Estimate of Costs:	
Base and foundation construction	$ 5,550.00
500 Linear feet of 8′ x 3′ x ¼″ fiber glass	2,700.00
60′ x 60′ x 10′ Butler steel building	4,950.00
Butler steel building erection cost	2,286.00
Building foundation and floor	6,472.00
Estimate for catwalk	500.00
Monorail and overhead hoist	1,000.00
Aeration and self-cleaning pump with associated testing contemplated	1,600.00
Engineering and labor	2,442.00
TOTAL	$27,500.00

From these figures, it is evident that the $55 per foot of spiral, including housing, and all equipment compares favorably with the $50 per foot of concrete ditch which offers only minimum facilities.

After construction of the housing, a movable catwalk and a monorail hoist will be installed to speed the handling and feeding operation.

A continuous pipe will be laid in the bottom of the raceway with jet holes drilled in such a manner as to force the water to rotate in a vertical plane. This will be regulated so that any waste food will be carried in suspension to the screens at the end of each segment where it will be removed mechanically or manually.

At the present stage of development, the fish management people have to feed and handle the fish from a catwalk lying on top of the raceway. They allege it is awkward and consequently do not like it. However, after completion of the building and other equipment is installed, feeding, handling and cleaning should be reduced to a minimum.

CONSTRUCTION OF LEVEES FOR IMPOUNDMENTS IN LOUISIANA MARSHES

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Construction of levees in the coastal marsh of Louisiana has a history dating back to early pioneer days when farmers built small protection levees around their fields to keep out flood water. These early agriculture areas were used for the production of sugar cane and later for cotton and rice. After a few years of farming many of the areas began to subside and the expense of maintaining levees was greater than the profit from the crops. As the areas were abandoned, they became shallow water impoundments and have provided good habitat for waterfowl for many years.

The intensive management of land areas in the coastal marsh for the purpose of waterfowl hunting began with the utilization of the old abandoned agricultural areas and has increased to the present-day practice of constructing water control levees and structures to regulate water conditions for the production of waterfowl food plants. Louisiana contains approximately six million acres of waterfowl habitat. This acreage has been divided into three categories: Federal U. S. Fish and Wildlife Service; State of Louisiana, Wild Life and Fisheries Commission, and private land owners. (Figure 1.)

The exploration for oil in the marshes of Louisiana began in the 1920's and has continued to the present time. Until the introduction of

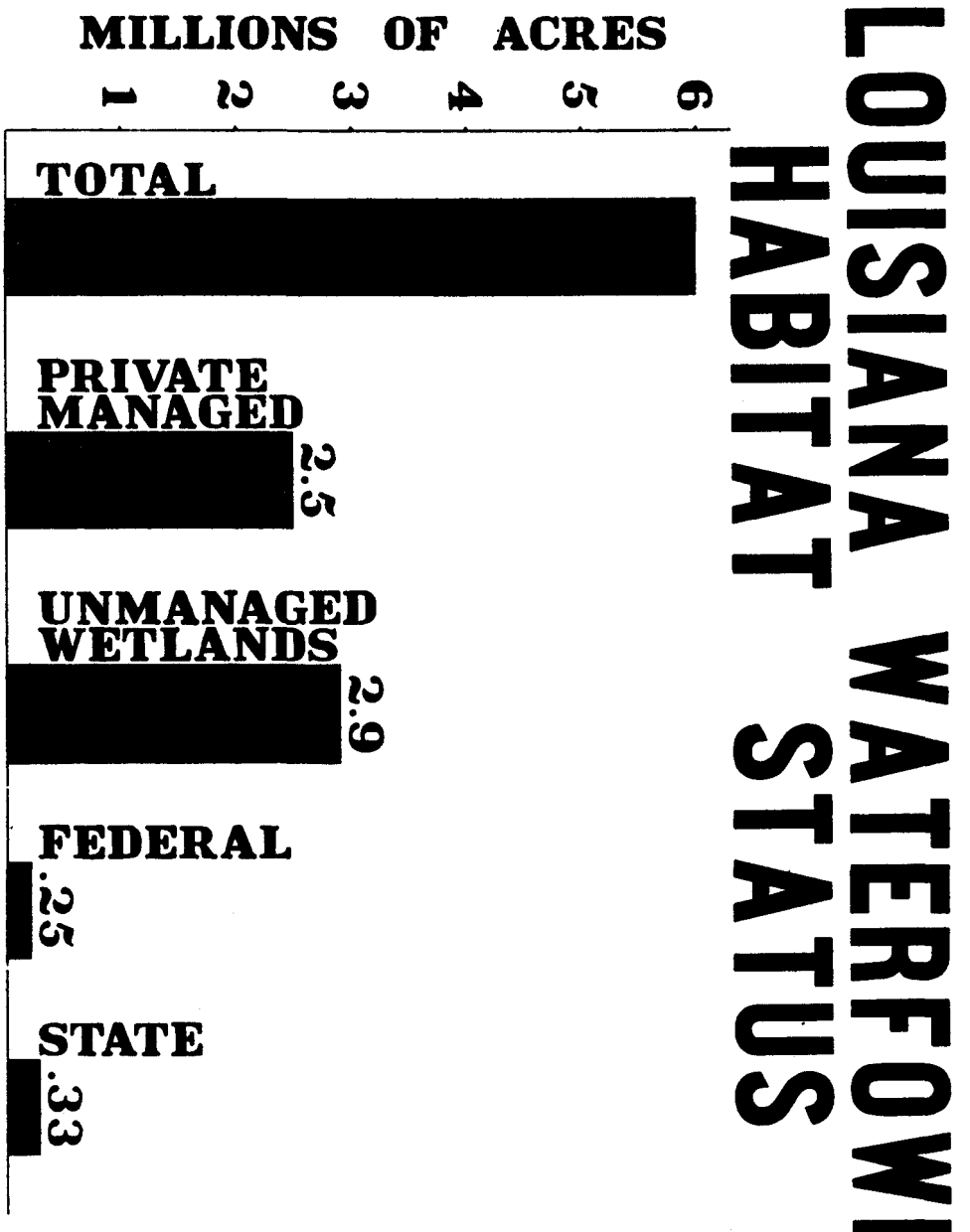
LOUISIANA WATERFOWL
HABITAT STATUS
MILLIONS OF ACRES
1
2
3
4
5
6
TOTAL
PRIVATE MANAGED
2.5
UNMANAGED WETLANDS
2.9
FEDERAL
.25
STATE
.33

Figure 1

the oil interest, the vast marsh area of the Louisiana coast had been virtually unchanged for hundreds of years. Within the past 40 years almost all of this area has been explored for oil. This has resulted in the establishment of large oil fields in areas which were once important wintering habitat for waterfowl. Damages to the area as a result of oil activity have been in the form of drainage, pollution, salt water intrusion and the actual loss of land areas through construction of canals and levees.

Louisiana Waterfowl

The Louisiana coastal marsh is comprised of approximately four million acres of land which varies in elevation of minus one foot to plus two feet sea level. Marsh land has been defined as an area having a water table that is equal to the land surface and in the Louisiana marshes salanities of this water varies from completely fresh to 90% sea water. This wide variation in salanity influences the establishment of plant communities which are capable of tolerating various degrees of salanity. The ability of these communities to produce food for wildlife determine their value as habitat areas. Temperature range along the coast is from a plus 20°F low to a plus 105°F high with an average rainfall of approximately 55 inches. The tidal range is about 18" between mean low and mean high tide; however, storm tides range from two feet to ten feet above mean high tide and usually occur somewhere along the coast two to three times annually.

The marshes of Louisiana have been divided into three distinct types. The delta marshes consist of some 300,000 acres of land from Venice, Louisiana, out to the Gulf of Mexico at the mouth of the Mississippi River. This area is quite recent in geological origin and is actively building at this time. Construction of impoundment levees sufficient in size to contain water in this area is virtually impossible because of the extremely fluid nature of the soil available for foundation material and levee construction. Levees that have been built for impoundment purposes in this area have all been placed on the natural levee system of active streams. In most cases these levees have been built through the initial use of hydraulic dredges and later brought up to the desired finished grade and slope by draglines and bulldozers.

The sub-delta marshes are about three million acres in size and extend from the delta to the western edge of Vermilion Bay. These vary in age from about 600 to 8,000 years old. The mineral deposits of these marshes are primarily of marine origin and, consequently, has a relatively high soil salanity. Soil conditions in this area are generally not conducive to the establishment and long-term maintenance of levees suitable for impoundments.

The third type of marsh is the prairie marshes of southwest Louisiana and are approximately three-quarter million acres in size. Geologically, this area is much older than the rest of the Louisiana coastal marsh land. Soils in this area are of a soft organic clay and are much better suited for impoundment constructions than are the other two types.

WATERFOWL IMPOUNDMENTS

Realizing the need for more intensive land management and overall improvements that could be gained through strict water control over marsh land, the Louisiana Wild Life and Fisheries Commission in 1953 initiated an impoundment construction program which today has encompassed some 46,000 acres of marsh in impoundments on the Rockefeller and Marsh Island Wildlife Refuges. The Rockefeller Refuge is located in the prairie marsh of Cameron and Vermilion parishes while the impoundment at Marsh Island is on the firm marsh adjacent to the Gulf of Mexico.

The first canal to be excavated on the Rockafeller Wildlife Refuge was in 1944 and was dug by Humble Oil Company to an oil well site. This drilling venture resulted in a dry hole and further drilling was not undertaken until 1948 when five large tracts on the refuge were leased for the purpose of oil exploration. The canal servicing the first well was abandoned and levees allowed to deteriorate to the point

where high salt tides could penetrate into marshes adjacent to this canal. With the accelerated oil activity on the refuge, salt water intrusion became an ever-increasing problem and it was with this problem facing the commission that the decision was made to construct a series of impoundments on the refuge. A complete geological study was made of the refuge and findings from this study were used in determining the placement of many of the impoundment levees (Nichols, 1959). Engineering services have been provided by the Department of Public Works in all of the refuge development programs. After detailed plans and specifications for canals, soil placement and water control structures have been approved by the Louisiana Wild Life and Fisheries Commission, the Department of Public Works advertises for bids on the proposed work. Contracts are awarded to low bidders and supervision of the work is carried out by engineers from the Department of Public Works. Prices received on bids for dirt work have varied from a low of about 10 cents to a high of 23 cents per cubic yard. Excavation for spoil material has been from canals varying from 40 ft. to 65 ft. in width and 7 ft. deep. The size of the canal depends upon the amount of spoil desired.

The overall development program on the refuge was planned to utilize existing oil canal levees for impoundment purposes; however, this was possible in only a relatively few places. At the present time the Wild Life and Fisheries Commission has approximately 15 miles of levees serving as water control installations on the Marsh Island Refuge and 120 miles on the Rockefeller Wildlife Refuge. In all cases the impoundment levees were constructed with draglines and most of these were mounted on floating barges. Several of the units were self-contained quarter boats and varied in capacity up to nine cubic yards. Corrugated metal culverts which were treated with a cold tar base preservative were installed in the levees to provide drainage. These culverts are designed to accommodate drainage of about 600 acres of marsh. Each are equipped with an overflow structure and a lift gate on the impoundment side. Where a structure empties into canals subject to tidal action it is equipped with a flap gate on the canal side to prevent high tides flowing into the impoundments. Structures are supported by 30-ft. round creosote timber piles. A structure of this type installed cost approximately $6,000.

Water control structures and levees are the essential parts of an impoundment and must be permanent in design and able to withstand long durations of exposure to salt and wave action. Management techniques for the impoundments are planned around the ability to dewater or retain water as desired to produce a given condition for the establishment of specific plant communities. Strict water control is essential in managing for all of the more desirable waterfowl food producing plants. It has been found that flooding wild millet *(Echinochloa walteri)* and sprangletop *(Leptochloa fascicularis)* after they have reached a height of six inches to 10 inches is very beneficial for the production of heavy seed crops.

A sound levee system is the essential requirement for a coastal marsh impoundment and must be constructed so as to maintain a desired height for the greatest number of years (Nichols, 1959). It has been found that most levee shrinkage occurs during the first year after construction. However, subsidance usually continues throughout the life of the levee and must be offset by periodic reshaping.

Extreme tides such as occurred on the western Louisiana coast during hurricanes Audrey, Carla and Cindy have adverse effects upon impoundment levees and accelerate the rate of erosion which occurs in the canal systems. Heavy damages occurred to the levees during hurricane Audrey because of the fact that most of the levees were less than three years old and had not had time for a suitable cover of grass to become established (Ensminger and Nichols, 1957).

It has been found from detailed studies that the greatest determent to an impoundment levee is the use by boats of the canal from which spoil is excavated. This sets up a wave wash on the berm of the canal

and with heavy usage in a very short time the berms will be eroded to a point where wave action will attack the base of the levee. In the Superior Oil Company's Deep Lake and Constance Bayou fields and the Union Producing Company's Deep Lake field it has been found that the canal system has increased from an original 65-ft. width to 175 ft. at one station and the least increase has been to 139 ft. This represents an increase in size of 269% and 214%, respectively. Cross sections taken in September, 1963 by Nichols indicates that this canal system is continuing to increase at the rate of about two inches per month due to erosion. (Tables 1, 2 and 3.) There is a direct correlation between the rate of erosion and the amount of boat traffic in a canal system. Estimates by engineers of the Louisiana Department of Public Works for the stabilization of these canals through bulkheading has been about $125 per linear foot of levee. With the realization of this high cost of maintenance of levees along canals used by boats, the Louisiana Wild Life and Fisheries Commission recently adopted a resolution requiring that additional oil development work on the Rockefeller Refuge be through the construction of road systems rather than canals. In excavating the spoil for a road bed borrow pits 300 ft. in length by 40 ft. in width are evenly alternated on each side of the roadway. This prevents the establishment of large canals which would tend to eat into the base of the roadways. Existing impoundment levees are being utilized by oil companies for roadbeds in areas where they are available.

Maintenance of the impoundment levees has been by the use of refuge equipment. The Refuge Division owns eight draglines, one bulldozer and several farm tractors which are utilized through the year for the maintenance of the complex levee system associated with the impoundments. A maximum height of five feet during the initial spoil placement should be adhered to in order to prevent excessive weight from damaging the foundation for the levee. If it is desired or necessary for additional

TABLE 1
UNION PRODUCING — HUMBLE CANAL SYSTEM

	Initial Width	May 1958	March 1961	April 1962	Sept. 1963	Increase Per Month 1958-1963	Per Cent Increase
Location 1	65′	127′	137′	141′	144′	.270′	222
Location 2	65′	136′	156′	156′	158′	.350′	243
Location 3	65′	143′	162′	171′	172′	.460′	265
Location 4	65′	110′	130′	139′	139′	.460′	214
Location 5	65′	124′	134′	141′	141′	.270′	217
Location 6	65′	118′	136′	144′	145′	.429′	223

TABLE 2
SUPERIOR OIL COMPANY CANAL — DEEP LAKE FIELD

	Initial Width	May 1958	March 1961	April 1962	Sept. 1963	Increase Per Month 1958-1963	Per Cent Increase
Location 1	65′	158′	171′	172′	175′	.270′	269
Location 2	65′	137′	153′	154′	155′	.286′	238

TABLE 3
SUPERIOR OIL COMPANY CANAL — CONSTANCE BAYOU FIELD

	Initial Width	May 1958	March 1961	April 1962	Sept. 1963	Increase Per Month 1958-1963	Per Cent Increase
Location 1	65′	150′	159′	159′	159′	.143′	245
Location 2	65′	137′	147′	147′	149′	.191′	229

material to be excavated from a canal, the spoil area should be increased to accommodate this material. After material for an impoundment levee has been placed it is permitted to dry for one to two years before it is reshaped and dressed to final grade. A finished grade of plus four feet above marsh elevation with a two to one slope on each side of the levee and an 18-ft. crown has been found to be adequate for the retention of water within impoundments and also sufficient in size to exclude all but the most severe storm tides. Ownership of equipment by the commission in this instance has proved to be very economical as well as essential. Various pieces of the equipment are used for occasional small construction and development jobs.

WATERFOWL USAGE

In 1958 an intensive study was begun to determine the effectiveness of the impoundments in waterfowl habitat management. Vegetative transects were established within the impoundments and in unimpounded marsh areas. These studies indicated that in impoundments permanently flooded with brackish water widgeongrass *(Ruppia maratima)* was the dominant plant species and is a very choice duck food plant. In impoundments where water levels have been manipulated wild millet and sprangletop have been the dominant species. In the permanently flooded fresh water impoundments duckweed *(Lemna minor)* was the dominant plant species. Without exception these species have made up over 50% of the plants in the impoundments but in the unimpounded areas made up less than 5% (Chabreck, 1960). The dominant plant species outside of the impoundments was marshay cordgrass *(Spartina patens)* and made up approximately 95% of the entire plant community, while inside the impoundments this plant occupied only approximately 40% of the community. In a brackish marsh area this species is the climax plant and has been found to be of very little value as a wildlife food plant. From a study of the availability of waterfowl foods in impoundments, it was found that seeds from 22 species comprising 11 plant families occurred in marsh floor samples. Some of the seed collected in this study were from plants that had not grown in the area for several years. It was evident that plants with durable seed contributed food for waterfowl long after the plants had disappeared from an area. There was little relationship between the vegetative stand composition on an area at the time of sampling and the seeds that were available in the soil (Jemison and Chabreck, 1962).

From waterfowl inventory records of the Louisiana Wild Life and Fisheries Commission it has been revealed that the Rockefeller Wildlife Refuge wintered less than 75,000 ducks during 1951 and 1952 prior to the construction of the impoundments. Aerial inventory by waterfowl biologists of the Refuge Division during the 1962-63 wintering season list the duck population for the refuge at 600,000. This figure has been about the same for the past two years; however, it is expected to increase as the refuges develop and management techniques are improved through information gained from the intensive research program being carried out on the area. Of the total number of ducks utilizing the Rockefeller Wildlife Refuge 80% are to be found in the impoundments. Impoundments on the refuges have provided conditions which are favorable to practically all species of ducks that winter in the Louisiana coastal marshes. Mallards, green wing teal, pintail and blue wing teal use the impoundments which produce stands of annual seed producing plants such as wild millet and sprangletop. Gadwall, American widgeon and shovelers use those areas which are heavy producers of widgeongrass. Diving ducks and American coots utilize the permanently flooded impoundments and large open ponds.

CONCLUSION

Construction of impoundments in Louisiana has proven to be very beneficial for migratory waterfowl. Approximately 80% of the total ducks on the Rockefeller Refuge during the past two years have been in impoundments. Soil conditions of the prairie marshes in southwest

Louisiana are more suited for the establishment and maintenance of a levee system than are those of the delta and sub-delta marshes.

The decision to construct impoundments should be based upon findings of a thorough geological investigation on the area.

In areas where the canals created by the excavation for levee material are to be used as access routes for boats, erosion may be expected to occur over the years to the extent where the impoundment levee system may be severely damaged or destroyed. Construction of impoundment levees from staggered borrow pits create less disturbance to marsh areas but tends to be more expensive. Perpetual maintenance of levee systems and water control structures is essential. Subsidance of levee systems may be expected to continue through the life of the levee and periodic raising of a levee is necessary to maintain the required elevations for proper water management. Initial costs of construction and maintenance of impoundment levees are extremely high. Investigation of other development techniques should be considered before the decision to construct levees and install water control structures is made.

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"CONTRACTING vs. USE OF OWNED EQUIPMENT"

BY JOHN E. BUXTON

October 1, 1963

Mr. Chairman and Gentlemen:

I have always thought that I was an average person in most respects, that my ability, reactions and motives were at least pretty close to that of the other fellow's; so, in attempting to analyze problems that involve a lot of personal ramifications—and what problems don't involve them — I sort of think that things that effect one will effect most in at least a similar fashion.

I have had some experience along the lines of this subject here in Arkansas, both with the Arkansas State Highway Department and the Game and Fish Commission. I was State Maintenance Engineer for the Highway Department four years and with the Arkansas Game and Fish Commission for ten years.

It is the prerogative of the elderly to reminisce; any way, prerogative or not, we do it whenever we have a captive audience; so before I start to argue the question, I'm going to talk about some of my experiences:

I went with the Highway Department in 1933. That was before some of you had started to work, and it was during the Big Depression. Actually, the Depression started in 1929, and when Franklin Roosevelt took office in 1933, things were bad all over. The Bank Holiday, the Blue Eagle, the WPA, the PWA, and other agencies I can't recall and too numerous to mention sprang up over night.

Arkansas Road Improvement Districts had defaulted on bond pay-