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The Kearny Freshwater Marsh

**The Dynamics of a Young Freshwater Marsh
in the Hackensack Meadowlands**

A Basin Management Plan

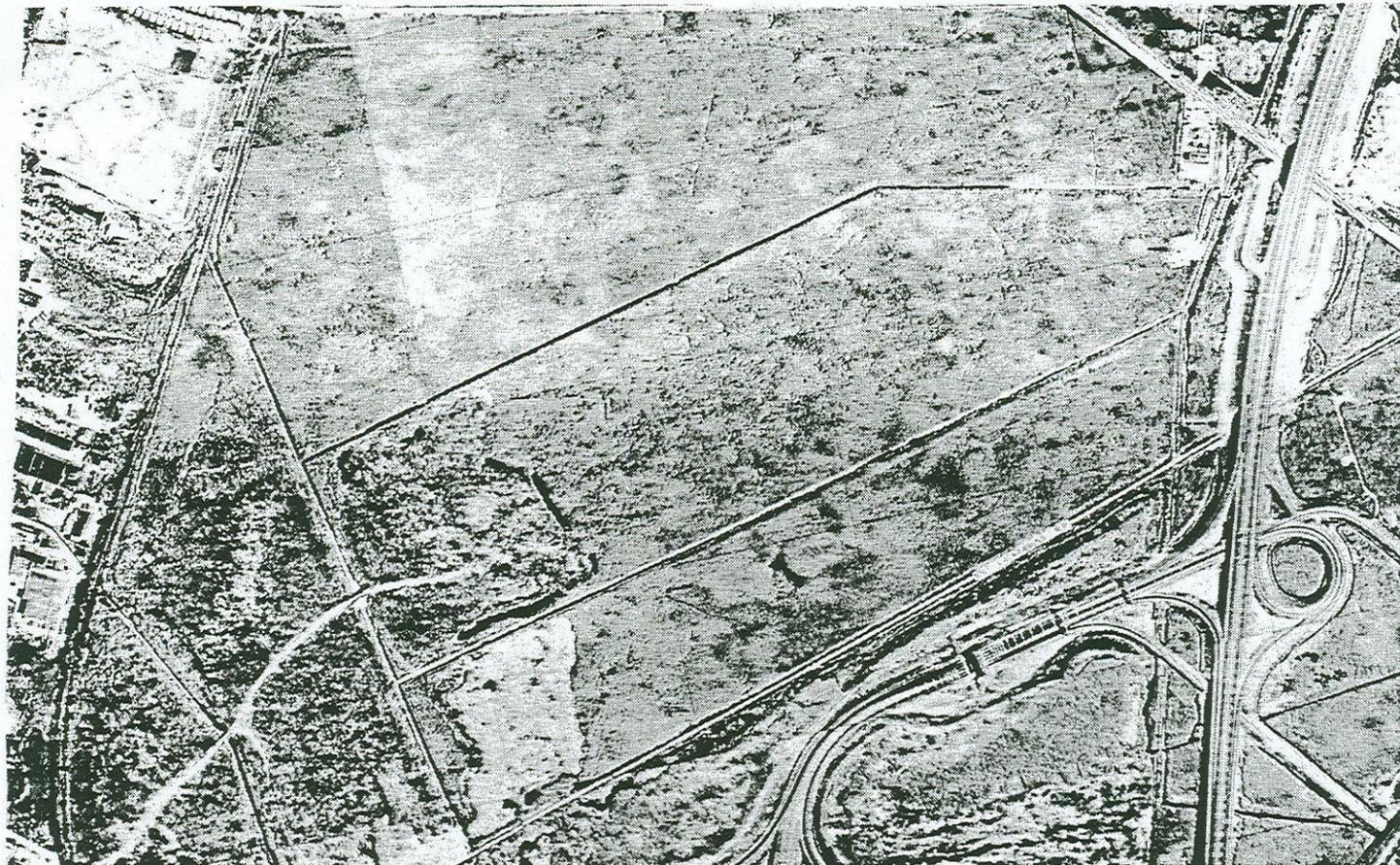
This basin management plan was made possible through a grant from the New Jersey Department of Environmental Protection, Division of Coastal Resources, as part of the federally approved Coastal Management Program. Its purpose is to expand upon the ideas set forth in the Commission's "Ecological and Resource Management Plan" (1978) and develop an understanding of what created and is changing the Kearny Freshwater Marsh.

Written By

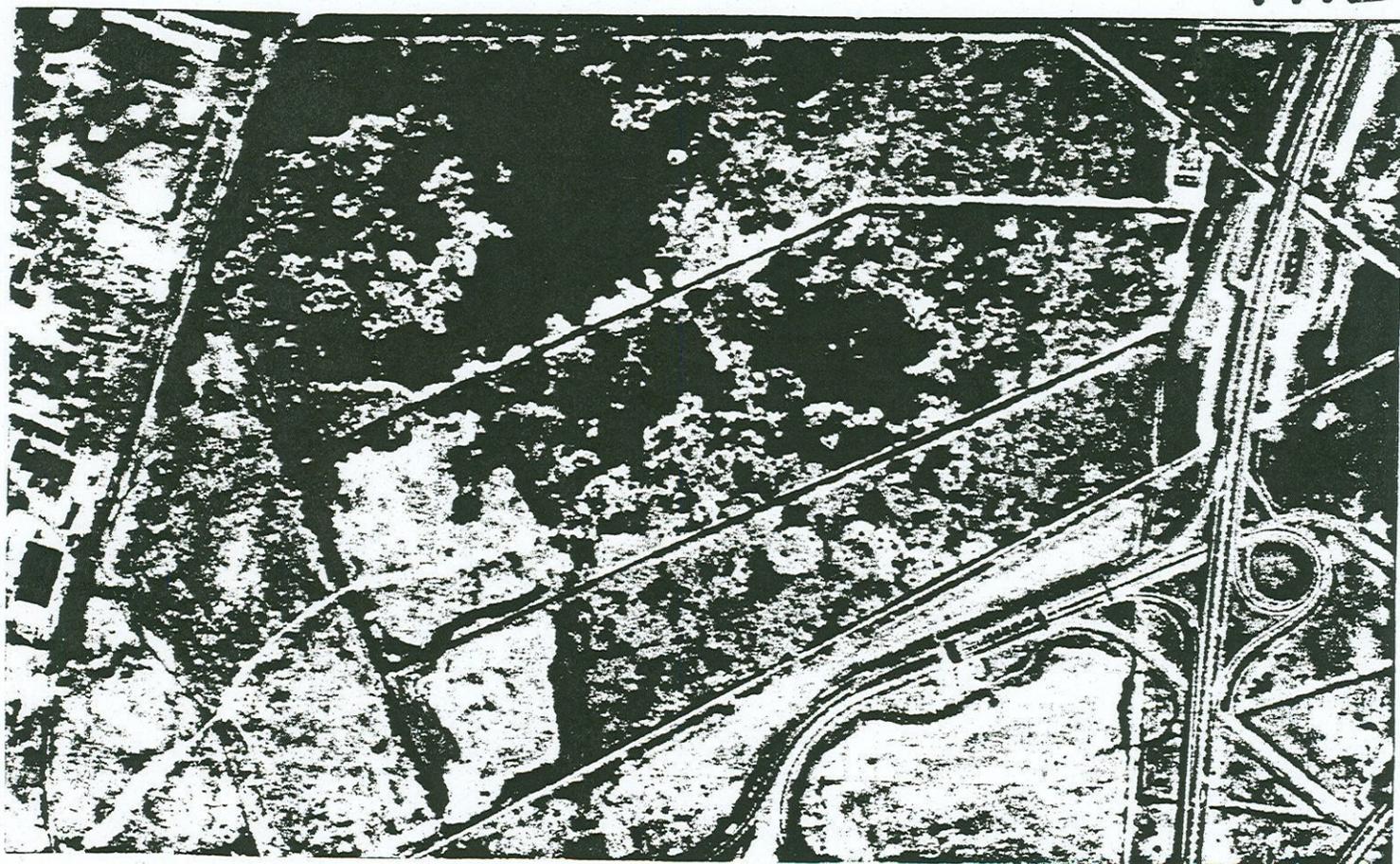
James M. Kocis

Special Thanks To

**Robert Daylor, BSC Engineering
Cassandra W. Gates, HMDC**



1972



1978

KEARNY FRESHWATER MARSH

Introduction

May, 1982.

A Yellow-crowned Night Heron was spied earlier this month in the Kearny Freshwater Marsh. Don Smith, staff naturalist for the HMDC, marked the spot where it emerged and has been keeping an eye out for its reappearance. It may have been just passing through; it may have decided to stay a while. There may be more than one. They may be nesting. Prior to the 1976 oil spill on the Hackensack River, there was a nesting pair with young in the Kingsland marsh adjacent to the Sawmill Creek Wildlife Management Area. Few have been spotted here since. Its reappearance, though unpredictable, was not unexpected; for we have come to expect the unexpected from the Kearny Freshwater Marsh.

The Black-crowned Night Heron, like most herons, nests in trees. Yet one of the largest Black-crowned Night Heron rookeries in New Jersey is in the Kearny Freshwater Marsh which has no trees. They have built their platform nests in thick stands of common reed.

Nesting species within the Kearny Freshwater Marsh which are uncommon nesting species in New Jersey include the Least Bittern, Ruddy Duck and the Pied-Billed Grebe.

The two aerial photographs that precede this page were taken five-and-a-half years apart, the top one in August 1972 and the bottom one in January of 1978. There was no Kearny Freshwater Marsh in 1972; it was simply a large expanse of dry reed fields sliced by mosquito ditches. No one expected the dramatic change that was to follow. The 1978 aerial reveals large open areas

Background

The Freshwater Marsh is part of a 1000 acre expanse of the Meadowlands District in Kearny that stretches from the developed ridge to the river. This thousand acres is cut by transportation and utility corridors into a distinct patchwork mosaic of landfills, industrial areas, and marsh. The Freshwater Marsh is in the western half of this thousand acres, and it lies within the area identified on tax maps as block 205, lot 19. It comprises 304 of the 405 acres of this lot, and like most of this thousand acres, is owned by the Town of Kearny. It is is ringed by rail lines, turnpikes and service road and cut through by utility corridors. A 63 acre landfill which began to fill its western edge was closed by the HMDC in 1971. It is bordered on the east by the Belleville Turnpike and the western spur of the New Jersey Turnpike. To the north, south, and northwest are high, elevated railbeds built by the Erie-Lackawanna Railroad Company: to the south, the Newark Branch; to the north the Boonton Branch; to the northwest the Harrison-Kingsland Branch.

Geographical History

Prior to the 19th century, this tract, like much of the Meadowlands, was covered by large cedar forests. Unlike its first inhabitants, Indians, who had left no mark on the land, the white colonists started challenging the marsh and changing its character from the very beginning.

"Upon the discovery of copper on his property in 1719, Arent Schuyler built a road along what is today the Belleville Turnpike. The road was later extended to the Hackensack River so that the ore could be picked up by large sea-going boats."

The Kearny Freshwater Marsh

those dikes south of the Boonton rail line, along the Kearny rivershore, held. A pump station was built in the late 1950's under the New Jersey Turnpike's eastern spur along the Hackensack River to help drain the thousand acres behind these dikes.

To summarize thus far:

Over the past several hundred years man's intervention in a thousand acres of the Kearny Meadowlands caused dramatic changes in the natural environment. These included

- the destruction of a large cedar forest and the opening of most of this expanse to the action of the tide,
- the fragmentation of this thousand acres by transportation and utility corridors
- and the diking of this marsh to 'reclaim' (some would say 'claim') it and prevent mosquito breeding, with subsequent drying and shrinking of the peats, resulting in a lower surface elevation.

The landscape of the Kearny Meadows today is but the result of a pattern begun over two centuries ago.

Recent Developments

When the Hackensack Meadowlands Development Commission was formed in 1969, this regional zoning agency broke with this past pattern of development and imposed a two year moratorium on building in most of the 19,730 acre Hackensack Meadowlands District. In 1972, after lengthy public hearings, a Master Plan was adopted. The zoning adopted for the then-dry field that was to become the Kearny Freshwater Marsh was "Special Use", which called for

The Kearny Freshwater Marsh

of water free of vegetation. The ditches are widened. Today the ponds are even larger, and the marsh is getting deeper.

What caused this now-precious marsh to be created? Could we have expected it? What is causing it to deepen? Could this have been predicted? Can it be stopped? Should it?

In 1978, the Commission wrote these words about the Kearny Freshwater Marsh in the "Ecological and Resource Management Plan for the Hackensack Meadowlands":

"...a Management Plan for this marsh must begin with the knowledge that this ecosystem is far from having attained steadiness."

So we begin this plan.

The Kearny Freshwater Marsh

Yet even here we meet an early conservationist:

"When John Schuyler inherited his father's homestead in 1730, he set aside part of the tract as a park, controlled the cutting of the cedars and other timber and protected wildlife. Many of his neighbors followed his example and the cedar swamps remained in their virgin state for almost 50 years."¹

By all accounts, the cedar forests were destroyed by a massive fire around the turn of the 19th century that was deliberately set to rid the meadows of "thieves and pirates". Hundreds of rot-resistant cedar stumps can still be seen through the clear water of the marsh and on the mudflats of the Sawmill Creek Wildlife Management Area attesting to this description. It is reported that the fire also burned "sufficient peat to permit the tide to flood the region"², although the global warming trend which has contributed to a general rise in ocean levels may also be a factor.

Various attempts at diking and draining these southerlymost Meadowlands succeeded for only a time. The most notable attempt was undertaken by the partnership of Driggs and Pike in 1869, which used patented sheet-iron core dikes (and which later sank in the mud). This diking and subsequent ditching drained the marshes, and the surface peats dried out and shrunk by as much as three feet in places. By 1873, a map of the area by G.M. Hopkins showed that, in addition to these dikes, the Kearny meadows were already crossed by 2 roads, 4 railroads and the Jersey City Aqueduct. The Hudson County Mosquito Commission later took over the task of maintaining these dikes around the turn of this century in their efforts to rid the area of the mosquito.*

In 1950, a massive hurricane wiped out most of these dikes, reintroducing the tide to what is now called the Sawmill Creek Wildlife Management Area. Yet

*Ominously, garbage dumps at the head of Sawmill Creek were already being described as early as 1914.

"special land uses of a regional importance not otherwise provided for in the regulations, such as sports stadiums, major education and health institutions, large cultural facilities, and other large scale development of that nature." In addition, a Special Use zone calls for a minimum of 40% of the acreage within the zone to be "common open space".

To the east of the Turnpike, the balance of this thousand acres, originally zoned Light Industrial and Marshland Preservation, was rezoned to Special Use in June of 1977. So today this thousand acre tract of Kearny Meadows is predominantly zoned for two "Special Use" areas, whose open space requirements combine to approximately 375 acres.

Yet the recent history of the Kearny Meadows, from 1969 to today, has been an acceleration of this past pattern of development. The construction of the western spur of the New Jersey Turnpike and the completion of Route 280 have fragmented this land mass further, and garbage dumps on adjacent lands in Kearny threaten to spill over into these Special Use zones.

So what has changed here to make a marsh from a dry field over the course of a couple of years?

During this time, some development occurred outside the Meadowlands District along the ridge and its drainage was routed into the marsh. Along the river edge, the tidegates have become open culverts, their flap-gates run away with age and neglect. Because of this, the tide now flows into the eastern Kearny marshes with the result that the brackish water is killing the existing vegetation. The pumping station under the eastern spur of the Turnpike continues to pump, but with these tidegates broken, it only helps to drain the marshes at low tide. These factors have undoubtedly contributed to

flooding of a backwater field, but can we trace, more precisely, the causes?

To this end, under this grant, we retained Mr. Robert Daylor of Boston Survey Consultants to examine the hydrologic system, and tell us what we need to do to better understand it. The following text and simple sketches are taken from his notes of his field investigations.

The Existing Hydrologic Conditions

(or where does the water go, when the water goes away?)

Figure 1 shows a simplified model of the drainage pattern in the Kearny Meadows which acts on the Freshwater Marsh (area 1). It was assembled from the examination of existing topographical information and from field survey.

Is this field now a marsh because

- 1) More water is coming in than before?
- 2) Less water is going out?
- 3) Both 1 & 2?

Absent any new natural springs in the area, the "more coming in" theory doesn't hold much water. The catchment area that empties into the marsh consists mainly of fairly old development. Could drainage have been re-routed? We will keep this question in mind.

"In the "Less Getting Out" category, the most likely candidate is the N. J. Turnpike/Belleville Turnpike system. With the exception of the tide gate/pump station systems at the river dike, all of the other embankment crossings are short barrel culverts that are tailwater controlled -- they probably function as simple orifices."

Supplemental Information and Translation: From early maps of this area, it appears that the area of the Kearny Freshwater Marsh was originally drained

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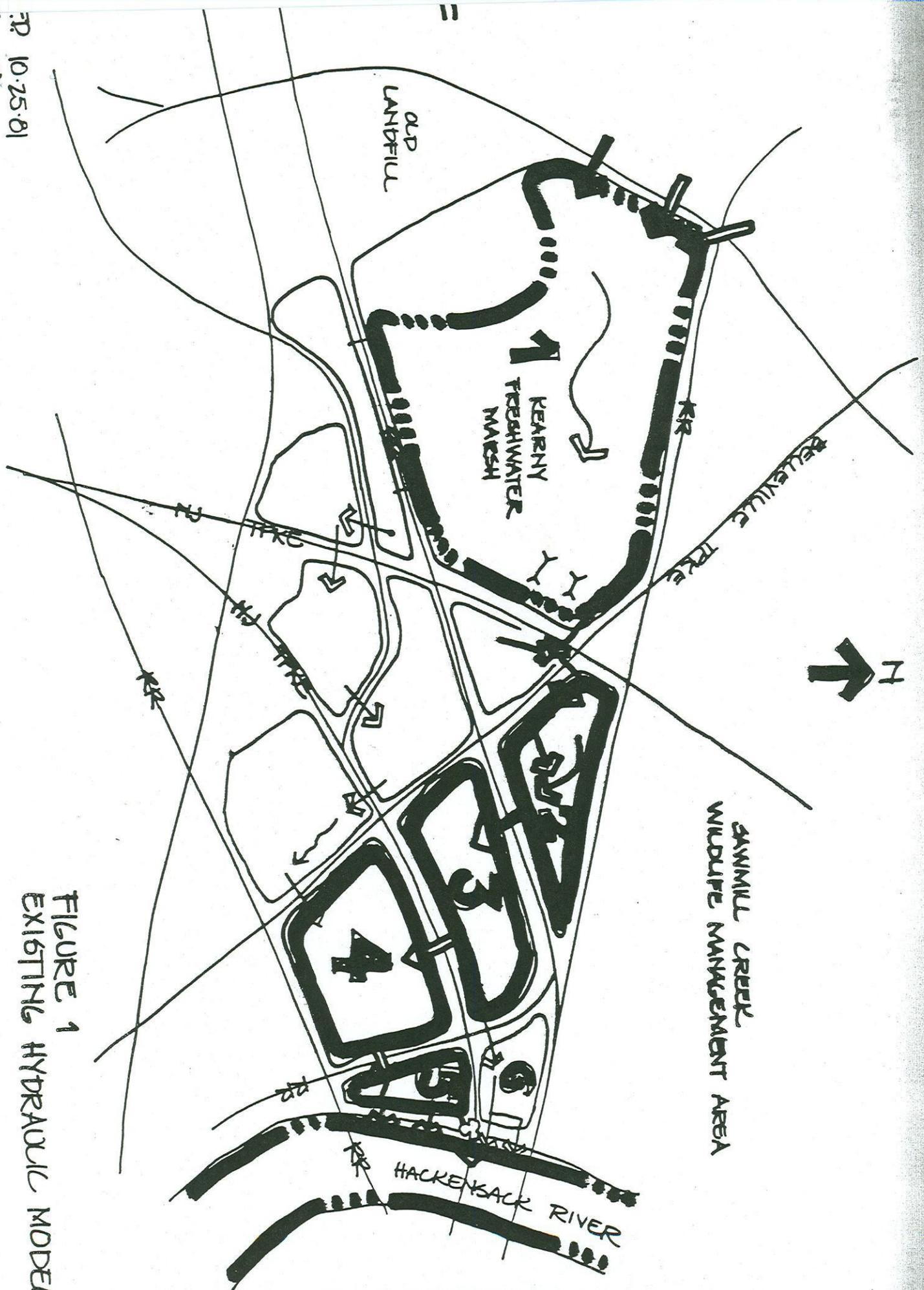


FIGURE 1
EXISTING HYDRAULIC MODEL

south by Frank's Creek, a tidal tributary of the Passaic River (which is actually closer to the marsh than the Hackensack). This natural drainage pattern may have changed, we speculate, during the landfilling that occurred along the western edge and was halted in 1971. Today the drainage for the entire marsh and all of its catchment area flows toward one "corner" of the marsh, at the Belleville Turnpike underpass to the N.J. Turnpike.

At this confluence, drainage flows through a complex maze of piping and emerges on the east side of the western spur of the Turnpike, on the north side of the Belleville Turnpike (See Figure 2). Drainage flows are limited by the size of the piping; drainage passes through one 60" pipe under the N.J. Turnpike which ties into a small catchment basin and immediately enters another 60" pipe to pass under the Belleville Turnpike, and emerges in a 72" pipe. This piping system is shown in figures 3 and 4.

The 60" pipe beneath the Belleville Turnpike is the subject of the most speculation, for it had to be set to pass beneath three large water mains buried beside or under the road. We guess that it had to be set somewhat lower than desired; the result is that it doesn't permit fast enough flow for adequate flushing. It is probably badly silted in, and therefore blocks flow. Based on the information at hand, we believe that this pipe's positioning is the main hydrological component to the creation of the Kearny Freshwater Marsh.

CONCLUSION #1

LESS IS GETTING OUT

If the pipe were routed out and unclogged, would the marsh disappear? No. The present condition is the natural condition given the angle of the pipes;

FIGURE 2
KEARNY MEADOWS
HYDROLOGIC PROFILE

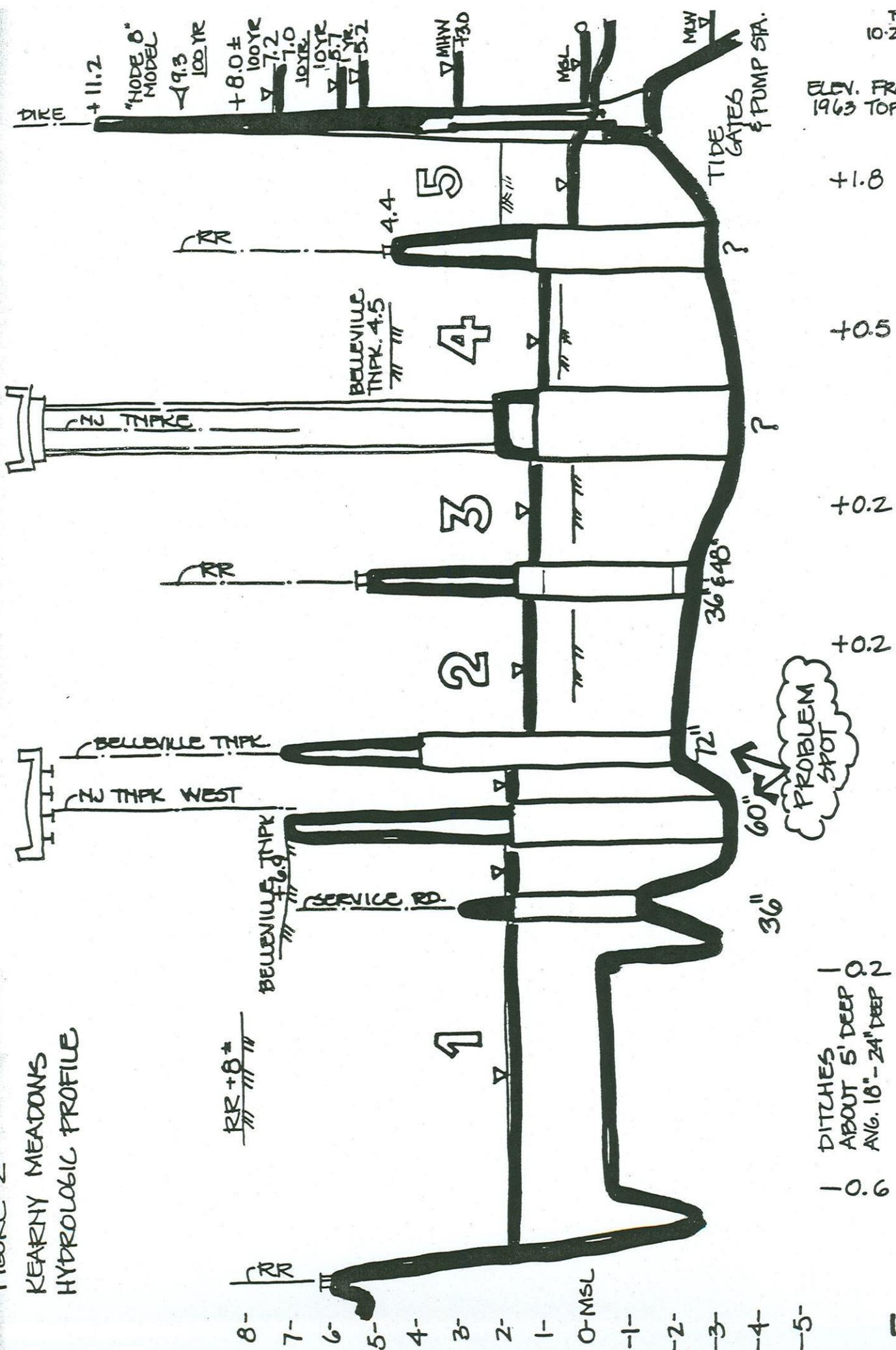
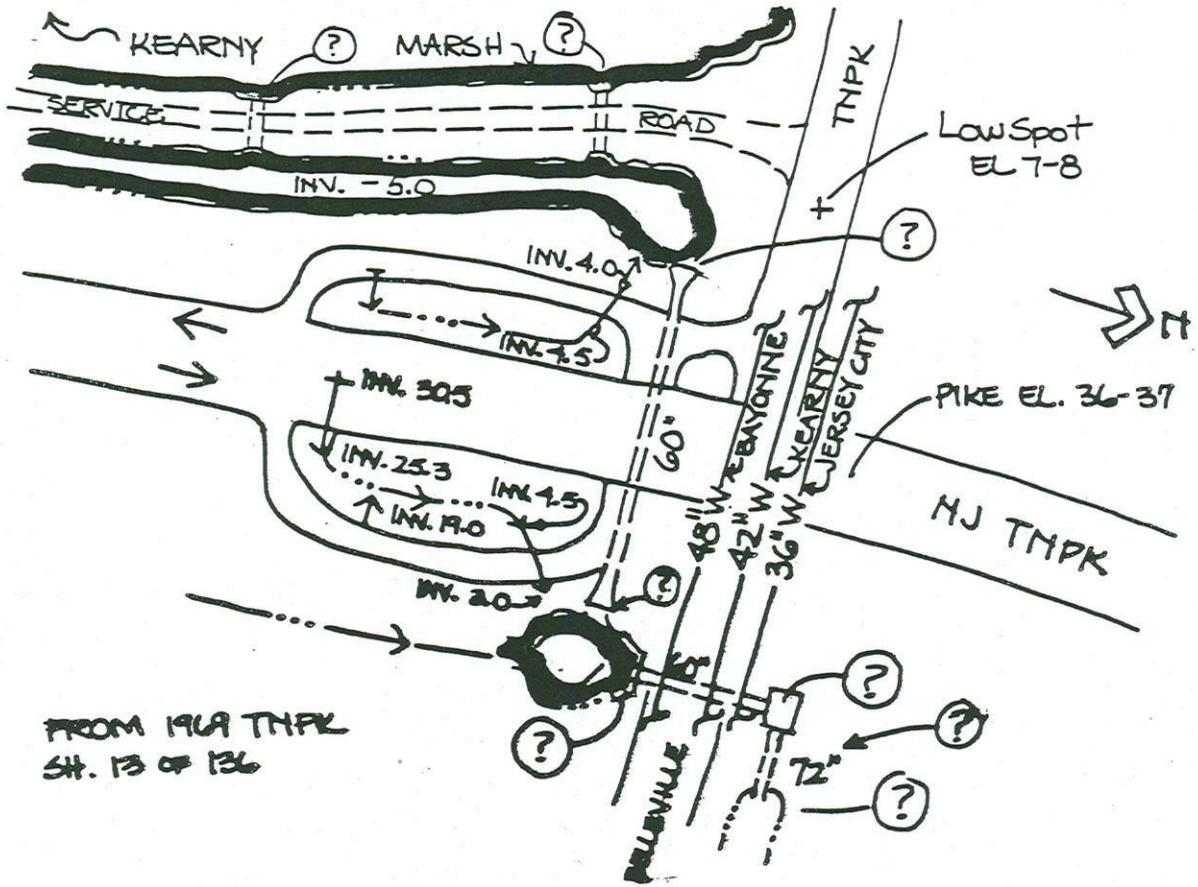
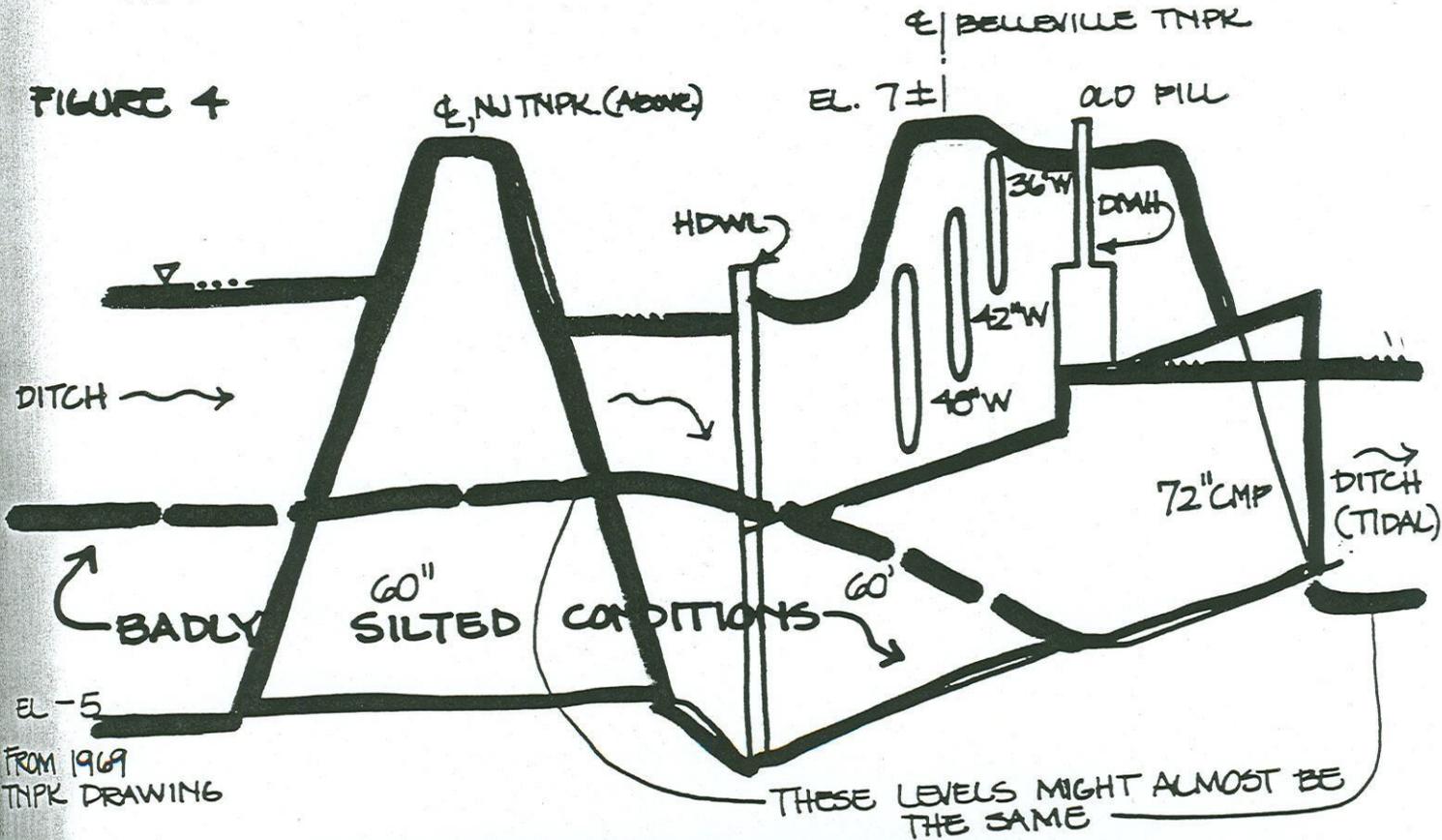


FIGURE 3



FROM 1969 TMRK SH. 13 OF 136

FIGURE 4



FROM 1969 TMRK DRAWING

THESE LEVELS MIGHT ALMOST BE THE SAME

levels would drop, but rapid siltation would quickly fill the pipe again.

What else is contributing?

From there to the river (basins 2-6), through marshes and ditches, the flow is mainly dictated by the tide, not by the size of the culverts. The record of salinity measurements helps confirm this hypothesis and indicates how much tidal penetration the eastern marshes have been experiencing. In 1979, water quality monitoring teams took salinity measurements on this pipe's outfall on the north side of the Belleville Turnpike and reported salinities close to zero. This meant that freshwater was flowing through these pipes toward the river, and tidal action in the eastern marshes was having limited effect. A shift occurred in 1980, when the salinity measurements on the north side were recorded to be as high as 10 parts per thousand. Yet during this time the salinities on the Freshwater Marsh side of this system have consistently read at or close to zero; this indicating an added resistance to flow, which contributes to a greater backlog in the pipe.

WHAT ONE CLOGGED PIPE HATH WROUGHT

Dick Kane of the New Jersey Audubon Society has been observing and cataloguing bird activity in the Kearny Freshwater Marsh weekly since 1974. He is a source of seemingly endless knowledge about this special place. Under this grant, he advised us on its management, and gave us an unforgettable slide presentation of what this marsh has become.

"The Kearny marsh is a jewel of a place, a veritable oasis of fresh water ponding marsh lying in the middle of this very salty tidal estuary system. When

I give this show around the state, I like to call the Kearny marsh New Jersey's "Prairie Pothole", because that's what it is. It is really a pothole or a slough of the type that you find in Iowa, North Dakota or Saskatchewan; in that the wildlife communities it contains are much more similar to those in the midwest than they are in the rest of New Jersey.

There is no replica of this marsh anywhere in the State of New Jersey, and the marvelous thing about it is that it happened by accident...

...The bird populations are truly amazing in this marsh...there is no other marsh in the State that has the waterfowl populations and waterbird population mix that this marsh has, and there may be no other marsh that's as productive per acre in the State...

...In the Kearny marsh, there is an abundant population of Least Bitterns, the smallest heron, which is a declining species in the state. The Kearny marsh therefore, has another importance, it houses some species that are threatened in this state or that are up for consideration for endangered species in other states...

...Another important thing about the marsh is the big heron roost which is used by all the herons who feed in the Hackensack River drainage in the summer. From June or July until October, all of the herons that feed in the Hackensack River drainage roost in this marsh in the evening. An average count of roosting herons in the peak of that season, the end of July, runs about 600 or 700 birds...

...Under the water lies the answer as to why the Kearny Marsh is such an attractive place for such a variety of species...It is also a great lesson in ecology, this moving water scene in the Kearny marsh because if you've ever looked at a pond and wondered how there can be so many ducks both in numbers and different species, on the surface of the water, the reason is that each of these animals occupies a different niche. Different species of duck eat different parts of the plants, and some species of ducks eat only animal food; eat only the snails. Some species can dive under the water and other can't and that means that they can all occupy the same habitat without exhausting the resource...

...There are some things that are found in the Kearny Marsh that are not known anywhere else. Grackles are not known to nest in Phragmites anywhere but here...Perhaps the most outstanding wildlife feature of the Kearny Marsh is the Coot population...there are hundreds of pairs in the Kearny marsh...The interesting thing about this is that the Coot does not nest in any numbers anywhere else in the state.

...The future of the Kearny Marsh is, as of now, undecided. If it stays sealed off, without salt-water intrusion, it's going to continue to be a great resource for the Coot and other species that live there. If the size of it is kept intact, it

can continue to house the heron roosts, the waterbird population and the other creatures that nest there. And this little oasis, a "pothole" or "slough", will remain, and probably needs to be perfected and sealed off by mechanical means because it could be changed by accident. Again, it happened by accident, and it could be changed by accident.

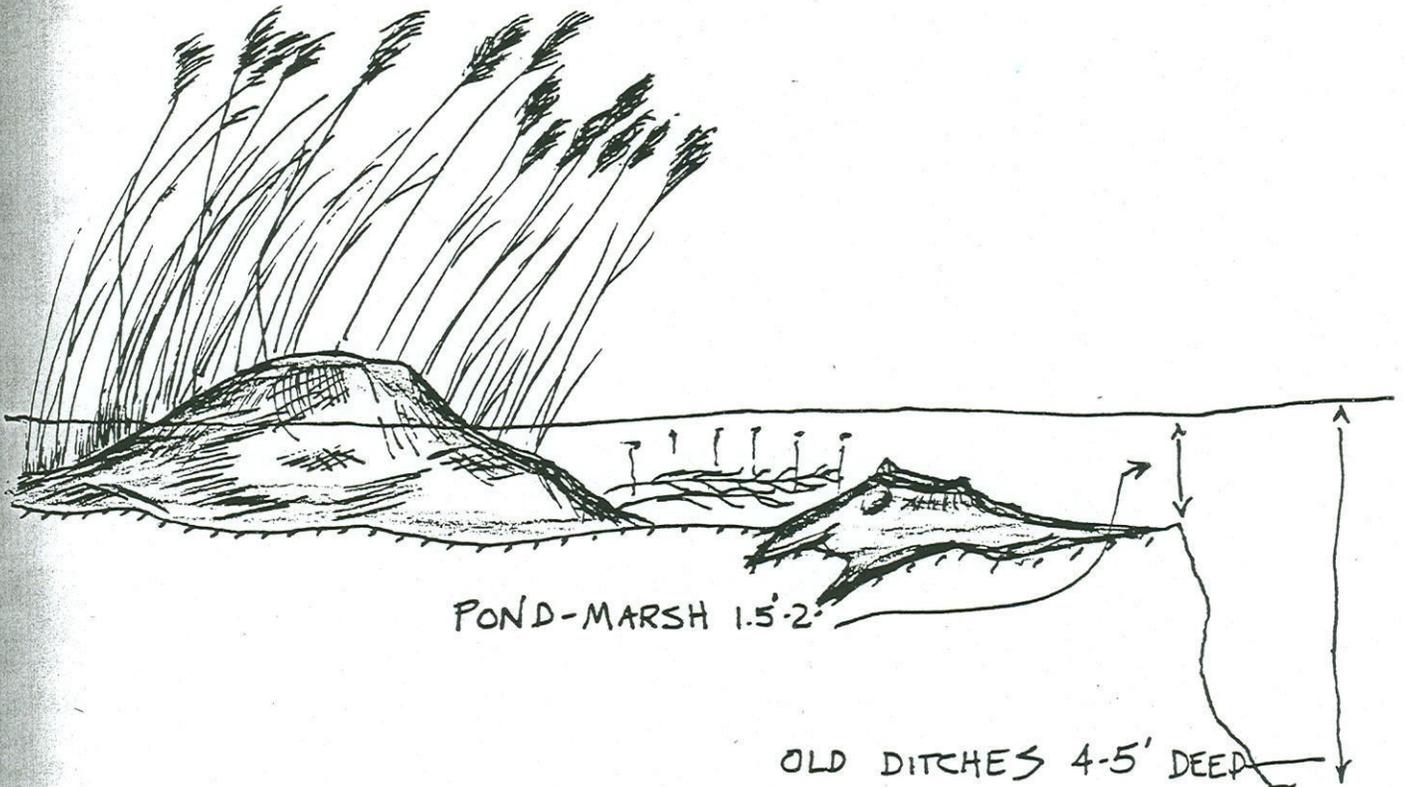
So, to manage this for the future of these waterbirds is an important task.

...The other thing is that this is an outdoor laboratory, this Kearny Marsh, because if it could be reproduced elsewhere, it could be the key to some very successful management techniques for waterfowl and waterbirds in the State."

Kearny Basin Management

To our delight, we have been rewarded by the unexpected in the Kearny Freshwater Marsh. Yet the marsh system, forming in reverse succession to what would be 'normal' in the natural sequence of ecosystem change, is rapidly becoming a pond/marsh fringe system. As planners and resource managers, we know that we cannot rely on more good luck for further rewards. We need and want to be better able to understand the present and predict the future so that this marsh will thrive.

As the first stage in this management plan, Don Smith, Staff Naturalist, prepared an up-to-date vegetation map of the Kearny Basin (This aspect of the Coastal Zone study has too taken on a life of its own. At the time of this report, Don Smith has completed a series of nine such vegetation maps, each for a major wetland basin within the larger estuarine ecosystem). This management plan looks at the land planning and ecosystem management elements that must be mastered.



What do we value in the existing system?

During brooding/hatching/fledgling periods, would a foot rise for some period be catastrophic to the waterfowl communities?

Would the area be more or less productive with 6" average lower water elevations?

Does the answer to this depend on other biome shifts?

What do we need to know to preserve them?

System Hydraulics - How does existing system work? Why is it getting deeper? How does it affect the present environment?

We need to know the elevations of all structures, channels, and critical dike, rail, and roads.

What techniques are available?

System Analysis with hydraulic modelling?

Seat of our Pants?

Kearny Freshwater Marsh Preservation

What about the saving of the marsh? Is its future so secure? Aren't we jumping the gun with talk about managing a resource on land owned by the town zoned for major development? What are our expectations in this realm?

From Dick Kane's eloquent "Birds of the Kearny Marsh" (1978, Appendix 1)

"All the environmental issues of the 1970's and 1980's are joined in the Kearny marsh. The land value may run as high as fifty thousand dollars an acre. The marsh is positioned near the (future) intersection of the New Jersey Turnpike with Route 280, and attractive location for development of various kinds. At present, the Hackensack Meadowlands Development Commission has the land zoned for 60% special use and 40% marshland preservation. Obviously, the town would stand to gain in ratables from its development.

Probably it is safe to say that in this case (as in many others), half a loaf is not better than none, ecologically speaking. Should the size of the marsh be reduced, there will undoubtedly be not only a loss in numbers of birds, muskrats and other wildlife, but a loss of species as well. The species diversity of the marsh, in other words, is proportional to its size....How small is too small a marsh? That is a question that is better left unanswered. In finding the answer, the resource is destroyed. The importance of habitat size in relation to wildlife diversity is central to the question of the Kearny marsh. Effectively to preserve marshland here means to preserve all of the marsh."³

Like so many aspects of this Coastal Zone Management program, this issue has come to the forefront of concerns in the past year. -- WE HAVE COME TO

REGARD THE PRESERVATION OF THE KEARNY FRESHWATER MARSH AS OUR MOST IMPORTANT OPEN SPACE GOAL OF 1982.

Why now?

Back in 1978, Chet Mattson, the Commission's Director of Environmental Programs & Planning wrote,

...Over the period 1970-1977 in the Hackensack Meadowlands Land Use Control District, the coastal ecosystem has changed. It is healthier, biologically broader, and more intricate in its ecological relationships.

Similarly, over the period, land use patterns have changed. In response to the Master Plan, land use types have become extensively broader in their variety and thus more intricate in their relationships to one another. Thus the two systems, developmental and natural, are evolving similarly towards greater complexity and interaction.

As well, land use expectations have stabilized and cohered in the District. Enough variety has occurred in the developed landscape to make visible the broader possibilities for the entire land mass. As a consequence, most of the developmental energy now, with some exceptions of course, is directed toward making the land Use Plan work. Like in the ecosystem, all of its parts are related.

The need for Resource Management has intensified due in large part to our successes in stabilizing development patterns and restoring the estuary.⁴

How have land use patterns stabilized and cohered in Kearny?

Land use planning conducted six years ago by the HMDC in cooperation with the Kearny Industrial Commission sparked interest in the development potential of this thousand acres. The June, 1977 zoning changes followed, which recognized the value of planning the tracts west of the Turnpike as a unit, and established Special Use 3. This zoning change, we believe, made the land even more attractive. Where once garbage dumps were the only land use contemplated, development rights were actually being fought over. An

agreement was signed this year which split this thousand acres between two developers, Hartz Mountain Industries, of Secaucus, and the Mimi Development Corporation, of Kearny. Most significantly, the town, Hartz, and Mimi all agreed to the preservation of virtually the entire Kearny Freshwater Marsh.

Preliminary conceptual design plans, in accord with this agreement, show concentrated development away from the marsh, and 285 acres of the 304 acre marsh preserved.

This preservation agreement has now to be formalized. With acceptance of this agreement, and by assigning an appropriate open space designation, the HMDC can allocate a large portion of the required common open space for two Special Use zones within one. When this is accomplished, the area of the resource will be forever preserved.

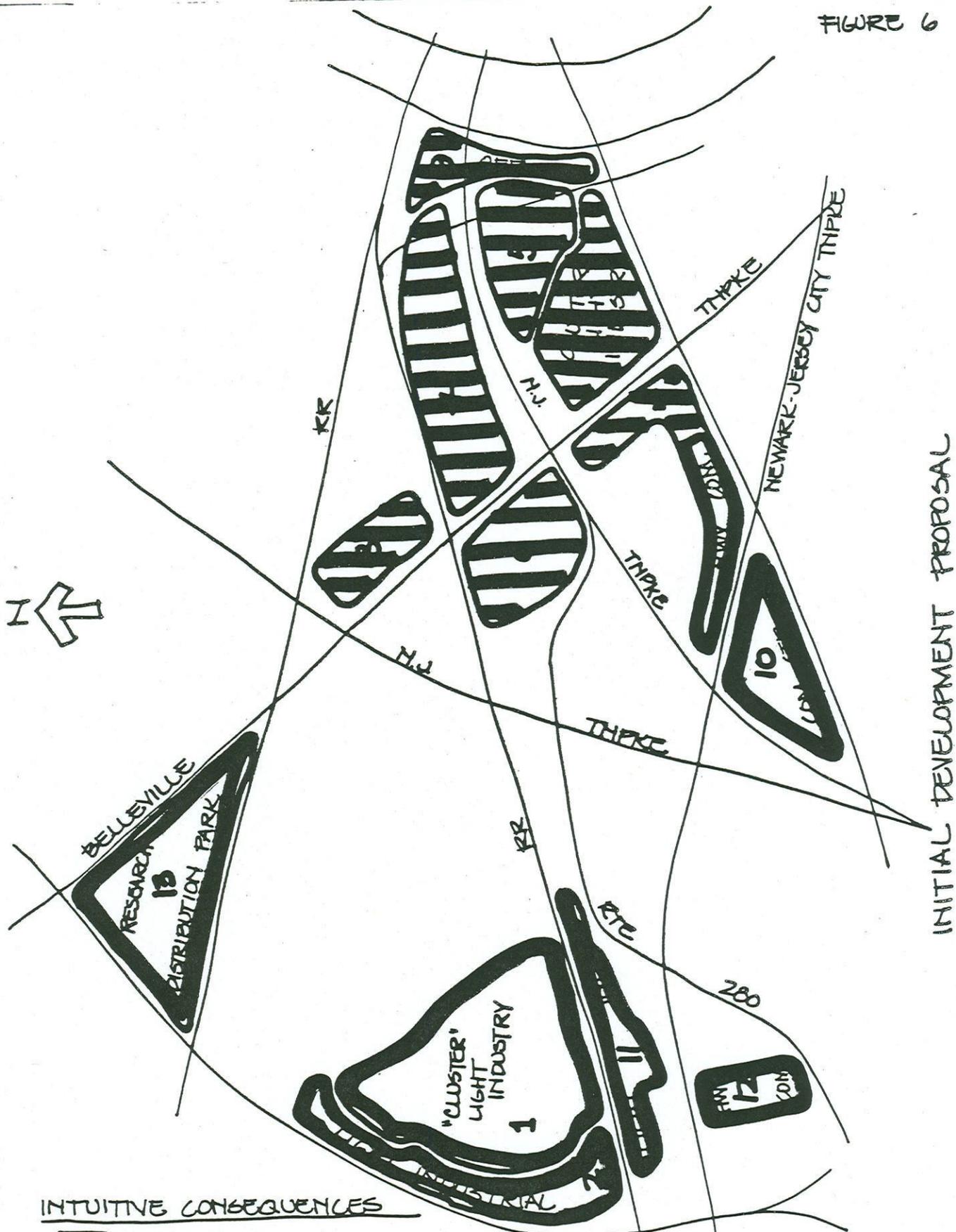
But the management questions will remain.

Water Management and Water Quality

We want to be able to manage the level of the marsh and we know from the current trend that we now have too much water as a resource, and are unable to control it.

New development around the Freshwater Marsh basin, without proper controls, will create increased runoff. In Bob Daylor's words, it "turns pots into pipes", and we have to "watch the juice" (see figure 6), i.e. take care that these flows go where we want them to go. One way, he suggests, we can help manage the level of this marsh is to require that no new development drain into this marsh. This will not only prevent increased levels of water, but of

FIGURE 6



INTUITIVE CONSEQUENCES



CHANGES POTS TO PIPES - "WATCH THE JUICE"

IF TIDE GATES FIXED - BIOME SHIFT - BRACKISH

REED MEADOW TO NEW FILL/DEVELOPMENT/

AND FRESH DITCH - SALINE HATCHERY/NURSERY/FORAGE LOST

INITIAL DEVELOPMENT PROPOSAL

sediment and pollutants as well.

In the case of our clogged pipe, gravity can't help us manage this siltation unless a sediment trap is created which maintains a clean pipe. Is this possible? We don't know.

To paraphrase Einstein, we would like the design of the water control structure to be as simple as possible, but not simpler. Its design and construction will undoubtedly be necessary for the effective management of the drainage system downstream as development progresses. Robert Daylor starts with a warning and provides some advice on how this can begin to be handled.

"...the present marsh/pond seems chiefly a product of the lack of maintenance provided to the culverts under the Belleville Turnpike and the New Jersey Turnpike. If they were to be cleaned without some intervening hydraulic structure to control the water level in the Kearny marsh, then in our opinion, it would quickly drain and revert to a wet phragmites field ditch system. DON'T LET THAT HAPPEN.

"The Kearny Marsh can be isolated from downstream water levels by some type of weir structure(s) at either the Transco Road or at the inlet to the 60 inch culvert under the turnpike. This should be in place before the clogged culverts are cleaned to prevent draining the marsh without any way to refill. Secondly, the level could be controlled by pumping.

"An intriguing idea would be to install the pumping station in that pool between the 60 inch pipe under the turnpike and the 60 inch pipe under the Belleville Turnpike. If we sized large mixed flow or axial flow pumps to discharge at a rate which would keep self-cleaning velocities in the culvert system (2-2.5 fps), then we could control stage while cleaning pipes at the same time. The suction side of the pump would draw down the 60 inch pipe under the New Jersey Turnpike, the large ditch west of the pike and skim off the top of the Kearny Marsh.

"We could prevent draining the Marsh dry by setting control weirs upstream of the Transco Road which would not permit levels to drop more than 6-12 inches below present stage."

This design process will be part of the three stage planning process required in this zone by the developer. As part of that process, and the outgrowth of

this Basin Management Plan, the next stage, to be conducted jointly by the HMDC and the planner/developer of the SU-3 SPA is to contain the following elements:

- up-to-date topographical information, including the elevation of all structures, channels, and critical dike and rail elevations.
- an inventory of the drainage works which connect the Kearny meadows.
- a series of surveyed water level gauges, set on the National Geodetic Vertical Datum of 1929 (NGVD).
- a system analysis with a hydraulic model, e.g. the SCS Model.
- under existing conditions
- under conditions imposed by SU-3 development.

"The Kearny marsh is, quite simply, the best freshwater marsh in New Jersey at this time, certainly in its resident waterbird diversity, probably in its sheer numbers of waterbirds, and possibly in its birds-per-acre productivity. This marsh developed almost by accident, even by mistake, without benefit of human wisdom or planning...The importance of this marsh cannot be overestimated. Not only is it a potential outdoor laboratory for the study of marsh creation, marsh productivity and marsh management, but it is also unique in the Meadowlands region and the state..."

Dick Kane 1978

WATER BALANCE

(All values in inches)

(Wet Year)

	J	F	M	A	M	J	J	A	S	O	N	D	Y
T°C* (1)	35.8	35.7	39.9	53.9	60.1	73.4	79.2	74.1	68.2	53.2	46.5	37.1	54.8
Ind (2)	.27	.26	.82	3.84	5.61	10.08	12.29	10.34	8.23	3.65	2.06	.42	57.87
Unadj P E(3)	.01	.01	.02	.06	.09	.15	.17	.15	.12	.06	.04	.01	
Adj PE (4)	.25	.25	.62	2.0	3.4	5.67	6.48	5.36	3.74	1.73	.98	.24	
P (5)	4.92	2.35	4.94	6.01	5.96	6.01	4.11	6.68	3.62	.89	3.41	4.40	53.3
C R/O (6)	.20	.20	.17	.17	.17	.17	.17	.17	.17	.17	.17	.20	
R/O (7)	.98	.47	.84	1.02	1.01	1.02	.70	1.14	.62	.15	.60	.88	9.43
I (8)	3.94	1.88	4.10	4.99	4.95	4.99	3.41	5.54	3.0	.74	2.81	3.52	
I-PE	3.69	1.63	3.48	2.99	1.55	-.68	-3.07	.18	-.74	-.99	1.83	3.24	
Acc Pot													
WL (9)	-	-	-	-	-	-.68	-3.75	-3.57	-4.31	-5.30	-	-	
ST (10)	7.20	7.20	7.20	7.20	7.20	6.54	4.27	4.37	3.92	3.45	5.10	7.20	
ST	0	0	0	0	0	-.66	-2.27	.10	-.45	-.47	1.65	2.10	
AE (11)	.25	.25	.62	2.0	3.4	5.65	5.68	5.44	3.45	1.21	.98	.24	
D (12)	0	0	0	0	0	.02	.8	0	.29	.52	0	0	
PERC (13)	3.69	1.63	3.48	2.99	1.55	0	0	.08	0	0	.18	1.14	14.74

- (1) Mean monthly air temperature for Newark, N.J.
- (2) Heat Index
- (3) Unadjusted daily potential evapotranspiration
- (4) Adjusted monthly potential evapotranspiration
- (5) Average monthly precipitation for Newark, N.J.
- (6) Runoff coefficient
- (7) Direct runoff
- (8) Infiltration

- (9) Accumulated potential water loss
- (10) Water storage capacity of the soil cover. It is assumed that the roots of the vegetated cover draw from all parts of the soil cover. Assumed 150 mm of storage capacity per meter of soil cover.
- (11) Actual evapotranspiration
- (12) Moisture deficit of soil cover
- (13) Percolation into solid waste

WATER BALANCE

(All values in inches)
(Dry Year)

	J	F	M	A	M	J	J	J	A	S	O	N	D	Y
T°C* (1)	25.2	29.1	36.4	46.7	64.0	67.8	71.4	70.9	65.5	51.0	41.7	54.2	47.52	
Ind (2)	0	0	.34	2.10	6.82	8.09	9.34	9.17	7.32	3.11	1.12	.11		
Unadj P E (3)	0	0	.01	.04	.11	.13	.14	.14	.11	.06	.02	0		
Adj PE (4)	0	0	.31	1.33	4.13	4.91	5.33	5.0	3.43	1.73	.49	0		
P (5)	2.86	2.91	2.81	2.60	1.23	1.23	1.73	2.87	2.20	2.31	1.48	1.86	26.09	
C R/O (6)	.20	.20	.17	.17	.17	.17	.17	.17	.17	.17	.17	.20		
R/O (7)	.57	.58	.48	.44	.21	.21	.29	.49	.37	.39	.25	.32	4.60	
I (8)	2.29	2.33	2.33	2.16	-1.02	-1.02	-1.44	2.38	-1.83	1.92	1.23	1.54		
I-PE	2.29	2.33	2.02	.83	-3.11	-3.89	-3.89	-2.62	-1.60	.19	.74	1.54		
Acc Pot	-	-	-	-	-3.11	-7.00	-10.89	-13.51	-15.11	-	-	-	-	
WL (9)	5.66	7.20	7.20	7.20	4.67	2.73	1.45	1.12	.90	1.09	1.83	3.37		
ST (10)	2.29	1.54	0	0	-2.53	-1.94	-1.28	-3.3	-2.2	.14	.74	1.54		
AE (11)	0	0	.31	1.33	3.55	2.96	3.04	2.71	2.05	1.73	.49	0		
D (12)	0	0	0	0	.58	1.95	2.29	2.29	1.38	0	0	0		
PERC (13)	0	.65	2.02	.83	0	0	0	0	0	0	0	0	3.50	

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WATER BALANCE

(All values in inches)
Average Year

	J	F	M	A	M	J	J	A	S	O	N	D	Y
T°C* (1)	28.6	30.2	38.5	50.0	59.8	68.9	73.5	71.6	64.9	54.6	43.5	31.6	51.3
Ind (2)	0	0	.6	2.86	5.52	8.47	10.12	9.42	7.12	4.03	1.45	0	49.59
Unadj P E(3)	0	0	.02	.06	.07	.13	.15	.14	.11	.07	.03	0	
Adj PE (4)	0	0	.62	2.0	2.63	4.91	5.72	5.0	3.43	2.02	.74	0	
P (5)	3.05	2.91	3.94	3.76	3.95	3.47	4.63	4.65	3.61	3.11	4.09	3.80	44.97
C R/O (6)	.20	.20	.17	.17	.17	.17	.17	.17	.17	.17	.17	.20	
R/O (7)	.61	.58	.64	.64	.67	.59	.79	.79	.61	.53	.70	.76	7.28
I (8)	2.44	2.33	3.27	3.12	3.28	2.88	3.84	3.86	3.0	2.58	3.39	3.04	
I-PE	2.44	2.33	2.65	1.12	.64	-2.03	-1.88	-1.14	-.43	.56	2.65	3.04	
ACC Pot	-	-	-	-	-	-2.03	-3.91	-5.05	-5.48	-	-	-	
WL (9)													
ST (10)	7.20	7.20	7.20	7.20	7.20	5.42	4.18	3.57	3.36	3.92	6.57	7.20	
ST	0	0	0	0	0	-1.78	-1.24	-.61	-.21	.56	2.65	.63	
AE (11)	0	0	.62	2.0	2.63	4.66	5.08	4.47	3.21	2.02	.74	0	
D (12)	0	0	0	0	0	.25	.64	.53	.22	0	0	0	
PERC (13)	2.44	2.33	2.65	1.12	.64	0	0	0	0	0	0	2.41	11.59

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