unpredictable in field tests owing to the variables encountered in the field test conditions. These variables are...clay mineralogy; age of the clay slurries; method of flocculant introduction; dilution of the clay slurries; pH of the slurry; mixing shear; conditioning and contact time."

Estech General Chemical Corporation, Enviro-Clear Process:

Estech has been experimenting with the Enviro-Clear thickening process for rapidly dewatering waste phosphatic clays. The process, as shown in figure 7, involves single flocculation for the treatment and disposal of three percent waste clays.

Phosphatic clays, chemical flocculant, and dewatered tailings are mixed together in a surge tank. After mixing, the material is passed into the thickener where additional agglomeration takes place. The thickened solids leave the bottom of the thickener and are pumped to mine cuts for further dewatering. The water released from the clay passes out the top of the thickener and is recycled into the mining operational system. The flocculated clays mixed with sand continue to consolidate and eventually reach 30 to 35 percent solids. Estech has built a full-scale plant at their Watson Mine in Polk County and have been encouraged by preliminary field disposal tests.

U.S. Bureau of Mines Rotary Trommel and Flocculation Process:

The rotary trommel and chemical flocculation developed by the U.S. Bureau of Mines is presently being field tested (Figure 8). The process involves mixing a chemical flocculant, polyethylene oxide (PEO) with clay waste containing three percent solids and subjecting them to static and rotating screens which rapidly dewaters the clays to 24 percent solids. Pit tests indicate that clay solids greater than 30 percent can be achieved in several months. Some clays require oxidation and treatment with lime in addition to PEO to achieve flocculation.

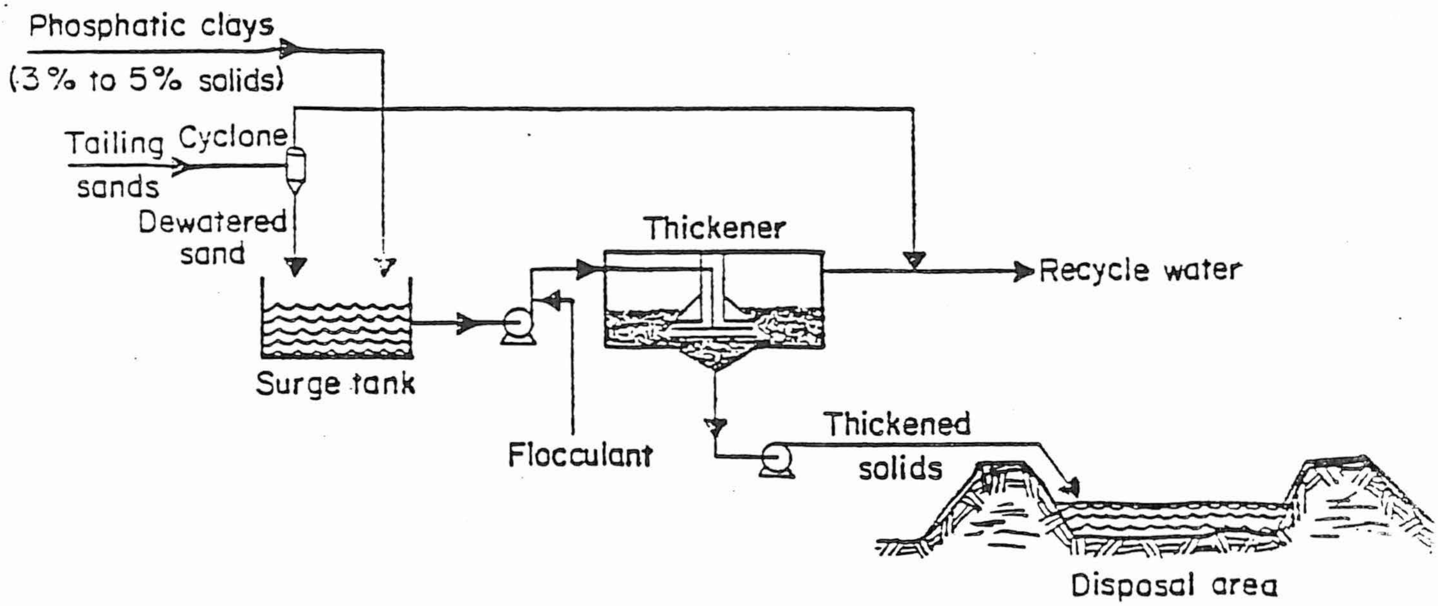


FIGURE 7: Estech Chemical Corp. process for clay disposal.
USBM, p. 30, 1983.

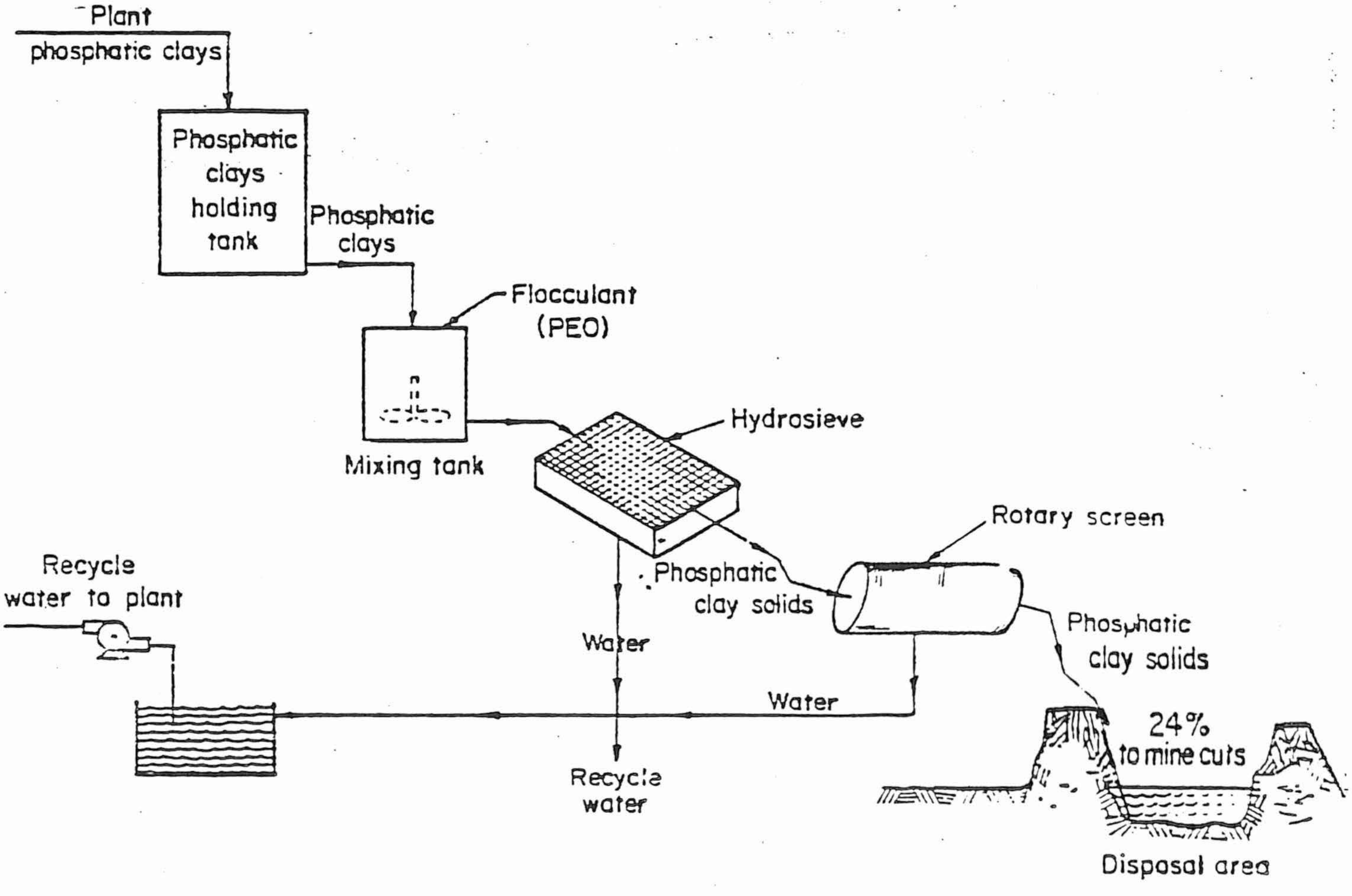


FIGURE 8 - Rotary screen process for clay disposal.
USBM, p. 28, 1983

Gardinier, Inc. Process:

Gardinier, Inc., has been experimenting with a process utilizing double flocculation for the treatment and disposal of waste clays (J. Taylor, 1982, p. 249-64) (Figure 9). The process involves adding flocculants to clay waste at one to six percent solids which causes the waste clay to agglomerate and settle. The thickened clays, consisting of 12 to 15 percent solids, are then pumped to another station where more flocculant is added to the thickened clay. The double flocculated material is then deposited in mine cuts where it continues to dewater until the mixture reaches 30 to 40 percent solids after a few weeks. The mine cuts are stage filled for approximately one year allowing the material to be exposed to the atmoshpere to enhance drying of the material. After the mine-cuts are filled with the thickened clay, they are capped with sand tailings and overburden.

CONSOLIDATION PREDICTIONS

Dr. James E. Lawver of International Minerals and Chemical Corporation has done an in depth comparison of the consolidation predictions of the various systems used by the phoshpate industry to dispose of phosphatic waste clay. (Table 1). The comparison is based on a site specific standard Central Florida phosphate mine using a value of 10,700 tons per acre of waste clay, 24 feet of matrix, and 26 feet of overburden. Based on data from table 1, graphs (Figures 10-12) showing the comparison of percent clay solids as a function of time were constructed. Except for conventional clay settling ponds, most of the techniques achieve approximately thirty five percent clay solids after 5 to 8 years. (Figure 10-12). This is the percent solids required if the waste clays are to fill the available void space in the mine cuts to allow ultimate disposal at approximately ground level over 85 percent of the area mined.

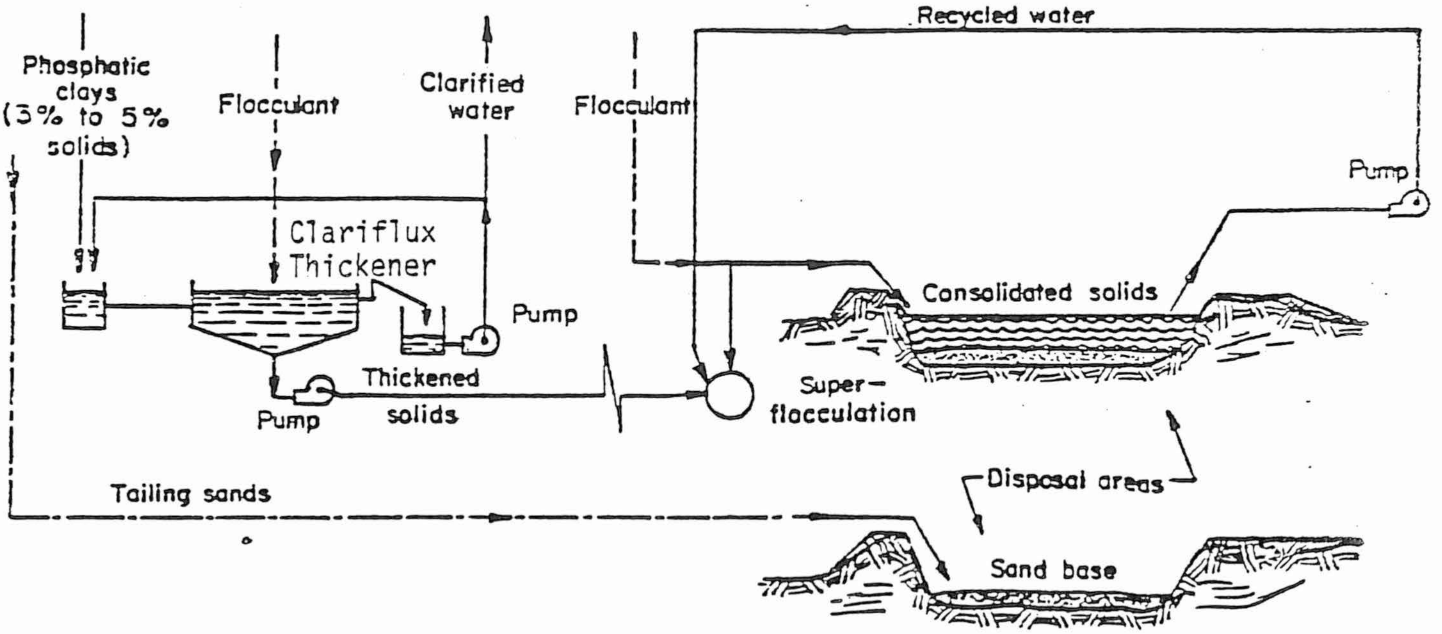


FIGURE 9 - Gardinier, Inc., process for clay disposal.
USBM, p. 29, 1983.

TABLE 1 - COMPARISON OF CONSOLIDATION PREDICTIONS OF VARIOUS WASTE DISPOSAL SYSTEMS

		A	B	C	D	E	F	G	H
Acres of Above Ground Settling Ponds	Total	440T	440T	1530	350T	585T	585	550T	>350
	Effective	350E	350E		278E	450E	450E	440	
Acres of In-Pit Storage (IPS)		1750	1750	1845	1750	1680	1695	1750	1750
Initial Slime Height Above Ground of In-Pit Storage		15'	15'	0'	10'	10'	10'	10'	10'
Initial % Solids of Clay in In-Pit Storage		3-5	3-5	3-5	12-14	15-18	15-18	12-14	18-22
% Solids of Clay in In-Pit Storage at Time of Final Fill		25	25	12-15	30	30.3	23.5	>30	>30
% Solids of Clay in In-Pit Storage 5 Years After Final Fill		28	28	36	35	35.7	36.3	>35	>35
Height of Slimes Above Ground of In-Pit Storage 5 Years After Final Fill		8.7	8.7	-13	7	7	-3.0	<10	<10
Ultimate % Clay Solids		31	40	42	36	36	42	>40	>40
Ultimate Height Above Ground of Final Surface		5	0	0	6	6	0	±2	<5
Turnaround Time Between Initial Mining and Reclamation		10Y	11Y	4Y	8Y	8Y	8Y	6-8Y	>5Y
% of Total Slimes Stored in In-Pit Storage		83	83	41	85	83	82	>80	>80
% of Slimes Ultimately Stored at or Below Ground Level		75	91	67	72	72	90	>88	>88

CODE

A = Conventional System
B = Conventional + Cap
C = Brewster Cap
D = Estech
E = CF
F = IMC-Agrico-Mobil Cap
G = Gardinier Cap
H = U.S.B.M.

BASIS

9,700 TPA Product
10,700 TPA Slimes
26,100 TPA Tailings

24 ft. MTX
26 ft. Overburden
50 ft. Pit

Production Rate

1.1×10^6 tpy slimes
2.7×10^6 tpy tailings
1.0×10^6 tpy product

Mining Rate 103 Acres/Year for 20 Years

Source: Dr. James Lawver, 1983.

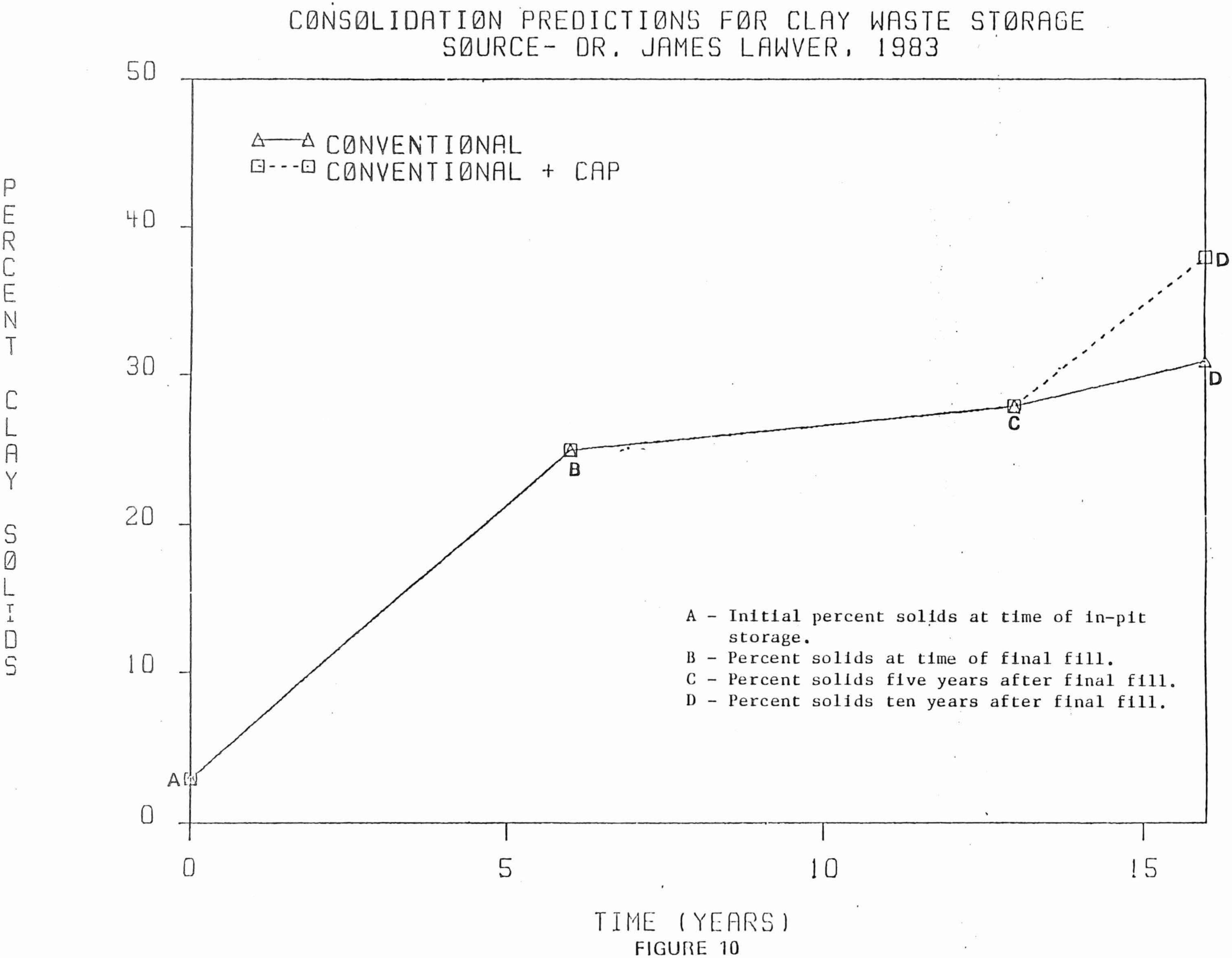

CØNSØLIDATIØN PREDICTIØNS FØR CLAY WASTE STØRAGE
SØURCE- DR. JAMES LAWVER, 1983
PERCENT CLAY SØLIDS
TIME (YEARS)
CØNVENTIØNAL
CØNVENTIØNAL + CAP
A
B
C
D
D
50
40
30
20
10
0
0
5
10
15
A - Initial percent solids at time of in-pit storage.
B - Percent solids at time of final fill.
C - Percent solids five years after final fill.
D - Percent solids ten years after final fill.

FIGURE 10

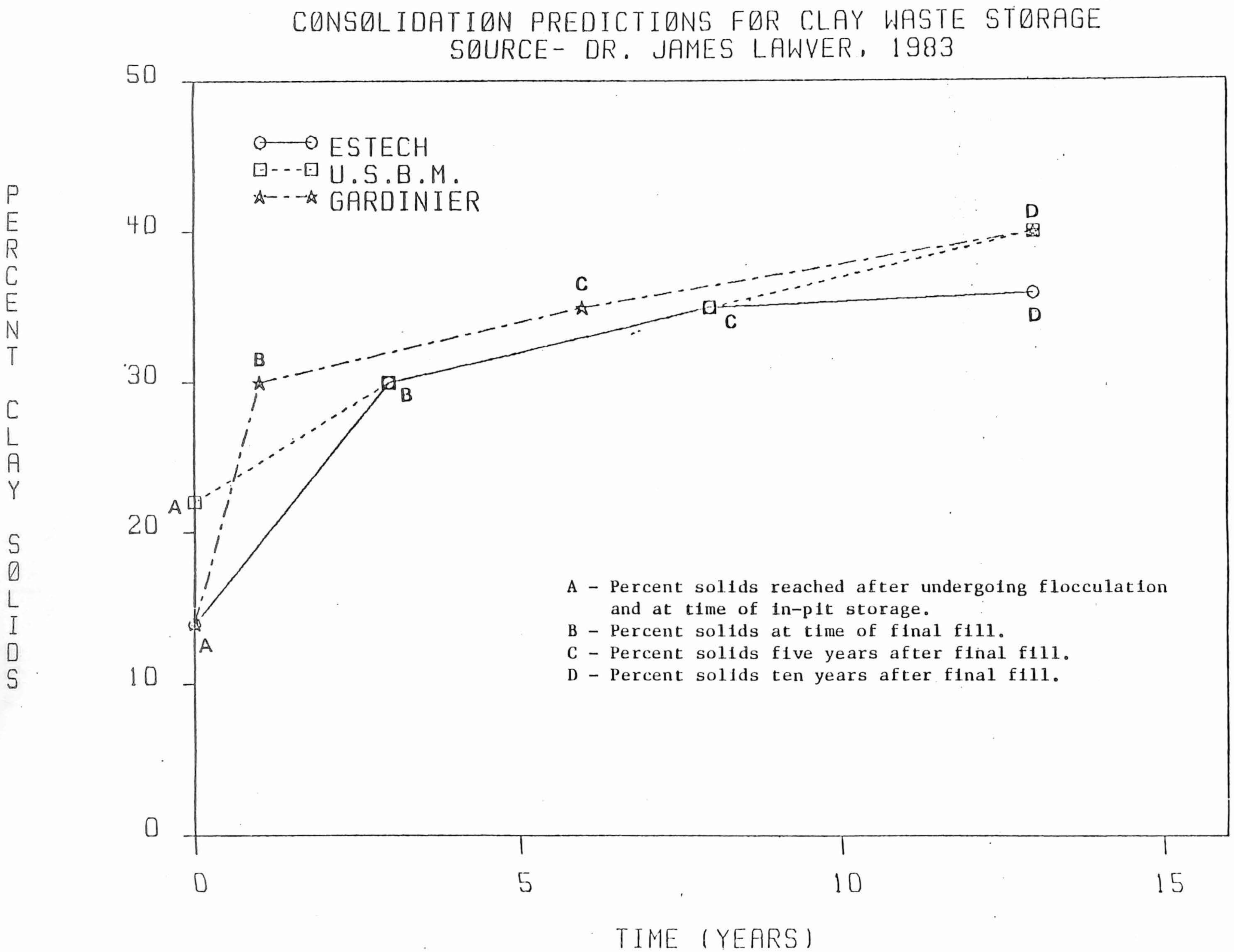

CØNSØLIDATIØN PREDICTIØNS FØR CLAY WASTE STØRAGE
SØURCE- DR. JAMES LAWVER, 1983
ESTECH
U.S.B.M.
GARDINIER
PERCENT CLAY SØLIDS
TIME (YEARS)
0
10
20
30
40
50
0
5
10
15
A
B
C
D
A - Percent solids reached after undergoing flocculation and at time of in-pit storage.
B - Percent solids at time of final fill.
C - Percent solids five years after final fill.
D - Percent solids ten years after final fill.

FIGURE 11

CONSOLIDATION PREDICTIONS FOR CLAY WASTE STORAGE
SOURCE- DR. JAMES LAWVER, 1983

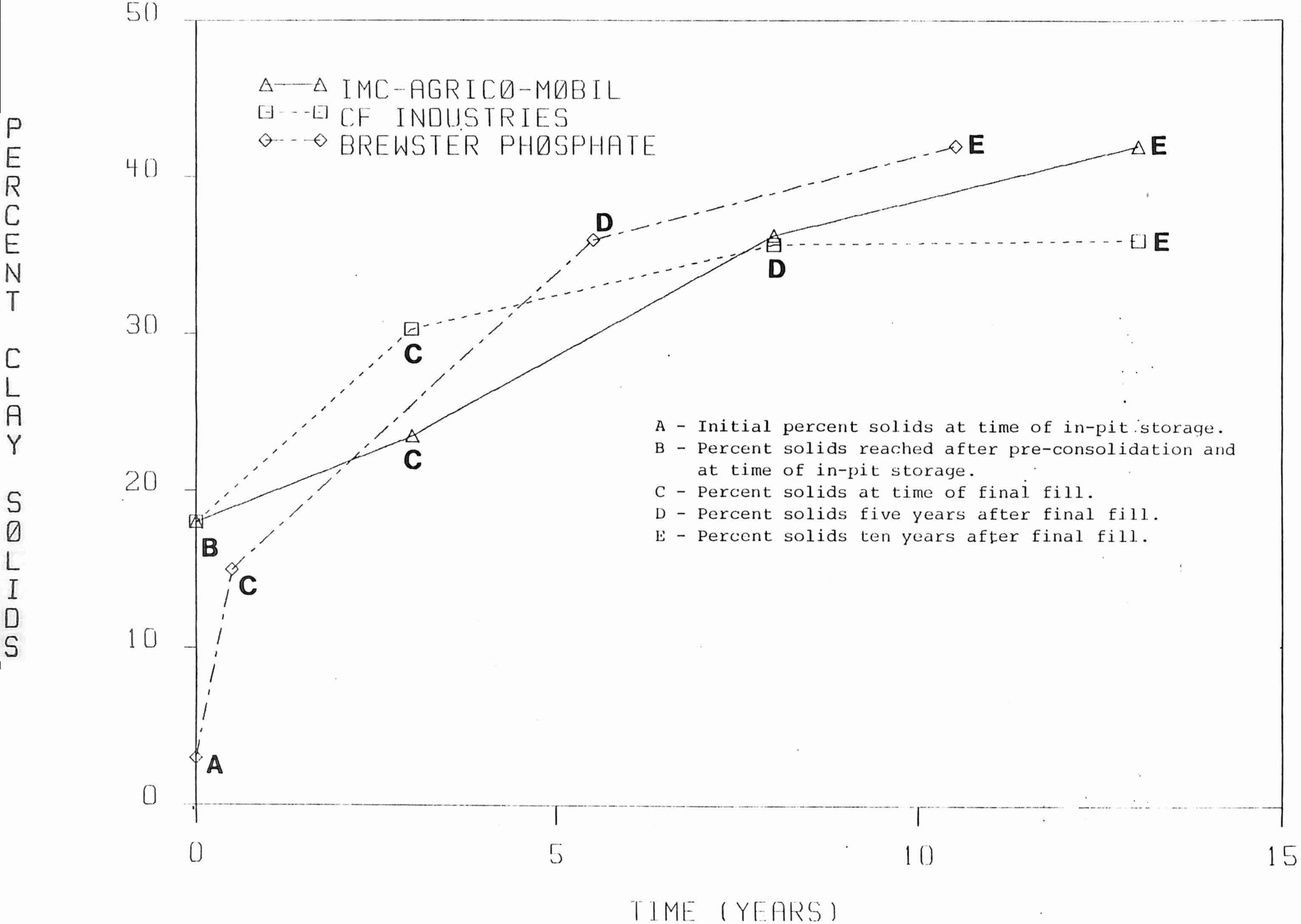


FIGURE 12

Field measurements by Brewster Phosphate at their Fort Lonesome Mine (B. Sapp, pers. comm., 1983) and Ardaman and Associates, Inc. (FIPR, 80-03-006, 1982, 122 pp.) at C.F. Industries Hardee Complex Mine are presented in figure 13. Comparison of figure 13 with figure 12 shows a slight difference between the field measurements and Lawvers computer model prediction. This difference may exist because of different size areas and pit depths.

SUMMARY

Much research work has been done since 1972 in an attempt to solve the problem of rapidly dewatering phosphatic clays. Research efforts conducted on dewatering phosphatic clays is to reduce the area needed for storing these clays and the height of storage dams, with an ultimate goal of returning the land to approximate the original surface elevations. To date, research efforts have not greatly reduced the area needed for storing phosphatic clays as up to 85 percent of the mined land is required for waste clay storage. However, if a feasible technique can be developed which will consolidate clay waste to greater than 50 percent, a stable land mass can be created, and the land would have greater economic and environmental qualities.

The efforts toward dewatering phosphatic clay can be classified generally as follows:

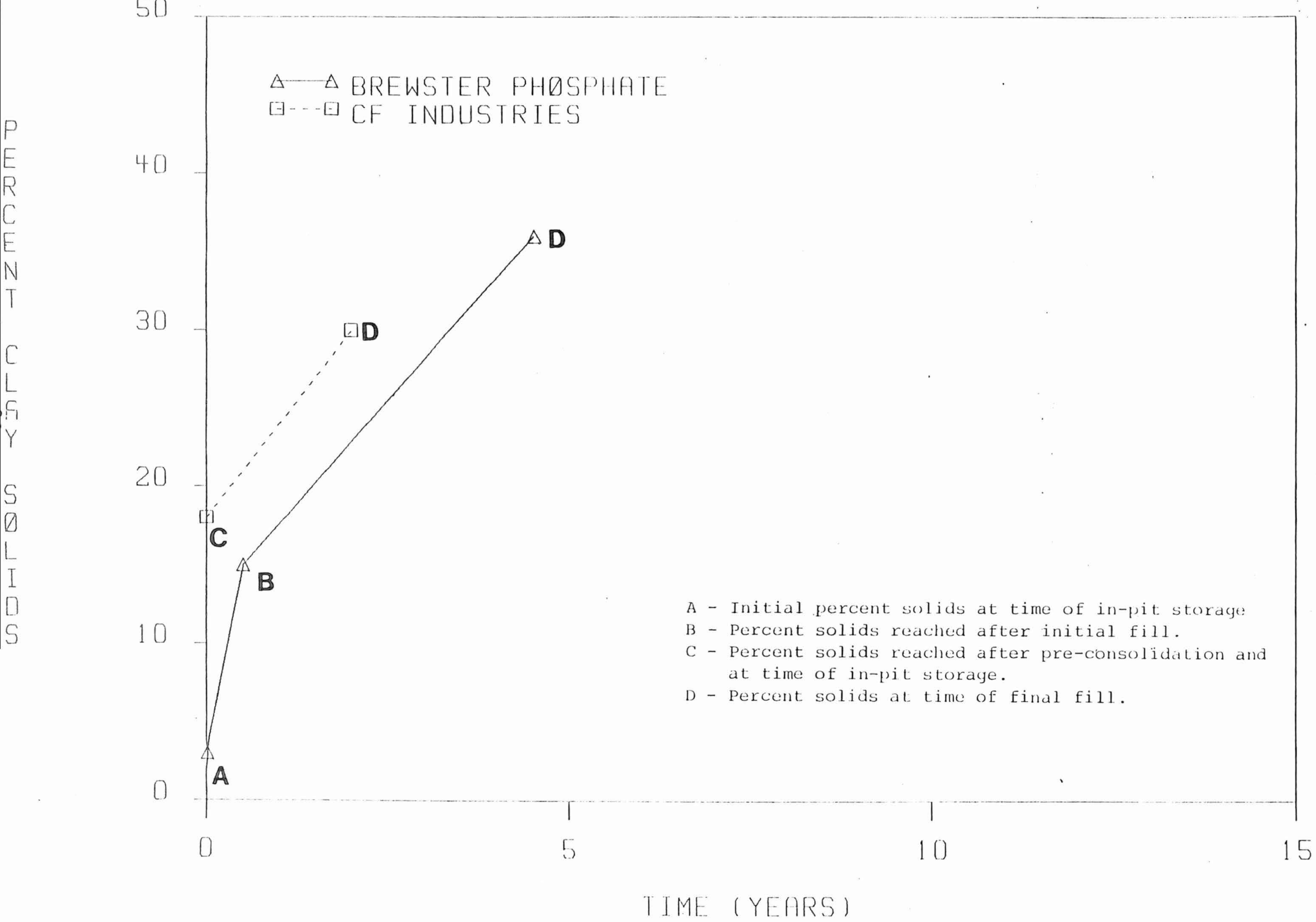
A. Conventional Settling Technology

1. Stage - Filling with subsequent dewatering.
2. Longtime dewatering of clays by ditching and subsequent capping with sand or overburden.

B. Physical settling Technology

1. Pre-thickening of clay in settling pond plus quartz sand cap or overburden.
2. Pre-thickening of clay in settling pond before dredging and admixing with quartz sand.
3. Pre-thickening of clay in mine cuts before addition of quartz sand by spraying.

ACTUAL CONSOLIDATION RATES FOR CLAY WASTE STORAGE
SOURCE- BREWSTER PHOS., ARDAMAN AND ASSOC., 1983



C. Chemical Settling Technology

1. Flocculation with addition of sand or overburden cap.
2. Flocculation plus addition of quartz sand to form a mix.
3. Flocculation minus addition of quartz sand.

Of the methods tested for dewatering clays, admixing of sand with the phosphatic clays is one of the most promising techniques. According to A. L. Holmes (Pers. comm., 1983) of C. F. Industries and Bobby Sapp (Pers. comm.,1983) of Brewster Phosphates, their sand-clay mix processes are at full scale field operation mode. Both companies have indicated that the method they are using may be suited only for their particular mine. Williams (1981, 15 p.) states that admixing of sand and clay is not a proven technique because research has not provided sufficent data to be able to predict a final landform that a sand-clay mixture will ultimately acquire. He (William, 1981, 15 pp.) also says that adopting standardized proportions for a sand-clay mix is impossible because ore bodies vary drastically in the constituent parts of sand, clay, and phosphate (Table 2).

In the list that follows, the advantages and disadvantages of sand-spray, sand-clay mix and capping are cited:

(Mobil Chemical Company, EIS, 1981, p. 2-50, Lawver 1982, p. 225-48, USMB, 1983, p. 24, 28):

(Advantages)

Reduce the number of acres devoted to conventional settling ponds.
Reduce the risk of dam failure.
Enhance the drainage characteristics of the soil over conventional clay areas.
Reduce reclamation time.
Expedite the initial consolidation rate of the clay.
Make possible the storing of clays at or near ground level elevation behind low level dams.
Dispose of sand and clay at the same disposal site.
Rapid recovery of water for reuse in the beneficiation process.

(Disadvantages)

Still require above ground dams even though they are low level.
Still risk dam failure and probable damage.
Still require considerable acreage for storage purposes.

TABLE 2

SUMMARY OF MATRIX SAND/CLAY RATIOS

Company	Mine	Matrix Sand/Clay Ratios
Grace	Four Corners	4.5:1
Estech	Duette	4.2:1
Beker	Manatee	4.0:1'
AMAX	Pine Level	3.75:1
Borden	Big Four	3.2:1
Brewster	Ft. Lonesome	2.5-3:1
CF Industries	Hardee Co.	2.6:1
Farmland	Hardee	2.5:1
Mississippi Chemical	Hardee Co.	2.2:1
Mobil	South Fort Meade	1.2:1

Source: Mobil Chemical Company, EIS, 1981, p. 2-36)

(Disadvantages, continued)

Low weight bearing capacity.
Restricted variety of land forms and land uses.
Logistics of providing the required sand for disposal.
Creation of mud waves in capping and sand-spray methods.
Difficulty of proper clay-capping techniques.
"Turn-around" time for proper clay thickening.

The chemical methods under study or presently operational are considered to have both advantages and disadvantages, which are listed below:

(USBM, 1983, p. 29, J. Lawver, pers. comm., 1983, Raden, 1982, p. 216-21, Taylor, 1982, p. 249-64):

(Advantages)
Rapid recovery of water for reuse in the beneficiation process.
Eliminate the need for numerous conventional settling ponds.
Induce rapid settling of clays which makes possible the storing of clays at or near ground level elevations behind low level dams.
Speed up reclamation.
Obtain the necessary clay solids to suspend all sand tailings produced into homogenous mixture that will not segregate.
Clays dewatered using PEO do not readily reslurry.

(Disadvantages)
Reuse of reclaimed water from the process may effect the beneficiation process. (Froth Flotation)
Changing mineralogy of clays causes difficulties in flocculant performances.
Low weight bearing capacity.
Restricted variety of land forms and land uses.
Still risk dam failure and probable damage from the stored material.
Still require considerable acreage for storage purposes.
Unknown impact of flocculant chemicals on ground water quality.

Regardless of whether physical or chemical settling techniques are used, other factors should be considered with regard to planning for clay waste disposal at any particular mine. According to Carrier (USBM, 1982, p. 500) and the U.S. Bureau of Mines (1983, p.32) each mine site waste disposal plan will have its unique characteristics because of the following variables:

1. Thickness of overburden.
2. Amount of clay in matrix.
3. Ratio of sand to clay in matrix.
4. Mineralogy and chemical composition of the clays in the deposit.
5. Volume of available below ground storage which includes the volume of both the overburden and matrix.

Ardaman and Associates, Inc.
1982 Field Evaluation of Sand-Clay Mix Reclamation, December 1982: Florida Institute of Phosphate Research, p. 6-1.

Carrier, W. D. III
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CONCLUSIONS AND RECOMMENDATIONS

Based on the review of published data, field observation, and personal communications with the phosphate industry, the following conclusions and recommendations are presented:

1. The conventional above ground storage of clay waste requires the use of approximately two-thirds of the land mined.

2. The physical and chemical dewatering of waste clays that are presently being considered will reduce the time between initial storage and reclamation of the areas where waste clays are stored.

3. Because overburden is currently being placed back in the mine cuts, approximately 85 percent of the mined area is required for placing waste clays at 35 percent solids (at approximately 10,000 tons of clay per acre).

4. After reaching 35 percent solids, the time factor for achieving additional consolidation of the clay waste is similar for all techniques.

5. Each mine has certain characteristics (as detailed by Carrier and USBM) which will affect the waste disposal plan for that mine.

6. In a new mine an initial settling pond will be necessary for storing clays until enough void space becomes available for utilizing sand mix and/or flocculation.

7. An initial settling pond will be necessary for pre-thickening clays to be used in sand mix, flocculation, and capping technique.

8. Initially, it will be necessary to store waste clays behind elevated dams if ground level is achieved and topographic lows are to be avoided over the total area.

9. Regardless of the presently recognized techniques being used for clay waste storage, the stability of the land will be such that land use of the areas may be limited to agricultural uses.

10. Research on the physical and chemical methods of dewatering clay wastes, with regard to chemical methods of dewatering clays, research should be conducted to determine whether flocculants create ground water quality problems.

11. As previously mentioned, the current method of mining requires placing up to 50 percent of the overburden in the mine cuts. If a different mining method can be perfected to remove the overburden the amount of land required for clay storage can be greatly reduced. To determine if this approach is realistic, research should be conducted which addresses both the technical aspects and associated costs of the new method.

12. Research should be conducted to improve land stability and the agronomics of the lands after reclamation is complete.

13. The ultimate research goal for rapidly dewatering clays should be to perfect a technique that will achieve clay solids of about 50 percent.

14. THE TECHNIQUE USED FOR DEWATERING WASTE CLAYS IS NOT AS IMPORTANT AS THE ULTIMATE GOAL OF ACHIEVING A STABLE LAND SURFACE AND MINIMIZING ABOVE GROUND CLAY STORAGE.

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