Rice University

Living with Topography

By

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IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE

Master of Architecture

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Living with Topography

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Abstract: Living with Topography

Opportunities lay in areas not typically thought of in terms of design. Earth moving is not typically considered further than the initial site excavation. In Houston, earthwork is constant, often changing land incrimentally.

The Port of Houston, ranking first in the United States in foreign waterborne commerce, and sixth in the world, requires the maintenance of its ship channel through regular dredging of sediments. Dredging is a reality of the Port of Houston and Disposal containment is its lifeline.

Recently, three of the eight upland dredging disposal sites reached capacity and are now closed. Although the Port of Houston authority has proposed to raise the height of existing sites to increase capacity, this is only a short-term solution. Once a site reaches capacity, the land sits fallow indefinitely. The dredge material stays in the site perminently and would be difficult to develope or build on. They are also not publicly accessable, although it is quite apperent that they are used recreationally buy local residents.

Treated as an engineering project, the two realities of waste site and recreation never meet. Redirection and design of existing earth moving and drainage techniques however, may allow for an operational switch from a permanent dredge storage system to a dry-bed removal system.

Increasing disposal area capacity by moving material bewteen sites would allow provisional and purhaps seasonal, public access to meet community demands such as a public park. The surrounding communities may benefit from living with dredge disposal area. A land use education area may serve as a showcase for a moving park that allows for the witnessing of fast geologic change as well as unlikely working relationships between the natural and the constructed.

Living with Topography

Dredge: Houston Navigational Channel

The Port of Houston Authority operates, maintains and schedules dredging for 26 sites between Houston and Galveston. The Army Corp. of Engineers builds and maintains the levee for each site. Sub-contractors maintain dewatering schedules.

The Port of Houston is currently in negotiations to purchase more land for dredge disposal in addition to increasing the levee height of existing disposal sites in order to plan for future capacity.

Figure 1.01-Estimated disposal containment area capacity.-The Port of Houston Authority

	Current Capacity (cy)	Estimated # Years *	Future Potential Capacity (cy)	Estimated # Years *
Glendale	83,958	0.2	8,298,429	18.4
Greens Bayou	363,997	CLOSED	--	--
Filterbed	181,000	0.4	3,171,454	7.0
House Tract / Stimpson	4,847,944	10.8	17,230,070	38.3
Clinton	1,036,724	2.3	23,358,802	51.9
East Jones	502,084	CLOSED	--	--
West Jones	34,877	CLOSED	--	--
Rosa Allen	838,760	1.9	9,109,855	20.2

Notes:

3 year dredging event = 2,250,000cy per site

*annual capacity = 450,000cy per site

cy = cubic yards

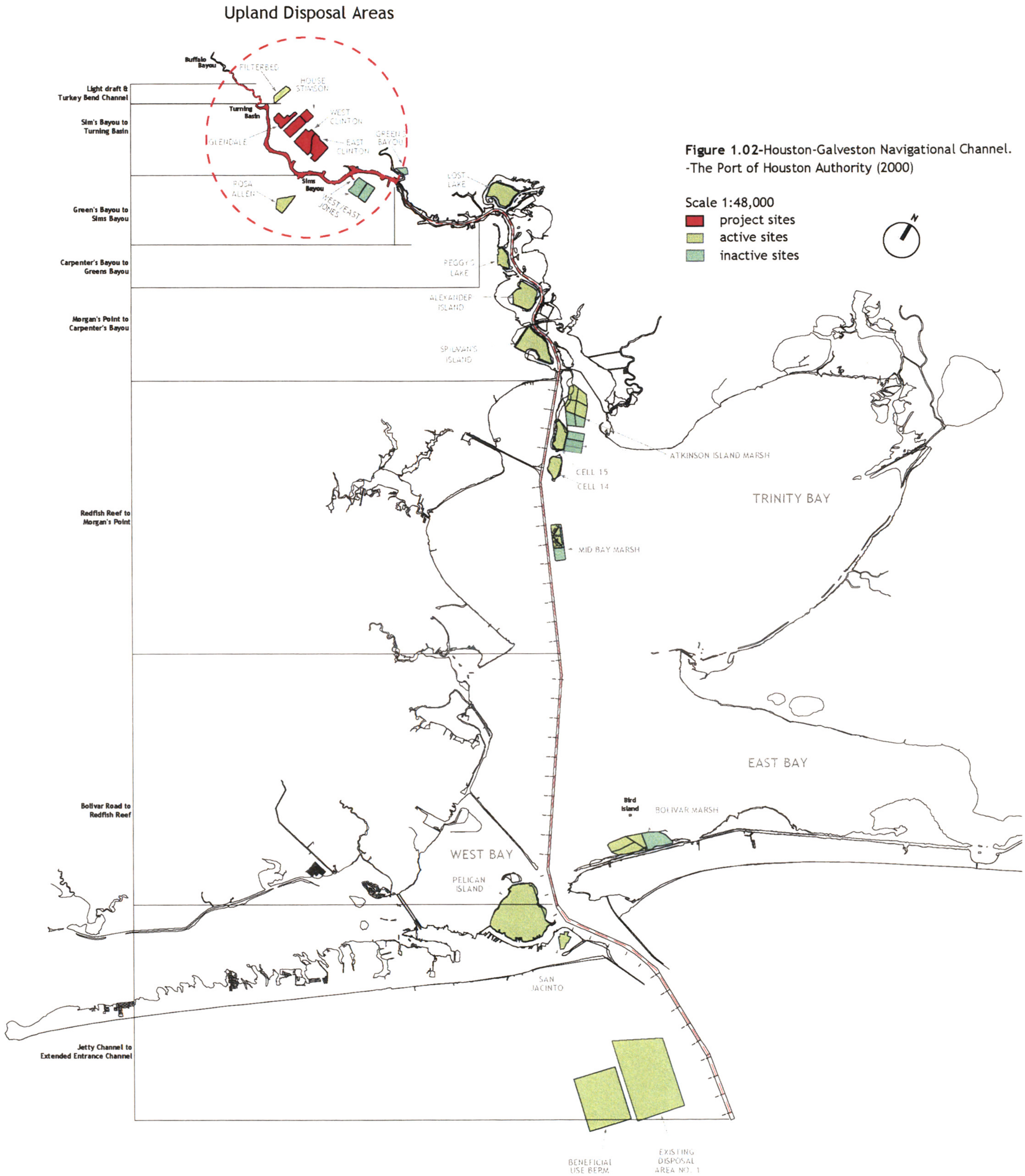


Figure 1.02-Houston-Galveston Navigational Channel.
-The Port of Houston Authority (2000)

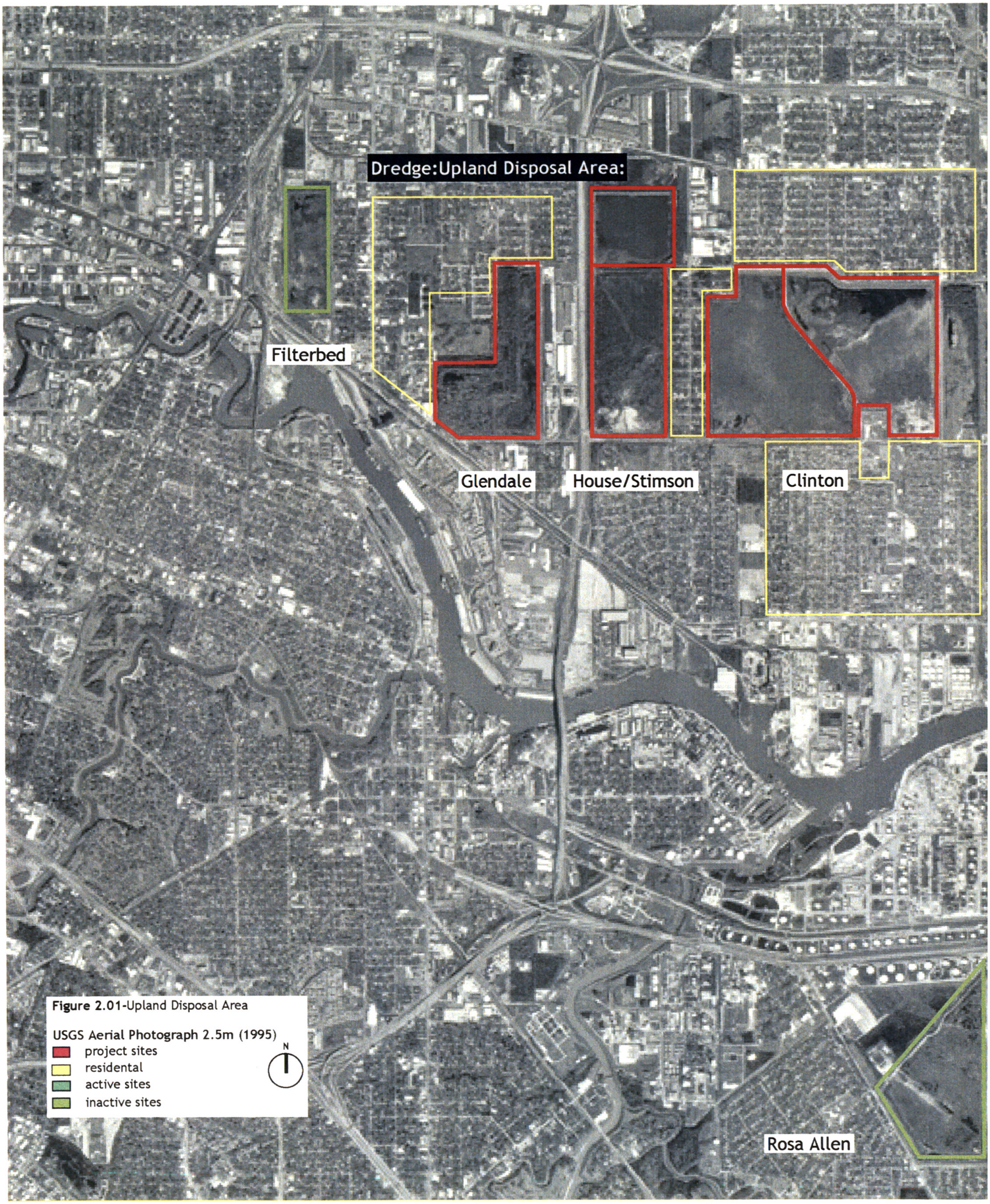


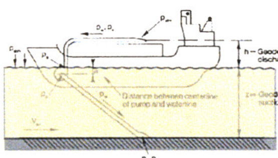
Figure 2.01-Upland Disposal Area

USGS Aerial Photograph 2.5m (1995)

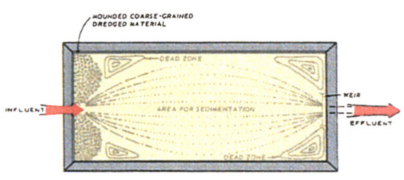

Greens Bayou
West Jones
East Jones

Figure 3.01- Dredging, containment and drainage sequance of disposal material. Sediment is pumped into sites as a slurry consisting of 5 parts water to 1 part clay. Drawings from "Handbook of Dredging Engineering" 2nd Ed.-John B. Herbich.

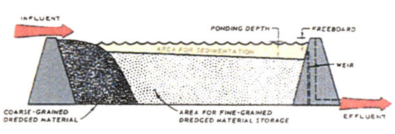
① Dredge



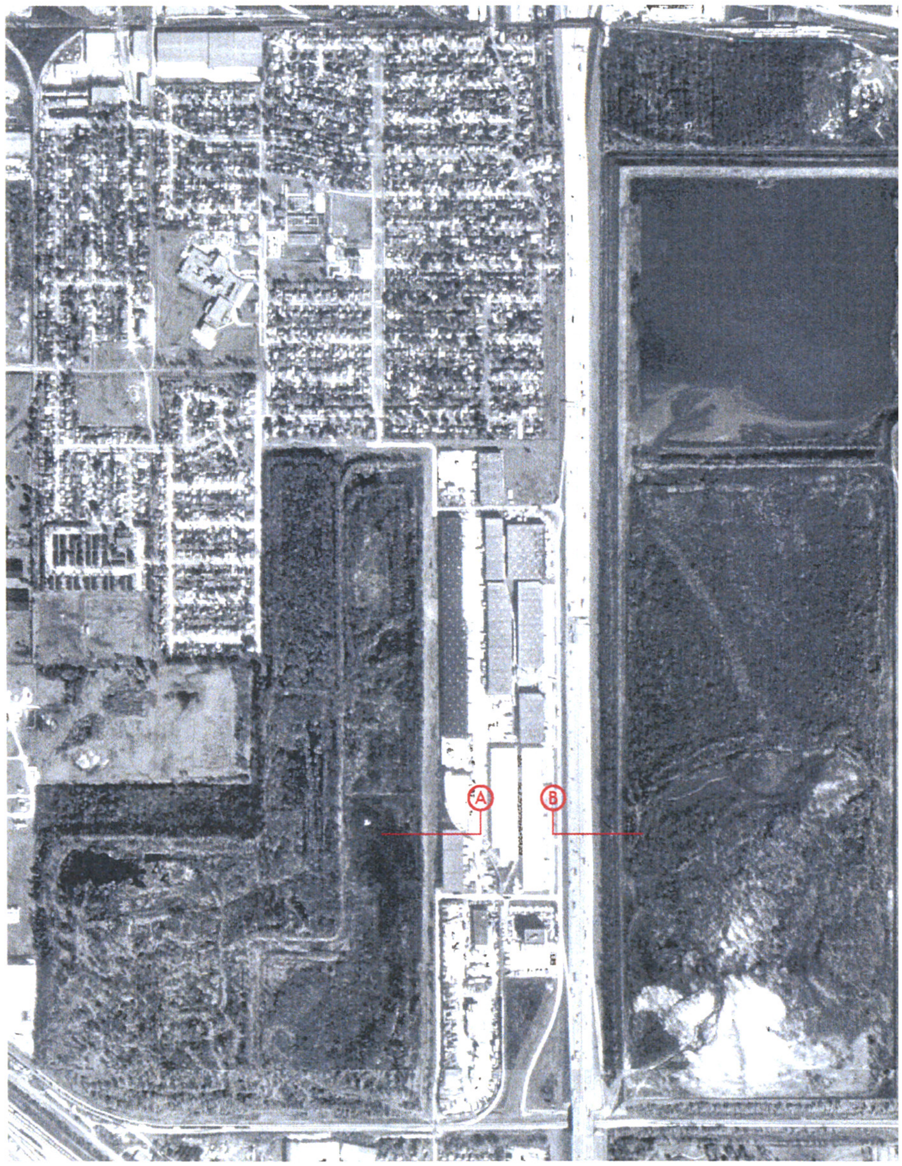
② Containment



③ Settle and Drain



Dredge: High Visability



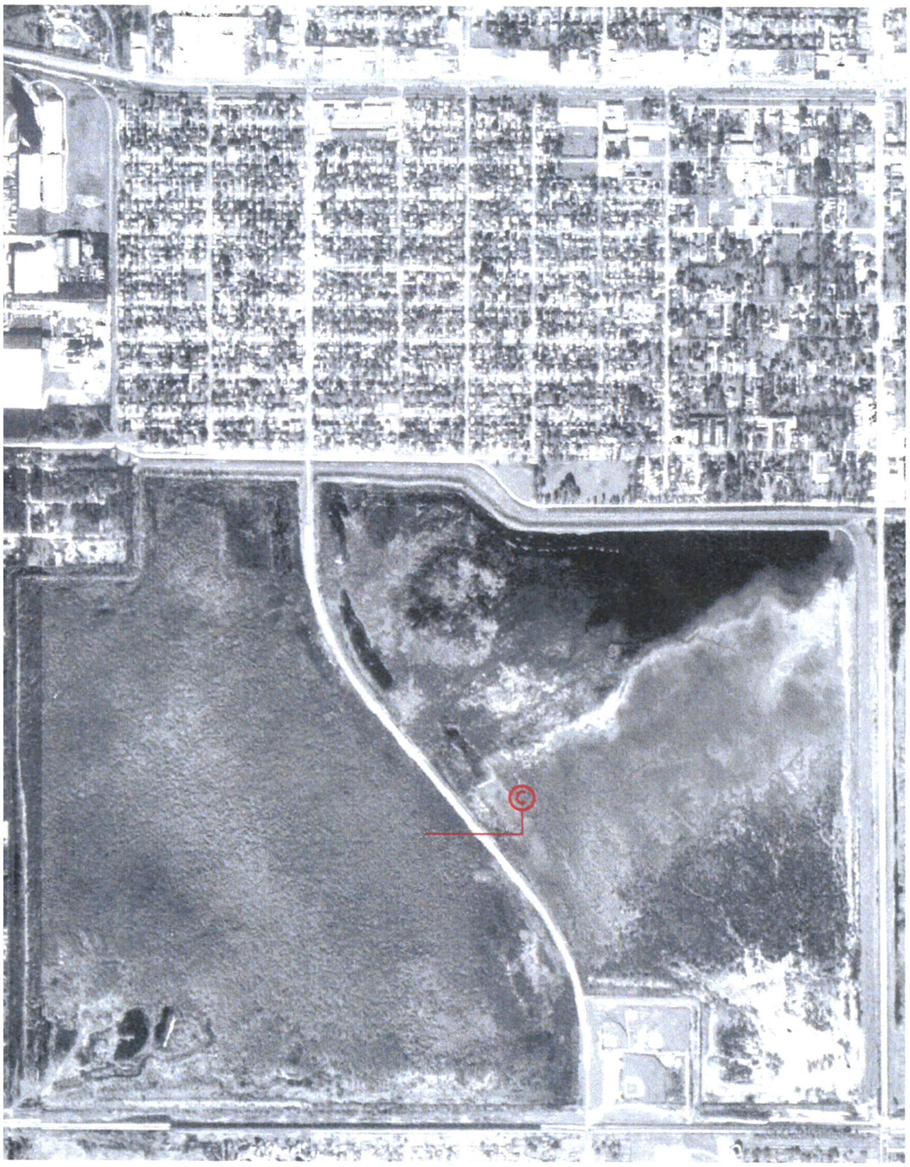
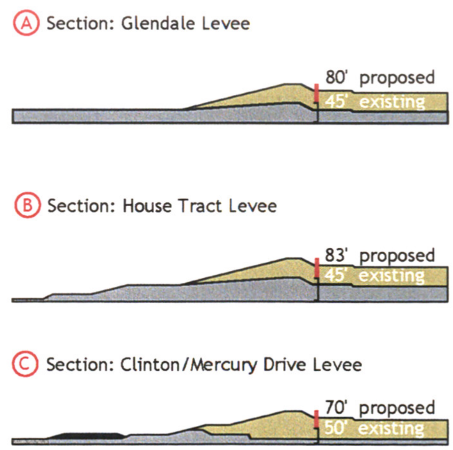


Figure 3.02- Aerial Photograph of Glendale, House Tract/Stimson and Clinton Disposal Containment Areas. -USGS 2.5m (1995)

Figure 3.03- Section of current plan to increase capacity of existing disposal areas by increasing height of levee walls. Height proposed is based on the maximum stability of levee.



Dredge: DAMP

Figure 4.01- Pipe entry photograph taken at Clinton disposal area. Pipe can discharge up to 4,000 cy per day.

Disposal areas are marsh like when first filled with wet dredge material. The time it takes for the material to dry depends on the porosity and permeability of the material itself. In addition, the drainage rate depends the amount of rain per year in the region, as well as the time of the year the dredge material is discharged into the site.

Water drains into spill boxes or wires with boards that are lifted 1/4" to let a stream of clear water run. The amount, rate of flow and discharge schedule are federally regulated and standardized.

Figure 4.02- Perimeter Trench photograph taken at Glendale disposal area.

Figure 4.03- Spillway photograph taken at Clinton disposal area.

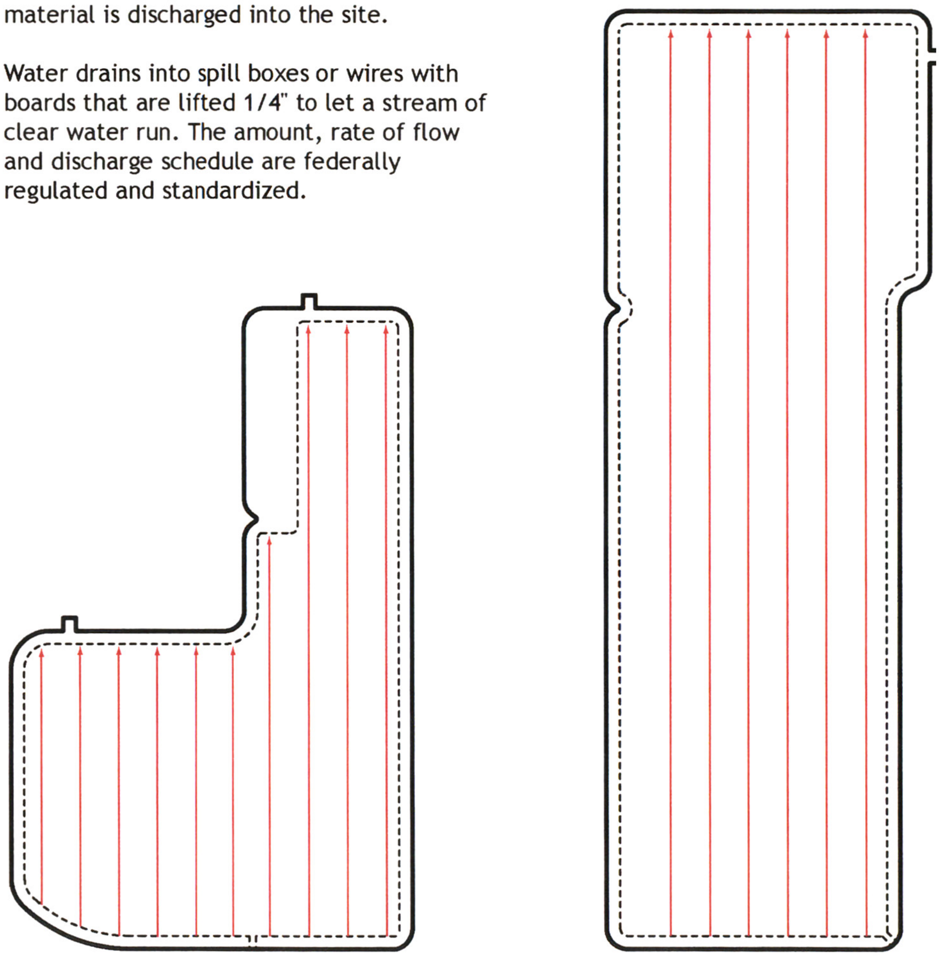


Figure 4.04- Current treching pattern for drainage of Glendale, House Tract/Stimson and Clinton Disposal Areas. Dredge is discharged into levee and is allowed to drain. Water is drained through interior trenches to perimeter trenches and then out through the spillway.

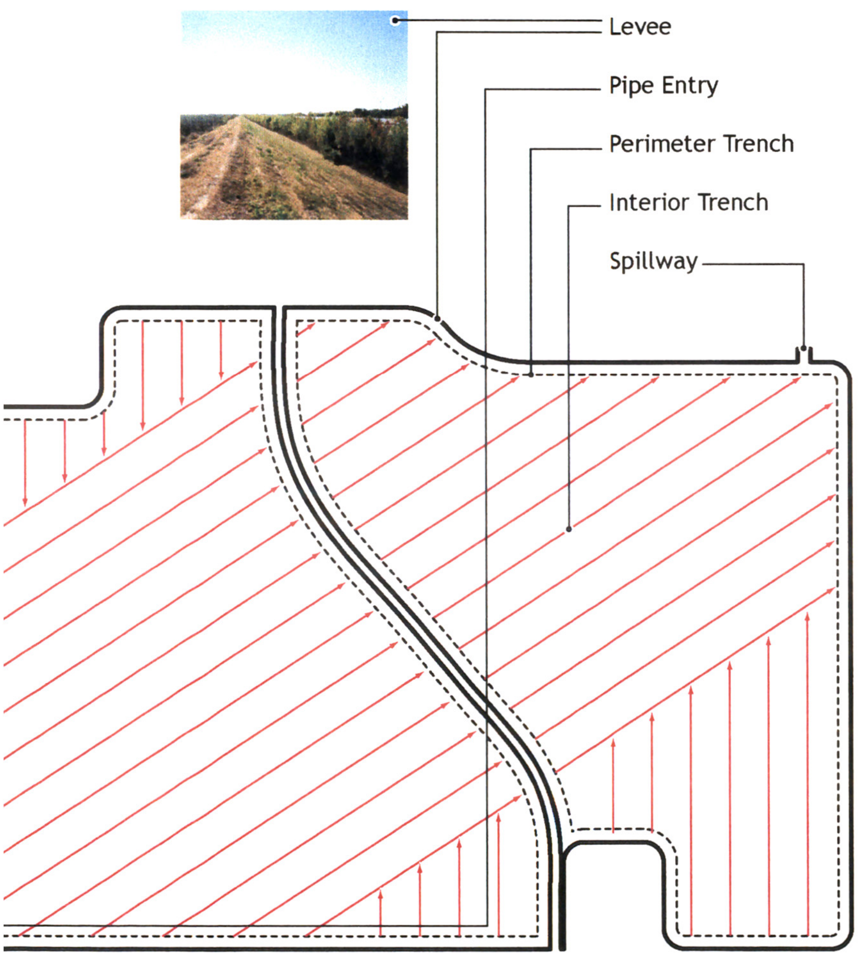
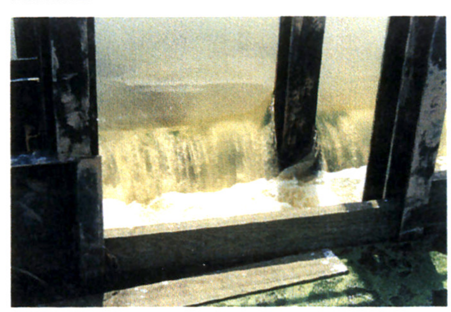


Figure 4.05- Photographs of the same area taken November 2002 and March 2003.

Figure 4.06- Water draining from disposal areas is federally regulated under the Clean Water Act of 1970 and requires a clearity level of 8 grams of clay per 1 liter of water.- Photo courtesy of Mike Martinez.



Moving Earth: Trenching

Clay which is the typical material dredged from the Bayou. It is a slow draining material that takes up to one to three years for a disposal area to drain. **A dry crust of up to six inches to eight inches will form on the surface of clay within 4 to 6 months after the discharge period.** Under this crust is a layer of trapped saturated clay that slows drainage and drying. Interior trenching, which is a technique that is currently used, allows for drainage of water from the underlayer by diging a 3' channel that allows water to collect and separate from the clay.

Interior trenching increases the clay shrinkage rate to .6 to .7 percent of the original amount of the liquid dredge material. This increases the capacity of the disposal area as well as increases compaction ability of the clay.

Sand will drain ten to one hundred times faster then clay. Course, fine and silica sands are dredged from the Bayou periodically. Turkey Bend Channel, which is the dredging location for House Tact/Stimson disposal area, is a particularly sandy region. As a result the House Tract/Stimson disposal area contants mostly sand.

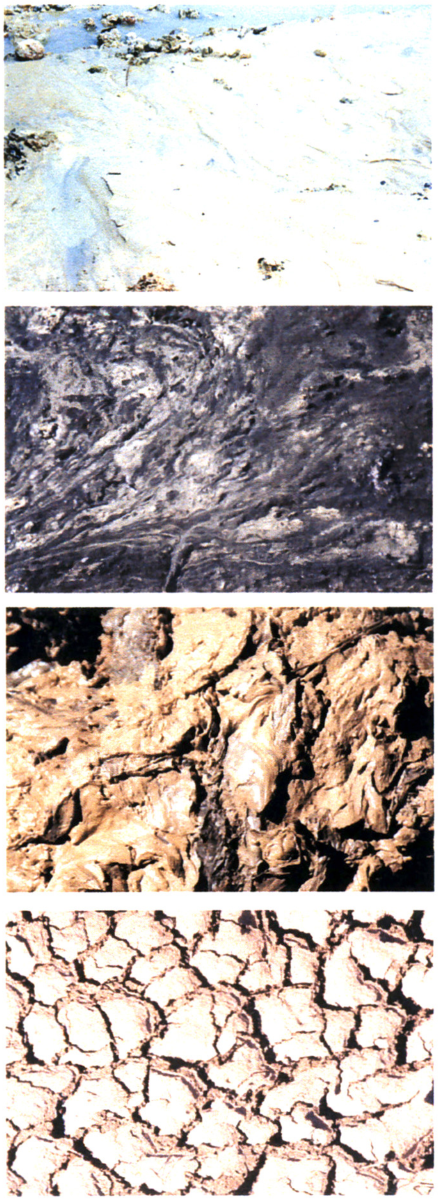
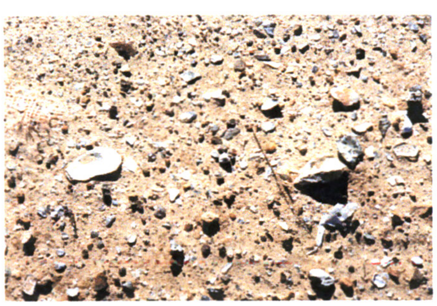
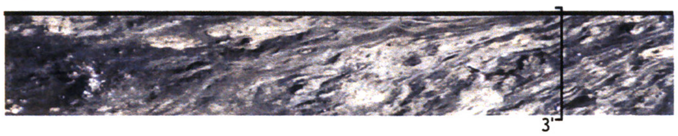


Figure 5.01- Clay dredge material in various states from wet to dry. Photographs where taken in Glendale and Clinton Disposal Area in March

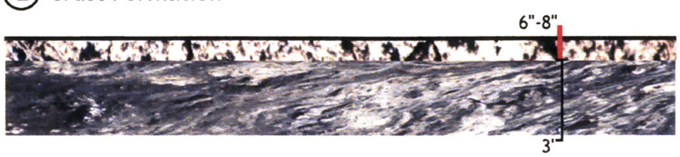
Figure 5.02- Sand is the primary dredge material being contained in House Tract/Stimson Disposal Area. Emergancy dredging due to tropical storm Alison in 2001 caused a large volume discharge of sand into the site. Photograph taken in March 2003.



(1) Dredge Discharge



(2) Crust Formation



(3) Interior Trench

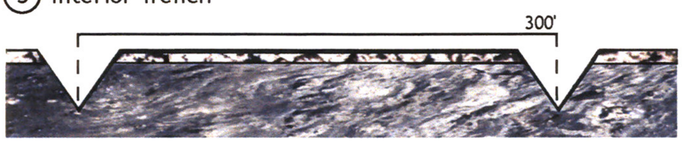


Figure 5.03- (1) Dredge Discharge schedule is dependent upon the use of the port. This requires coordination between various maintance contractors and private users of the port. Use of the port is given priority during dredging emergancies such as flooding and tropical storms.

Figure 5.04- (2) Crust Formation happens when the surface of clay drys. The surface shrinks and cracks (desiccation cracks see Fig.5.01) and forms a 6" to 8" thick crust. Trenching begins after crust formation to allow desiccation cracks to speed the drying process.

Figure 5.05- (3) Interior Trench is typically spaced 300' feet apart (see fig. 4.04.) The amount of trenching per site is determined by cost, amount of rain per season as well as discharge frequency.

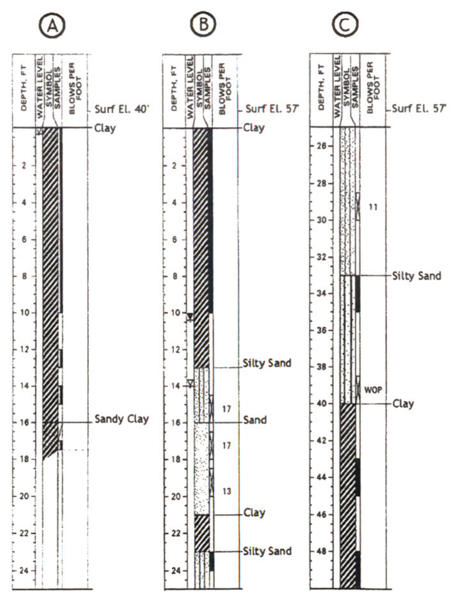


Figure 5.04- Soil boring logs taken from sites by Furgo Engineering for the Port of Houston Authority. Sample (A) was taken from Clinton Disposal Area in December 1997. Sample (B) and (C) was taken from House Tract/Stimson Disposal Area in January 1998.

Moving Earth: Soil Engineering

In addition to trenching, there are a variety of existing dewatering and soil stabilazation techniques that maybe used at every stage from wet to dry. Some techniques optimize passive mechanisms such as gravity drainage, sand layering as well as sunlight and heat from Houston summers.

Other techniques such as moving earth are costly, however permanent removal of clay from an area increases the life of a dredge site and usefullness of land after the site is filled. Allowing public access to some of these sites, which are currently being used unofficially by the surrounding neighborhoods, would not only increase land value but would benefit the surrounding community instead of being a impedence.

(1) Dry Sandbed

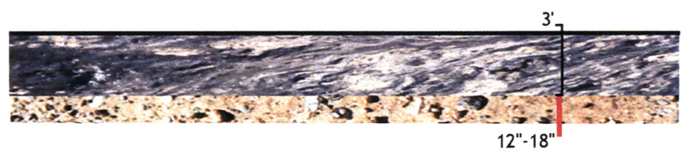


Figure 6.01- (1) Dry Sandbed speeds the drying and process of clay. A 12" -18" layer of sand is placed in an area before clay dredge material is discharged. Water drains significantly faster through sand and can help drain a 3' layer of clay 2 to 4 times faster.

(2) Intensive Trenching

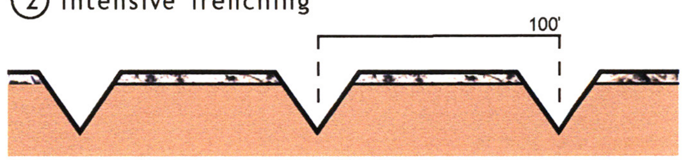


Figure 6.02- (2) Intensive Trenching increases the frequancy of trenchs from a 300' to a 100' spacing into particular areas to speed clay drainage. Typically, the more trenching the faster the clay will drain. The more trenching the higher the maintenance cost of a site. Changing the spacing will not increase the number of trenchs. This will create a variety of wet and dry zones.

(3) Crust Harvest

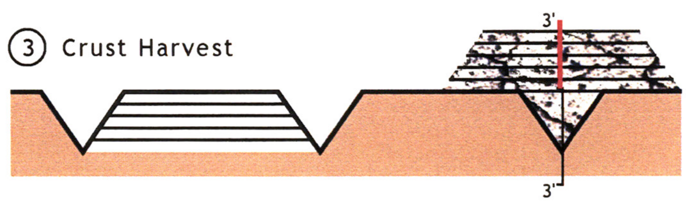


Figure 6.03- (3) Crust Harvest removes the top layer of dryed clay. This will help expose the wet layer under the crust to sunlight. The dry material removed maybe stacked as a steep mound that allows rainwater to run off. The use of geofabrics maybe necessary to provide structural stability for long term storage.

(4) Clay Preload

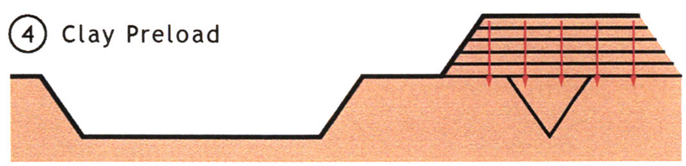


Figure 6.04- (4) Clay Preload is used to compact land by placing a surcharge over an area. It takes up to 6 months for the ground to reach desired level of compaction.

(5) Banking

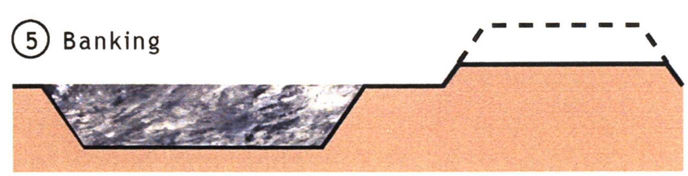
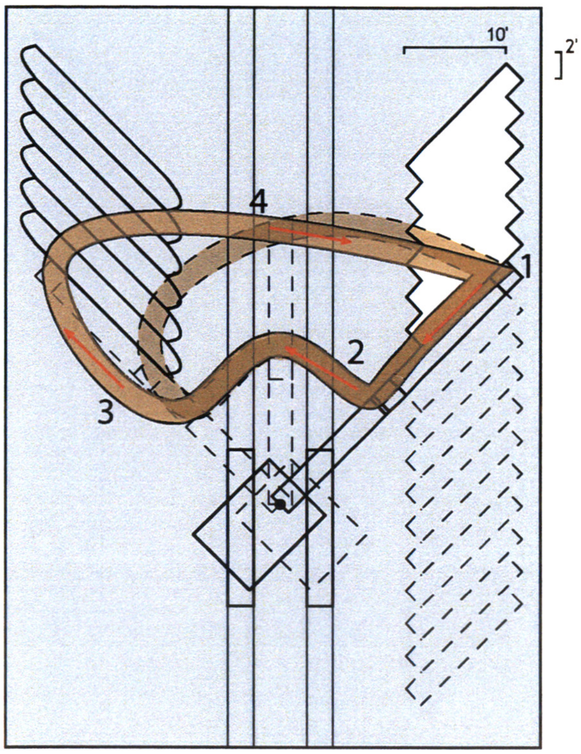


Figure 6.05- (5) Bank is the permanent removal of dredge material to another disposal site or sold off site. Clay is a highly organic impervious material used in the construction of sealing caps of landfills and contaminated land.



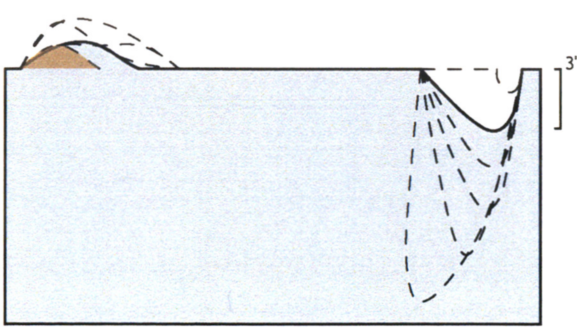


Figure 6.06- Excavator movement sequance and displacement of material.

Caterpillar 330B Excavator with R3.3D m boom and bucket capacity of 30 ft3.

	Amount	Displacement	Length	Width	Depth
Hour	1,800 ft3	36 ft	60 ft	10 ft	3 ft
Day	12,600 ft3	36 ft	420 ft	10 ft	3 ft
Week	63,000 ft3	36 ft	2,100 ft	10 ft	3 ft
Month	252,000 ft3	36 ft	8,400ft	10 ft	3 ft
Year	3,024,000 ft3	36 ft	100,800 ft	10 ft	3 ft

Figure 6.07- Auger: 35 miles per day*.

Figure 6.08- Long-Arm Excavator w/ Pontoon Bottom: 13,500 cuft per day*.

Figure 6.09- Bulldozer: 32,000 cuft per day*.
* Based on a 7 hour work day of equiptment owned and operated by site maintance management (J. Simmons Group.)

Figure 6.10- Dump Truck: 120 tons per day*.

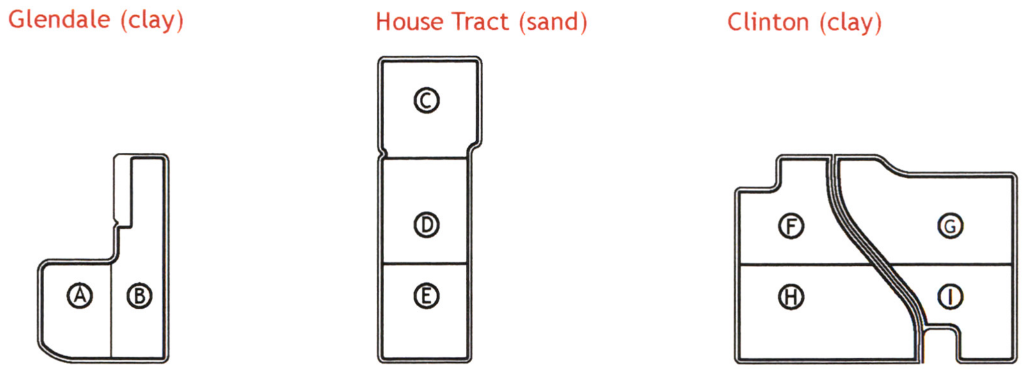
Earth Moving: Schedule

Sand dredge discharged into the House Tract/Stimson area is benefical to dewatering of Glendale and Clinton. **Moving clay sand bewteen three disposal areas would allow for a permanent spoil storage system to become a drying bed removal system.**

Scheduled discharge and transfer of material between sites would not only speed the clay dewatering process, it would allow for alternate public access to araes that are dry. Using a clay surcharge pre-loading system would take advantage of the weight of clay as a way of compacting ground for further access to sites such as roads, bicycle trails, and walking areas.

This is a proposal for a pilot project for eventual application to other dredge sites. Observation of results of experiments would involve compaction meters, surface elevation mapping and cores which would be available for public information and education.

Dredge Transfer Schedule: 9 Years



Glendale	House Tract	Clinton	Year
1	1	1	2003
2	2	2	2004
3 Clay from A to D 700 cy	3 Sand from E to H 1,000 cy	3	2005
4 Sand from C to B 1,000 cy	4 Clay from D to H 700 cy	4 2,300 cy	2006
5 2,300 cy	5	5	2007
6 Clay from B to D 1,900 cy	6 Sand from E to H 2,200 cy	6	2008
7 Sand from C to A 2,200 cy	7 Clay from D to I 1,000 cy	7 3,000 cy	2009
8 3,700 cy	8	8	2010
9 Clay from A to D 1,400 cy	9 Sand from E to G 2,500 cy	9	2011

Glendale:

- Does not have roads.

- Only sand is brought into Glendale from two adjacent sites.

- Fills at a faster because it is the smallest site.

- Clay is removed for preloading on ajacent sites and banking off site.

Housetract:

- Source of sand to two adajacent sites.

- As a result it is the most active site with the most amount of new roads and construction.

- Glendale is the source for clay surcharge for roads.

-Sand is never banked.

Clinton:

- New road is added onto Mercury Drive.

- Removal of clay is for banking off site only.

NOTES:

1 Closed to the public. Discharge period of dredge from Buffalo Bayou.

Clay dewaters out over a one year period after discharge.

Movement of clay or sand between sites.

Permanent removal of clay.

Amount of dredge material is based upon a three year dredge event cycle of 1.3 million cy.

Sand is placed before dredge material is discharged into site.

Clay is placed one year after dredge material is added to the site.

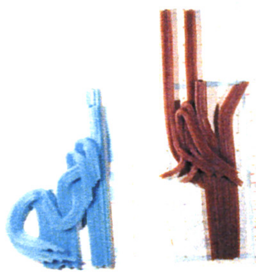
Banking refers to permanent removal of material off site.

Moving Earth: Topography

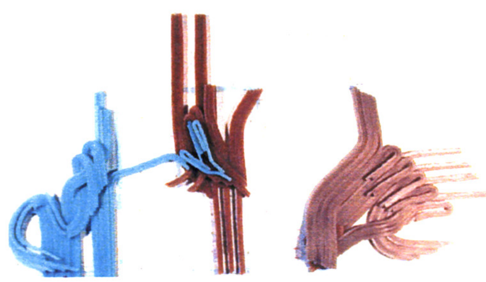
Designing trasfer and removal of material is determined through a series of yearly topographic growth models that is based on moving 100' wide strips of color coded wax. An increase of 450,000 cy of material for each site is added every three years.

Placement locations of sand and clay is recorded and planned for points of entry, roads, high traffic areas as well as dry sandbed areas that would dewater faster.

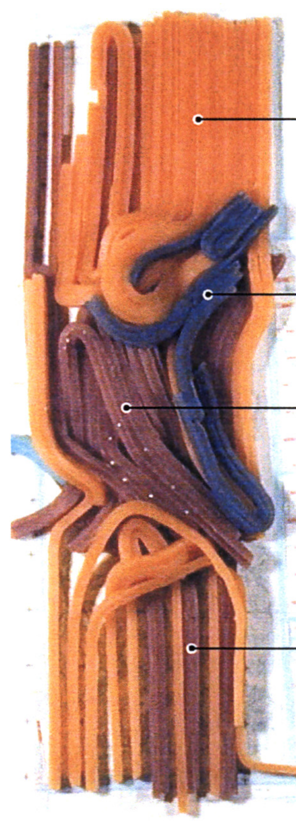
Year 1



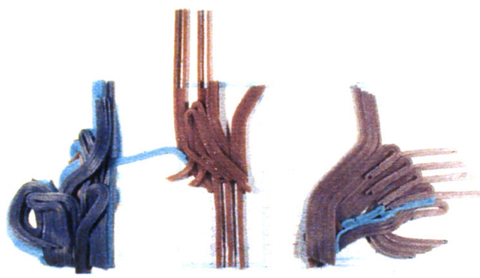
Year 2



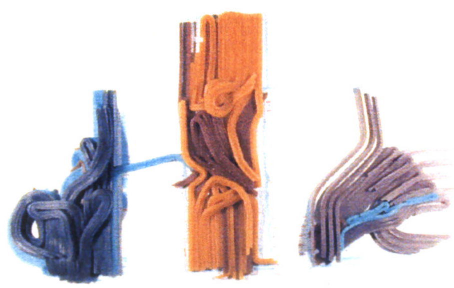
Year 3



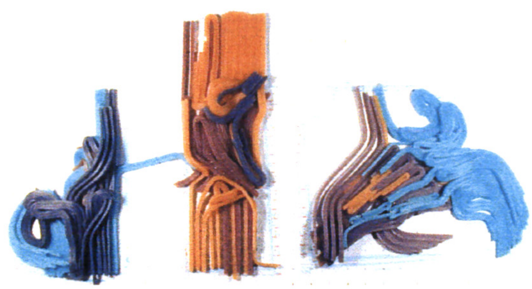
House Tract/Stimson Year 6



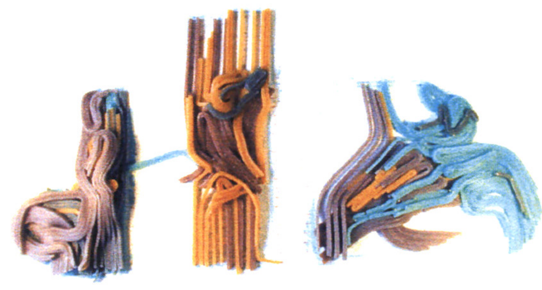
Year 4



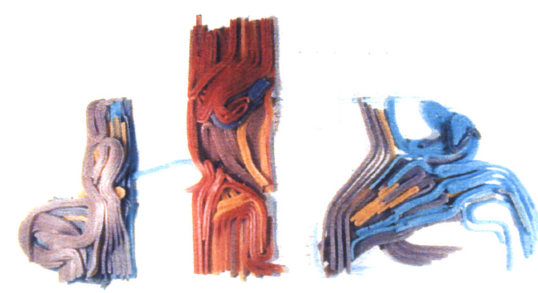
Year 5



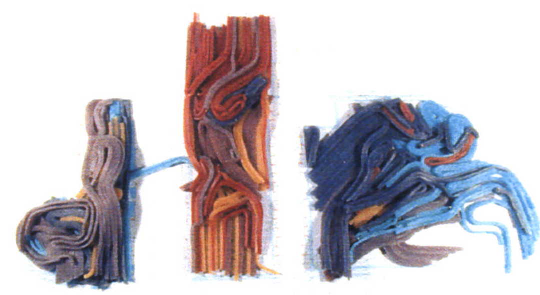
Year 6



Year 7



Year 8



Year 9

Park: Program

Figure 9.01- Clinton disposal area is already being used by neighboring communities for sporting events offically and horseback riding unoffically.

Figure 9.02- Maintenance contractors monitor dewatering progess on spillway viewing platform at House Tract/Simson disposal area.

Highly visable to the residental communites that live and work in the Fidelity Avenue area, dredge sites are the private property of the Port of Houston and are not publically accessable. Neighborhoods and street life are disconnected through dead ends and fences. **Sites are breading grounds for mosquitos and on very hot summer days give off a foul odor.** Some residents, although it has not been proven, fear that the waste material is toxic.

The sites are used by the residents unofficaly for horseback riding, offroad biking, dog walking and for some curious kids, a place of exploration. So much so that the J. Simmons Mangemant Group had to start a program for grade schools in the area to educate students about the workings and dangers of disposal areas.

The current plan to raise the levee will not address residents concerns and continue to exclude access. In addition, this plan insures that the land will sit fallow indefinitely after it reaches capacity.

Allowing local residents provisional access to three adjacent sites as a park may improve quality of life as well as help develope uses for the land after it reaches capacity. Because the sites are still active and material is being added, a proposal for a standard park is difficult. The park proposed does not fit with any current models of park. What is being proposed is a park that has constantly moving land features. As a result the park is mostly bold (no trees) and offers limited activities and facilities.

Figure 9.03- Typical catagories of parks for Houston compiled by the Houston Parks Department 1998 Matser Plan. The park being proposed does not fit in directly with one kind of park. However has elements of a few types

Park Type	Pocket Park	Neighborhood Park
Size	1 acre or less acres	1 - 10 acres
Hours	day/ sunset	day/ sunset
Parking	none	street
Facilities	play ground court sports gardens	play ground field sports open space swimming pool

Human Use

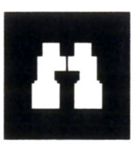

Parking


Riding

BMX


Run


Hike


View

Geologic


Dune


Pond

Machine


Auger

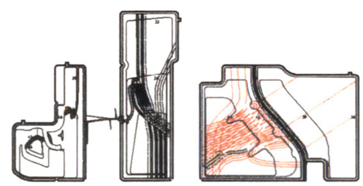

Excavator

Endangered


Allogator


Blue Herron

Figure 9.04- Fresh Kills Landfill 2,000 acres
Three Disposal Areas 1,200 acres
Central Park 850 acres



Community Park	Regional Park	Metro Park	Linear Park	Sp. Purpose Park
5 - 50 acres	50 - 200 acres	200 or more acres	50 ft min. width	10 or more
day/ sunset	24 hours	24 hours	24 hours	day only
1 - 3 lots	1 - 3 lots	1 - 3 lots	street	street
large play ground field sports open space trails picnic	large play ground sports complex open space trails support facilities	large play ground sports complex open space trails support facilities	trails bike support facilities	trails wildlife observation fishing

Park: Wildlife

Wildlife in dredge sites are hardy scavenger types that are medium to small bodied and tend to migrate. Vegetation in disposal areas are regularly cleared in order to speed dewatering process. **Clearing distroys animal habitats and prevents bird nesting.**

Patches that are created through intensive trenching and crust harvesting maybe also used buy wildlife as areas for nesting and habitation. Patchs may increase the diversity of plant and animal life in disposal sites.

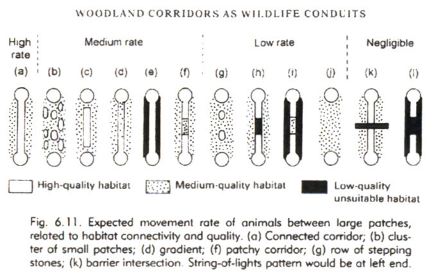


Figure 10.01- Realtionship between patches.- Land Mosaics

Figure 10.02- Typical wildlife, vegetation and habitat found in disposal sits.

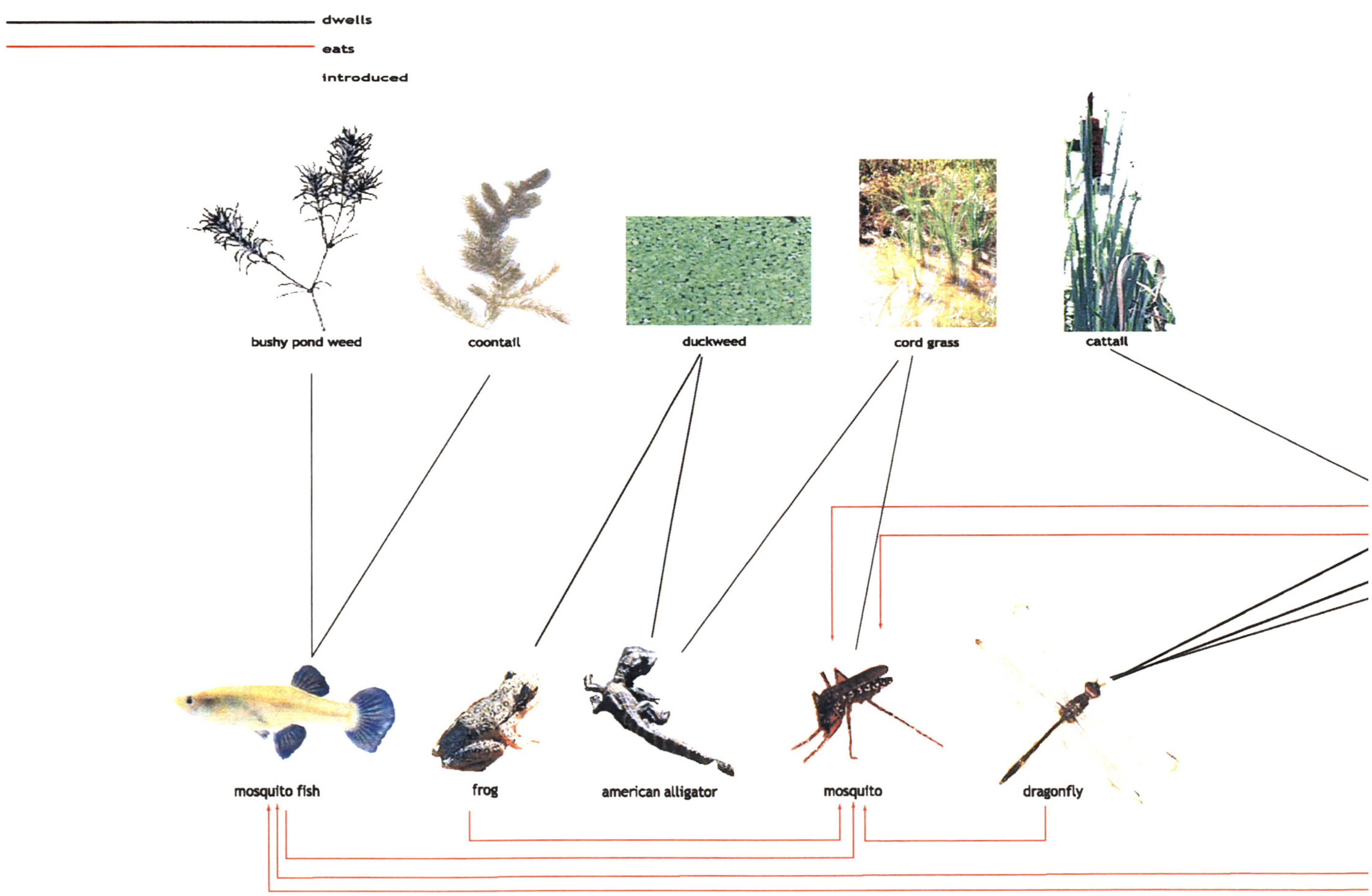
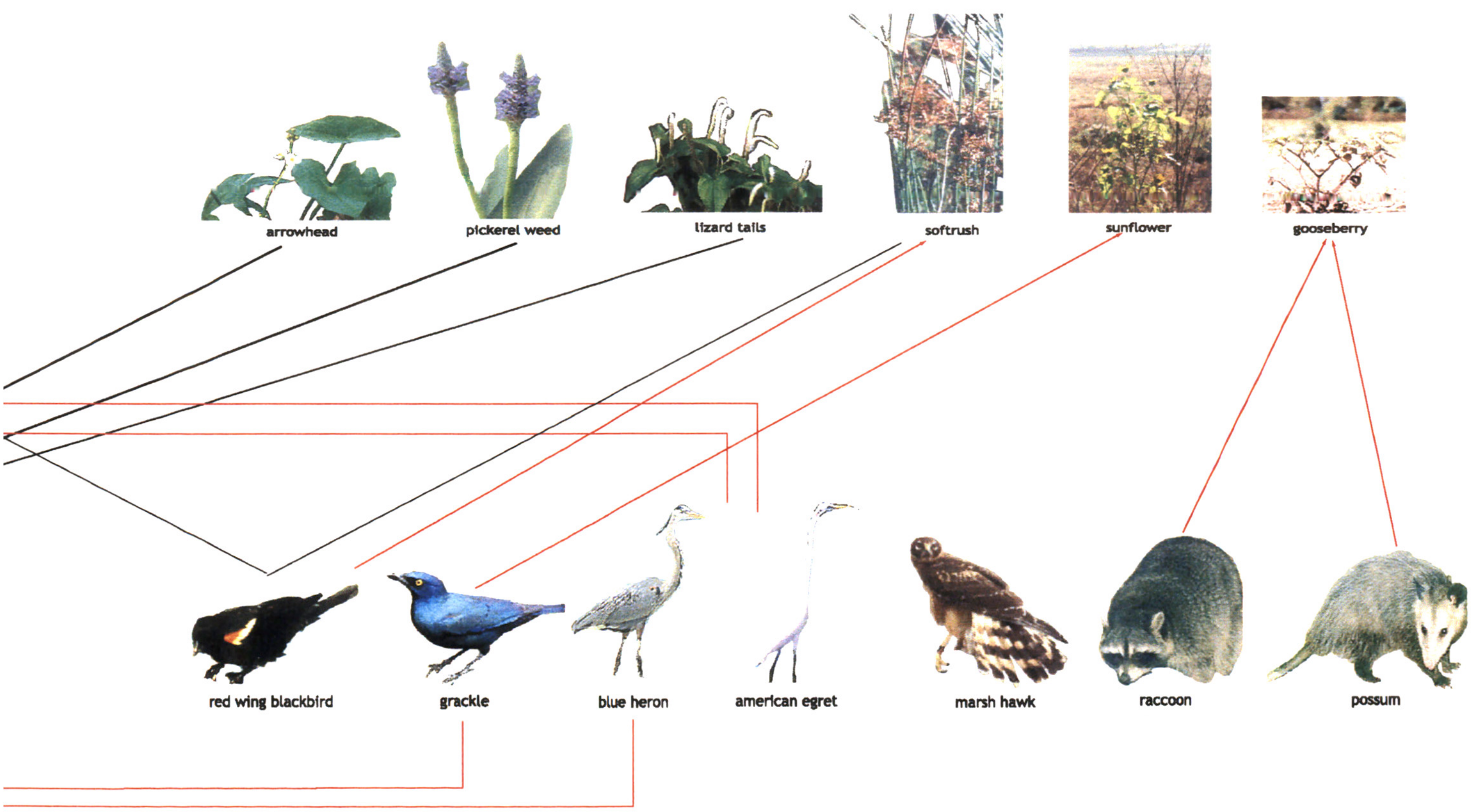


Figure 10.03- Disposal areas are cleared regularly to speed dewatering as well as preventing deep rooted plants to develope. Photograhp taken at Clinton Disposal Area.

Figure 10.04- Unusual working relationships between animal and machine. Egrets follow a bulldozer to find insects as earth is being turned. Photograph taken at Clinton Disposal Area.



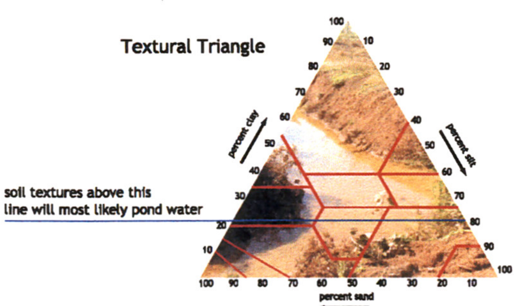
Park: Ponding

Double backing trenches modulate dewatering of dredge area and created ponds which acan be used as nature ponds and mosquito sinks. In additon, because patches are created, dry areas maybe occupied while larger areas are still dewatering.

Figure 11.01- Mosqutio larva is born in standing water. An effective mosqutio sink would have two elements one in water where mosqutio fish eat the larva. Dragon flies are effective against mosqutio after the larva stage. Planting arrowhead and pickerel weed will attract dragonflies.

Figure 11.02- Hydrology drawings indicate water zones for both typical trenching and intensive trenching. Darker areas indicate most wet areas.

Figure 11.03- Textural triangle is used to determine clay and sand proportions needed to cause ponding.



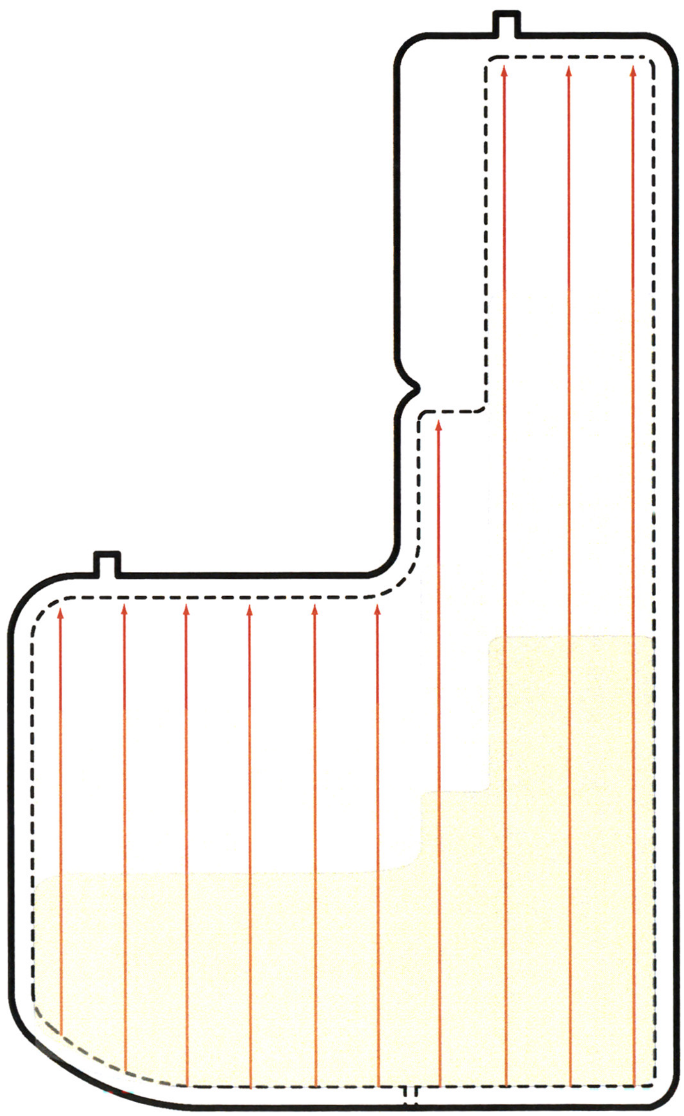
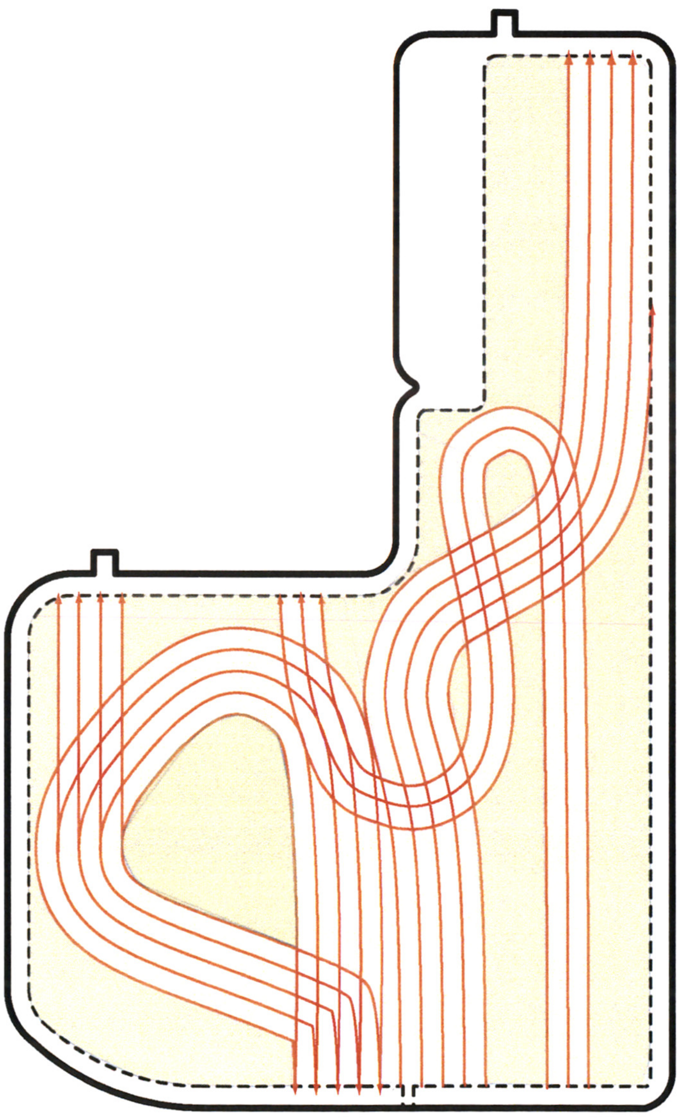


Figure 11.04- Secondary drainage systems are necessary for pond areas in case of flooding.



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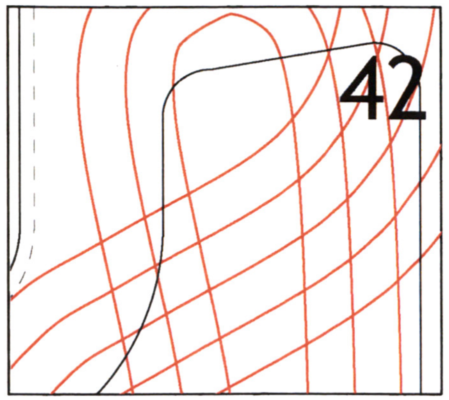
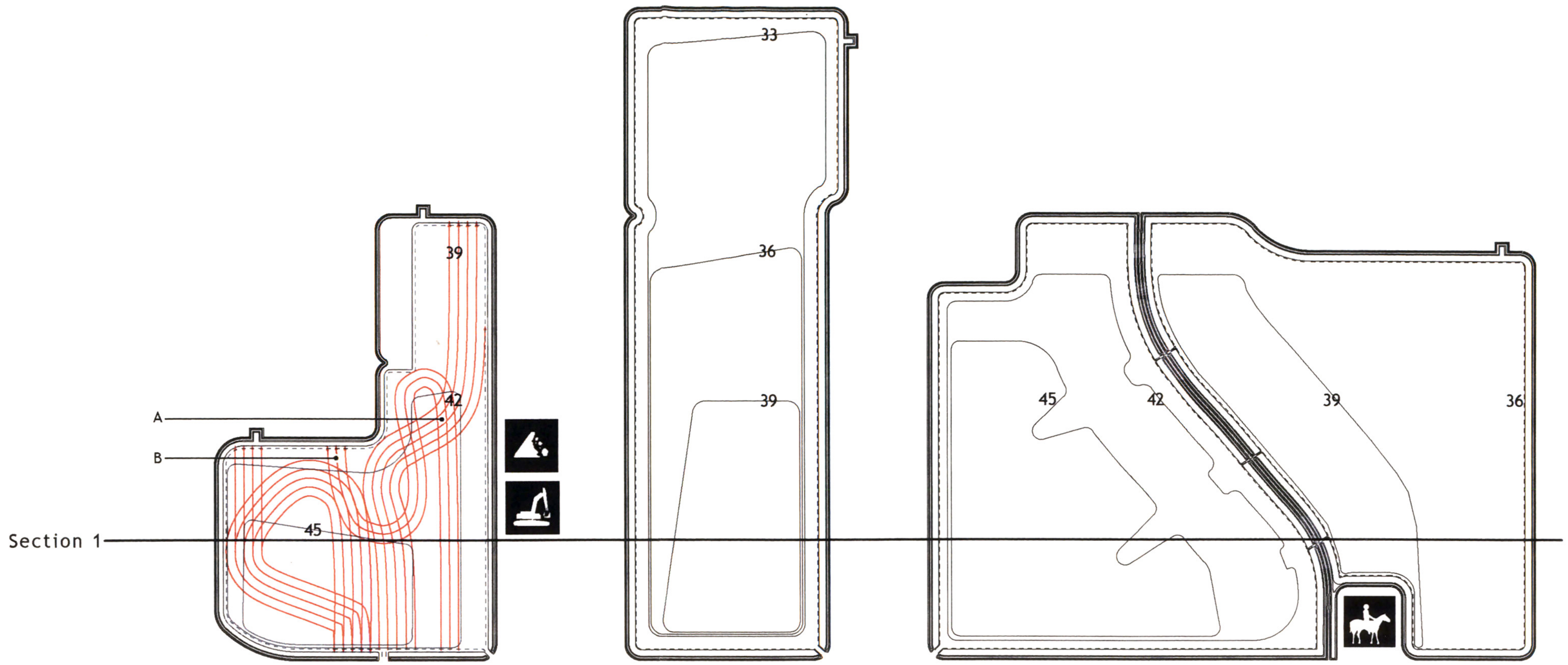
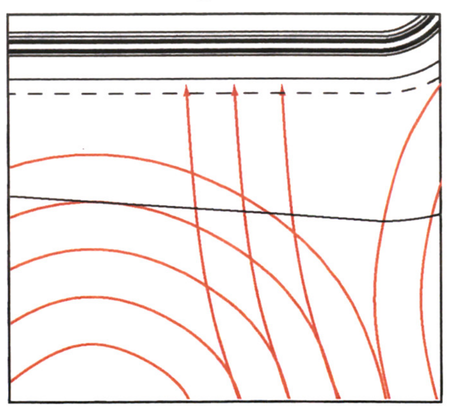
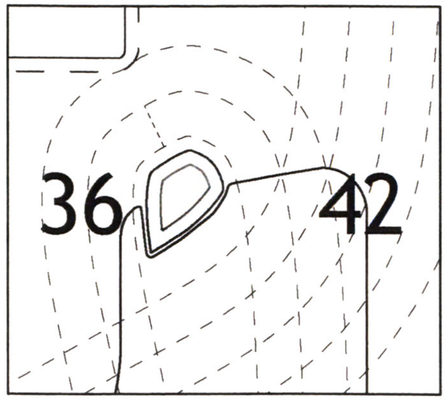


Detail A: Increasing interior trenches by double backing and crossing creates island areas that dewater two to four times faster then the typical 300' spacing.

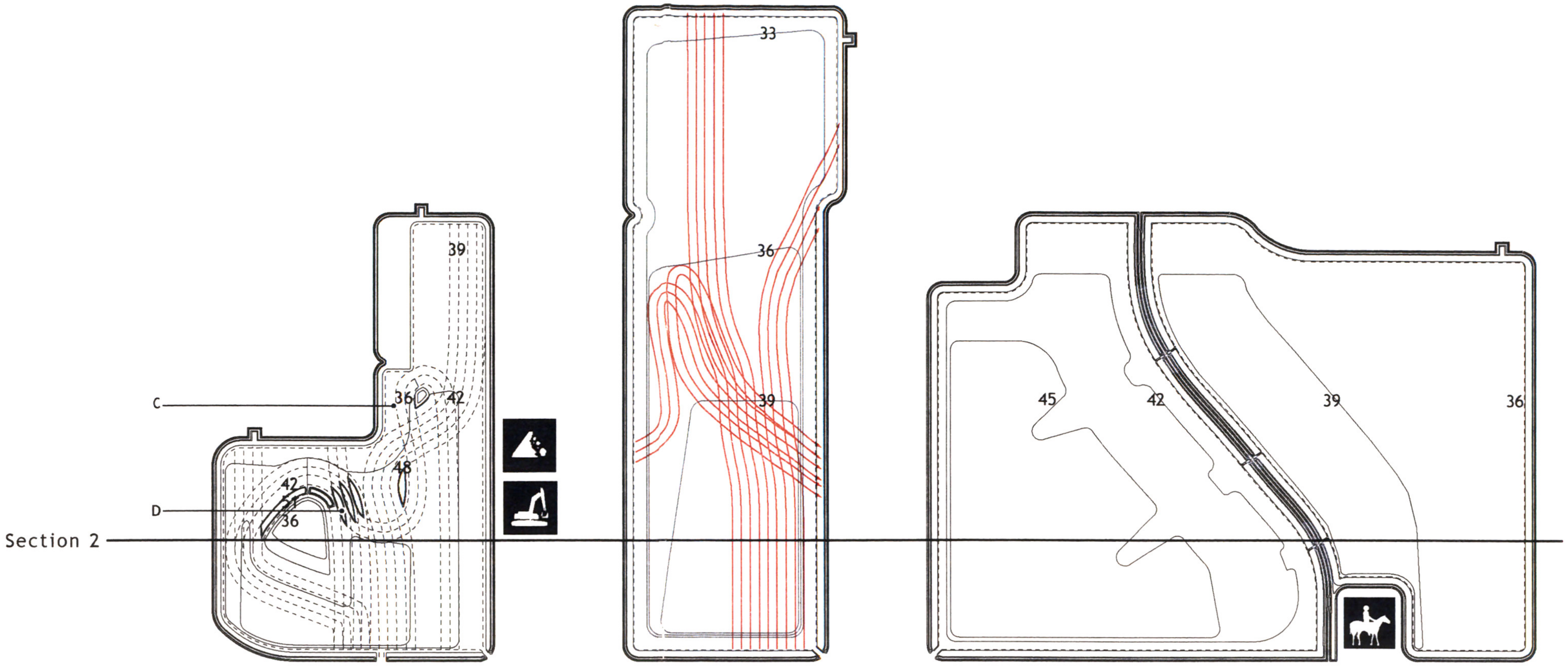


Detail B: Interior trenches drain directly into perimeter trenches. When double backing or crossing other trenches, water drains in a branching pattern into the perimeter trench. Arrows indicate drainage direction.

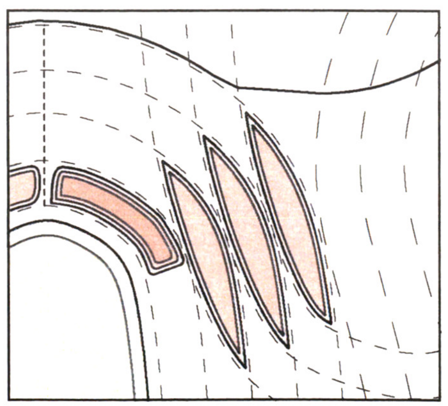


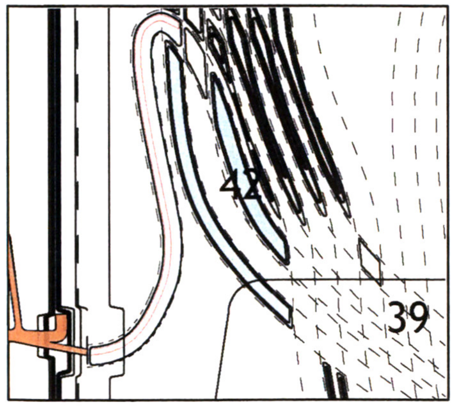


Detail C: Double backing interior trenches creates ox-bow bends. Drain water collected at the turning point is to collected for nature ponds and mosquito sinks. A secondary drainage system is necessary to maintain ponds and flooding.

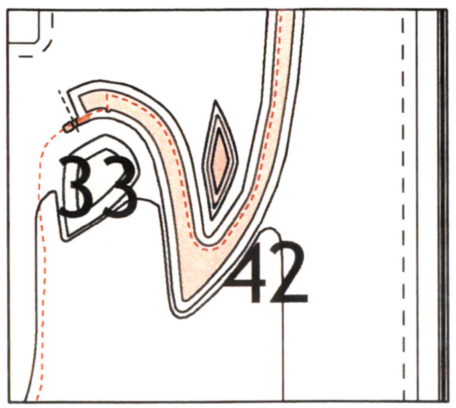


Detail D: Crust harvest between 100' spacing of trenches may begin 1 to 3 months after discharge period. Smaller isolated patches dewater faster and is harvested first.

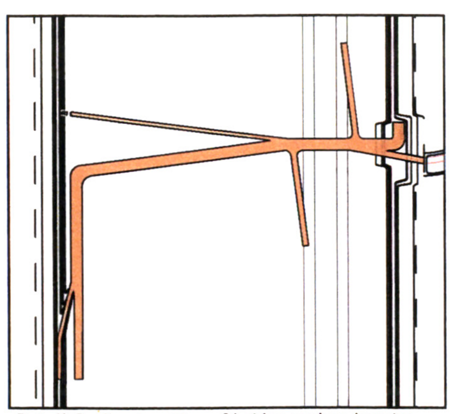




Detail E: Clay pre-load from Glendale to House Tract/Stimson area bridge and road construction.



Detail F: Construction of packed earth walk trail and mosquito sink from crust harvest.



Detail G: Construction of bridge and pedestrian walk over Interstate 610 to connect Glendale and House Tract/Stimson areas.