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LAKE APOPKA NORTH SHORE RESTORATION AREA FEASIBILITY STUDY ORANGE AND LAKE COUNTIES, FLORIDA

Lake Apopka North Shore Restoration Area Feasibility Study Orange and Lake Counties, Florida

Prepared for:
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Executive Summary

MACTEC Engineering and Consulting, Inc. (MACTEC) was contracted by the St. Johns River Water Management District (the District) to complete a Feasibility Study (FS) for a portion of the Lake Apopka North Shore Restoration Area (NSRA) located on the northern shores of Lake Apopka in Orange and Lake Counties, Florida. The restoration work at Lake Apopka came as a result of the Lake Apopka Restoration Act of 1985 and Florida's Surface Water Improvement and Management Act of 1987. In 1996, the Legislature enacted the Lake Apopka Restoration Act, Section 373.461, Florida Statutes, to provide that the District accelerate the restoration of the Lake Apopka basin by acquiring certain agricultural lands impacting Lake Apopka, along with their related facilities. These agricultural properties were formerly wetlands fringing the lake. The District purchased the 3,000 acre Duda Property in 1997 and purchased essentially all parcels in the 6,000 acre Zellwood Drainage and Water Control District (ZDWCD) Unit 2 area in 1998. Acquisition continued with the purchase of Unit 1, and currently the District owns approximately 20,000 acres. These lands are now known collectively as the NSRA; this FS addresses ZDWCD Unit 1 and Unit 2.

The purpose of this FS is to summarize the nature and extent of contamination and risks posed by organochlorine pesticides (OCPs) in soil within Units 1 and 2 of the NSRA, and evaluate remedial alternatives under a range of potential remediation target levels that would permit planned restoration of wetlands that had been drained for agricultural use between 1941 and 1985. The planned wetlands restoration is an important component of the restoration of Lake Apopka. The FS was performed using procedures adapted from US Environmental Protection Agency (USEPA) guidance for performing FSs for contaminated sites under the Superfund program (USEPA, 1988). The NSRA is not a superfund site and thus, the FS process prescribed by USEPA is not directly applicable to the current project. However, the Superfund FS process provides a useful framework that is relevant to the problem at hand. Specific modifications were made to the USEPA FS process, as will be described at various points in this document.

The OCPs of greatest potential concern at the site are toxaphene; DDE; the sum of DDD, DDE, and DDT, known as DDTx; dieldrin, and total chlordane (sum of alpha- and gamma-chlordane and heptachlor epoxide). These OCPs were historically applied to the fields during agricultural operations, and are present in surficial soils due to their environmental persistence. These chemicals were identified as chemicals of potential concern (COPCs) based on their frequency of occurrence in NSRA soils, their toxicity, and levels of these constituents that were observed in carcasses of birds that died in the vicinity of the NSRA during winter 1998-1999. Extensive soil sampling and analyses have occurred in the NSRA. These investigations have been summarized by Marzolf *et al.* (2003) and Marzolf (2004).

Based on the investigation's findings, it was determined that surface soil samples (the upper 1 ft) from the farm fields and field ends represent a sufficiently conservative data set for evaluation of remedial alternatives; and that this data set should be examined and evaluated after grouping by farm field. Farm fields are also believed to represent an appropriate exposure area for estimating exposure of piscivorous birds. Where food is plentiful the birds will feed over a relatively small area, as represented conceptually by the farm field, rather than foraging over the entirety of the NSRA. The resulting field soil characterization data set for ZDWCD Units 1 and 2 consists of 629 samples, grouped into 70 farm field units, covering approximately 9,000 acres.

For each of the 70 fields in the NSRA Units 1 and 2, a best estimate and a conservative estimate of the carbon-normalized concentrations of each of the COPCs was calculated. A set of Remedial Action Objectives (RAO) were provided by the District. These RAOs were derived by back calculation from fish tissue risk trigger levels. Following a review of these RAOs, and other data, a best estimate target level (BETL) and a conservative target level (CTL) was established for each of the COPCs. Values between these two limits are considered a reasonable range of potential remedial action objectives that may result from ongoing fish tissue samples or discussions with stakeholders. A comparison of the best estimate soil concentrations to the BETLs showed that 17 fields containing 2,200 acres of the 9,900 acres exceeded the BETLs with 787 acres requiring at least 50% reduction. Approximately 1,420 acres exceed the BETLs by less than 20%. Alternately for the worst case scenario; it is possible that 6,900 acres in 46 fields exceeded the CTLs, with 3,774 acres requiring at least 50% reduction to reach CTLs.

A list of 23 potential technologies or alternatives were developed and reviewed and was eventually reduced to 12 remedial alternatives to best reduce or remove exposure to the OCPs. These remaining remedial action alternatives (RAO) were then screened against CERCLA based criteria and reviewed in detail and cost estimates were developed. For several soil manipulation and bioremediation alternatives, testing programs are likely to reduce performance uncertainties, leading to a clearer identification of cost-effective alternatives.

These alternatives were applied against the remediation target levels (BETL and CTL) on a field by field basis and expected flood levels were overlayed. By doing this an apparent sequence emerged that would allow the District to proceed with wetland re-establishment with a known set of remediation approaches, costs and expectations. Although there remains some uncertainty about over-all cost, primarily because of target level uncertainty, an estimated low cost to meet current RAOs for Units 1 and 2 of the NSRA is approximately $6,700,000. The upper bound cost could be as high as $62,000,000. However, by using a phased approach, and accomplishing some remedial actions a large percent of the existing lands could be re-flooded relatively soon.

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List of Acronyms and Abbreviations

AOP	advanced oxidation process
ARAR	Applicable or Relevant and Appropriate Requirements
ATSDR	Agency for Toxic Substances to Disease Registry
BETL	best estimate target level
BGEPA	Bald and Golden Eagle Protection Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CSM	conceptual site model
CTL	conservative target level
COPC	Contaminants of Potential Concern
CWA	Clean Water Act
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethene
DDT	dichlorodiphenyltrichloroethane
DDTx	sum of DDD, DDE, and DDT
District	St. Johns River Water Management District
ESA	Environmental Site Assessments
FAC	Florida Administrative Code
FB	Flooding Block
FDEP	Florida Department of Environmental Protection
FS	Feasibility Study
ft	foot
ISCO	*In Situ* Chemical Oxidation
kg	kilogram
K_{oc}	organic carbon adsorption coefficient
L	Liter
mg	milligrams
MACTEC	MACTEC Engineering and Consulting, Inc.
MBTA	migratory bird Treaty Act
MITU	Mobile Injection Treatment Unit
MNA	monitored natural attenuation
MOU	Memorandum of Understanding

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List of Acronyms and Abbreviations (continued)

NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NSRA	North Shore Restoration Area
OCP	organochlorine pesticides
POP	persistent organic pollutant
RA	risk assessment
RAO	Remedial Action Objectives
RI/FS	Remedial Investigation / Feasibility Study
SCTL	Soil Cleanup Target Level
SDWA	Safe Drinking Water Act
SWIM	Surface Water Improvement and Management Act
THAN	T.H. Agricultural & Nutrition Company
TOC	Total Organic Carbon
TSD	Waste Treatment, Storage, or Disposal Facility
UCL95	95% upper confidence limit of the mean
USEPA	US Environmental Protection Agency
USFWS	US Fish & Wildlife Service
WRS	Westinghouse Remediation Services
ZDWCD	Zellwood Drainage and Water Control District

1.0 Introduction

MACTEC has been contracted by the District to complete a FS for the remediation of lands planned to be restored to wetland habitat in the Lake Apopka North Shore Restoration Area (NSRA). The NSRA in Figure 1-1 encompasses approximately 20,000 acres (31 square miles) to the north of Lake Apopka in Orange and Lake Counties, Florida. Figure 1-1 also highlights several major sub-portions of the NSRA that have differing land use/ management issues: Duda Farms, Sand Farm, and Units 1 and 2 of the former Zellwood Drainage and Water Control District (ZDWCD), and includes the Marsh Flow-Way (not part of the NSRA). These sub-areas are discussed further in Section 1.1.

The purpose of this FS is to summarize the nature and extent of contamination and risks posed by organochlorine pesticides (OCPs) in soil within Units 1 and 2 of the NSRA, and evaluate remedial alternatives under a range of potential remediation criteria that would permit planned restoration of wetlands that had been drained for agricultural use between 1941 and 1985. The planned wetlands restoration is an important component of the restoration of Lake Apopka. The FS was performed using procedures adapted from US Environmental Protection Agency (USEPA) guidance for performing FSs for contaminated sites under the Superfund program (USEPA, 1988). The NSRA is not a superfund site and thus, the FS process prescribed by USEPA is not directly applicable to the current project. However, the Superfund FS process provides a useful framework that is relevant to the problem at hand. Specific modifications were made to the USEPA FS process, as will be described at various points in this document.

1.1 Site Background and Conditions

Historically, Lake Apopka was the second largest lake in the state. In the 1940s, however, the northern third (mostly sawgrass marsh with rich peat soil), now called the NSRA, was isolated from the remainder of the water body by levees and drained for rowcrop, or "muck" farming (Figure 1-1). Drawing water from the surface water of Lake Apopka for irrigation, the farms pumped excess water consisting of field and irrigation run off and rainfall back to the lake as wastewater. This wastewater contained high levels of phosphorus from fertilizers, and when combined with other point and non-point sources of nutrients, it caused a dramatic change in the ecology of the lake. In March of 1947, the first algal bloom was observed and a continuous bloom has persisted to date, eliminating larger macrophytes (aquatic vegetation) in the lake by shading and degrading benthic habitat through high rates of sedimentation. By 1950, much of the rooted aquatic vegetation in the lake had disappeared. These changes led to the demise of the previously healthy sport fishery Lake.

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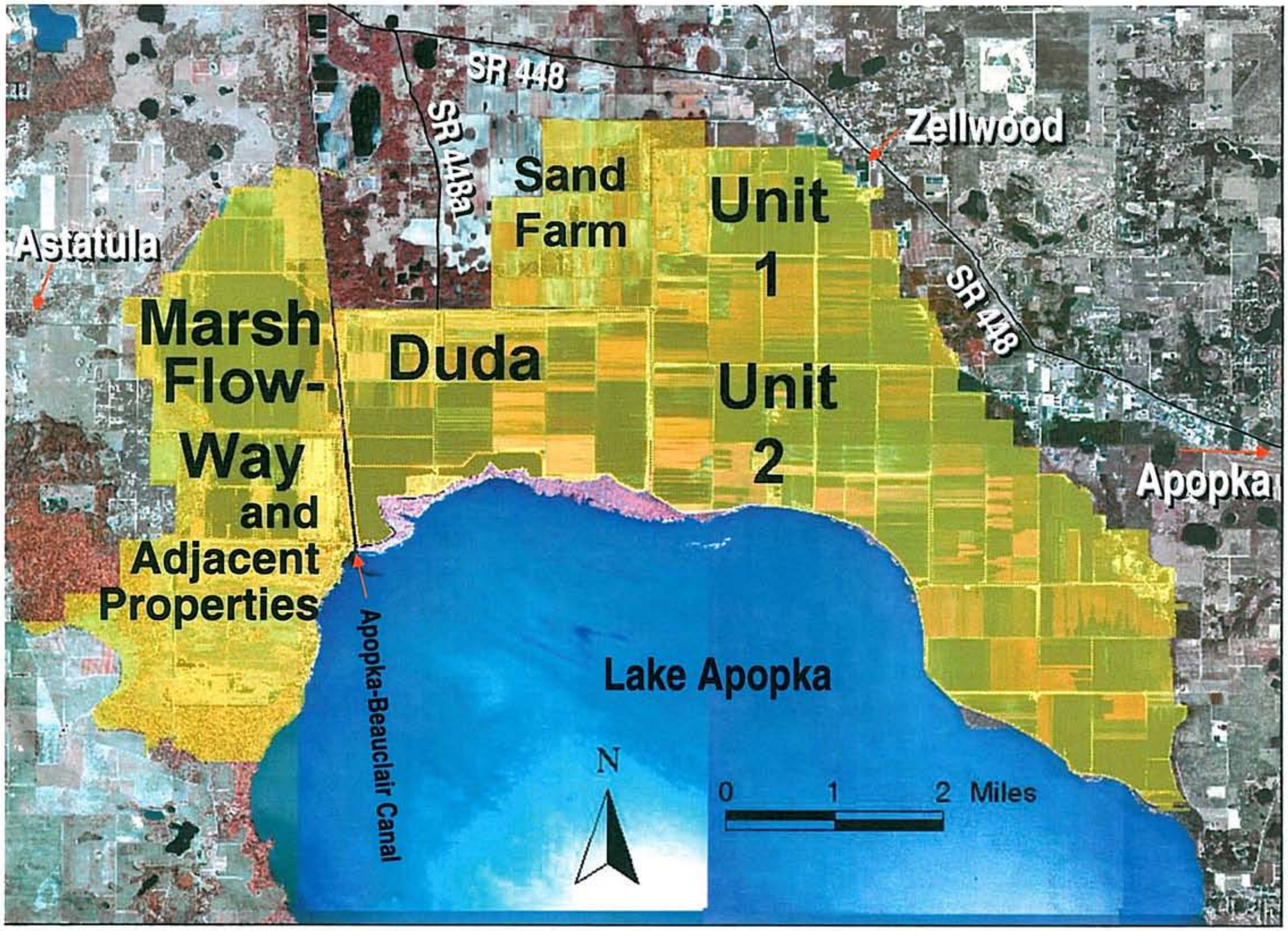

Source: SJRWMD, 2004.

Prepared/Date: CAH 7/26/04
Checked/Date: WAT 7/27/04

Lake Apopka North Shore Restoration Area SJRWMD, Orange & Lake Counties, FL	MACTEC	Lake Apopka North Shore Restoration Area PROJ. NO. 609604004 Figure 1-1

In the ensuing decades, the muck farms worked over 18,000 acres for agricultural production of multiple crops per year. Pesticides were used extensively both through aerial and ground application during the period of agricultural production. Wastewater contaminated by agricultural compounds was discharged from the farms at an estimated 20 billion gallons annually (approximately one third of the lake's total volume). Consequently, by the mid-1960s Lake Apopka was known as Florida's most polluted lake due to excess nutrients.

The biota of both Lake Apopka itself and the NSRA reflected the stressed environment. In the lake, blue-green algae dominated the water column throughout the year. Benthic invertebrate populations in the lake acre were low in diversity and density, and were composed of pollution-tolerant taxa that can endure high levels of organic enrichment. Gizzard shad, blue tilapia, and sunfish dominate the fish community. In the NSRA, the canals in between fields support some aquatic vegetation and fish populations that include brown bullhead, blue tilapia, and mosquito fish. During late summer and early fall some farmers flooded their fields to minimize soil subsidence and erosion and to control nematodes; these shallow-water habitats attracted large numbers of shorebirds, wading birds and other aquatic species (Pranty and Basili 1998).

Several Florida statutes, consistent with Federal law such as the Clean Water Act (CWA), have mandated restoration activities in the Lake Apopka watershed. The District is responsible for planning and implementing these restoration projects. Wetland restoration in the NSRA has been identified as a critical element for the overall restoration of Lake Apopka. The 1996 Lake Apopka Improvement and Management Act (Section 373.461, Florida Statutes 1996) determined it was in the public interest to pursue a buy-out of all the farms on the north shore of Lake Apopka and eliminate the major source of phosphorus pollution to the Lake. The Florida Legislature appointed the District as the agency responsible for implementing the buy-out program. The plan for restoration after the buy-out focused on re-flooding the farm fields and elimination or breaching of the levees that separated the fields from the main body of the lake after a period of 8-10 years, allowing Lake Apopka to return to its historic size.

This course of action was determined following several years of research into the causes and alternatives for reversing adverse water quality trends in Lake Apopka. Therefore, the public benefits of the planned restoration are well established, and the District intends to restore as much of the NSRA to wetland habitat as is feasible and consistent with other environmental goals and requirements. The District understands, however, that years of agricultural use of the NSRA has resulted in high levels of pesticide residuals in the soils, and that these pesticide residuals caused or contributed to significant bird mortality. Consequently, wetland restoration can only proceed if the ecological risks posed by these COPCs can be mitigated and/or eliminated. Alternative actions are evaluated in this FS primarily by consideration of their effectiveness in minimizing exposure of piscivorous birds to COPCs, balanced against their implementation cost.

The District's objective is to restore as much of the NSRA to wetland habitat as is feasible, balancing the cost of remediation against the benefit of wetland restoration. This process of balancing costs and benefits could result in restoring most, but not all, of the NSRA to wetland habitat, if it is determined that cost of restoring all the habitat is unreasonable. This FS is intended to provide the District with information that can support the evaluation and balancing of costs and benefits of alternative actions. The FS retains actions that isolate excessively contaminated soils from the food chain of piscivorous birds, including alternatives that would prevent some portions of the NSRA from reverting to wetland habitat (e.g., onsite landfill).

The Marsh Flow-Way is located just west of the Apopka-Beauclair Canal and the NSRA (Figure 1-1). This area has been designated as a wetland treatment area. Water is pumped out of Lake Apopka to the western boundary of the Marsh Flow-Way, where it is released and flows toward the east. During migration across the wetland treatment area, phosphorus is deposited and treated in the Flow-Way, prior to return to the lake by the Apopka-Beauclair Canal. This process has contributed to the improvement of Lake Apopka. The major improvement to the water quality of Lake Apopka can be attributed to the reduction in external phosphorus loading from the watershed and harvesting of gizzard shad. External phosphorus loading was reduced through regulatory action during the period of farming, and through District management of the NSRA after purchase of the farms.

The Marsh Flow-Way (MFW) has and has been in partial operation since November 2003. The MFW includes cells b1, b2, c1 and c2, and only cells b1, b2, c1, and c2 have been tested for OCPs in this area. Since no sampling has been done in the adjacent properties; therefore, it is difficult to determine what the overall OCP levels are for all of these properties, and therefore is not being addressed by this FS. The MFW project has reportedly not been responsible for the major improvements in Lake Apopka to date. Reduction in external P loading from the watershed and harvesting of gizzard shad are the main projects believed responsible for improved water quality. External loading of P was reduced through regulatory action (during the period of farming) and through District management of the NSRA after purchase of the farms.

Likewise, neither the Duda Farms parcel immediately east of the Flow-Way and north of Lake Apopka, nor the Sand Farm area north of the Duda Farms are addressed by this FS. The Duda Farm parcels were flooded in late 2002 and early 2003, because it was determined that the parcels had relatively low levels of OCPs in soils. The Sand Farm area, immediately north of the Duda Farms also has relatively low levels of OCPs in soils, and is planned to be restored to wetlands in the near future. Monitoring conducted subsequent to re-flooding the Duda Farms substantiates the conclusion that the lands could be safely restored (Coveney, 2004a).

The ZDWCD Units 1 and 2, comprising approximately 9,000 acres of the NSRA are addressed by this FS. These areas typically have higher concentrations of OCPs in soil than the Marsh Flow-Way, Duda Farms, and Sand Farms areas, and some portions of Units 1 and 2 may require special management or remediation prior to re-flooding. This FS develops information that will be used to identify appropriate and cost-effective approaches for restoration of these former wetlands to allow prioritized and accelerated re-flooding.

In preparation for purchase and re-flooding the farm fields of Duda Farms, Sand Farm, and ZDWCD Units 1 and 2, during the mid-1990s, the District completed Environmental Site Assessments (ESAs) to identify areas of concern where historical land use might have resulted in contamination (Bartol, 2004). These ESAs addressed both point and non-point sources of contamination. Point sources investigated included pump stations; petroleum storage tanks; pesticide storage, dispensing, mixing, loading, and rinsing areas; vehicle maintenance areas; landfills and other waste disposal sites. Non-point sources were farm fields where pesticides were applied. The ESAs designated 178 Areas of Concern which were investigated. These assessments led to removal of 24,000 tons of contaminated soil and 20,000 tons of solid waste. Results of an environmental risk assessment (RA) completed in 1997-98 (Atra, 1997; Atra, 1998) indicated that the soil pesticide residues in farm fields resulting from pesticide applications did not present an acute toxicity risk to wetland fish or wildlife. Elevated hazard quotients of dichlorodiphenyltrichloroethane (DDT) and its metabolites indicated a concern for chronic reproductive effects on piscivorous birds, but did not indicate a potential for acute lethality.

After the final crop harvest in the summer of 1998, a large portion of the NSRA was flooded as had been the standard practice at the end of the year's growing season. The fields were to be drained during the winter and alum residual was to be added as an amendment to prevent phosphorus release when restoration flooding began. The District began draining the fields in order to begin spreading the soil amendment , but the fields that remained flooded into early winter attracted large bird populations. Between November 1998 and March 1999 bird mortalities were reported on and near the NSRA, and 676 birds were eventually reported to have died in the vicinity during the winter of 1998-1999. In response, the District accelerated and completed the drainage of the NSRA to reduce the attractiveness of the area for wading birds. The fields have been kept dry since, and have become vegetated with opportunistic grasses, herb, and shrubs.

Extensive sampling and analysis of the soils and analysis of bird and fish tissues of Lake Apopka NSRA was completed by the District in response to the bird mortality episode. Upon review of the data collected, the US Fish & Wildlife Service (USFWS, 2003) concluded that OCP toxicosis caused or contributed to the deaths of many of the birds. The primary agents of toxicosis were toxaphene and dieldrin, and the primary route of exposure was from soil to fish to birds.

In response, the District together with the Natural Resource Conservation Service (NRCS), has sponsored a variety of research studies in an effort to address and solve the problems posed by the presence of OCPs for the restoration of the Lake Apopka NSRA. These activities include resolving analytical issues on the quantitation methods for toxaphene (Richter and Schell, 2003);

a tilling demonstration project (Bartol, 2004); biodegradation studies (Ogram and Chang, 2004; Clark and Chen, 2003); micro- and meso-cosm studies to better define exposure pathways and rates for piscivorous birds (Coveney *et al*., 2003; Gross *et al*., 2003; Marzolf *et al*., 2003); and this FS. These studies have led to a better understanding of the distribution of OCPs in the soils of the NSRA, the cause of the bird mortality event, and improved estimates of levels of OCPs that may contribute to adverse effects on piscivorous birds if soils were to be re-flooded. At this time, however, acceptable levels of OCPs in soils of lands planned to be re-flooded have not been precisely defined, nor accepted by all stakeholders.

1.2 Identification of Contaminants of Potential Concern (COPCs)

The USFWS (2003) identified OCPs as the COPCs at the site. The extensive sampling effort has revealed that toxaphene and dichlorodiphenyldichloroethene (DDE) are the most prevalent COPCs followed by dichlorodiphenyldichloroethane (DDD), dieldrin, DDT, chlordane compounds, and endosulfan II. Table 1-1 presents a summary the frequency of detection for all OCPs in ZDWCD Units 1 and 2, where 629 field surface soil samples were collected in a 9,000 acre area, i.e., at a density of approximately 1 sample per 15 acres. The percentage presented is the ratio of the number of detections to the total number of samples (629) considered.

Table 1-1. Summary of the Frequency of Detection of OCPs in Surficial Field Soils in ZDWCD Units 1 and 2

Contaminant	# of Samples	% detected
4,4'-DDD	629	82%
4,4'-DDE	629	99%
4,4'-DDT	629	66%
aldrin	629	0%
alpha BHC	629	0%
alpha chlordane	629	60%
beta BHC	629	0%
delta BHC	629	0%
dieldrin	629	67%
endosulfan I	629	0%
endosulfan II	629	37%
endosulfan sulfate	629	1%
endrin	629	0%
endrin aldehyde	629	3%
endrin ketone	629	0%
gamma BHC (lindane)	629	0%
gamma chlordane	629	46%
heptachlor	629	0%
heptachlor epoxide	629	9%
methoxychlor	629	0%
toxaphene	621	93%

Source: SJRWMD, 2004.

Prepared by/Date: MLJ 7/15/04

Checked by/Date: WAT 7/15/04

Of the detected OCPs, endosulfan II has the lowest bioaccumulation potential as indicated by its octanol/water partition coefficient (Jones, *et al.*, 1997). Endosulfan II also has a limited ecotoxicity data base (Jones, *et al.*, 1997). Therefore it has not been identified as a critical COPC.

Conrow *et al.* (2003), Lowe *et al*. (2003), Gross *et al*. (2003), Mackay and Gard (2003), Mackay (2003), indicate that toxaphene, DDT and its metabolites, and dieldrin are the chemicals most likely to have contributed to the bird mortality event.

District and USFWS are currently evaluating impacts in the Duda Farms parcel, which was re-flooded in 2002, by comparing biological tissue concentrations of DDE, DDTx, total chlordane, dieldrin, and toxaphene to toxicologically relevant benchmarks, and this selected list of OCPs are evaluated further as COPCs in this FS. This subset of OCPs represent the greatest risk at the site due to their frequency of detection and toxicity. Whereas most remedial actions evaluated in this FS will have similar, if not identical, effect on all the OCPs, evaluation of actions that mitigate the risk of an adverse effect caused by this subset of OCPs is likely to similarly mitigate risks associated with all the COPCs. The validity of this assumption must be tested later in the process of implementation of remedies, for example during restoration design, implementation, confirmation sampling, and follow up monitoring actions.

1.3 Nature and Extent of Contamination

In response to the bird mortality event, the District, in coordination with USFWS, initiated an extensive soil sampling effort to determine the nature and extent of contamination in the NSRA. The primary sampling strategy to determine the distribution of contaminants in the areas where pesticides were applied was stratified random sampling. This procedure achieves an approximately uniform spatial density of samples, while avoiding the potential to systematically sample recurring features, such as canals, canal banks, field ends, or certain soil types. Sampling methods were described by Marzolf *et al*. (2003).

OCP concentration distribution with depth was also investigated by a lesser number of soil borings, referred to as soil profile investigations. Several hypotheses regarding the potential factors affecting contaminant distribution were investigated by special targeted sampling programs. In addition, interlaboratory comparisons were performed on a split soil sample when it was observed that different laboratories were returning substantially different results for OCPs in bird tissue split samples. These interlaboratory differences were most pronounced for toxaphene. Results of these various investigations are summarized here (see also Marzolf *et al*. 2003, and Marzolf, 2004).

Marzolf *et al.* (2003) reported that OCP concentrations in the NSRA were significantly correlated with total organic carbon (TOC) content of the soil. This is important because organic carbon tends to bind the OCPs to the soil and limit migration potential and bioavailability. The organic carbon content of the former muck farms soils are very high, averaging 36% in Units 1 and 2.

Rouhani and Wild *(2000)* determined, using geostatistical techniques, that there was little evidence of spatial patterns in the data. There was no evidence of a gradual or predictable gradient in concentration “radiating” from common source areas, or varying with latitude, longitude, or topography. On the other hand, distinct fields with common prior ownership exhibited relatively homogeneous OCP concentrations, but the concentrations within a field could be distinctly different from that of an adjacent field previously owned by a different farmer.

The District investigated hypotheses that canals or canal banks may have higher concentrations than the “ambient” farm fields, but found this was not the case. In addition to the stratified random samples of the farm fields, additional samples were intentionally sited in canals and along canal banks – approximately 1 canal sample and 1 bank sample for every 10 ambient field samples. These data show that canal sediments, and canal bank sediments tended to have slightly lower concentrations of OCPs than the adjacent farm fields (Marzolf, 2004).

It had also been hypothesized that the ends of fields, where tractors would have to turn, might receive a greater load of pesticide than the center of the field. This hypothesis was investigated by targeting a number of samples (approximately 1 “field end” sample for each 13 “ambient field” samples) near the boundaries of fields where farm vehicles would turn. This “field end” subset of samples did not have significantly different concentrations of OCPs when contrasted with the ambient field samples. Therefore, for subsequent evaluation of farm fields, the “field end” samples have been combined with “ambient field” samples.

In addition, a series of depth profiles were collected to determine the distribution of OCPs with depth in the soil profile. Figures 1-2 and 1-3 illustrate typical depth profiles for DDTx and toxaphene, respectively for site ZNS0116. Typically, the 1 to 2 ft interval has approximately 0.1 the concentration observed in the upper foot (0-1 ft interval) of the profile, with the 2 to 3 ft interval containing only approximately 3% of the upper 1 ft. Approximately 90% of the OCP mass is in the 0-1 ft interval of the soil profile.

Applying the findings of Marzolf *et al*. (2003) and Marzolf (2004) it is concluded that the FS evaluation should be based on the OCP concentrations in fields and field ends from the upper 1 ft of the soil profile. Justifiably, these data conservatively represent most of the area of the NSRA. Further it is concluded that each field as identified by previous owner, represents a relatively homogeneous area that may be distinct from adjacent areas. Due to the potential for concentrated feeding by piscivorous birds, fields also represent reasonable exposure units or exposure areas. Within a field the concentration of each OCP can be reliably estimated from available data, and this represents a reasonable estimate of the concentration of OCPs that receptors may be exposed to during an acute or subchronic exposure period.

Figures 1-4 and 1-5 illustrate the distribution of toxaphene and DDTx the most prevalent COPCs by fields. Concentrations were carbon normalized prior to averaging (units are µg/kg TOC) DDTx. These figures illustrate the heterogeneous nature of OCP contamination in ZDWCD Units 1 and 2.

1.4 Conceptual Site Model

The conceptual site model (CSM) provides a framework within which the source and release mechanism, transport of contaminants, and environmental pathways of concern are identified. At this site surface soils are intended to be flooded as part of a wetland restoration. Upon flooding, OCPs in the soil may be released in the overlying water bioaccumulated by benthic macroinvertebrates that could colonize the sediments/wetland soils. Fish and shellfish may accumulate contaminants, either through contact with the overlying water or through their diet, which will include benthic organisms in close contact with the soils/sediments. Birds that eat the fish may then further accumulate and/or magnify the COPCs in their tissues, which may then cause adverse toxic effects to these piscivorous birds.

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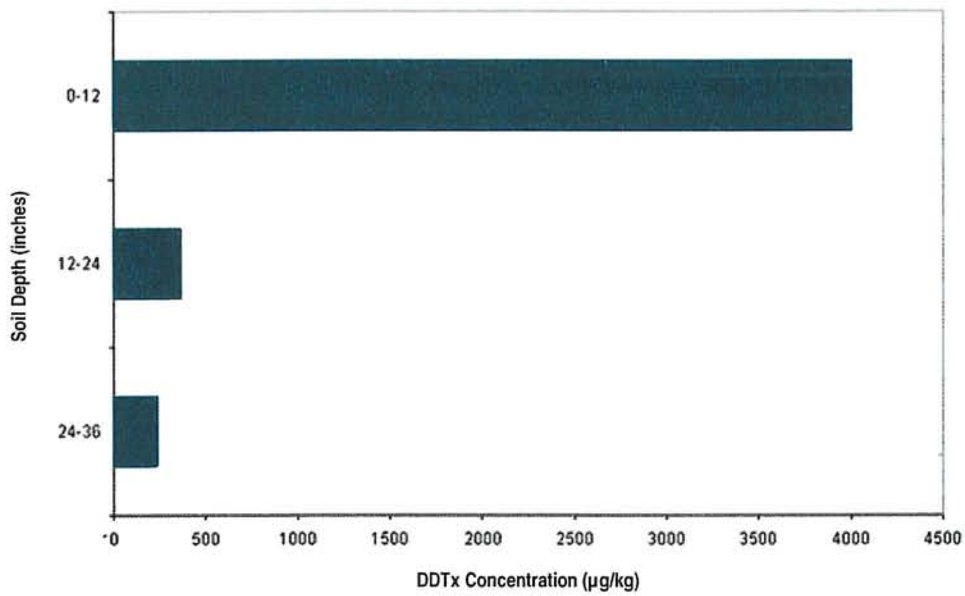
Typical Concentration Profile – DDTx Concentration at Different Soil Depths



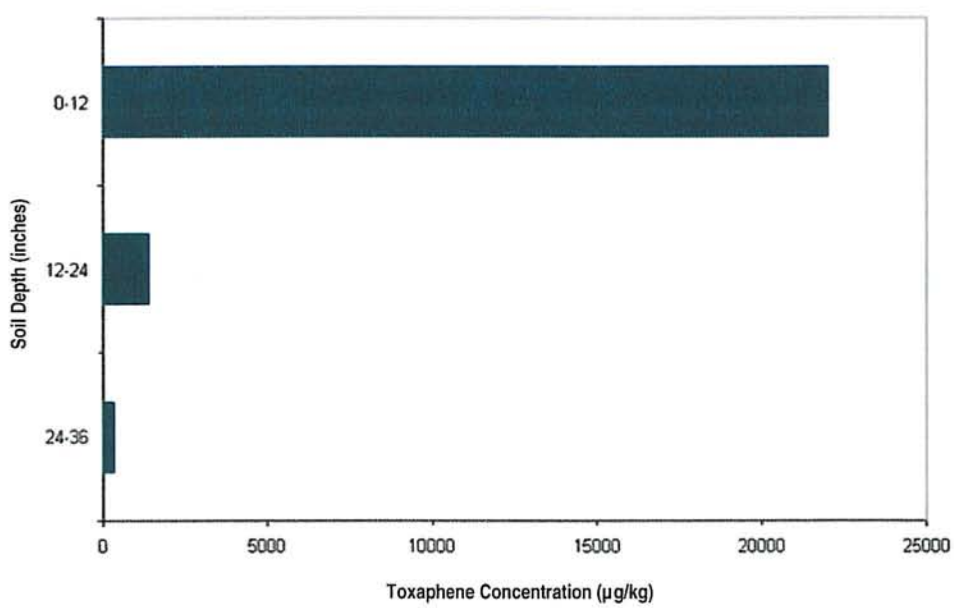
Graph generated using data from the DDTx concentration profile of Site ZNS0116

Source: MACTEC, 2004.

Prepared/Date: MLJ 7/26/04
Checked/Date: WAT 7/27/04

Lake Apopka North Shore Restoration Area SJRWMD Orange & Lake Counties, FL	MACTEC	Typical Distribution of DDTx Versus Depth in the Soil Profile (ZNS0116) PROJ. NO. 609604004 Figure 1-2

Typical Concentration Profile – Toxaphene Concentration at Different Soil Depths



Graph generated using data from the Toxaphene concentration profile of Site ZNS0116

Source: MACTEC, 2004.

Prepared/Date: MLJ 7/26/04
Checked/Date: WAT 7/27/04

Lake Apopka North Shore Restoration Area SJRWMD Orange & Lake Counties, FL	MACTEC	Typical Distribution of Toxaphene Versus Depth in the Soil Profile (ZNS0116) PROJ. NO. 609604004 Figure 1-3

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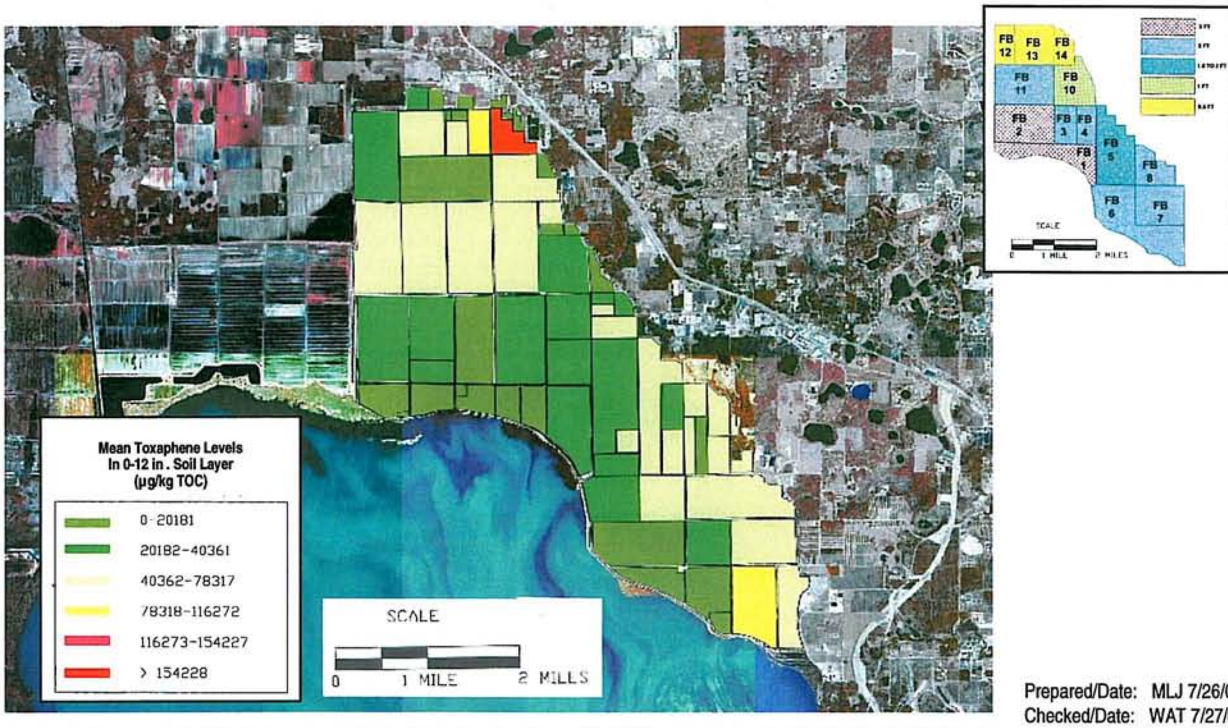
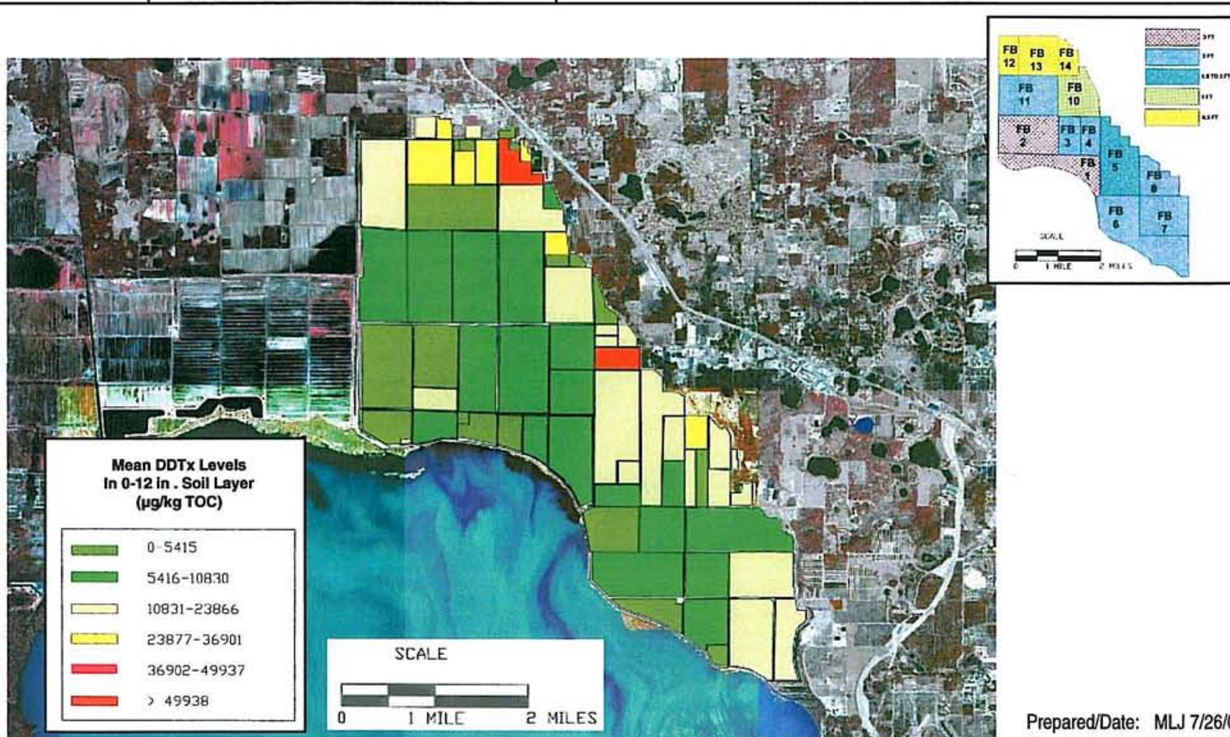


Source: SJRWMD, 2004;
MACTEC, 2004.

Prepared/Date: MLJ 7/26/04
Checked/Date: WAT 7/27/04

Lake Apopka North Shore Restoration Area SJRWMD Orange & Lake Counties, FL	MACTEC	Toxaphene Field Concentration Surface Soil PROJ. NO. 609604004 Figure 1-4



Source: SJRWMD, 2004;
MACTEC, 2004.

Prepared/Date: MLJ 7/26/04
Checked/Date: WAT 7/27/04

Lake Apopka North Shore Restoration Area SJRWMD Orange & Lake Counties, FL	MACTEC	DDTX Field Concentration Surface Soil PROJ. NO. 609604004 Figure 1-5

The primary source of COPCs at the site are the soils within 1 ft of the land surface. The planned restoration of the site would result in re-flooding these soils during part or most of the year, as a more natural hydroperiod is established for these former wetlands. When the fields are flooded, those soils will then have the features of wetland soils and/or freshwater sediments.

The contaminated soils have very high organic carbon content, averaging 36%. The OCPs are not very soluble in water, are highly lipophilic (fat-loving), and strongly adsorb to soil organic carbon. Upon flooding, the soils may be presumed to be saturated, or nearly saturated during most of the year. When sampled, primarily under a non-flooded condition, these soils exhibited an average moisture content of 52% (SJRWMD, 2004). One kilogram (kg) of soil, then, would contain 0.52 kg of water, 0.17 kg of organic carbon (0.36 kg/kg x 0.48 kg of soil) and approximately 0.31 kg of essentially inert mineral soil. For dieldrin, with an organic carbon adsorption coefficient (K_{oc}) of 2 x 10^4 L/kg (USEPA, 1996), then, 99.992% of the dieldrin in the soil is adsorbed to the organic carbon, and only 0.008% of the dieldrin mass is in the aqueous phase at equilibrium. dieldrin is the most soluble, and least lipophilic of any of the COPCs, so all the other OCPs are even more strongly bound with organic matter. This explains the immobility of these contaminants in soil, and why the contaminants are retained only in the upper 1 ft of the soil profile, the zone that has been repeatedly tilled.

These factors indicate that the chemicals of potential concern (COPCs) do not migrate effectively into the aqueous phase. Most of the uptake and accumulation by higher trophic level organisms, such as piscivorous birds, is through the food chain, which is based, in part, on benthic macroinvertebrates, filter feeders, and other organisms in intimate contact with the sediments.

Agricultural uses of some COPCs were banned prior to 1983. Specifically, use of dieldrin on food crops was banned in 1970, DDT in 1972, and chlordane in 1983 (ATSDR, 1993, 1994, 1994a, 1996). Limited uses, for example on cotton or as termiticides was permitted into the 1980s, and toxaphene use on certain crops, including corn in Florida, was allowed up until 1990, but eventually all uses of these pesticides were banned in the US. Thus their continued occurrence in soils of the NSRA is evidence of their immobility and persistence in soils. They are not readily biodegraded, although they may be biodegraded slowly under ideal conditions.

Toxaphene is reported to be quite persistent in aerobic surface soils, with reported half lives of up to 11 years. Estimates of the half life for DDT biodegradation in soil range from 2 to more than 15 years (ATSDR, 1994a). The bulk of the literature indicates that chlordane persists in soils for over 20 years in some cases (ATSDR, 1994). ATSDR (1993) provides information indicating the half life of dieldrin in soils is between 2.5 and 6 years.

All of the COPCs are semivolatile organic compounds, indicating a slight tendency to volatilize and be released to the atmosphere. Toxaphene is a complex mixture of compounds, and the fresh chemical contains some relatively volatile components. It is reasonable to assume, however, that the more volatile constituents of toxaphene have already volatized from NSRA soils to the atmosphere, and the remaining persistent components of the toxaphene mixture have low volatility. Each of the other COPCs have low degrees of volatility with Henry's Law Constants of less than 5×10^{-4} atm m^3/mol (ATSDR, 1993, 1994, 1994a, 1996), indicating limited potential to be released to the atmosphere from NSRA soils.

In summary, all the COPCs are tightly bound to soil organic carbon, with limited potential to dissolve in water or volatilize to the atmosphere. When the soils are flooded, very limited release to soil/sediment pore water, and the overlying surface water in a dissolved form is expected to occur, although the resultant low levels of contamination in surface water are likely to be undetectable. Thus, overlying water is not considered to require remediation to mitigate risk in or around the NSRA. This is why water has been excluded from this FS. For the most part aquatic biota, including benthic invertebrates, and fish are exposed via ingestion, including filter feeding, of bottom sediments or suspended sediments to which the COPCs are adsorbed and/or ingestion of contaminated prey.

Upon entry into aquatic biota, the chemicals equilibrate with the lipid (fat) reservoirs of the living organisms. Just as the COPCs tend to be strongly bound to soil/sediment organic carbon, they are also lipophilic and will accumulate in the fatty tissues of plants and animals. The COPCs then accumulate through the aquatic food chain. Some may biomagnify insofar as higher trophic level organisms may have higher concentrations of some COPCs than observed at lower trophic levels. Consequently, it is possible that the highest predators in the aquatic food web, which include piscivorous birds, may have the highest observed concentrations of these chemicals in their tissues. This bioaccumulation pathway apparently resulted in toxic exposures of piscivorous birds, including wood storks and white pelicans when the NSRA lands were flooded in 1998.

2.0 Feasibility Study Methodology

2.1 The FS Process

The development of remedial alternatives consists of developing Remedial Action Objectives (RAOs) and then identifying applicable technologies and developing those technologies into remedial alternatives to meet the RAOs. The District requires that a range of alternatives be presented in the FS and evaluated objectively.

The first step in the FS process is to develop RAOs, which are media-specific goals established to protect, in this case, the bird populations at Lake Apopka NSRA. The RAOs specify the COPCs, media of interest, and exposure pathways, and are established such that a range of alternatives can be developed to achieve the objectives. RAOs for Lake Apopka NSRA are developed considering the site investigation information provided by the District.

Once RAOs are identified, general response actions for each medium of interest are developed. General response action typically fall into the following categories:

- no action,
- containment,
- excavation,
- treatment,
- disposal, or other actions (e.g. water regime management) that, singularly or in combination, may be taken to satisfy the RAOs established for the site.

The next step in the FS process is to identify and screen applicable technologies for each general response action. This step eliminates those technologies that cannot be implemented technically. Those technologies that pass the screening phase are then assembled into remedial alternatives. It should be noted that the purpose of the FS report for Lake Apopka NSRA is not to present all the possible variations and combination of remedial actions that could be taken at Lake Apopka NSRA, but to present distinctly different alternatives representing a range of opportunities for meeting the RAOs. It is expected that these different alternatives may be adjusted during the proposed plan and decision process as additional data are accumulated, and to lesser extent during detailed design to accomplish RAOs in a manner similar to the initially proposed alternative. This FS report does not present information on alternatives that fail to meet the RAOs, except for a no action alternative, which provides a baseline for comparison of all alternatives in accordance with typical Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) FS Process.

Once remedial alternatives are identified they are uniformly compared to consistent criteria. As discussed in Section 1.0, this FS generally follows USEPA guidance. One of the important deviations from the NCP FS approach is the evaluation criteria that have been used to evaluate alternatives. The following paragraphs explain the evaluation criteria used in this FS and why these differ from those required by the USEPA at Superfund Sites.

The nine criteria stipulated by the NCP are the following:

- Overall protection of human health and the environment;
- Compliance with the Applicable or Relevant and Appropriate Requirements (ARARs);
- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility, and volume of contaminants through treatment;
- Short-term effectiveness;
- Implementability;
- Cost;
- State acceptance; and
- Community acceptance.

Compliance with ARARs is CERCLA specific. Since the NSRA is not regulated by CERCLA, this criterion is modified as discussed below, to specifically address the regulatory requirements affecting the Lake Apopka NSRA. Protection of human health is not considered a criterion under this FS because the event triggering this remediation effort was not derived from human exposure to contaminated soils or water, but by the avian mortality event. Ecological risks pose the most formidable challenges under the re-flooding/wetland restoration scenario. Human exposure potential is limited under the planned land-use scenario. The District recognizes its responsibility to protect human health from Distrcit actions associated with the restoration program but plans to address these issues by a separate risk management process. Therefore the remainder of the document addresses actions that would permit Lake Apopka restoration to proceed while mitigating risks to ecological receptors, specifically piscivorous birds. Thus the protection of the avian populations at the NSRA has replaced this criterion. The reduction of toxicity, mobility, or volume of contaminants is not a criterion used in this FS when analyzing alternatives for two reasons. First, this criterion is a requirement under CERCLA that does not apply to this FS. The second reason is that MACTEC has determined that the effectiveness of treatment can be evaluated at this site within the retained criterion of long-term effectiveness and permanence. Stakeholders' acceptance has taken the place of the State and community acceptance criteria to better reflect the involvement of the USFWS in the decision making process. Thus, the nine criteria USEPA are reduced to seven, and are modified as follows:

- Protection to the avian populations that are expected to utilize the restored Lake Apopka NSRA habitat;
- Compliance with regulatory requirements;
- Long-term effectiveness and permanence;
- Short-term effectiveness;

- Implementability;
- Cost; and
- Stakeholder's acceptance.

2.2 Remedial Considerations

Prior to establishing RAOs for Lake Apopka NSRA, several issues concerning the NSRA should be considered including regulatory requirements, and current and future land use.

Current Land Use – As a result of the bird mortality event, the north shore farming area was drained. Water is pumped from Unit 1 and 2 fields as needed, and as a result, the fields have become vegetated with upland grasses, herbs, and shrubs. The land surrounding Lake Apopka NSRA is made up of residential areas, ornamental plant farms, with sod and row crop farms across Jones Road. DISTRICT currently owns numerous parcels of land that are contiguous with the Lake Apopka NSRA.

Planned Future Land Use – Several Florida statutes, consistent with Federal law such as the CWA, have mandated restoration activities in the Lake Apopka watershed. The District is responsible for planning and implementing these restoration projects. Wetland restoration in the NSRA has been identified as a critical element for the overall restoration of Lake Apopka. The 1996 Lake Apopka Improvement and Management Act (Section 373.461, Florida Statutes 1996) determined it was in the public interest to pursue a buy-out of all the farms on the north shore of Lake Apopka and eliminate the major source of phosphorus pollution to the Lake. The Florida Legislature appointed the District as the agency responsible for implementing the buy-out program. The plan for restoration after the buy-out focused on re-flooding the farm fields and eventual elimination or breaching of the levees that separated the fields from the main body of the lake, allowing Lake Apopka to return to its historic size.

This course of action was determined following several years of research into the causes and alternatives for reversing adverse water quality trends in Lake Apopka. Therefore, the public benefits of the planned restoration are well established, and the District intends to restore as much of the NSRA to wetland habitat as is feasible and consistent with other environmental goals and requirements. The District understands, however, that years of agricultural use of the NSRA has resulted in high levels of pesticide residuals in the soils, and that these pesticide residuals caused or contributed to significant bird mortality. Consequently, wetland restoration can only proceed if the ecological risks posed by these COPCs can be mitigated and/or eliminated. Alternative actions are evaluated in this FS primarily by consideration of their effectiveness in minimizing exposure of piscivorous birds to COPCs, balanced against their implementation cost.

The District's objective is to restore as much of the NSRA to wetland habitat as is feasible, balancing the cost of remediation against the benefit of wetland restoration. This process of balancing costs and benefits could result in restoring most, but not all, of the NSRA to wetland habitat, if it is determined that cost of restoring all the habitat is unreasonable. This FS is intended to provide the District with information that can support the evaluation and balancing of costs and benefits of alternative actions. The FS retains actions that isolate excessively contaminated soils from the food chain of piscivorous birds, including alternatives that would prevent some portions of the NSRA from reverting to wetland habitat (e.g., onsite landfill).Re-flooding of portions of Units 1 and 2 is likely to occur in phases covering defined Flooding Blocks containing varying size and number of fields. Initial maximum field water depth information was provided to MACTEC by the District. Those depths reflect the District's estimate of how much water the individual flooding blocks can hold without overtopping their containment levees into neighboring fields. These depths characterize maximum flooding with the current infrastructure (roads, levees). This shallow flooding certainly would be done during an interim phase in the restoration but does not necessarily characterize the final restoration. Flooding to lake level for one or both of Unit 1 or Unit 2 is a possibility. In that case water would be much deeper than the initial flooding unit depths. Even during interim, shallow flooding, there is no absolute protection from a breach in the outer levee during high-water periods. Indeed, many of the options are dependent upon the outer levee being maintained for an extended period of time.

Where excavation of soil is discussed, it is recognized that there will be an impact on the interim and final depth of reflooding of the borrow areas. Lowering of the ground elevation is not specifically a benefit for final restoration, because flooding of excavated areas to lake levels that would create more deep-marsh habitat (4-5 feet depth) is generally considered less desireable, for example, than building up land contours beneficial to the goal of re-creating shallow marsh (2-3 foot depth).

The planned future land use places some restriction on the types of remedial alternatives that can be implemented. One important factor is the need to maintain the soil's physical structure and level of organic matter. The muck soils were formed in a wetland or lake sediment environment and their physical characteristics and levels of organic matter are conducive to re-establishing a health wetland habitat. Aggressive treatment techniques, particularly chemical oxidation technologies, may adversely affect the fertility of the soils and their ability to support their intended use. It is also likely that chemical oxidation could reduce the soil's bulk volume, since the soils contain so much organic matter, and that oxidizing this material would result in further settling of the land, which would also make it more difficult to establish a health wetland habitat.

3.0 Remedial Action Objectives

This section presents the goals and objectives for remedial action at Lake Apopka NSRA that provide the basis for selecting appropriate RAOs, and subsequently, identifying remedial technologies and developing alternatives to address contamination at the site. To establish these objectives, regulatory requirements are first identified. Next, RAOs are defined based primarily on consideration of the regulatory requirements and the CSM.

3.1 Regulatory Requirements

Regulatory requirements are used to define the appropriate extent of site remediation, identify sensitive land areas or land uses, develop remedial alternatives, and direct site remediation.

3.1.1 Chemical-Specific Regulatory Requirements

These are standards that limit the concentration of a chemical found in, or discharged to the environment, and determine the extent of site remediation by providing either actual remediation levels or the basis for calculating such levels. Chemical-specific requirements for a site may also be used to indicate acceptable levels of discharge in determining treatment and disposal requirements, and to assess the effectiveness of remedial alternatives.

The Safe Drinking Water Act (SDWA) does not apply since no groundwater or surface water, used for potable supply has been adversely affected.

FDEP soil cleanup target levels (SCTL) are not applicable to the site due to exemptions for agricultural use of pesticides, and because they are not relevant under the planned future land use, which is neither residential nor commercial/industry.

The Endangered Species Act, the Migratory Bird Treaty Act (MBTA), and/or the Bald and Golden Eagle Protection Act (BGEPA) apply, given that the remediation of Lake Apopka NSRA was triggered by the bird mortality event.

The Endangered Species Act (Section 9, 16 U.S.C. § 1538) prohibits harming, wounding, killing any endangered species of fish or wildlife within the US or the territorial sea of the US. Harm is defined [50 Code of Federal Regulations (CFR) § 17.3] as: "an act which actually kills or injures wildlife. Such act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering." Such actions may be permitted for projects in the public interest, but only after consultation with USFWS which may result in a permit.

The MBTA contains similar language, but extends protection to a larger number of species, including all birds that died during the bird mortality event. The MBTA does not include comparable language preventing "harm", and incorporates different standards of liability and penalties.

The USFWS determined that both these laws had been violated by the District, but agreed not to pursue criminal or civil penalties when the District entered into an agreement [Memorandum of Understanding (MOU)] with USFWS to provide compensation for the adverse effects and agree to a process of consultation for future restoration projects.

The consultation provisions of the MOU have led to establishment of criteria for fish tissue and bird egg tissue concentrations of COPCs that have been accepted by the District as a trigger for consultation with USFWS for the Duda Farms re-flooding component of the NSRA restoration (USFWS, 2002). These levels represent tissue concentrations that may be associated with adverse toxicological effects in piscivorous birds, and are presented in Table 3-1.

Table 3-1. Biological Tissue Trigger Levels

Contaminant	Fish Tissue (mg/kg, wet weight)	Bird eggs (mg/kg, wet weight)
total chlordane	0.29	1.5
DDTx	3.6	3.0
dieldrin	0.69	3.0
toxaphene	4.3	--

Source: USFWS 2002.

3.1.2 Location-Specific Regulatory Requirements

The District must balance potentially conflicting regulatory requirements affecting the site. Several Florida statutes, including laws intended to implement provisions of the federal CWA, have mandated restoration activities in the Lake Apopka watershed, and specifically in the NSRA. The District is responsible for planning and implementing these restoration projects. The Lake Apopka Improvement and Management Act (Section 373.461, Florida Statutes 1996) determined it was in the public interest to buy the farms in the NSRA to eliminate the major source of phosphorus pollution to the Lake. This course of action was determined based on extensive research into the causes and alternatives for reversing adverse water quality trends in Lake Apopka. Therefore the public benefits of the planned restoration are well established, and the District has been directed by the State of Florida to restore as much of the NSRA to wetland habitat as is feasible and consistent with other environmental goals and requirements.

The District understands, however, that years of agricultural use of the NSRA has resulted in pesticide residuals in the soils, and that the pesticide residuals contributed to mortality of birds, including birds protected by the Endangered Species Act and the MBTA. Consequently wetland restoration can only proceed if the risks posed by these pesticides can be mitigated and/or eliminated.

These requirements govern site features (e.g., wetland, floodplains, wilderness areas, and endangered species) and man-made features (e.g., places of historical or archeological significance). These requirements place restrictions on concentration of hazardous substances or the conduct of activities based solely on the site's particular characteristics or location.

There are no identified historical or archeological sites of significance at Lake Apopka NSRA. However there are migratory birds and endangered species that have used this area (when flooded) as roosting and feeding grounds. Thus the Endangered Species Act, the MBTA and the BGEPA do apply. Dredge and fill permitting requirements of Section 404 of the CWA are location-specific requirements that may apply to some of the remedial alternatives. Their requirements are coordinated with Florida DEP requirements by use of a single permitting package, the Environmental Resource Permit administered by Florida Department of Environmental Protection (FDEP) and the USACE.

The Disrtict also has a Thrity-Year Lease Easement Deed (Bott, 1996) with the Natural Resources Conservation Service (NCRS). It is assumed that implementation of remedial alternatives and post-treatment land use will be required to comply with the provisions of this document as to access and use.

3.1.3 Action-Specific Regulatory Requirements

These requirements are technology or activity based regulations that control activities for remedial actions. Action-specific regulatory requirements generally set performance or design standards, control, or restriction on particular types of activities. To develop technically feasible alternatives, applicable performance or design standards will be considered during the detailed analysis of remedial alternatives. Action-specific requirements for the potential actions include performance standards for water control structures, administered by the District. Dredge and fill permitting requirements, previously introduced in Section 3.1.2, are not only location-specific, but also action-specific.

3.2 Identification of RAOs

RAOs are media-specific goals that are established to the bird populations that have, or will adopt Lake Apopka NSRA as their habitat. Alternatives will be evaluated primarily by their ability to achieve the water quality and wetland restoration objectives of the Lake Apopka restoration program while preventing exposure of migratory and/or threatened and endangered bird species to concentrations of COPCs that will result in adverse toxicological effects. The remedial actions must be evaluated not only in the context of preventing adverse toxicological effects to birds, but also their effectiveness in supporting the Lake Apopka restoration program.

The overriding RAO is to prevent exposure by migratory and/or threatened and endangered bird species to levels of COPCs that can produce adverse toxic effects. Based on the CSM (COPCs from soil/sediments to fish to birds), it is possible to disrupt the exposure pathway in several ways as expressed by the RAOs:

- Minimize contact of surface water with soils containing COPCs exceeding the soil remediation target levels provided in Table 3-1, Section 3.3;
- Prevent/minimize establishment of fish populations in surface waters in contact with soil/sediments exceeding the soil remediation target levels provided in Table 3-1, Section 3.3;
- Prevent/minimize birds from foraging in areas where sediments exceed the soil remediation target levels provided in Table 3-1, Section 3.3.

Virtually all of the remedial action alternatives evaluated are directed to achieve the first of these three objectives, with the third alternatives addressed indirectly. It may be possible, however, to interdict the exposure route in other ways, so the alternative RAOs are articulated here. Second and in particular, manipulation of water level depths and/or duration and timing may be useful in achieving either of the latter two RAOs.

The soil quality assessment revealed that approximately 90% of the contamination is limited to the 0 to 1 ft interval. Soils more than 1 ft below ground surface present limited exposure potential to piscivorous birds. Consequently, no RAO will be established for subsurface soil, and the aforementioned objectives apply to surface soil, defined as the upper foot of the soil/sediment profile.

3.3 Action and Target Levels

Action levels, or the concentration of contaminants above which remedial action would be necessary, are defined in this sub-section. The information presented in this section will be used to identify appropriate remedial technologies for the NSRA in Section 4.0, and an evaluation of those alternatives is presented in Section 5.0.

Action levels are the concentration of contaminants in media (in this case soil) above which remedial action or control would be necessary to meet the RAO. Action levels are identified here for soil because the RAO established for the NSRA relate only to this medium. The soil/sediment action levels are based on the CSM, and the biological tissue trigger levels presented in Table 3-1.

The District has conducted, and continues to conduct scientific research on the relationship between soil/sediment concentrations of COPCs and the concentration of the COPCs in fish and bird tissues. The District has applied the best information available at this time to estimate soil/sediment concentrations expected to be associated with the fish and bird tissue trigger concentrations that are in use to monitor the Duda Farms restoration (see Table 3-1). The estimated soil/sediment concentrations represent the District's best estimate of concentrations of COPCs in soil/sediments of the NSRA that are likely to be acceptable to USFWS and, if achieved in NSRA soils, would permit re-flooding of parcels in the NSRA without significant risk to piscivorous birds, or other potential receptors. These concentration targets are preliminary and subject to change. This set of target ranges in soil was developed by the District in order to guide the evaluation of this FS for possible remediation technologies for OCPs. The best estimate target level (BETL) were calculated from trigger values in fish tissue provided to the District by USFWS in their consultation on the former Duda farm (Coveney, 2004b). The conservative target levels (CTL) are one half of the BETLs and incorporate potential uncertainties that may be resolved by ongoing research. These remediation target levels are expressed as TOC normalized concentrations, and are presented in Table 3-2.

Table 3-2. Potential Soil Target Action Levels

COPC	**Soil/Sediment (mg/kg TOC)**	
	Conservative Target Level	**Best Estimate Target Level**
total chlordane	2.0	4.0
DDE	6.7	13.4
DDTx	11.3	22.5
dieldrin	2.5	4.9
toxaphene	31.6	63.2

Source: Coveney, 2004b.

The selection of criteria was established being aware of potential uncertainties in effects levels and bioaccumulation potential of the COPCs, which is the reason that a range has been presented. It is possible that the final target level will only be defined by re-flooding specific parcels and monitoring the accumulated concentrations in biological tissue, and by this process fine-tuning the contaminant levels that may be present in re-flooded lands without adverse ecotoxicological effects. This experimental approach has been initiated by monitoring conducted on the Duda Farms property that was re-flooded in 2002. On that parcel, concentrations of toxaphene in fish tissue have consistently been less than the target level of 4.3 milligram per kilogram (mg/kg), wet weight. Specifically, the maximum concentration that has been observed in fish tissue samples since 2002 has been 1.0 mg/kg, while the average concentration has been approximately 0.40 mg/kg. Thus, average concentrations of toxaphene in fish tissue have been approximately 10% of the toxaphene trigger level for fish. Likewise, the carbon normalized surface soil concentration of toxaphene in the re-flooded area averaged approximately 11 mg/kg TOC prior to re-flooding, which is about 17% of the BETL from Table 3-2, which in turn is based on the District's best estimate bioaccumulation factors relating fish tissue to soil/sediment. These results suggest that the District bioaccumulation factors are consistent with full scale re-flooding results, and thus that the BETLs are more accurate than the CTLs, which are one half of the District's best estimate. Figures 3-1 through 3-10 contain maps of concentrations of each of the COPC concentration as the ratio of the carbon normalized OCP concentration to the potential remediation target levels. Figures 3-1 and 3-2 illustrate the ratio of the concentration of carbon normalized concentrations of chlordane to the BETL and CTL, respectively. Each succeeding pair of figures provides a comparison by COPC versus BETL and CTL goals. Where the field concentration is shown as either light or dark green, no remedial action is required. Comparing each pair of COPC maps shows the difference in acreage requiring remediation is very sensitive to the target levels determined to be protective.COP concentration to the CTL.

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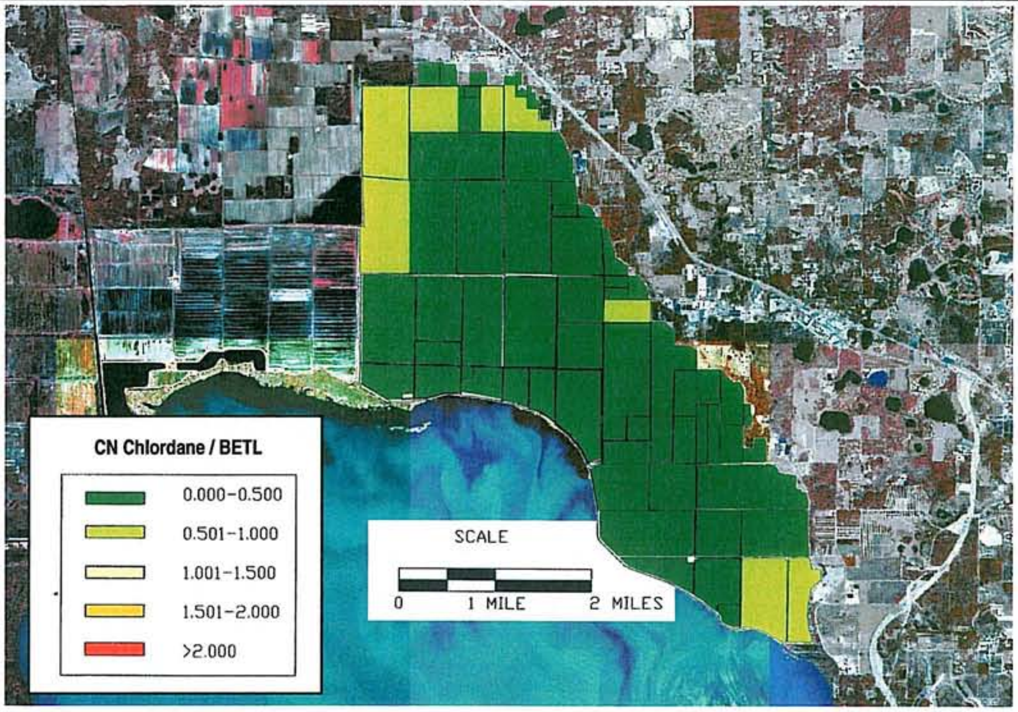

Source: SJRWMD, 2004; MACTEC, 2004.

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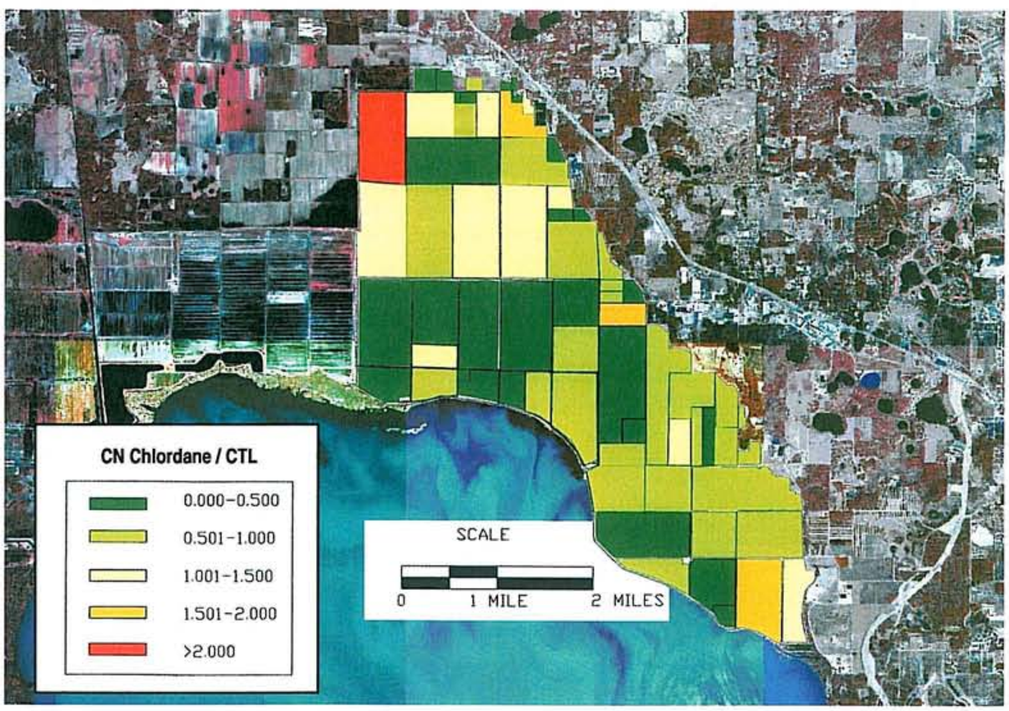
Lake Apopka North Shore Restoration Area SJRWMD Orange & Lake Counties, FL	MACTEC	Carbon-Normalized Chlordane / BETL PROJ. NO. 609604004 Figure 3-1



Source: SJRWMD, 2004; MACTEC, 2004.

Prepared/Date: MLJ 9/9/04
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Lake Apopka North Shore Restoration Area SJRWMD Orange & Lake Counties, FL	MACTEC	Carbon-Normalized Chlordane / CTL PROJ. NO. 609604004 Figure 3-2

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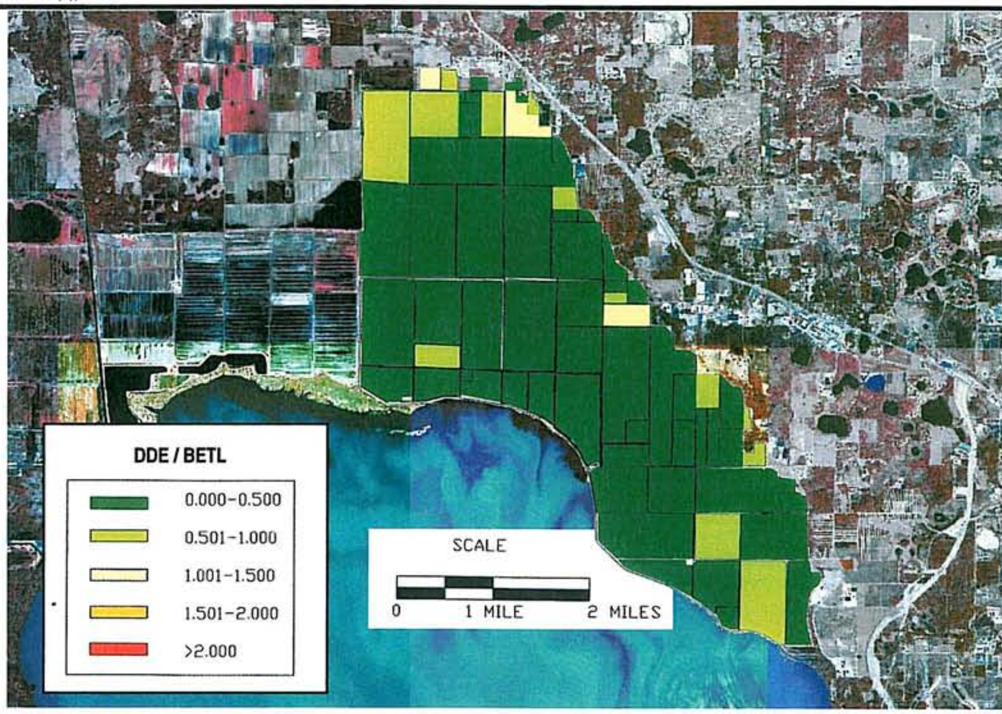

Source: SJRWMD, 2004; MACTEC, 2004.

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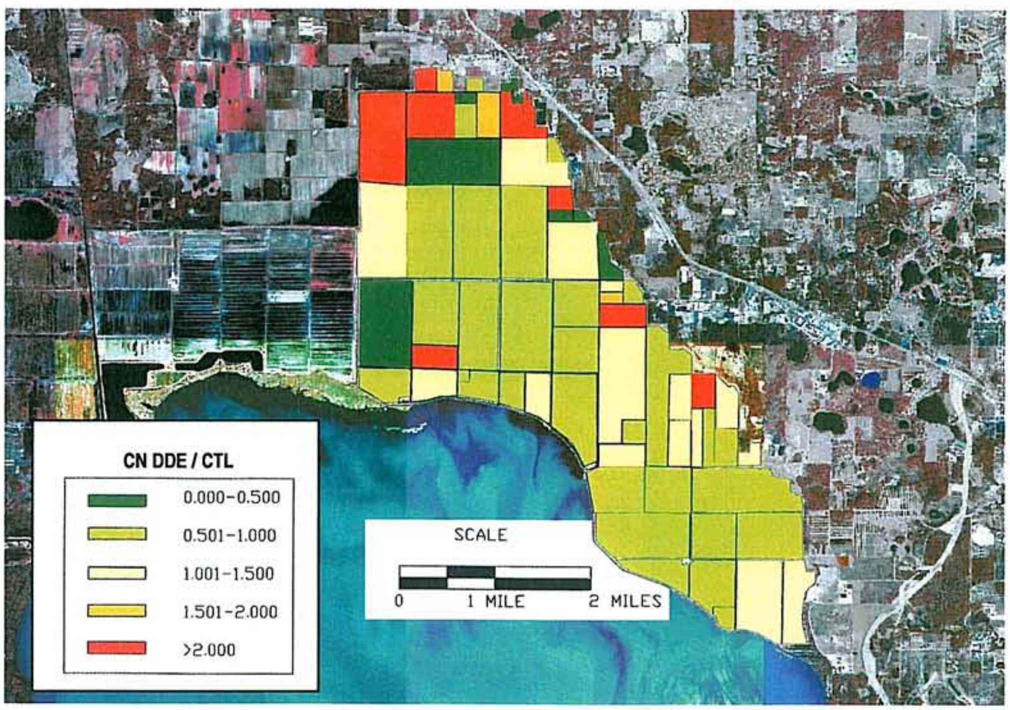
Lake Apopka North Shore Restoration Area SJRWMD Orange & Lake Counties, FL	MACTEC	Carbon-Normalized DDE / BETL PROJ. NO. 609604004 Figure 3-3



Source: SJRWMD, 2004; MACTEC, 2004.

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Lake Apopka North Shore Restoration Area SJRWMD Orange & Lake Counties, FL	MACTEC	Carbon-Normalized DDE / CTL PROJ. NO. 609604004 Figure 3-4

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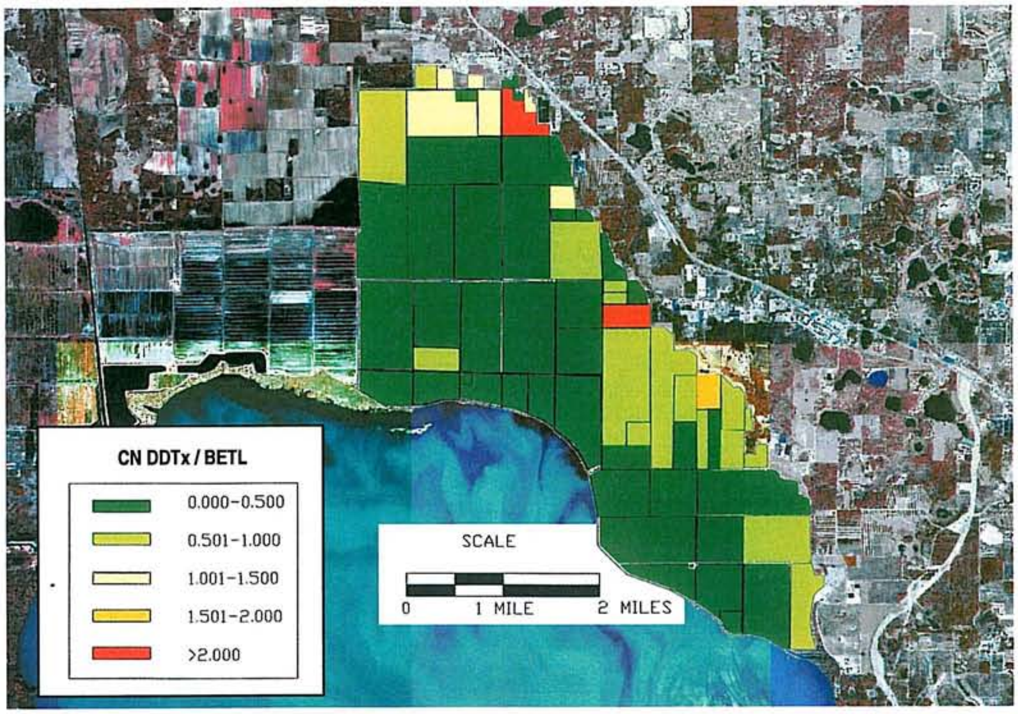

Source: SJRWMD, 2004; MACTEC, 2004.

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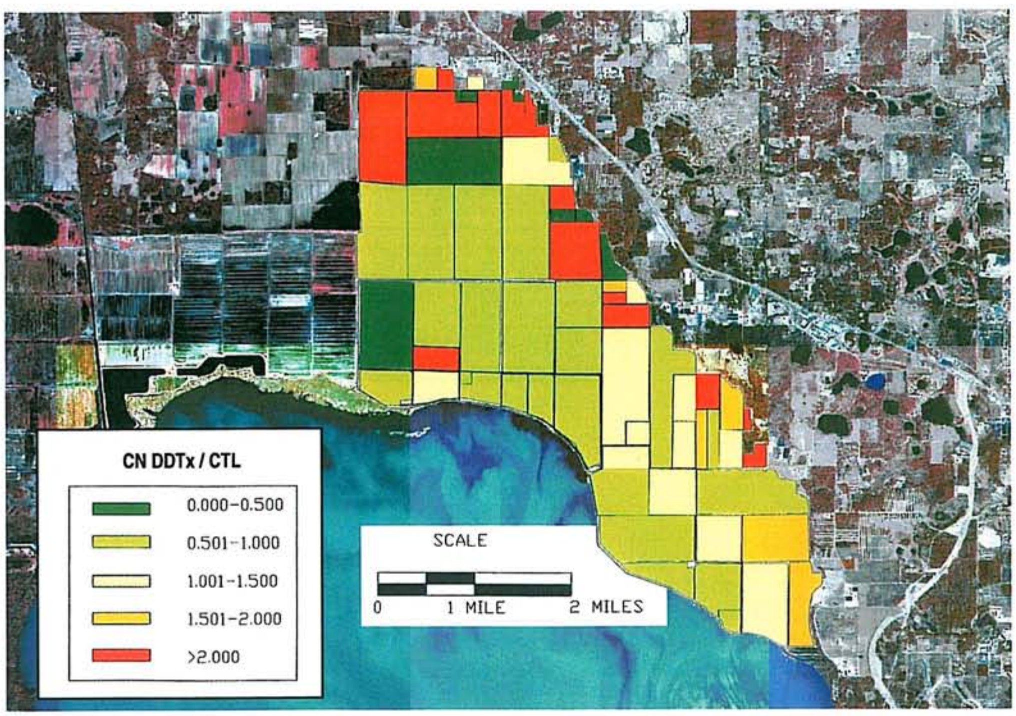
Lake Apopka North Shore Restoration Area SJRWMD Orange & Lake Counties, FL	MACTEC	Carbon-Normalized DDTx / BETL PROJ. NO. 609604004 Figure 3-5



Source: SJRWMD, 2004; MACTEC, 2004.

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Lake Apopka North Shore Restoration Area SJRWMD Orange & Lake Counties, FL	MACTEC	Carbon-Normalized DDTx / CTL PROJ. NO. 609604004 Figure 3-6

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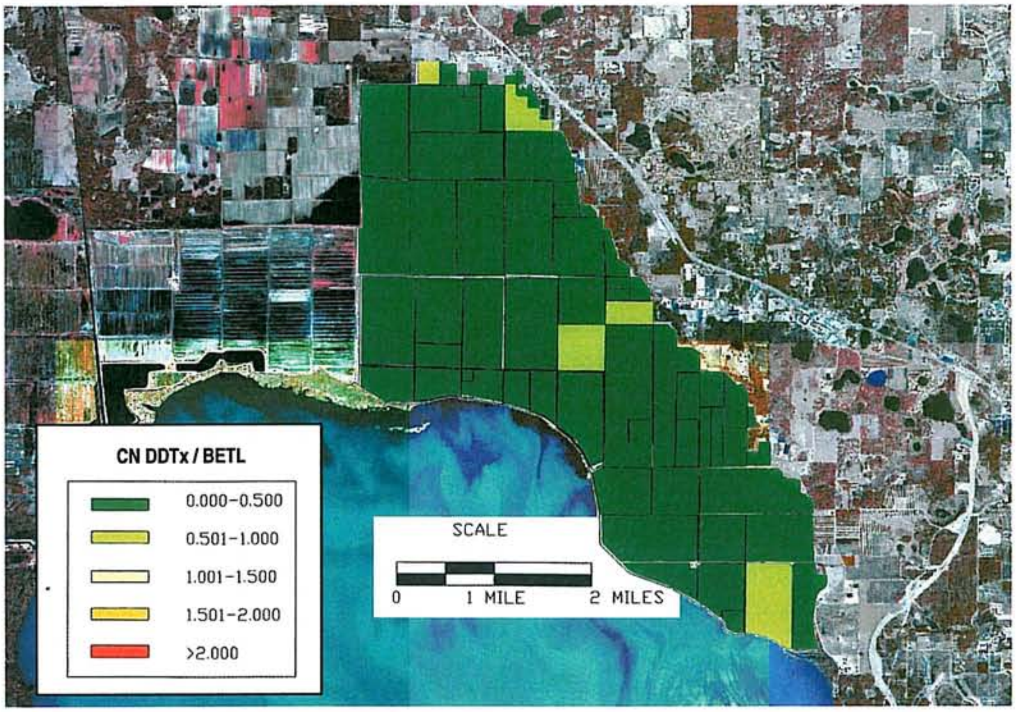
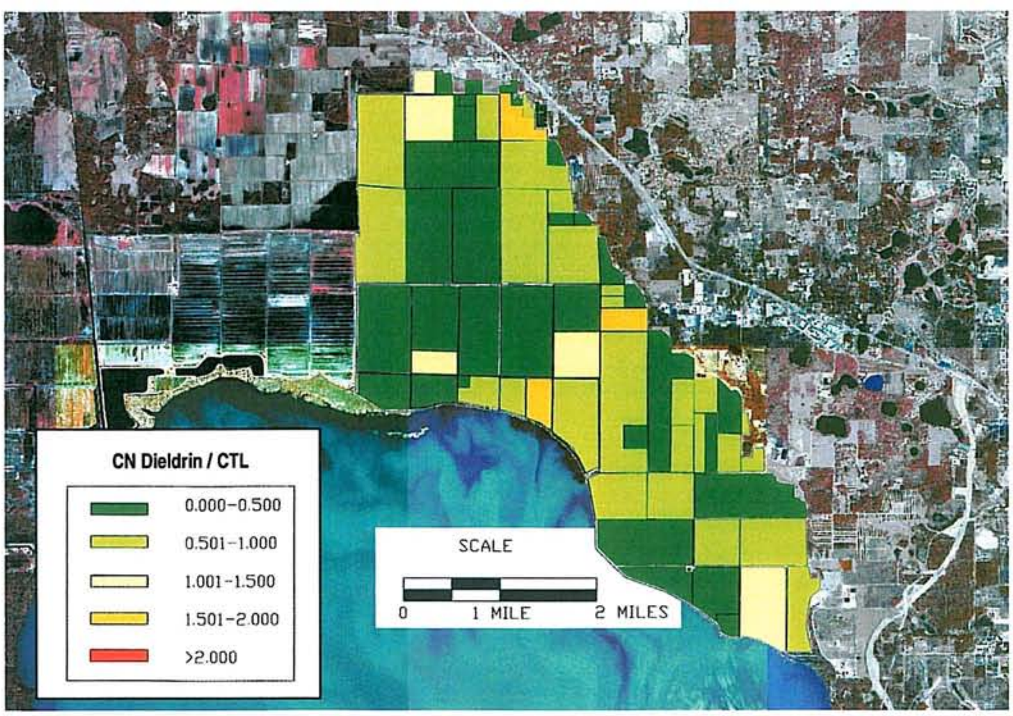


Source: SJRWMD, 2004;
MACTEC, 2004.

Prepared/Date: MLJ 9/9/04
Checked/Date: WAT 9/9/04

Lake Apopka North Shore Restoration Area SJRWMD Orange & Lake Counties, FL	MACTEC	Carbon-Normalized Dieldrin / BETL PROJ. NO. 609604004 Figure 3-7

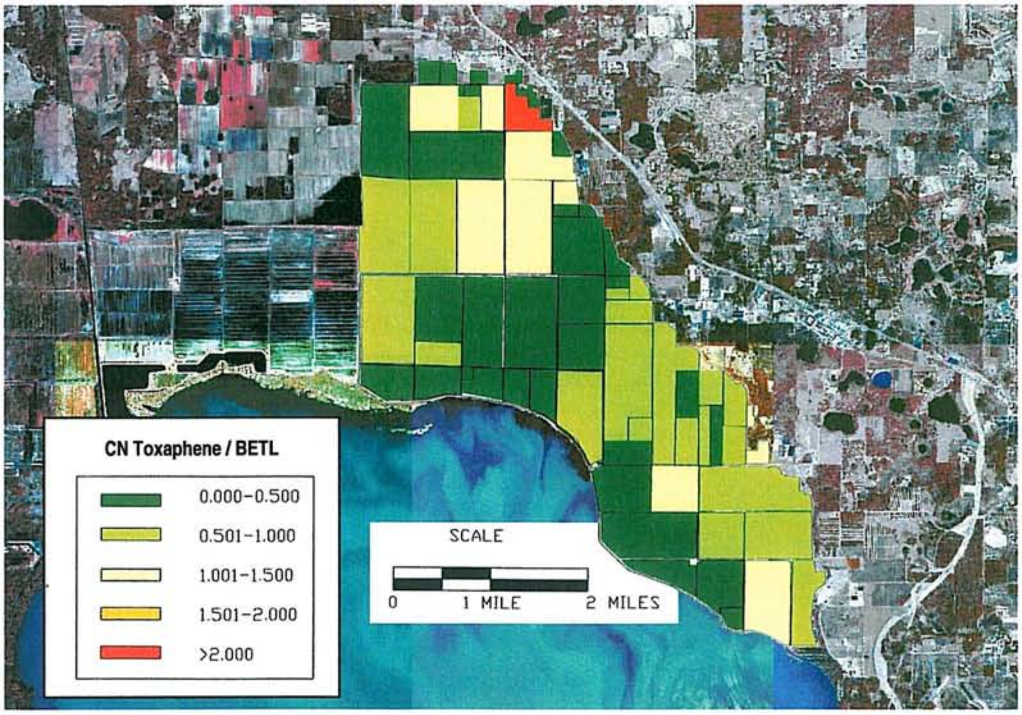


Source: SJRWMD, 2004;
MACTEC, 2004.

Prepared/Date: MLJ 9/9/04
Checked/Date: WAT 9/9/04

Lake Apopka North Shore Restoration Area SJRWMD Orange & Lake Counties, FL	MACTEC	Carbon-Normalized Dieldrin / CTL PROJ. NO. 609604004 Figure 3-8

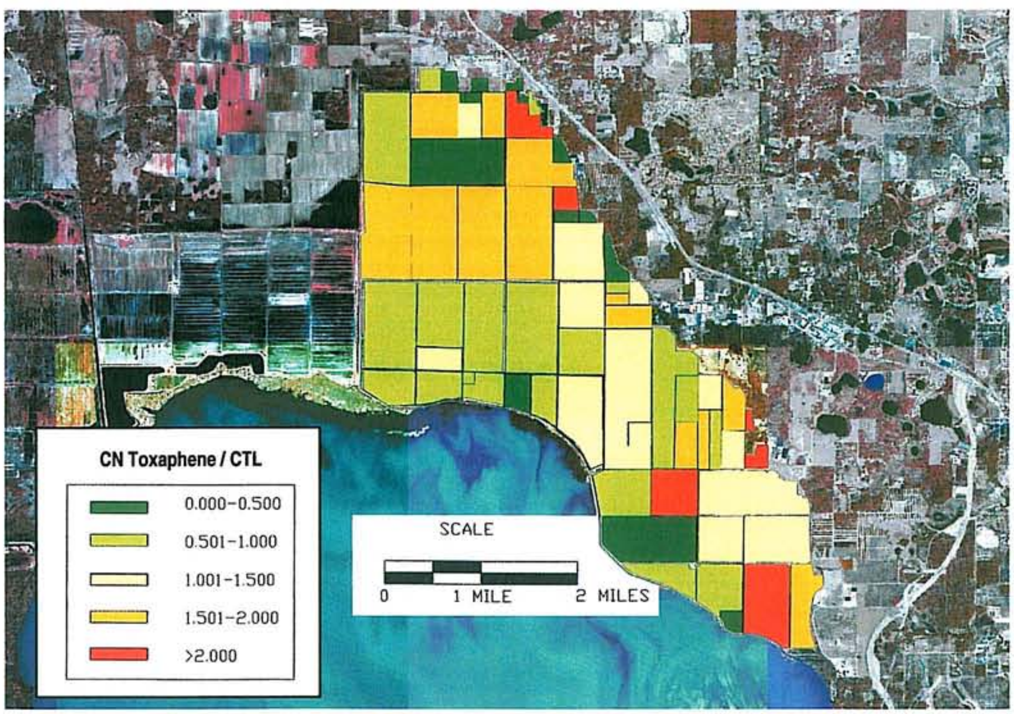
p:\eeg\2004\projects\sjrwmd apopka fs\report\figures\new flood zone maps.ppt 09 04 CH



Source: SJRWMD, 2004; MACTEC, 2004.

Prepared/Date: MLJ 9/9/04
Checked/Date: WAT 9/9/04

Lake Apopka North Shore Restoration Area SJRWMD Orange & Lake Counties, FL	MACTEC	Carbon-Normalized Toxaphene / BETL PROJ. NO. 609604004 Figure 3-9



Source: SJRWMD, 2004; MACTEC, 2004.

Prepared/Date: MLJ 9/9/04
Checked/Date: WAT 9/9/04

Lake Apopka North Shore Restoration Area SJRWMD Orange & Lake Counties, FL	MACTEC	Carbon-Normalized Toxaphene / CTL PROJ. NO. 609604004 Figure 3-10

3.4 Method of Summarizing the Available Data in Context of the RAOs and Remedial Alternatives

A procedure was developed to allow a robust evaluation of alternatives consistent with the nature and extent of contamination, biogeochemical characteristics of the COPCs, the exposure mechanisms as represented by the CSM, uncertainty regarding the distribution of contaminants, uncertainty regarding the final remediation criteria, and features/effectiveness of one or more of the retained technologies. This procedure is unique to the problem at hand.

It has been determined that although concentrations of OCPs may vary substantially from field to field, concentrations within a field (as described by owner and alum block) are relatively homogeneous, and therefore may be reliably estimated with a small number of samples. It was also determined (Marzolf, 2004) that ambient and field end samples characterize most of the area within the NSRA conservatively (canal sediments and canal bank sediments may have somewhat lower concentrations, but canals make up a small part of the total area). In addition more than 90% of the contaminant mass is found within the upper foot of the soil profile, and the COPCs are not mobile due to their chemical properties and the high organic content of the soils. Procedures for summarizing exposure concentrations also consider that exposure may be affected, to some extent, by the tendency for piscivorous birds to concentrate their seasonal feeding in relatively small areas if food is plentiful. Therefore it would be inappropriate to estimate exposure averaged ("diluted") over the entire NSRA. Consequently the field is an appropriate exposure area. Therefore, surface soil samples grouped within fields are an appropriate unit for estimating exposure and evaluating actions in the context of the Remedial Action Objectives for Units 1 and 2 of the NSRA.

It has also been shown that the COPCs are strongly associated with soil organic carbon, such that exposure by piscivorous birds is expected to be directly related to the soil concentration after normalization by soil organic carbon content (i.e., the concentration of contaminant per mass of soil organic carbon). This quantity is expected to be directly related to exposure and bioaccumulation potential of the COPCs.

Further, because it has been shown that concentrations of OCPs are correlated with soil organic carbon content, the carbon normalized concentration is expected to exhibit less relative variance than the dry weight concentrations, and therefore can be estimated with greater precision from monitoring data.

Carbon normalization and grouping data by fields substantially reduces the uncertainty in estimating exposure. However, uncertainty remains, not only in the exposure concentrations (for example, some fields are characterized by only one sample, many by less than 10), but also in understanding the allowable exposure concentration. These potential uncertainties are accounted for by the following procedure developed to support the detailed evaluation of alternatives for this FS, and these uncertainties may be reduced by subsequent investigations.

To accommodate the various aspects of this restoration project, the following procedure was developed to summarize, sort, and characterize site data:

1. Concentrations of OCPs were normalized to the organic carbon content of the soil prior to any further manipulation. When calculating the average and the UCL95, OCP concentratrions coded with "U" (compound analyzed but not detected), were included in the calculations at one half of the detection limit reported.
2. By field, both a best estimate exposure concentration (average) and a reasonable maximum exposure concentration [e.g., 95% upper confidence limit of the mean (UCL95)] were calculated from the carbon normalized data.
3. All ambient and field end data from the upper 1 ft depth interval were used to calculate these estimated exposure concentrations.

When calculating both the average and the reasonable maximum exposure concentration, it was assumed that the carbon normalized OCP concentrations by field were normally distributed. This was subsequently spot-checked, and found to be a reliable assumption for most of the data sets. The standard student's t method, appropriate for normally distributed data, was used to estimate the UCL95. The reasonable maximum exposure concentration was taken as the lesser of the UCL95 or the maximum concentration, by field.

Whereas there is still remaining uncertainty in the concentrations that can be left in place without significant adverse effects on piscivorous birds, a range of possible concentration reductions were considered. At the least, the average concentration must be less than the BETL (Table 3-2). At the worst case, the reasonable maximum concentration may need to be reduced to the CTL. This latter case would represent the most extensive and costly level of remediation that may be required. The true level of remedial activity, per field, may be within the range bracketed by these extreme assumptions.

The best estimate and reasonable maximum exposure concentrations estimated for each contaminant of concern, by field, are provided in Appendix A, which also provides the percent reductions required to achieve the alternate criteria.

4.0 Remedial Action Alternatives

The approach and rationale leading to the development of remedial alternatives are presented in this section. The development of remedial alternatives consists of identifying applicable technologies, screening the identified technologies, and using the selected technologies to develop remedial alternatives that accomplish the identified RAOs. For the NSRA, remedial alternatives will be developed for surface soil because this is the only medium identified previously as posing a risk to the avian populations.

The primary goal of alternative development for the NSRA is to provide alternatives that will significantly reduce the risk of another episode of avian mortality when the NSRA is restored to flooded wetland use.

The remaining subsections identify types of technologies that contribute to achieving the RAOs, evaluate the select representative technologies for each technology type, and develop remedial alternatives using the selected technologies. A detailed evaluation of the remedial alternatives is presented in Section 5.0.

General response actions describe potential medium-specific measures that may be employed to address the RAOs. Potential response actions for the NSRA are developed for soil and are discussed in more detail in Section 4.2. These response actions include no action, limited action, containment, or isolation, *in situ* treatment, and *ex situ* treatment.

4.1 Identification of Screening and Remedial Technologies

In this section, traditional and innovative technologies have been researched and categorized according to their basic operating principle. The remedial technologies described in this section are evaluated using general criteria recommended by USEPA FS guidance which are effectiveness, implementability, and cost. Based on the results of this screening, a recommendation is made to either eliminate or retain the technology for the development of remedial alternatives.

For the remedial alternatives retained for subsequent analysis in Section 5.0 and 6.0, one representative technology was then selected from each technology type for costing purposes. For example, Anaerobic-Aerobic Bioremediation may be selected from a group of six bioremediation technologies as the representative *in situ* technology. However, it is realized that emerging technologies are often continually and rapidly introduced and commercialized; sometimes due to needs demonstrated by large sites such as the NSRA. If a new technology arises that uses the same operating principles and achieves the same or better objectives at lower cost compared to the currently favored technology, it could be considered for implementation during the remedial design.

The following list of remedial technologies and process options were identified as potentially applicable to the overall site. These remedial alternatives include scenarios that can be categorized as more or less aggressive. However, less aggressive, more passive options are not necessarily less protective.

1. No Action Alternative
2. Limited Action [e.g., institutional controls, monitored natural attenuation (MNA)]
3. Island/peninsula construction (on-site landfilling above flooding levels)
4. Clay Capping
5. Soil Cover
6. Berms alone to preclude flooding
7. Soil layer inversion (1-3 ft deep plowing, assumed to achieve 30% reduction)
8. Vertical Blending (45% reduction maximum)
9. Horizontal Blending [within a flooding block (FB)] of contiguous fields
10. Soils removed and used for roads or berms
11. Soils placed in existing canals and covered
12. Composting- (e.g. Xenorem) - Anaerobic-Aerobic Bioremediation
13. Soil reactor *ex situ* chemical oxidation treatment (ex: Soilsavers)
14. Low temperature Thermal Desorption treatment
15. Incineration
16. Mobile solvent extraction
17. Soil Washing with surfactants
18. Supercritical Fluids Treatment (carbon dioxide)
19. Landfarming –shallow tilling with bio and/or chemical treatment amendments (liquid fertilizers, ISCO, etc.)
20. Bioremediation –Anaerobic-aerobic dechlorination (for example DARAMEND® or SAMNA; also considered water level cycling with or without sulfate addition per Ogram and Cheng, 2004)
21. Nano-particles iron treatment
22. Phytoremediation (with native species only)
23. Excavation and off-site disposal

These identified technology options and alternative actions were initially screened then evaluated further using the criteria of implementability, effectiveness, and cost. A summary of the results of this evaluation in included in Table 4-1, and a discussion of each alternative is included below. For those alternatives that involve long-term management of the contaminated soil on-site, the alternatives were evaluated considering both flooded and non-flooded endpoint land use until monitoring (with natural attenuation, e.g., MNA) indicates future flooding is possible.

Table 4-1. Screening for Remedial Technologies for the Lake Apopka NSRA

Representative Technology	Effectiveness	Implementability	Cost	Screened Result
No action	Not effective in meeting Lake Apopka restoration goals	Requires continuous pumping in order to maintain drained fields. Includes maintenance of access roads, levees.	Moderate	Retain
Limited Action – Institutional Controls	Not effective in meeting Lake Apopka restoration goals	Requires continuous pumping in order to maintain drained fields. Includes maintenance of access roads, levees. Chemical monitoring in Soils.	Moderate	Retain
Containment				
Island/peninsula construction (above flooding levels)	Effective in preventing contaminated soil from becoming in contact with surface water.	Relatively easy to implement utilizing standard remedial construction technologies. Applicable to up-slope highest concentration areas	Low-Moderate	Retain
Clay Capping	Effective in preventing contaminated soil from becoming in contact with surface water.	Relatively easy to implement utilizing standard remedial construction technologies. Under flooded conditions inspection and repair work may be necessary. Under non-flooded conditions, erosion control technologies may need to be implemented.	Moderate-High	Eliminate
Soil Cover Capping (flooded or non-flooded)	Effective in preventing contaminated soil from becoming in contact with surface water if appropriate cover soil is used.	Moderately difficult to implement on the type of soil present at the NSRA	Low	Retain
Berm only containment of non-flooded areas	Effective in preventing contaminated soil from becoming in contact with surface water.	Difficult to implement except for areas at a higher elevation.	High	Eliminate
Deep Plowing Soil layer inversion (1-3 ft deep)	Demonstration project 32% reduction	Deeper plowing possible	Low	Retain
Vertical blending	Disc tilling demonstrated 21% reduction	Assume 45% reduction with better mixing of 0-2 ft depth	Low-Moderate	Retain
Horizontal blending (within FB) of contiguous fields	Varies with concentration s and mixing	Source materials must be adjacent fields	Low-Moderate	Retain
Soils removed and used for roads and berms	Only possible for some soils and few areas, limited structural use	Not applicable for high TOC soils	Low	Eliminate

Table 4-1. Screening for Remedial Technologies for the Lake Apopka NSRA

Representative Technology	Effectiveness	Implementability	Cost	Screened Result
Soils placed in existing ditches or canals and covered	Isolates soils	Limited volume, potential groundwater impact	Low	Eliminate
Reduction/Treatment/Disposal Options				
***In situ* treatment**				
Land farming – shallow tilling with bio and/or chemical treatment amendments (liquid fertilizers, ISCO, etc.)	Augmented tilling for chemical-bio reduction dependent on dosing, Water level cycling –sulfate addition requires testing.	Full-scale implementation requires site specific testing	Low-Moderate	Retain
Bioremediation – Anaerobic-aerobic dechlorination (i.e., DARAMEND® or SAMNA®)	Documented full-scale pesticide reduction	Bench-demonstration optimization vs partial reduction needed for costing. Commercially available	Low-Moderate	Retain
Nano-particle iron treatment	Undocumented beyond bench scale	Undocumented	Unknown	Eliminate
Phytoremediation with native species only	Not effective	Requires non-flooding, harvesting; polishing only for lower concentrations	Low	Eliminate
***Ex situ* treatment**				
Composting – Xenorem – anaerobic-aerobic bioremediation	Demonstrated 60-70% reduction in 1-2 years	Adds up to 50% amendment volume Requires Extensive transport & soil handling	Moderate-High	Eliminate
Soil reactor *ex situ* chemical (Soilsavers advanced oxidation process (AOP) treatment	Can destroy high concentrations of toxaphene over limited portions of the site	No setup, portable Bench-demonstration needed vs TOC content	Moderate-High	Retain
Low temperature thermal desorption treatment	Demonstrated destruction	Requires extensive mob, permitting and testing, soil preparation	High	Eliminate
Incineration	Demonstrated destruction	Requires large fixed base operation	Very high	Eliminate
Mobile Solvent Extraction	Undocumented Bench scale data only	Requires solvent recovery and reuse	Very high	Eliminate
Soil washing with surfactants	Not effective on high organic content soils	Undocumented	Very High	Eliminate
Supercritical fluid treatment (carbon dioxide)	Undocumented beyond bench scale	Not commercialized	Very high	Eliminate
Excavation/Off-site landfill disposal	Proven full scale	Only limited by landfill capacity	Very high	Retain

Source: MACTEC, 2004.

4.1.1 No Action Alternative

A no action alternative is typically included in the FS process to provide a baseline comparison to other remedial alternatives evaluated in the detailed analysis. The no action alternative is defined as conducting no response and no long-term monitoring of the extent of the OCP contamination of the soil. The no action alternative in the present case involves preserving the land that constitutes the NSRA in dry condition, for which the District will be required to maintain their current drainage program in place. The no action alternative will not be discussed under the identification and screening discussion, but will be evaluated as part of the remedial alternatives in Section 5.0.

4.1.2 Limited Action Alternative

The limited action alternative consists of long-term monitoring activities, physical barriers, and administrative actions to reduce the potential for exposure to the contaminated media. Limited action could also include public information programs, providing a database of information about the site, and evaluating changes in site conditions over time.

The limited action alternative as applicable to the NSRA, would include maintaining the NSRA dry by continuing the drainage program that the District has now in place, and including monitoring programs including soil sampling could be implemented in conjunction with the remedial actions. Monitoring does not actively prevent exposure to contaminants. However, monitoring could be used in combination with other actions as a means to evaluate the short-term impacts and long-term effectiveness and permanence of these actions.

The institutional controls, such as deed restrictions and installation of a fence or berm around a field or FB, were eliminated because these did not achieve the RAOs. Institutional controls do not prevent wildlife from coming into direct contact with the contaminated soil and they do not minimize the potential for surface water contact with the contaminated soil.

4.1.3 Containment-Isolation Options

This action involves containment of the contaminated soil on-site with little or no treatment, and protecting human health and the environment by preventing potential exposure and/or reducing the mobility of contaminants. Natural attenuation is assumed to continue following containment as isolation and may be accelerated by the containment action, but no such benefit is applied to estimate achievement of target remediation levels. Even shallow tilling alone has achieved approximately 20 percent reduction after six months (SJRWMD, 2004). Several potential methods screened for implementation include:

1. Island/peninsula construction (on-site landfilling above flooding levels),
2. Clay Capping,
3. Soil Cover (flooded or non-flooded),
4. Surface solidification - sealing/compaction,

5. Berms alone to preclude flooding,
6. Soil layer inversion (1-3 ft deep plowing, assumed to achieve 30% reduction), (Bartol, 2004)
7. Vertical Blending (45% reduction maximum) assuming 0-2 ft mixing and $\leq$ 10% of 0-12" OCPs in 12-24 inch interval,
8. Horizontal Blending (within an FB) of contiguous fields,
9. Soils removed and used for roads or berms,
10. Soils placed in existing ditches or canals and covered.

For containment, the technologies include *in situ* capping, on-site containment and offsite containment. Off-site options were eliminated for practical reasons due to the size of the NSRA. Solidification is a process in which contaminated soil is mixed with cohesive materials such as cement or fly ash to immobilize the contaminant. This technology is most effective on liquid waste and sludge with metal contaminants (Anderson, 2004; Batelle, 2003; *In Situ* Fixation, Inc. 2004; and Nicholson, July 2004). Solidification processes have not been demonstrated to be effective with OCP contaminated soils, and would be very difficult to implement with the high organic content of the muck.

Following evaluation of the site conditions and areas requiring action, placement of soils as fill in ditches and canals without liners was eliminated because of the volumes of soils involved and the possibility of adverse impact on groundwater. Use of soils in on-site road or berm construction is also difficult to implement because of the soil's physical properties and was eliminated and not evaluated further because this technology does not have the capacity to treat more than a small fraction of the contaminated soils.

4.1.4 Reduction/Treatment/Disposal Options

The remedial action involves some form of surface soil movement or excavation and on-site disposal of the contaminated material. Off-site disposal is considered impractical due to the size of the site. This action may also require some degree of treatment of the material prior to disposal if the waste exceeds target levels. None of the resulting soils are assumed to be classified as hazardous. The process options involving the disposal of soil as hazardous waste were eliminated because the toxicity characteristics leaching procedures performed on the soil have demonstrated that the material is not a characteristic hazardous waste in accordance with 40 CFR 261.24. Field level treatment may be performed *ex situ* or *in situ*.

4.1.4.1 *In situ* Treatment Processes

In situ treatment encompasses various innovative technologies to effect a reduction of contaminant concentrations in the soil without removing the soil. Biological and physical treatment technologies were considered. These may be performed separately or in conjunction with potential alum or other chemical amendment treatments.

1. Landfarming –shallow tilling with bio and/or chemical treatment amendments (liquid fertilizers, ISCO, etc.)
2. Bioremediation –Anaerobic-aerobic dechlorination (for example DARAMEND® or SAMNA®; or water level cycling with or without sulfate addition per Ogram and Cheng, 2004)
3. Nano-particles iron treatment
4. Phytoremediation (with native species only)
5. Mobile solvent extraction

For *in situ* treatment, the technologies include biological treatments and physical-chemical treatments. Nano-particle treatment was eliminated because this technology is not sufficiently developed and the materials needed are not available in adequate supply (Zhan, 2004; Roco, 2003; and Wilcoxon, 2004). Phytoremediation (a biological treatment technology) was also eliminated during the initial screening process (Burken, 1996; Shrimp, 1993; and Planteco, 2004). Phytoremediation involves either hyperaccumulation of contaminants by plants or rhizosphere-enhanced biodegradation. Neither of these phytoremediation processes has been demonstrated to be effective on high concentrations of toxaphene. Solvent extraction was eliminated because of the lack of demonstrated treatment of high TOC soils. Further, the process is not economically available unless solvents can be recovered and reused (ITRC, 2003; Dennis, 1992; Engle, 1995; Criffiths, 1995; Meckes, 1996; Sahle-Demessie, 1996; and Semer, 1996).

4.1.4.2 *Ex situ* Treatment Process Options

The *ex situ* treatment general response options include a number of chemical, biological and physical treatment technologies. In most instances, only partial treatment is required for a field to reach the desired Target Levels. Chemical treatment involving oxidation and reduction technologies that can destruct the high concentrations of toxaphene over limited portions of the site were retained, and could be applied on reduced quantities where the treated soils were used for subsequent blending to achieve target levels. The process of chemical oxidation is most effective on highly reactive compounds, and has been demonstrated to work on chlorinated compounds and pesticide contaminated media.

Treatment technologies being developed, used, or considered world-wide for pesticide and other Persistent Organic Pollutant (POP) remedial action and destruction of outdated pesticide stockpiles were considered for screening.

Regardless of the treatment process step selected, *ex situ* treatment involves excavating the soil and providing on-site treatment of the contaminants, hence the process step is necessarily coupled with other containment option process steps. Therefore, for reduction, treatment, and disposal, the primary technology is still some form of physical isolation from the biosphere involving soil movement or mixing types of excavation to avoid unnecessary effort.

Potential *ex situ* treatment technologies considered include:

1. Composting- Xenorem - Anaerobic-Aerobic Bioremediation
2. Soil reactor *ex situ* Chemical treatment (ex: Soilsavers)
3. Low temperature Thermal desorption treatment
4. Incineration
5. Soil Washing with surfactants
6. Supercritical Fluids Treatment (Carbon dioxide)

Ex situ composting was eliminated because full-scale use on pesticides at a landfill TSD facility for over two years failed to reach satisfactory endpoints (Adventus, 2004). The *ex situ* treatment general response actions include a number of chemical, biological and physical treatment technologies. Chemical treatment involving oxidation and reduction technologies was considered because of the high concentration of toxaphene over some limited areas, and the ability to provide high degrees of destruction in some soils. Aggressive oxidative treatment is not recommended because it would reduce soil organic carbon content and adversely affect the potential of the soil matrix to support the intended land use. Soil washing alone was eliminated because the process has not been adequately demonstrated for pesticides and high organic content soils. Surfactant amendment as part of ISCO treatment, or even as part of *in situ* bio-treatment to improve bioavailability is considered worthwhile for further investigation. *Ex situ* treatment using supercritical fluids is eliminated because it has not been adequately developed beyond bench and small pilot scale applications. Soil washing was also eliminated because it is not sufficiently effective on high organic content soil.

4.1.5 Innovative Technologies

A number of the processes evaluated can currently be categorized as Innovative Technology, where this is defined as “a newly introduced, yet technically feasible, process or application that is not well established by widespread use under a variety of site-specific conditions or for which performance or cost information may be incomplete. This includes processes, and manufacturing, monitoring, measurement, source reduction, pollution prevention, waste reduction and remediation technologies” (USEPA, 2004).

MACTEC performed extensive literature searches to locate the most current data on soil remediation of pesticides. Where such data exists, it typically is reported for pilot or full-scale treatment of “hot spot” source soils at pesticide production, formulation, or spill sites. Treatment goals for these CERCLA sites tend to be low (μg/kg) and the costs reflect high, 90 percent or greater reduction. Therefore, actual cost data for broad acreage applications, and productivity and performance data for lesser reduction “partial” biological or chemical treatment options was found to be nearly non-existent. Unit costs per ton or per acre for such processes (for example, DARAMEND and Soilsavers FX) had to be estimated with a greater degree of uncertainty based on discussions and correspondence with the commercial providers and making assumptions considered reasonable given the Apopka site conditions.

4.2 Screening of Remedial Technologies and Processes

The general response actions were further defined to specify remedial technology types and process options for the site. There are two steps involved in the screening process. The initial screening as described above in Section 4.1 was performed to eliminate process options based on technical implementability and site-specific conditions. Technologies not sufficiently developed or robust enough to treat broad acreage sites were eliminated in this step. Several technologies were retained despite the need for further development or demonstration on broad acreage sites such as the NSRA.

The second screening step was performed to evaluate the remaining process options based on institutional implementability, probable effectiveness, and cost. The results of this two-step screening process are intended to provide a basis for selection, if possible, of several options for the target level ranges applied to each of the 70 fields in Units 1 and 2 that meet the needs of the range of general response action objectives.

The retained technologies or unit process physical actions serve as a toolbox of options that can be applied on a field basis. This approach is advantageous because it provides a flexible but rational development of the alternatives for further analysis of the overall actions possible for this large and complex site.

4.2.1 Island/Peninsula On-Site Containment

This option consists of constructing a limited number of on-site elevated landfill-like vaults most probably at or near the upgradient flooded shore or where existing roads and dikes afford access for construction of a stable waste pile or cell. Assuming the muck soils do not have proper physical characteristics, these vaults may be constructed using a high density geo-synthetic material. The contaminated soil will be excavated and placed in the vault. A geomembrane cap may then be installed on top of the material to provide a barrier between the material and the environment, and the surface covered with clean soil for re-vegetation. The long-term effectiveness, implementability and cost are discussed below.

4.2.1.1 Effectiveness

This alternative is effective in terrestrial applications and will achieve the RAOs by preventing fish and bird contact with the contaminated soil. Long-term effectiveness of the islands must be monitored in perpetuity. Under surrounding flooded conditions, the effectiveness of this alternative is dependent on the outer edge barrier cover. The islands would be re-vegetated.

4.2.1.2 Implementability

Island construction higher than flooded lands can be performed using standard construction technologies. This option must include adequate erosion controls and maintenance. This option requires CWA Act Section 404 (dredge and fill) permitting, but it is assumed the action is permittable because the overall restoration program is in the public interest.

4.2.1.3 Cost

The stabilized soil island represents a significantly lower cost alternative than a soil or clay cap cover. The permitting, long-term maintenance and monitoring will increase the overall cost of this alternative. The construction cost of this alternative is estimated to require at least $9,400 per acre (Appendix B), and would require long-term maintenance of the sloped edges in contact with adjacent flooded lands. This cost is based on building the waste materials into piles up to eight feet high. Soil scraping and movement costs are based on minimum movement distance of no more than 400 feet.

4.2.2 Clay Capping

Clay caps can be used to contain the contaminated soil in place. The cap would consist of a properly designed and installed 6 inch minimum thickness material with appropriate edge toe slopes adequate to provide isolation and resist erosion under relatively traffic free conditions. Size would depend on the field size, but this option is only judged applicable to the smallest fields with highest concentrations requiring the highest degree of treatment. The long-term effectiveness, implementability and cost will vary based on future land use.

4.2.2.1 Effectiveness

The clay cover will achieve the RAOs by preventing fish and bird contact with the contaminated soil. Long-term effectiveness of the cap must be monitored over a 30 year period. If the site is flooded, human and animal contact with the cap will be minimal. There is a negligible potential, however, for the COPCs to leach through the cap in flooded subaqueous conditions since the COPCs are tightly bound to the NSRA soil. Under nonflooded conditions, the cap will be susceptible to weathering and damage by burrowing wildlife. However, the actual performance of the cap should be more reliable under non-flooded conditions. This alternative would not result in an ideal substrate for flooded wetland restoration vegetation, unless further covered with soil or dredged material.

4.2.2.2 Implementability

This alternative is relatively easy to implement, utilizing standard remedial construction technologies. The approach to long-term maintenance of this alternative is different for flooded and non-flooded conditions. Under flooded conditions, inspections and any necessary repair work on the cap will be difficult to implement in sub-aqueous conditions. Recreational use in the immediate vicinity of the flooded cap must be prohibited because boat-motor propellers and anchors can damage the cap. Under non-flooded conditions mowing on a regular basis will be required to control vegetative growth (large roots will damage the cap). Maintenance and repair work on the cap will be easier to implement under non-flooded conditions which is not consistent with restoration objectives.

4.2.2.3 Cost

The clay cap cover represents a relatively high cost alternative, and long-term maintenance and monitoring will only increase the overall cost. Under flooded conditions, long-term maintenance is problematic and might involve items such as bathymetric surveys and underwater camera profiles to determine the integrity of the cap over time. If repairs are necessary, specialized equipment will be required to install additional portions of the clay cover. Long-term monitoring of sediments, surface water and aquatic life will be necessary. Under non-flooded conditions, site maintenance items such as fencing and mowing will be required and long-term groundwater monitoring will be necessary. The cost of this alternative ranges from $98 to $108 per ton ($158,000 to $174,000 per acre)

For capping process options, both clay and solidified stabilization covers were considered and retained. Clay capping and other solidified covers were were initially considered for elimination from further evaluation because the do not provide meaningful reduction in risk when compared with a simple soil cover, yet they are relatively more costly, and because such a cap is a poor substrate for shallow marsh vegetation. However, these problems can be at least partially overcome by covering the cap in some areas with a one foot layer of soil or dredged material, and because there is the possibility that the NurRF project (LCWA) on Cell H (property north of current phase 1 MFW) will result in a large amount of available clay material that could be used for capping. Therefore this alternative was retained for future consideration.

4.2.3 Soil Cover Option

As an alternative to other types of caps, a surface applied and stabilized layer of at least 6 inches of clean soil from on-site or dredged material from the lake could be constructed on areas of collected contaminated soil for isolation and containment *in situ*. The soils would be scraped into a prepared area, leveled and compacted, then covered with deeper clean soils or dredged material from on-site. The covered area would be smaller than the original field, thus the cover area would depend on the size of the non-flooded area in a field. The cover material would be compacted over the contaminated muck soil before re-flooding the surrounding area. Banks and surfaces would be stabilized for erosion control. A vertical berm section would be constructed around the perimeter of the area, to a depth of approximately 2 feet below land surface. The long-term effectiveness, implementability and cost are evaluated below.

4.2.3.1 Effectiveness

The effectiveness of this alternative is dependent upon the condition of the soil cover. If the surface is not properly constructed and maintained, then there will be a potential for erosion and fish and bird contact with the contaminated soil. There is a neglibible potential for contaminants to leach through the cover and into surface water after the surrounding area is flooded since the COPCs are tightly bound to the NSRA soil. This alternative is only considered applicable for a small amount of acreage in up-slope areas with high concentrations. This option would actually involve more soil excavation and transport than island construction, but would not allow flooding of as much acreage, because the height of the islands are greater than the simply covered soils.

4.2.3.2 Implementability

This alternative would be moderately difficult to implement on muck soils with high organic content. The low-density muck soils may not support optimum compaction of the cover. After the surrounding area is flooded, the soils may swell and shift over time with attendant soil cover cracking. The contaminated muck and deeper soils can be collected and layered with available earthmoving equipment.

The use of dredge material made available by the dredging of surficial lake sediments as a capping material is considered viable, although the chemical absence of OCPs, available quantities, transport distances, location of staging areas, and availability timewise versus soil restoration is currently unknown. These issues would require resolution and further cost evaluation during design. Areas in the lake or the Apopka-Beauclair Canal in the vicinity of the NSRA may be dredged for navigation reasons. Further, use of dredge material for such capping would be beneficial because it would avoid the problem of deepening borrow areas in the NSRA.

4.2.3.3 Cost

The soil cover alternative represents a lower cost alternative than the clay cap cover but higher cost than the island construction because of the initial construction costs and long-term maintenance costs. The labor and materials involved in the initial construction of the cover are also less costly and assumed available on-site, either from deeper soils in some areas, or from the existing levees.

4.2.4 Berm Only Containment of Non-Flooded Areas

This option essentially consists of constructing a limited number of on-site berms at or near the currently defined limits of the up-slope re-flooded shoreline or where roads and dikes afford construction of an enclosure. The option is similar to the island or soil cover construction except that no additional material would be placed in the interior on top of contaminated soils. The contaminated soil surface would require re-vegetation to prevent exposure, and the enclosed interior could not be subject to flooding or standing water. The long-term effectiveness, implementability and cost are discussed below.

4.2.4.1 Effectiveness

This alternative is effective in terrestrial applications and will achieve the RAOs by preventing fish and bird with the contaminated soil. Long-term effectiveness of the berms must be monitored over a 30 year period. Under flooded conditions, the effectiveness of this alternative is less certain and dependent on the outer edge barrier to prevent surface water contact with contaminated soils. It is possible that infrequent, periodic events such as hurricanes could add water to the contaminated soil area requiring temporary pumping controls and attendant handling of contaminated water.

4.2.4.2 Implementability

The construction of the berms may be more difficult to implement than the placement of caps or covers using on-site materials due to the need for adequate grade construction materials. Higher berms with adequate design freeboard would be required to barrier areas with deeper surrounding flooding depths. This would restrict use to only the up-gradient shoreline where flooding depths of less than 1 ft are projected. Two to four ft height berms around future off-shore deeper areas would be difficult to construct to guarantee the interior would not flood by infiltration from surrounding flooded areas. Therefore, this alternative was retained but should be considered only in FBs with less than 1 ft flooding depth along the far North edge of the NSRA. Use of this alternative is highly limited, and may be better considered in conjunction with a dredged material soil cover.

4.2.4.3 Cost

The berm represents a lower cost alternative than the capping, cover, or island options. The permitting, long-term inspection, maintenance, and monitoring will increase the overall cost of this alternative. The capital cost of this alternative is estimated to be approximately $7,294 per acre based on a 2 ft berm dike and 834 linear ft per acre.

4.2.5 Soil Layer Inversion

Deep plowing is a physical treatment alternative that involves inverting entire layers of soils by use of special mechanical means using offset plows and moldboard plows (Allen, 2004). This technology would permanently seal the contaminated 0-1 ft layer beneath one ft or more of adequately clean material. In addition, soil tilling of the materials during preparation for flipping will provide an oxygen source for the indigenous microbes and may increase the rate of natural decomposition after burial, but this is incidental to the technology. This option has been attempted in a limited testing program at Apopka on the 0-2 ft depth soils under wet site conditions site.

4.2.5.1 Effectiveness

This alternative has shown 32 percent reduction in the contaminant concentrations, during the District's demo in 2003 in the fields, versus a 45 percent theoretical reduction calculated assuming the 1-2 ft layer contains no more than ten percent of the 0-1 ft concentration (Bartol, 2004). J. Allen of Allen Machine and Equipment Co., Roscoe, Texas has completed two 2003 soil inversion pilot studies in Florida, one at the Apopka NSRA and one in an orange grove at Fort Pierce. According to Mr. Allen, neither demonstration test has completely met expectations, because Allen Machine and Equipment Co. allowed someone else to furnish the equipment and do the critical site preparation for these pilot studies. The Fort Pierce pilot study reportedly turned out much better than the one at Apopka, but was hampered by citrus roots. As previously reported to the District, the old adage, "too wet to plow", definitely applied to the Apopka site, but the test was completed anyway to gain initial data since the equipment had been mobilized from Texas. Plowing when it is wet is not believed to be a problem if the site is prepared properly. Soil, whether it is muck, peat, sandy, sandy loam, clay, etc., has the tendency to stick together when it is wet, making it slab out instead of turning (flipping) at the desired depth. In Mr. Allen's opinion, this can be overcome with the addition of custom designed soil deflectors with a precise curvature which are placed on each mold plow bottom.

The 2003 Apopka NSRA pilot test did not have the proper equipment on-site for the test. The site had extremely wet conditions, excessive roots, and poor preparations prior to the deep- plowing phase, hence the Baker moldboard type plow did not achieve the level of success desired. Because of the slippage and spinning of tractor tires due to lack of horsepower for the conditions, the test was not done at a consistent speed critical to controlling the depth of the turn or "flip".

Further demonstration with larger equipment capable of layer inversion of a larger layer is desirable.

4.2.5.2 Implementability

This alternative is easily implementable under existing conditions at the site but needs additional testing. Soil inversion is a permanent solution that if properly done provides sealed burial of contaminated soils away from possible fish and bird exposure, and would leave the treated areas ready for re-flooding with no loss of acreage. Surface water contact with OCPs would be limited to the extent that the lower depth soils brought to the surface are much less contaminated. If additional profiling shows an area contains deeper contamination, the inversion depth would need adjustment, or the soils blended and inverted to achieve the final result. Inversion is easily coupled with other alternatives if necessary.

Based on consultation with the experienced plow builder and operator, J. Allen, MACTEC has defined the following preliminary definition of the soil inversion process believed to be adequate for NSRA restoration:

4.2.5.3 Recommended Soil Inversion Procedure

The procedures required to achieve the ultimate performance in the conditions at the District at the Apopka site are critical and varied according to the site conditions encountered and the equipment utilized. After evaluating both initial pilot studies, Allen recommends that the following procedure is necessary to achieve the advertised 95-98 percent inversion that would provide far greater reduction than the 32 percent limit currently proven by the limited 2003 demonstration test.

Phase 1- Shred, mow, or chop any vegetation to a height of 3 to 4 inches. This step is necessary to eliminate impediments to plowing such as vines that can turn the plow into a large rake.

Phase 2 - Plow with a large offset or tandem disc plow to a depth of 10” to 12”. This must be done as many times as necessary until all roots, vines, etc., are cut into small pieces and the soil. (muck or peat) is pliable, similar to potting soil. Once this is accomplished, plow this same plot one more time, pulling a set of plow packers at the same time to firm up the soil and keep the soil level for the deep-plowing phase.

Phase 3 - Using a Baker Plow with 32” to 38” disk blades or square bottoms (bi-directional moldboard) fitted with special soil deflectors, plow 24 inches to 36 inches deep. This is designed to provide a 95% to 98% turn on the soil, wet or dry, turning the soil a full 180 degrees. Also pull a plow packer at the same time to break up all the clods and firm the soil up for the next phase.

Phase 4 – Using a pressure washer, wash the large offset or tandem plow, the plow packers and tractor, so as not to contaminate the new soil; plow and pack the top 10 inches of this plot, returning it back to a flat and packed state ready for re-vegetation and/or re-flooding.

Phase 5 – Take confirmatory OCP soil samples to confirm the surface soils are acceptable for re-flooding.

In spite of the very limited on-site data the District has gathered to date on tilling (vertical blending) and inversion, the potential reduction in surficial concentration so far appears greater for inversion than blending the top 2 feet. However, the blending technique used was not nearly as robust as the trenching type equipment currently in use in New Jersey and Pennsylvania (NJDEP, 2004 and CBA, 2004). Both these techniques could be tested further in the NSRA to develop the knowledge and skills to optimize these options.

The soil inversion technique, in particular, needs field demonstration of methods to physically verify inversion depth and consistency. Use of buried tapes and markers within test trenches in inversion test stripe is one such suggested method. In addition, there are established rapid immunoassay field analytical methods for the toxaphene and DDT_x OCPs that could be calibrated against the selected fixed laboratory method to enhance performance monitoring and reduce cost. These critical measurement tools should be included in subsequent pilot demonstration tests.

4.2.5.4 Cost

The costs associated with this alternative are low, and would also require the cost of a robust demonstration study, and longer term monitoring to document effectiveness. Basic minimum costs for the deep plowing soil inversion step are typically $350 per acre but based on the previous limited testing are expected to be higher, and may be highly dependent on total acreage and extent of surface site preparation steps. When all the preparation and productivity factors are considered (Appendix B), a cost of $1,500 to $2,600 per acre is considered reasonable pending further testing. These costs assume that District purchase and operation of all equipment, and potential salvage value of tractors and plows would tend to drive the cost toward the lower end of the range.

4.2.6 Vertical Blending

Deep tilling and possible use of scarification equipment to provide mixing and homogenization of surface soils with cleaner lower soils is a physical treatment alternative that involves mixing and tilling the soil by mechanical means. Application of this technology is dependent on the concentration profile. Soil mixing was investigated because it was considered applicable to a wide area, and uses nearly the same equipment that would be required for any alternatives involving soil movement or inversion. Soil blending has been demonstrated in full-scale applications on pesticide contaminated agricultural soils (CBA, 2004.). An incidental benefit of blending is that it would provide an oxygen source for the indigenous microbes and may increase the rate of natural decomposition.

4.2.6.1 Effectiveness

This alternative may achieve adequate reduction in the contaminant concentrations, if the starting concentrations surface and depth profile are reasonably low. Toxaphene has an estimated half-life of 1 year to 14 years in soil (ATSDR, 2001). Preliminary studies at this site indicated that intensive (weekly) tilling (disk plow) of 1-2 ft or less achieved a reduction of approximately 20% in surface soil concentrations of toxaphene over a 6 month period (Bartol, 2004).

However, flooding will attract wildlife (e.g., piscivorous birds) to the area, increasing the potential for wildlife exposure to residual toxaphene. Hydraulic control during periods of high rainfall would also be difficult under flooded conditions, and discharge of potentially contaminated stormwater to surface water bodies could result in surface water quality violations. The degree of success and length of time required to achieve target goals using this technology has not been documented. Additional equipment testing, monitoring, and resolution of analytical issues would be required to determine if tilling will achieve the desired remediation goals on this site, especially for applications in areas requiring higher than 20 percent reduction.

A proven mixing alternative already being used on agricultural soils is offered by CBA Environmental Services, Inc. using modified rock trenching equipment they have produced for over 10 years. CBA utilizes several patented technologies and processes associated with the Mobile Injection Treatment Unit (MITU). Specifically, CBA has utilized the MITU-LVR model to complete several pesticide blending projects. These blending projects have involved blending impacted soils with onsite clean soils to depths ranging from 2 to 12 feet. CBA's MITU-LVR and proprietary blending process were utilized on a site in southeastern Pennsylvania to achieve the first Act 2 Closure of a site contaminated with pesticides through historical agricultural use. The MITU-LVR equipment and process also continues to be utilized on multiple historic pesticide contaminated blending projects throughout the United States (CBA, 2004). The success of these rock trencher based units is based on the custom designed mixing drum or disk attachments. The equipment has routinely been used to disperse soil amendments and can provide one pass treatment of approximately one acre per day in trench widths of up to 16-ft. One such smaller disk unit easily capable of 2-3 foot depth mixing that may be faster than drum head units on wet Apopka soils is shown below.

CBA, Inc., 2004

Based on District limited success with mixing demonstrated using on-site traditional tilling techniques, and discovery of the CBA mixing equipment, this alternative is retained for further evaluation.

4.2.6.2 Implementability

This alternative is implementable under existing conditions at the site, but the ease of application will depend on the field moisture conditions, depth, and the degree of historical deeper plowing, which is not well known. Plowing for complete mixing of 0-2 ft soils by tilling may require a large number of passes in some areas, and would be hampered by the presence of roots and rocks at depth. The site specific optimum sequence of steps necessary would need to be developed. Use of modified rock trenching equipment using specially designed disk and drum attachments has successfully mixed pesticide contaminated soils to a depth of twelve feet in a single pass (CBA, 2004).

4.2.6.3 Cost

The costs associated with this alternative are similar to the costs for soil inversion and relatively low, but would require the cost of a demonstration testing program, and longer term monitoring to document effectiveness. Base costs of $1,700 to 3,500 per acre were estimated for blending ($2,710 per acre used in alternative costing) but could be as low as $660 per acre for limited tilling pass low level reduction areas. Costs are highly dependent on site conditions, total acreage, and depth.

4.2.7 Horizontal Blending

Shallow soils that can be vertically mixed can also be combined between adjacent fields before mixing with a minimum of distance movement, especially if ditches, roads, or canals are not a hindrance. Horizontal blending is assumed to use the same earthmoving equipment as vertical blending and island construction. The primary concerns are whether adequate volumes of the sufficiently different concentrations and TOC are present to allow the final composite to meet remediation criteria. Blending would require preliminary confirmation of the ending soil quality, especially where the TOC content of the sources varies. Field applications would also require determination of whether deeper than 1 ft cleaner soils were needed in the mix.

4.2.7.1 Effectiveness

This option may be expected to achieve the same general reduction range of 21-32% as tilling or deep plowing, and allow complete re-flooding but would result in residual contaminant concentrations in contact with surface water. Toxaphene has an estimated half-life of 1 year to 14 years in soil (ATSDR, 2001). It is not anticipated that tilling and blending would effectively treat the elevated concentrations detected on-site in a timely manner.

Biodegradation of OCPs may also be expected to occur due to aeration and natural attenuation. The degree of success and length of time required to achieve remediation goals using this technology has not been documented. The same type of treatability study required for vertical blending would be required to determine if this combination option will achieve the desired remediation goals on this site.

Horizontal blending does not decrease overall exposure since exposure is reduced in one area below a risk threshold while increasing exposure in another area (although still below the risk threshold). Because techniques that reduce overall exposure should be an emphasized over techniques that merely dilute COPCs horizontally, this alternative is overall judged less effective than inversion and vertical blending that would reduce overall exposure.

4.2.7.2 Implementability

This alternative is implementable under existing conditions at the site. However, the use of such blending would be highly location specific and dependent on availability of sufficient materials of adequate quality in adjacent fields, and the ability to maintain the sources in a non-flooded condition. This site specific option is retained for further evaluation.

4.2.7.3 Cost

The costs associated with this alternative are relatively higher than other options involving blending because soil must be moved between fields would require higher than simple tilling or plowing, would be location specific, and require longer term monitoring to document effectiveness. Horizontal blending is estimated to cost at least $4,500 to $6,100 per acre.

4.2.8 Landfarming

Landfarming, also known as land treatment or land application, is an above-ground biological remediation technology for soils that traditionally reduces concentrations of constituents by spreading excavated soils in a relatively thin layer on the ground surface and accelerating or stimulating aerobic microbial activity within the soils through aeration and/or the addition of minerals, nutrients, and moisture. Soil texture affects the permeability, moisture content, and bulk density of the soil. For the NSRA, these activities may be performed *in situ.*

Ogram and Cheng (2004) have reported to the District that cycling the soils between anaerobic and aerobic conditions could enhance biodegradation. They are investigating the benefits of adding sulfate to stimulate sulfate reducing bacteria which may also dechlorinated OCPs. Biodegradation of toxaphene may be enhanced by anaerobic conditions such as flooding (Howard, 1991). Landfarming has been proven most successful in treating petroleum hydrocarbons including diesel fuel, No. 2 and No. 6 fuel oils, JP-5 jet fuel, oily sludge, and wood-preserving wastes and certain pesticides. The more chlorinated or nitrated the compound, the more difficult it is to achieve biodegradation. Full-scale operations have been conducted, particularly for sludges produced by the petroleum industry (EPA, 2004). Land farming is considered a commercial technology, with highly variable site specific performance, rates, and costs.

Tilling is the mechanism that provides an oxygen source for the indigenous microbes and may increase the rate of natural decomposition following periodic flooding. The depth of treatment is limited to the depth of achievable tilling. The enhanced microbial activity results in degradation of adsorbed constituents through microbial respiration. Contaminated soils may be mixed with soil amendments such as soil bulking agents and nutrients (nitrogen or phosphorus) tilled into the earth. Soil conditions are controlled to optimize the rate of contaminant degradation. Conditions normally controlled include moisture content, aeration (by tilling the soil with a predetermined frequency, the soil is mixed and aerated), and pH (buffered near neutral pH 7 by adding crushed limestone agricultural lime or lowered by adding elemental sulfur). Excessive amounts of certain nutrients (i.e., phosphate and sulfate) can repress microbial metabolism. The composition of nutrients and acid or alkaline solutions/solids for pH control is developed in biotreatability studies and the frequency of their application is modified during landfarm operation as needed.

Although sufficient types and quantities of microorganisms are usually present in the soil, recent applications of *ex situ* soil treatment include blending the soil with cultured microorganisms or animal manure. Soil microorganisms require moisture for proper growth. Excessive soil moisture, however, restricts the movement of air through the subsurface thereby reducing the availability of oxygen which is also necessary for aerobic bacterial metabolic processes. The ideal range for soil moisture is between 40 and 85 percent of the water-holding capacity (field capacity) of the soil or about 12 percent to 30 percent by weight. Periodically, moisture must be added in landfarming operations because soils become dry as a result of evaporation, which is increased during aeration operations (i.e., tilling and/or plowing). Excessive accumulation of moisture can occur at landfarms in areas with high precipitation or poor drainage. Water Management systems for control of runon and runoff are necessary to avoid saturation of the treatment area or washout of the soils in the landfarm. Run-on is usually controlled by earthen berms or ditches that intercept and divert the flow of stormwater. Runoff can be controlled by diversion within the bermed treatment area to a retention pond where the runoff can be stored, treated, or released under a National Pollution Discharge Elimination System (NPDES) permit.

Landfarming with or without periodic flooding is a potentially chemical-biological treatment alternative that may offer substantial benefit for relatively small effort, although determination of optimum conditions is required. Landfarming is retained for further consideration.

4.2.8.1 Effectiveness

This alternative may achieve some reduction in the contaminant concentrations, if the starting concentrations are reasonably low. Toxaphene has an estimated half-life of 1 year to 14 years in soil (ATSDR, 2001). It is not anticipated that tilling alone would effectively treat the elevated concentrations detected on-site in a timely manner without augmentation. The degree of success and length of time required to achieve remediation goals using this technology has not been documented. Treatability tests and demonstration are necessary to determine where and to what degree landfarming can be applied to achieve the desired remediation goals on this site, as opposed to more intensive bioremediation. Breakdown products from typical peroxygen or other oxidant chemical amendments would leave the soils oxygen rich.

4.2.8.2 Implementability

This alternative is implementable under existing conditions at the site. Aqueous amendments can be sprayed and spread with standard agricultural equipment as part of already discussed tilling and mixing operations.

4.2.8.3 Cost

The costs associated with this alternative but would include the cost of a treatability study, and longer term monitoring to document effectiveness. Since the period of time required to achieve the target goal is longer than for other alternatives, the cost is higher. The low percent reductions needed in some areas may allow tilling the reagents into the soil with only a low degree of mixing required. In a tilling scenario, not including operation of the tilling/mixing equipment, the costs can range from $8/ton up to $20/ton ($12,900 to $32,300 per acre).

The landfarming option would need to conduct a bench testing program to determine the optimal treatment scenario accounting for the *ex situ* treatment versus tilling and particularly the dry weight versus TOC weighted target goal.

4.2.9 *In Situ* Bioremediation

Anaerobic-aerobic bacterial enhancement (i.e., bioremediation) increases the rate of the natural microbial degradation of contaminants by supplementing these microorganisms with nutrients, carbon sources or electron donors. This process can involve the addition of an enriched culture of microorganisms for quicker decomposition or the use of indigenous microbes in the soil. Enzymes created by the bacteria enhance the dechlorination of the COPCs. A commercially available process called DARAMEND™ was used to evaluate this alternative, although other providers exist. This process can be applied *ex situ* or *in situ*. Performance on duplicate bench test have shown up to 68% reduction of OCP's, and full-scale projects for example at the THAN Superfund Site have achieved over 90% reduction with multiple cycles (EPA, 1997 and Adventus, 2004).

Ogram and Cheng (2004) indicate that cycling the soils between anaerobic and aerobic conditions could enhance biodegradation. This could be accomplished by managing water levels coupled with tilling. Ogram and Cheng (2004) also support the addition of sulfate to stimulate sulfate reducing bacteria prior to an anaerobic cycle. Sulfate reducing bacteria have also been shown to be capable of reductive dechlorination of OCPs. The process under investigation by Ogram and Cheng (2004) has not been demonstrated at the field scale.

4.2.9.1 Effectiveness

Based on overview of available literature the effectiveness of this alternative for treatment of the toxaphene concentrations detected at the site has been documented at approximately 50 per cent reduction per treatment cycle (Allen, 1999; Battelle, 2003; Felsot, 1991; Kantachote, 2004, Portier, 1989; USEPA, 1992, 1996, 1997, 2001, 2004). The selection of this alternative requires a demonstration scale testing to validate effectiveness on the site for various concentrations and TOC conditions. One notable case study using bioremediation on toxaphene-contaminated soil was performed by Adventus. Bacterial enhancement is retained for either *in situ* or *ex situ* application based on the documented success of this alternative for treatment of elevated toxaphene and other OCP concentrations (Adventus, 1997, 2004; and Planteco, 2004).

Adequate soil treatment would allow re-flooding directly or after tilling or other blending. The re-flooded soils would contain residual OCPs in contact with surface water.

4.2.9.2 Implementability

This alternative is reasonably implementable under existing conditions at the site using commercially available processes and equipment. Fields requiring higher than 50% reduction would likely require more than one treatment cycle. Reduction is expressed as a percentage of the remaining contamination, i.e. the second cycle would remove 50% of the remaining 50%. Two full cycles would remove an estimated 75 percent. Where less than 50% reduction is required, weaker and shorter treatment cycles can be performed based on monitoring.

4.2.9.3 Cost

The cost for this alternative is moderate to high depending on the length of the time and volume of additive required to reach the clean up goals. Costs for this alternative generally range from $10,000 to $20,000 per acre for *in situ* and *ex situ* versions of the application plus the tilling or transport cost to get soil to treatment. These costs are based on other much smaller sites requiring much higher COPC percent reduction to specific ARARs. Overall costs for large scale applications on broad acreage to lesser degrees is undocumented.

4.2.10 *Ex Situ* Chemical Treatment

This option involves excavation and staging of all or part of the soils from a highly contaminated small acreage field, treatment at up to 100 tons per hour, followed by testing and replacement / blending. The representative process, Soilsavers FX is a patented soil treatment technology that has already been approved and used on a variety of Florida sites. The chemical oxidation process relies on the Soil FX™ treatment system which is comprised of the Water FX™ reactor that produces hydroxyl rich water that is used in combination with a number of different oxidizers, catalysts, reducers, acid and bases that are selected based on the contaminant of concern, soil matrix, moisture content, organic content, and remediation goal.

A key component of the process is the specially designed reactor-mixing system that can accommodate a wide variety of amendments and optimize treatment contact. The process has been proven for chlorinated compounds, and the treated soil has been used for construction. The patented advanced oxidation process (AOP) has treated more than 3.5 million tons of soil in six states since 1994, including difficult to treat clayey matrices and dredge materials containing semivolatile organic compounds such as cool tar. The contaminants are usually destroyed to innocuous endpoints in 1-2 days with no significant off-gassing or toxic by-products. AOP processes typically leave the soil oxygen rich (Soilsavers 2004; Torshin, 2003).

This process is not applicable on a wide acreage scale, regardless of cost, because it would substantially reduce soil organic carbon content. Any oxidation of the organic carbon matrix may increase the availability of phosphorus, thereby increasing the P flux from the treated area, thereby having a deleterious effect on a primary objective of the restoration project – to reduce nutrient loading to Lake Apopka. Most oxidants would act indiscriminately on both OCPs and soil organic carbon content, so the high levels of organic carbon in NSRA soils would increase oxidant demand and cost, and reduce the oxidative treatment of OCPs. However, proportionate reduction of both OCPs and soil organic carbon would not reduce carbon normalized OCP concentrations, and therefore have little effect on bird tissue concentrations. Finally loss of soil organic carbon could cause further settling of the NSRA, which also is contrary to the overall site shallow marsh depth restoration objectives.

4.2.10.1 Effectiveness

AOP can treat all of the OCPs non-selectively. Chemical demand will also be exerted by the soil organic carbon. A treatability study would be required to determine whether the SoilsaversFX process would effective on higher TOC concentration soils, and to determine the minimum dosages necessary versus concentration to avoid time and effort in over-treatment. Most applications have required nearly complete removals.

Soilsavers does not have documented full scale field experience treating the pesticides of concern at the Apopka project including DDT, DDE, dieldrin, chlordane and toxaphene. However, there is Soilsavers bench scale results that document oxidation of all of the pesticides of concern except toxaphene (Soilsavers, 2004). Toxaphene was not present in the soil matrix tested. Table 4-2 summarizes the bench scale treatment of DDD, DDT and dieldrin with reductions in 90% to 99% range. These concentrations are lower than those present at Apopka but they do demonstrate the ability to achieve high percentage reductions at low concentrations.

Table 4-2 presents bench test results from work with starting concentrations similar to those found at Apopka except for DDT which are on the low side in the bench test.

Table 4-2. FPM Pesticide Bench Results (mg/kg)

OCP	Pre Treat 1	Post Treat 1	Pre Treat 2	Post Treat 2
heptachlor	12,000	720	8,900	600
aldrin	1,700	<190	1,400	<190
heptachlor epoxide	1,900	430	2,000	560
dieldrin	9,000	2,900	7,300	3,900
4,4’-DDE	2,600	800	2,200	990
4,4'-DDD	5,700	1,900	5,100	1,800
4,4’-DDT	2,800	880	2,400	780
alpha chlordane	22,000	7,500	18,000	8,600
gamma chlordane	23,000	7,900	16,000	9,200

Source: Soilsavers, 2004.

Bench scale percent reductions range from 56% to 68% based on first round bench work. Subsequent bench tests and field applications have been achieving percent reductions greater than 90% and in many cases greater than 99% for recalcitrant compounds. The bench test process is used to determine the optimal combination of reagents relative to contaminant concentrations, remediation criteria and soil matrix.

4.2.10.2 Implementability

The Soilsavers FX process requires a minimal equipment mobilization and set-up effort. Since electrical power is not available at the site, an electrical generator for limited power will be needed. AOP treatment will be more difficult to implement with high organic and moisture content soil.

4.2.10.3 Cost

The cost for this treatment alternative is relatively high due in part to soil handling. The total mass of contaminant requiring removal will have a direct impact on the amount of oxidizer required and therefore the cost to treat. Based on experience treating a wide range of contaminants the per ton treatment cost (assuming the soil is excavated and stockpiled for treatment) is from a low of $12/ton up to $30/ton ($19,400 to to $48,400 per acre) for the average percent reductions required at Apopka, and assuming the need for complete one pass treatment. This assumes that Soilsavers will dry the soil, screen out the large material, apply the reagents and stockpile the soil for testing by others. The difference in price is reagent cost. The greater the percent reduction and mass, the greater reagent doses required. Higher TOC will require more oxidizer to treat. Conversely the treatment criteria for soils high in TOC is also higher so the cost may not be significantly affected by TOC.

Complicating the pricing is that Soilsavers has not been called upon to achieve low percent reductions (less than 75%). Typically 99% and greater reductions are required therefore thorough mixing; curing, drying and layered applications are required. In this case many of those steps may not be needed as the starting concentrations are relatively low and the percent reductions are low. The above cost estimates assume all those steps are required. Based on the relatively high cost, but high effectiveness and demonstrated implementation, this alternative is considered applicable for the NSRA, but primarily only at the highest concentration areas with the lowest TOC.

4.2.11 Low Temperature Thermal Desorption

Thermal desorption involves the process of heating the contaminant at low temperatures (300 to 1000 degrees Fahrenheit) to volatilize the organic contaminants, separate them from the soil media, and capture them in a carbon adsorption system.

4.2.11.1 Effectiveness

Thermal desorption is an effective method for treating chlorinated pesticides in high concentrations. A full-scale thermal desorption treatment project was implemented at the T.H. Agricultural & Nutrition Company (THAN) Superfund Site in Albany, Georgia. The average initial toxaphene concentration at the site was 257 ppm and a removal efficiency of 99.29 percent was achieved in a 3 month period (USEPA, 1995). A treatability study would be required to determine whether thermal desorption would be effective on higher concentrations of toxaphene, and for high organic and moisture content soil.

4.2.11.2 Implementability

The thermal desorption process requires a significant equipment mobilization and set-up effort. Since electrical power is not available at the site, an electrical facility would have to be constructed, or a natural gas powered unit utilized. Thermal processes are more difficult to implement with high organic and moisture content soil.

4.2.11.3 Cost

The cost for this treatment alternative is high. Mobilization and set-up costs are generally about $1,000,000. The cost for the design and implementation of the thermal desorption system at THAN was $250 per ton of soil (USEPA, 1995). Based on the high cost of over $403,000 per acre and difficulty of implementation, this alternative is not considered applicable for the NSRA.

4.2.12 Incineration

Incineration uses controlled flame combustion to volatilize and destroy organic contaminants in a variety of media including soil, sludge, liquid and gas. The primary combustion unit is generally operated between 1200 to 3000 degrees Fahrenheit. The byproducts, or bottom ash, created during the incineration process can be disposed of in a landfill, or used for clean backfill if they are not hazardous waste by characteristic or listing.

A significant disadvantage of incineration is its corresponding effect of reducing the soil's total organic carbon content, which would adversely affect its ability to support the planned land use as wetland habitat.

4.2.12.1 Effectiveness

This alternative is proven to be an effective means of treating pesticide-contaminated soil. On-site incineration was used to remediate 7,840 tons of pesticide-contaminated soil at the Yakima Pit Superfund Site in Yakima, Washington over a four-month period (USEPA, 2004).

4.2.12.2 Implementability

A significant effort is required to mobilize equipment and materials and set up the mobile incinerator in a remote area. Like thermal desorption, power supplies must be installed, or a gas powered unit used. A test burn must be conducted to measure the treatment efficiencies and air emissions concentrations.

4.2.12.3 Cost

The mobilization and set-up costs associated with this process are high (~$1,000,000), and power consumption and labor to operate the system are costly. On-site incineration costs were $770 per ton of soil at the Yakima Pit Superfund Site, which had material volumes similar to those at the Lust Airstrip. In addition, this activity will require permitting as an air pollution source, which will impose additional costs. In general, the cost to implement this technology ranges from $300 to $1,000 per ton (Frazar, 2000). Based on the high cost and difficulty of implementation, this alternative is not considered applicable for the NSRA.

4.2.13 Excavation and Off-site Landfill Disposal

This alternative includes the time-tested options of scraping contaminated soils into staging piles, and loading into dump trucks or roll-offs for transport to the nearest Subtitle D permitted landfill. In addition to scraping excavation of the surface one foot of muck, this alternative would require limited de-watering to preclude hauling free liquids to the landfill. It is also assumed the landfill has sufficient capacity, and will accept the waste. Surface mowing and any clear and grub materials are assumed to be left in place.

4.2.13.1 Effectiveness

This alternative is proven to be an effective means of treating pesticide-contaminated soil, but has not been used for very large areas and volumes.

4.2.13.2 Implementability

A moderate effort is required to mobilize equipment and materials and set up the mobile in a remote area. Like all the other alternatives involving soil handling, there will be field variable performance differences based on depth, moisture, roots, etc.

4.2.13.3 Cost

The mobilization and set-up costs associated with this process are low. In the LUST FS this alternative was estimated to cost $68 per ton for 9,000 tons in July 2002. Escalating these costs to August 2004 would equate to a unit price of approximately $73.50 per ton. In general, the cost to implement this alternative in the District was recently reportedly to range from $50 to $65 per ton (Bartol, 2004), exclusive of mowing and clearing, and other factors such as fuel price inflation. Based on a 1.0 ton/cu yd average soil (1,613 tons per 1,613 cu yd or acre-ft of soil), even this lower cost range equates to a relatively high cost of at least $80,700 to $104,900 per acre. Despite the cost, this proven alternative is considered applicable for several relatively small but highly contaminated fields in the NSRA, and was retained for further consideration.

4.2.14 Summary of Technology Screening

Based on the information and findings presented in this section, the following technologies have been retained for further evaluation:

- Isolation/Containment Technologies
  - Island On-Site Containment
  - Berm Containment
  - Clay Capping
  - Soil Cover
  - Soil Layer Inversion
  - Vertical Blending
  - Horizontal Blending
- *In Situ* Treatment
  - Landfarming (Water Level Cycling and/or tilling with amendments)
  - Bioremediation (Anerobic-Aerobic)
- *Ex Situ* Treatment
  - Soil Reactor *Ex Situ* Chemical Treatment
  - Excavation and Off-site Landfill Disposal

4.3 Development of Remedial Alternatives

4.3.1 No Action and Institutional Controls Alternative

Under this passive alternative, no action will be taken at the site to remove, treat, or contain the soil contamination. The no action alternative includes monitoring of surface water, sediment, and fish tissue samples for a 30 year period to determine the impact of the COPCs on the environments. The no action alternative is being evaluated as a baseline alternative. The site presents limited exposure potential for protected bird species under the no-action alternative. Under the no action alternative, flooding of the property could not be accomplished in accordance with applicable state and federal regulations.

4.3.1.1 Effectiveness

The no action alternative is not effective in achieving the RAOs.

4.3.1.2 Implementability

The no action alternative is easily implemented, but will not achieve the RAOs. Action would be required in some areas to maintain pumping and control structures to insure the land remains un-flooded. Maintenance costs would also include inspection and erosion controls, and mowing in some locations to maintain roads.

4.3.1.3 Cost

The no action alternative will have a baseline annual monitoring only cost requiring negotiation with other agencies. NSRA site minimum administrative and maintenance costs are estimated at $450,000 per year, not including periodic 5 year reviews of the site. These costs do not include any significant levee maintenance, or pumping controls costs or any increased costs associated with control of increased P flux from soils.

4.3.2 Active Remediation Application Considerations

Soil remediation of 0-12 inch depth soils containing various amounts of OCPs is needed to accomplish varying degrees of risk reduction - management. Specifically, reduction of OCPs to Target levels is needed to allow timely re-flooding in support of the lake Apopka Restoration. Hydraulically, flooding will likely be accomplished on a FB size basis, therefore, the need exists to apply active remediation measures on an Alum Block or field size basis within FBs to accelerate completion of risk reduction within those prioritized areas. The location and timing of treatment may be based on a number of factors including topographic boundaries and control structures, and the time needed to accomplish and perform confirmation monitoring of adequate treatment.

Typical site restorations often involve source reduction and perimeter containment first, followed by broader plume reduction and monitoring. In this case, however, the essentially large scale "non-point" source nature of the problem is more conducive to treatment of lower strength areas to allow more rapid re-flooding.

Technology options can be coupled in different treatment trains on a field level for more effective, faster, and less costly remediation alternatives, and to avoid broad application of actions that are in excess of what is required. For example, a field might be subject to custom restoration involving partial reduction by tilling and amendments, followed by vertical blending with deeper soils.

Based on these underlying assumptions, and to maintain maximum flexibility, MACTEC has assembled a matrix of technology and actions as process unit building blocks that may be applied to various contamination levels, soil conditions, or other site conditions. When put together as a treatment train, these options provide alternatives for field level remediation. The sum of these alternatives and the deployment scenario and schedule define the overall site restoration. This approach is technically advantageous because it can be applied even if site concentrations, size, treatment depths, or target remediation levels change.

The remainder of this section presents the development of remedial alternatives to address OCP contaminated soil at NSRA. Technologies/process options retained following the screening describe in Sections 4.1 and 4.2 are combined to form remedial action alternatives. Alternatives are developed to attain the RAO discussed in sections 3.2 and 3.3, using the general response actions either singly or in combination (no action; limited action; containment, *ex situ* and *in situ* treatments). A range of remedial alternatives have been considered to address contaminated media at the site to satisfy the established RAOs. For the no action alternative, the only action required to be implemented is the draining of excess water in order to maintain the fields dry.

Remedial alternatives have been developed following a consistent methodology and rationale to determine which technologies are suitable for each field. Tables 4-3 shows the different remedial alternatives with the selected options taking into account the location (up-slope, near features or similar blocks, interim flooding depth, etc.) and characteristics (size, TOC content) of the field in question. Table 4-3 also presents the minimum percent reduction required for each field in order to meet the carbon normalized BETL shown in Table 3-2. Table 4-4 contains analogous information for each field in order to meet the CTL shown in Table 3-2. These tables are arranged in order of higher to lower percent reduction required. The percentage reduction for the critical containment required to meet the BETLs and CTLs, extracted from these tables are shown on Figures 4-2 and 4-3. A column with a field identification number has been included in Tables 4-3 and 4-4. Figure 4-1 presents the NSRA area with these field identification numbers and associated owner – alum block field identification. The fields proposed for the different remedial alternatives are shown in Figures 4-4 and 4-5. These figures follow the information presented in Tables 4-3 and 4-4.

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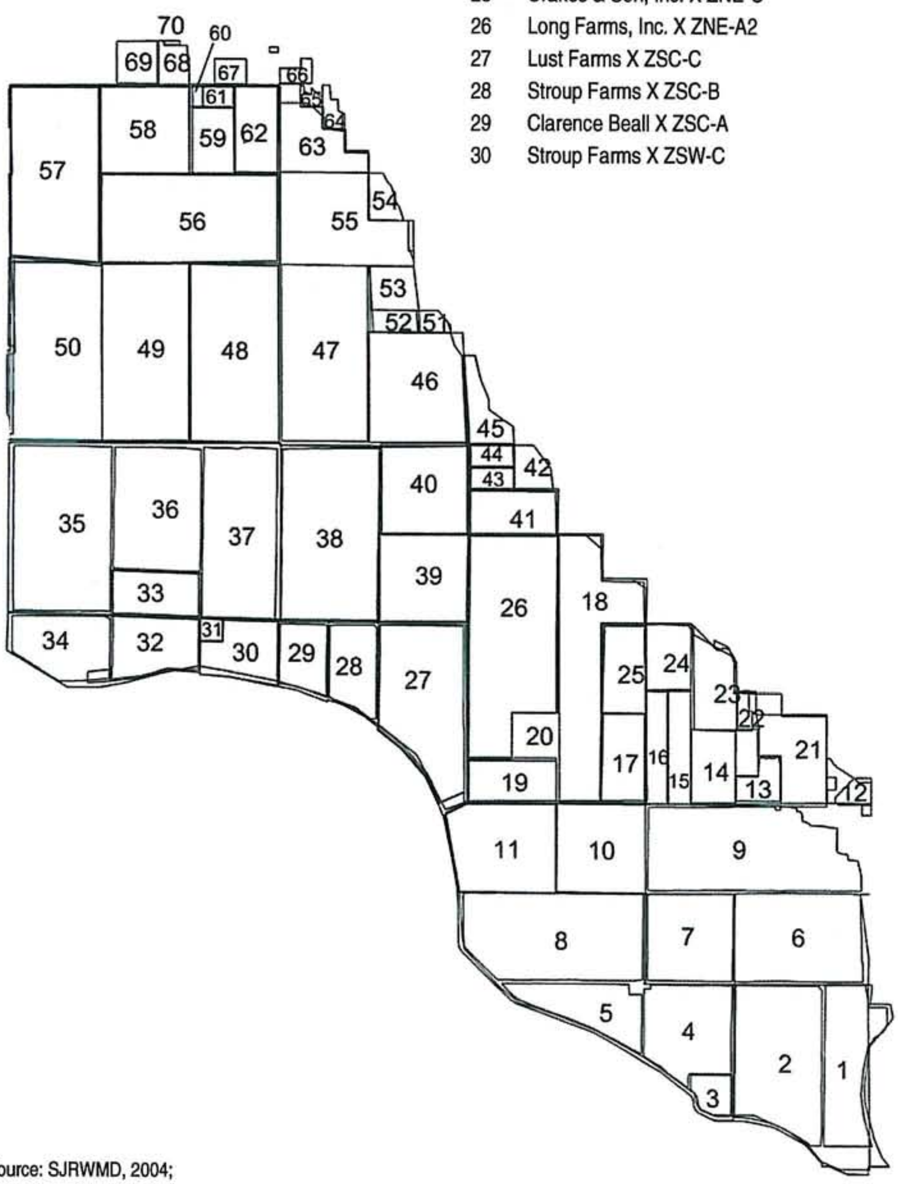
Field #	Owner X Alum
1	Zellwin Farms X ZSE-J
2	Zellwin Farms X ZSE-I
3	Clonts Farm X ZSE-H
4	Clonts Farm X ZSE-G
5	Clonts Farm X ZSE-C
6	Lust Farms X ZSE-F
7	Stroup Farms X ZSE-E
8	Clonts Farm X ZSE-B
9	Lust Farms X ZSE-D
10	Lust Farms X ZSE-A
11	Long Farms, Inc. X ZSE-A
12	Lust & Long Precooler X ZNE-F
13	Long Farms, Inc. X ZNE-F
14	Long Farms, Inc. X ZNE-D1
15	Lust Farms X ZNE-D
16	Long Farms, Inc. X ZNE-D2
17	Lust Farms X ZNE-C
18	Lust Farms X ZNE-B
19	Stroup Farms X ZNE-A
20	Lust Farms X ZNE-A
21	Mulford Hickerson c/o Peat Hummus Corp X ZNE-F
22	Long Farms, Inc.
23	Long Farms, Inc. X ZNE-E
24	Crakes & Son, Inc. X ZNE-D
25	Crakes & Son, Inc. X ZNE-C
26	Long Farms, Inc. X ZNE-A2
27	Lust Farms X ZSC-C
28	Stroup Farms X ZSC-B
29	Clarence Beall X ZSC-A
30	Stroup Farms X ZSW-C
31	Zellwood Drainage District X ZSW-C
32	Crakes & Son, Inc. X ZSW-B
33	Clarence Beall X ZNW-B
34	Zellwin Farms X ZSW-A
35	Zellwin Farms X ZNW-A
36	Zellwin Farms X ZNW-B
37	Zellwin Farms X ZNW-C
38	Zellwin Farms X ZNC-A
39	Clarence Beall X ZNC-B
40	Crakes & Son, Inc. X ZNC-B
41	Crakes & Son, Inc. X ZNE-A2
42	Smith X ZNE-A
43	Long Farms, Inc. X ZNE-A1
44	Crakes & Son, Inc. X ZNE-A1
45	Long Farms, Inc. X Z1S-E
46	Zellwin Farms X Z1S-E
47	Zellwin Farms X Z1S-D
48	Zellwin Farms X Z1S-C
49	Zellwin Farms X Z1S-B
50	Zellwin Farms X Z1S-A
51	Shaffer X Z1S-E
52	Marsell X Z1S-E
53	Grinnell Farms, Inc. X Z1S-E
54	General Impex X Z1N-G
55	Zellwin Farms X Z1N-G
56	Robert Potter & Sons, Inc. X Z1N-F
57	Hensel & Rodgers X Z1N-A
58	Long Farms, Inc. X Z1N-C
59	Grinnell Farms, Inc. X Z1N-D
60	Rice X Z1N-D1
61	Rice X Z1N-D2
62	Zellwin Farms X Z1N-D
63	Zellwin Farms X Z1N-E
64	Marsell X Z1N-E
65	Bates X Z1N-E
66	Grinnell Farms, Inc. X Z1N-E
67	Shortz X Z1N-B2
68	Shortz X Z1N-B1
69	NAPA X Z1N-B
70	Progressive Growers (Rice) X Z1N-B



Source: SJRWMD, 2004;
MACTEC, 2004.

Prepared/Date: MLJ 7/26/04
Checked/Date: WAT 7/27/04

Lake Apopka North Shore Restoration Area SJRWMD Orange & Lake Counties, FL	MACTEC	Field Names PROJ. NO. 609604004 Figure 4-1

Table 4-3. Remedial Alternatives for the Minimum Percent Reduction to Meet the BETL

Field Identification Number	OWNER X ALUM[1]	Acres	Flooding Block Designation	Flooding Block Depth (ft)	Critical Contaminant	% Reduction Low	% Reduction High	Average Carbon-Normalized Concentration Of Critical Contaminant (µg/kg TOC)	% TOC	Island construction	Berm Only Containment of the Non-Flooded Areas	Soil cover	Soil layer Inversion	Vertical blending	Horizontal blending	Landfarming –tilling with bio and/or chemical amendments	Bioremediation-aerobic-anaerobic dechlorination	Soil Reactor *ex situ* Chemical Treatment	Excavation/Off-Site Land Disposal
41	Crakes & Son, Inc. X ZNE-A2	76.687	FB5	1.5 TO 2	DDTx	68%	- 91%	71114	47.74	X		X				X	X	X	X
63	Zellwin Farms X Z1N-E	96.277	FB14	0.5	DDTx	57%	- 85%	158803	27.08		X	X				X	X	X	X
24	Crakes & Son, Inc. X ZNE-D	58.624	FB8	2	DDTx	34%	- 78%	10210	48.43	X		X		X		X	X		
56	Robert Potter & Sons, Inc. X Z1N-F	307.969	FB13	0.5	toxaphene	22%	- 69%	17600	31.19				X	X		X	X		
2	Zellwin Farms X ZSE-I	246.960	FB6	2	toxaphene	20%	- 73%	79048	31.99				X	X	X	X	X		
53	Grinnell Farms, Inc. X Z1S-E	40.591	FB10	1	DDTx	18%	- 75%	27658	31.03				X	X	X	X	X		
10	Lust Farms X ZSE-A	156.729	FB6	2	toxaphene	14%	- 74%	73874	39.88				X	X	X	X	X		
48	Zellwin Farms X Z1S-C	314.405	FB11	2	toxaphene	13%	- 62%	72987	33.23				X	X		X	X		
64	Marsell X Z1N-E	13.332	FB14	0.5	DDTx	11%	- 78%	25273	30.43		X		X	X	X	X	X		
62	Zellwin Farms X Z1N-D	75.071	FB13	0.5	DDTx	9%	- 69%	24820	35.57				X	X	X	X	X		
58	Long Farms, Inc. X Z1N-C	159.357	FB13	0.5	DDTx	9%	- 69%	24750	13.55				X	X	X	X	X		
68	Shortz X Z1N-B1	24.043	NFB		DDE	7%	- 46%	12468	19.25				X	X		X	X		
13	Long Farms, Inc. X ZNE-F	40.112	FB8	2	toxaphene	7%	- 74%	68276	35.88				X	X		X	X		
59	Grinnell Farms, Inc. X Z1N-D	56.731	FB13	0.5	DDTx	7%	- 54%	24386	44.00				X	X		X	X		
69	NAPA X Z1N-B	34.135	NFB		DDE	7%	- 54%	21420	4.02				X	X		X	X		
55	Zellwin Farms X Z1N-G	198.201	FB14	0.5	toxaphene	4%	- 64%	65527	32.41				X	X		X	X		
47	Zellwin Farms X Z1S-D	307.701	FB10	1	toxaphene	3%	- 61%	6917	37.91				X	X			X		

Source: SJRWMD, 2004; MACTEC, 2004.

[1] OWNER X ALUM is a code identifying farm fields.

Prepared by/Date: MLJ 7/22/04

Checked by/Date: EMK/WAT 7/24/04

Table 4-4. Remedial Alternatives for the Maximum Percent Reduction to Meet the CTL

Field Identification Number	OWNER X ALUM[1]	Acres	Flooding Block Designation	Flooding Block Depth (ft)	Critical Contaminant	% Reduction Low	% Reduction High	Average Carbon-Normalized Concentration Of Critical Contaminant (µg/kg TOC)	% TOC	Island construction	Berm Only Containment of the Non-Flooded Areas	Soil cover	Soil layer flipping	Vertical blending	Horizontal blending	Landfarming -tilling with bio and/or chemical amendments	Bioremediation-aerobic-anaerobic dechlorination	Soil Reactor *ex situ* Chemical Treatment	Excavation/Off-Site Land Disposal
41	Crakes & Son, Inc. X ZNE-A2	76.687	FB5	1.5 TO 2	DDTx	68%	- 91%	71114	47.74	X		X				X	X	X	X
63	Zellwin Farms X Z1N-E	96.277	FB14	0.5	DDTx	57%	- 85%	15880	27.08		X	X				X	X	X	X
24	Crakes & Son, Inc. X ZNE-D	58.624	FB8	2	DDTx	34%	- 78%	10210	48.43	X		X				X	X	X	X
64	Marsell X Z1N-E	13.332	FB14	0.5	DDTx	11%	- 78%	25273	30.43		X	X				X	X	X	X
53	Grinnell Farms, Inc. X Z1S-E	40.591	FB10	1	DDTx	18%	- 75%	27658	31.03	X		X				X	X	X	X
10	Lust Farms X ZSE-A	156.729	FB6	2	toxaphene	14%	- 74%	73874	39.88						X	X	X	X	X
13	Long Farms, Inc. X ZNE-F	40.112	FB8	2	toxaphene	7%	- 74%	68276	35.88						X	X	X	X	X
2	Zellwin Farms X ZSE-I	246.960	FB6	2	toxaphene	20%	- 73%	79048	31.99						X	X	X	X	X
56	Robert Potter & Sons, Inc. X Z1N-F	307.969	FB13	0.5	toxaphene	22%	- 69%	17600	31.19							X	X	X	X
62	Zellwin Farms X Z1N-D	75.071	FB13	0.5	DDTx	9%	- 69%	24820	35.57							X	X	X	X
58	Long Farms, Inc. X Z1N-C	159.357	FB13	0.5	DDTx	9%	- 69%	24750	13.55							X	X	X	X
33	Clarence Beall X ZNW-B	75.371	FB2	3	DDE	0%	- 67%	10153	26.98						X	X	X	X	X
46	Zellwin Farms X Z1S-E	214.079	FB10	1	DDTx	0%	- 65%	23156	41.25							X	X	X	X
55	Zellwin Farms X Z1N-G	198.201	FB14	0.5	toxaphene	4%	- 64%	65527	32.41						X	X	X	X	X
57	Hensel & Rodgers X Z1N-A	306.203	FB12	0.5	DDE	0%	- 64%	20860	2.09							X	X	X	X
17	Lust Farms X ZNE-C	75.425	FB5	1.5 TO 2	toxaphene	0%	- 63%	50763	38.84							X	X	X	X
43	Long Farms, Inc. X ZNE-A1	19.117	FB5	1.5 TO 2	DDTx	0%	- 62%	20893	39.58							X	X	X	X
48	Zellwin Farms X Z1S-C	314.405	FB11	2	toxaphene	13%	- 62%	72987	33.23						X	X	X	X	X
47	Zellwin Farms X Z1S-D	307.701	FB10	1	toxaphene	3%	- 61%	6917	37.91							X	X	X	X

Table 4-4. Remedial Alternatives for the Maximum Percent Reduction to Meet the CTL

Field Identification Number	OWNER X ALUM[1]	Acres	Flooding Block Designation	Flooding Block Depth (ft)	Critical Contaminant	% Reduction Low	% Reduction High	Average Carbon-Normalized Concentration Of Critical Contaminant (µg/kg TOC)	% TOC	Island construction	Berm Only Containment of the Non-Flooded Areas	Soil cover	Soil layer flipping	Vertical blending	Horizontal blending	Landfarming -tilling with bio and/or chemical amendments	Bioremediation-aerobic-anaerobic dechlorination	Soil Reactor *ex situ* Chemical Treatment	Excavation/Off-Site Land Disposal
50	Zellwin Farms X Z1S-A	329.036	FB11	2	toxaphene	0%	- 58%	56961	25.80							X	X	X	X
49	Zellwin Farms X Z1S-B	308.098	FB11	2	toxaphene	0%	- 57%	56572	29.88							X	X	X	X
1	Zellwin Farms X ZSE-J	143.455	FB6	2	toxaphene	0%	- 56%	52116	40.28							X	X	X	X
16	Long Farms, Inc. X ZNE-D2	47.085	FB8	2	toxaphene	0%	- 55%	59669	43.49							X	X	X	X
23	Long Farms, Inc. X ZNE-E	73.439	FB8	2	toxaphene	0%	- 54%	55441	44.25						X	X	X	X	X
59	Grinnell Farms, Inc. X Z1N-D	56.731	FB13	0.5	DDTx	7%	- 54%	24386	44.00							X	X	X	X
69	NAPA X Z1N-B	34.135	NFB		DDE	7%	- 54%	21420	4.02						X	X	X	X	X
14	Long Farms, Inc. X ZNE-D1	64.537	FB8	2	toxaphene	0%	- 48%	45136	30.84							X	X		
20	Lust Farms X ZNE-A	39.893	FB5	1.5 TO 2	toxaphene	0%	- 47%	60180	52.58							X	X		
68	Shortz X Z1N-B1	24.043	NFB		DDE	7%	- 46%	12468	19.25							X	X		
6	Lust Farms X ZSE-F	222.705	FB7	2	toxaphene	0%	- 44%	47650	35.58					X		X	X		
9	Lust Farms X ZSE-D	316.043	FB7	2	toxaphene	0%	- 42%	47115	37.95					X		X	X		
28	Stroup Farms X ZSC-B	78.596	FB1	3	dieldrin	0%	- 40%	14567	39.73					X	X	X	X		
44	Crakes & Son, Inc. X ZNE-A1	19.603	FB5	1.5 TO 2	DDTx	0%	- 36%	14750	38.15					X		X	X		
25	Crakes & Son, Inc. X ZNE-C	73.932	FB5	1.5 TO 2	DDTx	0%	- 33%	13810	39.33					X	X	X	X		
26	Long Farms, Inc. X ZNE-A2	356.644	FB5	1.5 TO 2	toxaphene	0%	- 31%	38819	48.32				X	X	X	X	X		
27	Lust Farms X ZSC-C	242.009	FB1	3	toxaphene	0%	- 31%	34331	44.33				X	X		X	X		
19	Stroup Farms X ZNE-A	75.694	FB5	1.5 TO 2	toxaphene	0%	- 29%	1199	44.71				X	X		X	X		
39	Clarence Beall X ZNC-B	150.972	FB4	2	dieldrin	0%	- 28%	5023	38.59				X	X		X	X		

Table 4-4. Remedial Alternatives for the Maximum Percent Reduction to Meet the CTL

Field Identification Number	OWNER X ALUM[1]	Acres	Flooding Block Designation	Flooding Block Depth (ft)	Critical Contaminant	% Reduction Low	% Reduction High	Average Carbon-Normalized Concentration Of Critical Contaminant (µg/kg TOC)	% TOC	Island construction	Berm Only Containment of the Non-Flooded Areas	Soil cover	Soil layer flipping	Vertical blending	Horizontal blending	Landfarming -tilling with bio and/or chemical amendments	Bioremediation-aerobic-anaerobic dechlorination	Soil Reactor *ex situ* Chemical Treatment	Excavation/Off-Site Land Disposal
7	Stroup Farms X ZSE-E	148.245	FB7	2	toxaphene	0%	- 22%	32806	36.85				X	X		X	X		
42	Smith X ZNE-A	29.283	FB5	1.5 TO 2	toxaphene	0%	- 18%	32414	34.00				X	X	X	X	X		
40	Crakes & Son, Inc. X ZNC-B	156.145	FB4	2	toxaphene	0%	- 18%	6404	39.90				X	X		X	X		
32	Crakes & Son, Inc. X ZSW-B	94.714	FB1	3	DDE	0%	- 12%	15835	30.80				X	X	X	X	X		
35	Zellwin Farms X ZNW-A	321.842	FB2	3	toxaphene	0%	- 10%	31701	37.95				X	X		X	X		
11	Long Farms, Inc. X ZSE-A	181.786	FB6	2	toxaphene	0%	- 8%	28228	47.84				X	X	X	X	X		
38	Zellwin Farms X ZNC-A	332.688	FB3	2	toxaphene	0%	- 5%	28939	36.36				X	X		X	X		
36	Zellwin Farms X ZNW-B	211.451	FB2	3	toxaphene	0%	- 4%	26440	34.63				X	X	X	X	X		

Source: SJRWMD, 2004; MACTEC, 2004. Prepared by/Date: MLJ 7/22/04

[1] OWNER X ALUM is a code identifying farm fields. Checked by/Date: EMK/WAT 7/24/04

No other fields require action to meet the CTLs. Supporting documentation in Appendix A.

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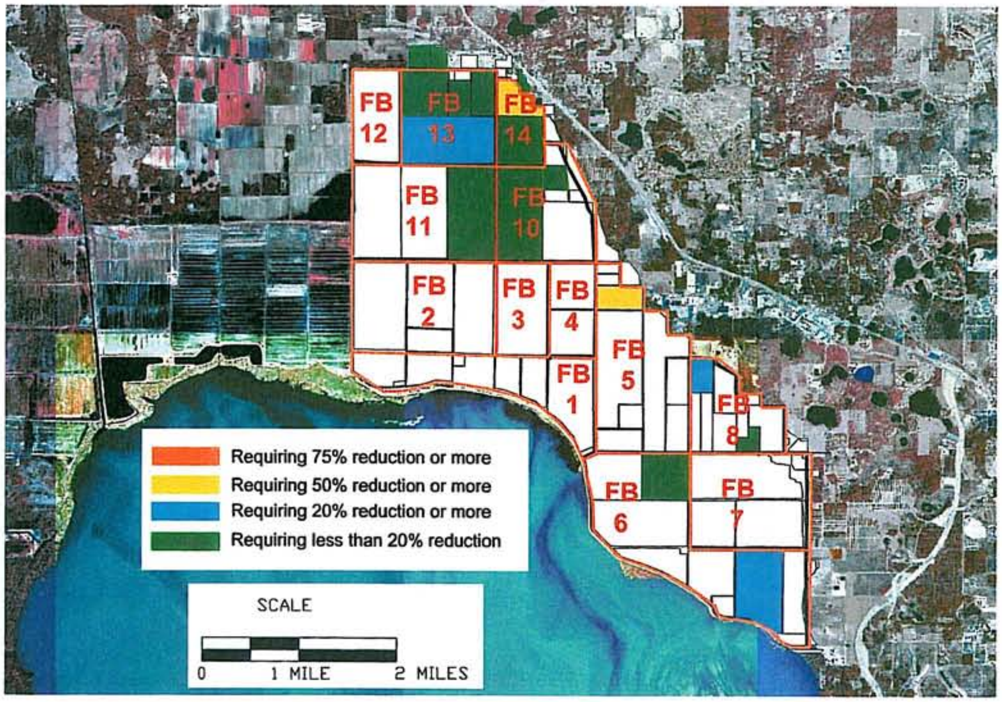
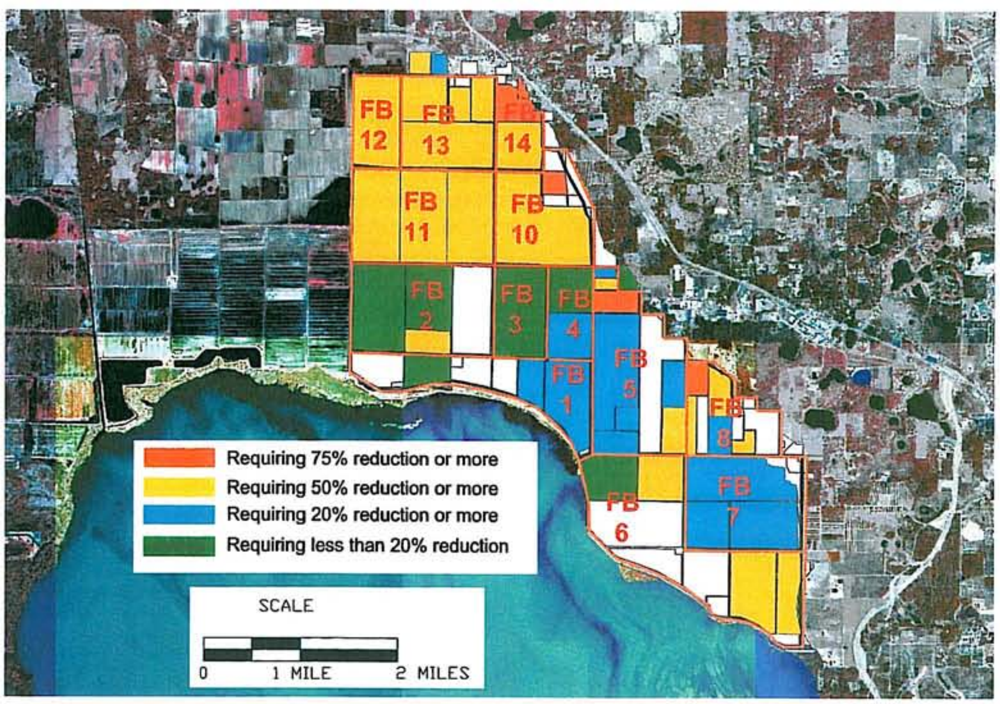


Source: SJRWMD, 2004; MACTEC, 2004.

Prepared/Date: MLJ 7/26/04
Checked/Date: WAT 7/27/04

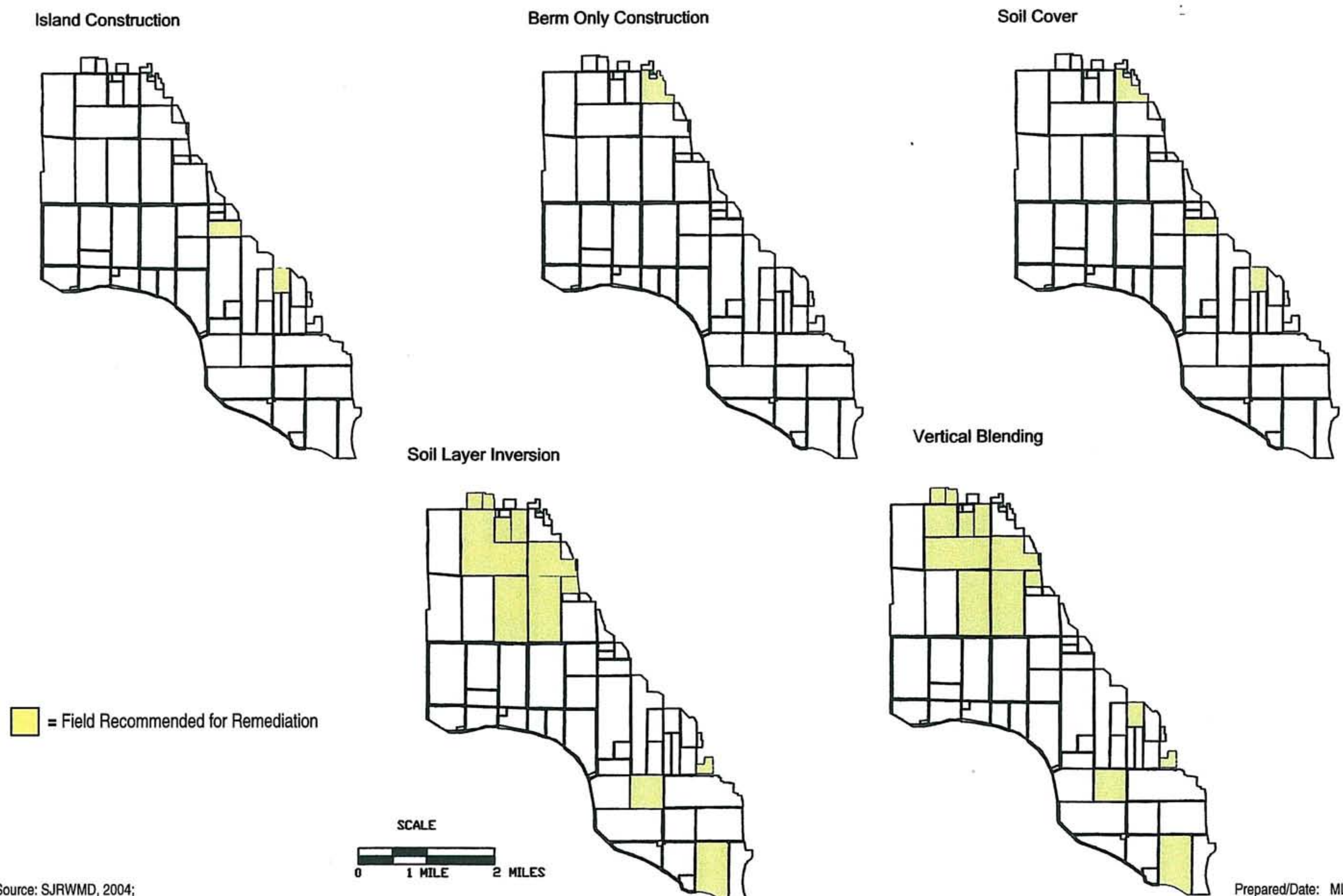
Lake Apopka North Shore Restoration Area SJRWMD Orange & Lake Counties, FL	MACTEC	Minimum Treatment to Meet BETL PROJ. NO. 609604004 Figure 4-2



Source: SJRWMD, 2004; MACTEC, 2004.

Prepared/Date: MLJ 7/26/04
Checked/Date: WAT 7/27/04

Lake Apopka North Shore Restoration Area SJRWMD Orange & Lake Counties, FL	MACTEC	Maximum Treatment to Meet CTL PROJ. NO. 609604004 Figure 4-3



Source: SJRWMD, 2004;
MACTEC, 2004.

Prepared/Date: MLJ 7/26/04
Checked/Date: WAT 7/27/04

Lake Apopka North Shore Restoration Area ZDWCD Units 1 and 2 SJRWMD, Lake & Orange Counties, FL	MACTEC	Applicable Technologies to Achieve BETL PROJ. NO. 609604004 Figure 4-4a

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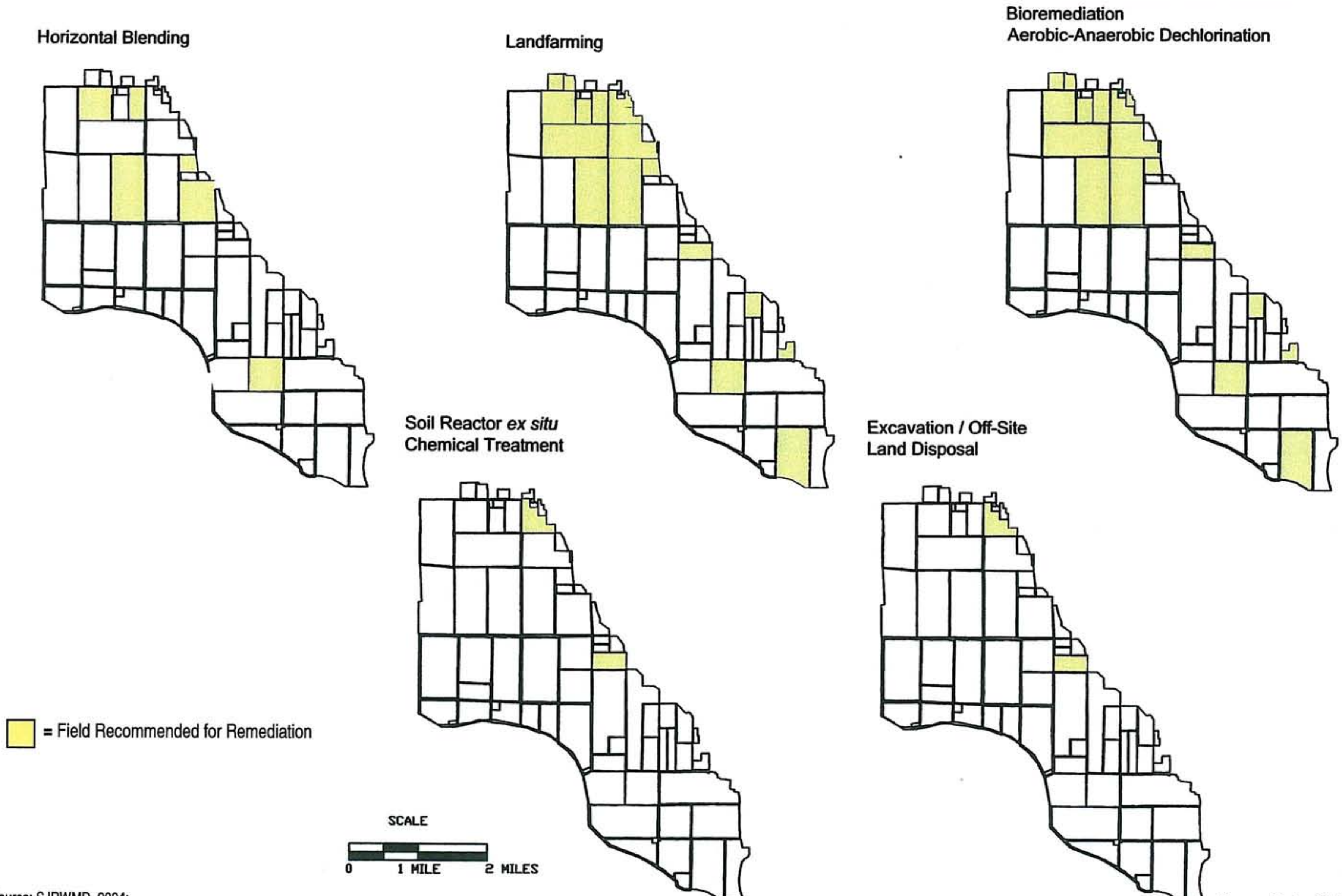

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MACTEC, 2004.

Prepared/Date: MLJ 7/26/04
Checked/Date: WAT 7/27/04

Lake Apopka North Shore Restoration Area ZDWCD Units 1 and 2 SJRWMD, Lake & Orange Counties, FL	MACTEC	Applicable Technologies to Achieve BETL PROJ. NO. 609604004 Figure 4-4b

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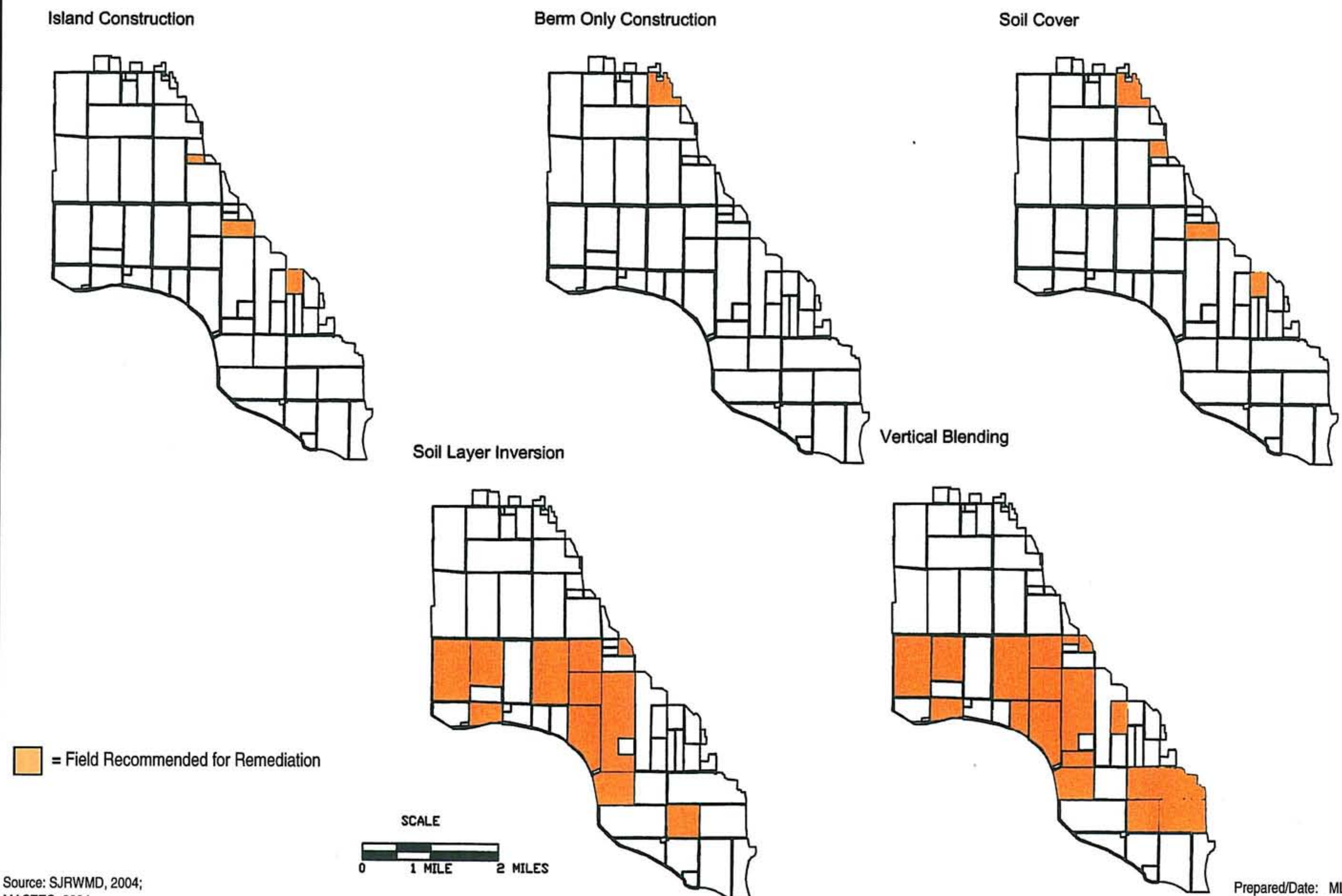

Source: SJRWMD, 2004; MACTEC, 2004.

Prepared/Date: MLJ 7/26/04
Checked/Date: WAT 7/27/04

Lake Apopka North Shore Restoration Area ZDWCD Units 1 and 2 SJRWMD, Lake & Orange Counties, FL	MACTEC	Applicable Technologies to Achieve CTL PROJ. NO. 609604004 Figure 4-5a

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Lake Apopka North Shore Restoration Area ZDWCD Units 1 and 2 SJRWMD, Lake & Orange Counties, FL	MACTEC	Applicable Technologies to Achieve CTL PROJ. NO. 609604004 Figure 4-5b

The rationale and methodology used to select applicable attenuation method was as follows:

- Fields requiring a high percentage reduction (highly contaminated fields) to meet the established remediation target level, and are located at the up-slope boundary of the NSRA (i.e., Crakes & Sons, Inc farm located in alum block ZNE-A2) are considered for isolation/containment and the more aggressive *ex situ* treatment options.
- Fields with high concentrations of contaminants located adjacent to fields considered for isolation/containment alternatives, are considered for scraping and removal of the top 1 ft soil layer to be disposed of at the adjacent, highly contaminated field considered for isolation/containment (horizontal blending).
- Fields with high concentrations of contaminants located adjacent to existing roads are also considered for scraping and removal of the top 1 ft soil layer to form wider covered berms alongside the existing roads.
- Fields moderately contaminated and adjacent to fields requiring no treatment, are considered for use elsewhere in soil horizontal blending.
- Fields requiring 45% reduction or less are considered for soil vertical blending.
- Fields requiring 32% reduction or less are considered for site proven soil layer inversion.
- Fields requiring 75% reduction or less with TOC levels at or above 10% are considered for bioremediation (aerobic-anaerobic dechlorination).
- Fields requiring more than 50% reduction would require several cycles depending on concentrations.
- Fields with smaller acreage requiring 75% reduction or less with TOC levels less than 10% are considered for landfarming with chemical amendments and/or soil reactor *ex situ* chemical treatment (ISCO). Such fields may require custom dosing treatment and possible polishing cycles depending on concentrations.

To present the different alternatives that will address the two distinct remediation levels presented in Table 3-2, the alternatives to meet the BETL are developed in Section 4.3.3, and the alternatives to meet the CTL are developed in Section 4.3.4.

4.3.3 Remedial Alternatives for the Minimum Percent Reduction to Meet the BETL

Table 4-3 shows a total of 17 fields requiring remedial action to meet the RAOs BETL. The minimum percent reduction required ranges from 68 to 3% for the carbon normalized critical parameter. Following the method and rationale discussed above to determine the most appropriate technology for the characteristics of each field, possible alternatives are presented for three different ranges of percent reduction requirements, including 1) fields requiring reduction of 50% or above, 2) fields with a percent reduction between 50 and 20% and, 3) fields requiring less than 20% reduction. Restoration of each of these sub-groups of fields is discussed further in the following sections.

4.3.3.1 Remedial Alternatives for Fields Requiring a Percent Reduction Greater than 50%

There are two fields in this category as shown in Table 4-4 for which DDTx is the critical contaminant, with a total area of approximately 173 acres. These two fields are located at the east boundary of the NSRA.

4.3.3.1.1 No Action

The "no action" alternative is usually incorporated in the FS in order to have a baseline reference with which to compare other alternative. In the case of the NSRA, no action (as well as limited action) demands that the fields are kept in a dry condition to avoid the contact of surface water with contaminated soil/sediment, in this way preventing the establishment of fish habitat that may attract bird populations. This alternative prevents the realization of a critical element for the overall restoration of Lake Apopka.

4.3.3.1.2 Limited Action

The limited action alternative is similar to the no action alternative mentioned above with the distinction that it would include monitoring programs including soil sampling and the implementation of remedial actions. Though monitoring does not prevent exposure to contaminants, it could be used in combination with other remedial actions to evaluate the short-term and long-term effects of these actions.

4.3.3.1.3 Isolation/Containment

Several technologies were selected, including construction of bermed areas or islands that would preclude flooding the field or part of the field, soil covers, soil layer inversion, vertical blending, and horizontal blending.

The two fields considered here are located at the east boundary of the NSRA and both exhibit a high concentration of DDTx making them suitable for the construction of bermed areas to preclude flooding. If implemented, this alternative would represent a 1.7% of the total NSRA would be unavailable for flooding. These two fields would not be suitable for either soil layer inversion, or vertical soil blending given that the these technologies would at most result in a 45 and 30% reduction, respectively, which is not sufficient to meet the BETL.

4.3.3.1.4 *In situ* Treatment

The technologies considered here are landfarming, which consists or tilling the upper foot of soil with the addition of chemical and/or biological amendments, and multi-cycle bioremediation with the addition of amendments necessary for aerobic-anaerobic reductive dechlorination. Amendments would be tilled into the soil in both cases, including nutrients, enzymes, bacteria, moisture, bulking agents, pH, and moisture control additives. Surfactant treatments are also sometimes applied to accelerate pollutant biovailability.

4.3.3.1.5 *Ex situ* Treatment

The processes examined here are soil reactor *ex situ* chemical treatment. This alternative would require staging and handling of excavated soils for custom treatment. The AOP cavitation mixing reactor would not require the additional handling. The treatment is capable of processing 100 to 250 tons per hour, and producing an acceptable product in one pass. The better the initial treatment, the less soil would require treatment and disposal by blending on-site in the same field. ADP is anticipated to be simple and fast technology to implement.

4.3.3.2 Remedial Alternatives for Fields Requiring Between 50 and 20% Reduction (BETL)

There are three fields in this category as shown in Table 4-3. DDTx is the critical contaminant for the field located at the east boundary of the NSRA, toxaphene is the critical contaminant for the other two fields, one located at the north east shore of the lake and the other just north of Interceptor Road. These three fields represent a total area of approximately 614 acres.

4.3.3.2.1 No Action

The "no action" alternative demands that the fields are kept in a dry condition to avoid the contact of surface water with contaminated soil/sediment, in this way preventing the establishment of fish habitat that may attract bird populations. This alternative prevents the realization of a critical element for the overall restoration of Lake Apopka.

4.3.3.2.2 Limited Action

The limited action alternative is similar to the no action alternative mentioned above with the distinction that it would include monitoring programs including soil sampling and the implementation of remedial actions. Though monitoring does not prevent exposure to contaminants, it could be used in combination with other remedial actions to evaluate the short-term and long-term effects of these actions.

4.3.3.2.3 Isolation/Containment

Several technologies were examined here, including construction of bermed areas or islands that would preclude flooding all or part of the field, soil covers, soil layer inversion, vertical blending and horizontal blending.

Two of the fields considered here is located at the east boundary of the NSRA making then suitable for the construction of a bermed area to preclude flooding. If implemented, this alternative would be represent a less of 173 acres or less than two percent of the total NSRA that would be unavailable for flooding.

Using the methodology describe above, these three fields would be suitable for either soil layer inversion, or vertical soil blending given that the these technologies would result in a 45 to 30% reduction, respectively, sufficient to meet the BETL.

Horizontal soil blending is also considered for these three fields given that they are located adjacent to fields with no remedial action requirements.

4.3.3.2.4 *In situ* Treatment

The technologies and soil handling options considered here included landfarming, which consists or tilling the upper foot of soil with the addition of chemical and/or biological amendments, and bioremediation with the addition of amendments necessary for aerobic-anaerobic reduction dechlorination. Due to the lower reduction required (20 to 50%), shorter or less intensive amendment programs would be required

4.3.3.2.5 *Ex situ* Treatment

The processes examined here are soil reactor *in situ* chemical treatment (Soilsavers FX) and low temperature thermal desorption. This group of fields would require only partial volume or strength treatment to reach the point of allowing blending to accomplish the remainder of the RAOs. Further analysis would be needed to determine the point at which mobilizing and permitting the thermal treatment becomes less economical than the chemical option. Also, the chemical blending process option would require preliminary bench testing to optimize the dosing for various concentration and TOC conditions.

4.3.3.3 Remedial Alternatives for Fields Requiring Less Than 20% Reduction (BETL)

There are 12 fields in this category as shown in Table 4-4. DDTx is the critical contaminant for five fields, toxaphene for five fields and DDE for the remaining two fields. Four of these fields are located at the north and east boundaries and three are located relatively close to the north boundary of the NSRA. These 12 fields represent a total area of approximately 1,420 acres.

4.3.3.3.1 No Action

The “no action” alternative demands that the fields are kept in a dry condition to avoid the contact of surface water with contaminated soil/sediment, in this way preventing the establishment of fish habitat that may attract bird populations. This alternative prevents the realization of a critical element for the overall restoration of Lake Apopka.

4.3.3.3.2 Limited Action

The limited action alternative is similar to the no action alternative mentioned above with the distinction that it would include monitoring programs including soil sampling and the implementation of remedial actions. Though monitoring does not prevent exposure to contaminants, it could be used in combination with other remedial actions to evaluate the short-term and long-term effects of these actions.

4.3.3.3.3 Isolation/Containment

Isolation technologies were examined here included soil layer inversion, vertical blending and horizontal blending.

Using the selection methodology described above, these fields would be suitable for either soil layer inversion, or vertical soil blending given that the these technologies would result in an estimated 45 and 30% reduction, respectively, sufficient for these fields to meet the BETL.

Horizontal soil blending is considered for some of these fields given that they are located adjacent to several similarly sized fields with no remedial action requirements that are planned for flooding to the same depth.

4.3.3.3.4 *In situ* Treatment

The technologies considered here are landfarming, which consists or tilling the upper foot of soil with the addition of chemical and/or biological amendments, and bioremediation with the addition of amendments necessary for anaerobic-aerobic reductive dechlorination. Landfarming may be expected to achieve at least as much reduction as the recent tilling demonstration (20%) even without amendments to accelerate and improve the degradation. Four of the fields totaling over 450 acres already exhibit DDT breakdown to DDE.

4.3.3.3.5 *Ex situ* Treatment

The processes examined here are soil reactor *ex situ* chemical treatment. Minimum treatment of 1,420 acres would only be done on higher strength fields requiring greater than 70% reduction to more quickly allow blending to achieve the final endpoints. Due to the large acreage involved, this option is subject to further economic analysis to verify such action is worthwhile.

4.3.4 Remedial Alternatives for the Maximum Percent Reduction to Meet the CTL

Table 4-4 shows a total of 46 fields requiring remedial action to meet the RAOs CTL. The percent reduction required ranges from 91 to 4%. Following the method to determine the most appropriate technology for the characteristics of each field, the alternatives are presented for four different ranges of percent reduction requirements:

1. A percent reduction of 75% or higher,
2. Fields requiring a percent reduction of 50% to 75%
3. Fields requiring a percent reduction of 20% to 50%,
4. Fields requiring a reduction less than 20%.

4.3.4.1 Remedial Alternatives for Fields Requiring 75% or Higher Reduction

There are five fields with a total area of approximately 286 acres in this category as shown in Table 4-4 for which DDTx is the critical contaminant. These five fields are located at the north-east and east boundaries of the NSRA.

4.3.4.1.1 No Action

The "no action" alternative demands that the fields are kept in a dry condition to avoid the contact of surface water with contaminated soil/sediment, in this way preventing the establishment of fish habitat that may attract bird populations. This alternative prevents the realization of a critical element for the overall restoration of Lake Apopka.

4.3.4.1.2 Limited Action

The limited action alternative is similar to the no action alternative mentioned above with the distinction that it would include monitoring programs including soil sampling and the implementation of remedial actions. Though monitoring does not prevent exposure to contaminants, it could be used in combination with other remedial actions to evaluate the short-term and long-term effects of these actions.

4.3.4.1.3 Isolation/Containment

Several technologies were examined here: construction of bermed areas or islands that would preclude flooding the field or part of the field, *in situ* capping which would seal contaminants under soil covers, soil layer inversion, vertical blending and horizontal blending.

The five fields considered here are located at the north-east and east boundaries of the NSRA and all exhibit a high concentration of DDTx making them suitable for the construction of bermed areas to preclude flooding. If implemented, this alternative would represent 286 acres or approximately 3.2 percent of the total NSRA would be unavailable for flooding.

These five fields would not be suitable for either soil layer inversion, or vertical soil blending given that the these technologies would at most result in a 45 and 30% reduction, respectively, not sufficient to meet the CTL.

4.3.4.1.4 *In situ* Treatment

The technologies considered here are landfarming, which consists or tilling the upper foot of soil with the addition of chemical and/or biological amendments, and bioremediation with the addition of amendments necessary for aerobic-anaerobic dechlorination. Since bioremediation reductions are a percent of the remaining contaminant, at least two full treatment cycles would be required.

4.3.4.1.5 *Ex situ* Treatment

The processes examined here are soil reactor *ex situ* chemical treatment. Implementation considerations for 75% reduction are the same as for the highest reduction BETL group. Both options require custom mass destruction of staged soils, and need only be used to the extent necessary to allow use in blending or cover.

4.3.4.2 Remedial Alternatives for Fields Requiring Between 50% and 75% Reduction

There are 21 fields in this category as shown in Table 4-4. For 13 of these fields toxaphene is the critical contaminant, for five fields the critical contaminant is DDTx and for the remaining three fields the critical contaminant is DDE. These 13 fields comprise a total area of approximately 3,490 acres. Twelve of these fields are located in Unit 1, north of the McDonald Canal Road, two are located at the south-east end of the of Unit 2, one is located at the east boundary of the NSRA, the remaining are scattered within Unit 2.

4.3.4.2.1 No Action

The "no action" alternative demands that the fields are kept in a dry condition to avoid the contact of surface water with contaminated soil/sediment, in this way preventing the establishment of fish habitat that may attract bird populations. This alternative prevents the realization of a critical element for the overall restoration of Lake Apopka.

4.3.4.2.2 Limited Action

The limited action alternative is similar to the no action alternative mentioned above with the distinction that it would include monitoring programs including soil sampling and the implementation of remedial actions. Though monitoring does not prevent exposure to contaminants, it could be used in combination with other remedial actions to evaluate the short-term and long-term effects of these actions.

4.3.4.2.3 Isolation/Containment

Several technologies were examined here: construction of bermed areas or islands that would preclude flooding the field or part of the field, soil covers, soil layer inversion, vertical blending and horizontal blending.

Three fields considered here are located at the north and east boundaries of the NSRA. Another field borders the east shore of Lake Apopka. These fields, given their location and required percent reduction to meet the CTL make them suitable for the construction of bermed areas to preclude flooding. If implemented, this alternative would represent 231 acres or a maximum of 2.6 percent of the total NSRA that would be partially unavailable for flooding, even if simply capped; islands would be significantly smaller.

The fields covered in this subsection would not be suitable for either soil layer inversion, or vertical soil blending alone given that the these technologies would at most result in a 45 and 30% reduction, respectively, not sufficient to meet the CTL.

Horizontal blending of soil between fields can also be an option to some degree for those fields located contiguous to "clean" fields. Ten such fields are part of the 21 fields examined in this subsection.

4.3.4.2.4 *In situ* Treatment

The technologies considered here are landfarming, which consists or tilling the upper foot of soil with the addition of chemical and/or biological amendments, and bioremediation with the addition of amendments necessary for aerobic-anaerobic dechlorination. Treatment amendments would be tailored to the critical contaminant, and treatment would be prioritized in order to prepare blocks for flooding sooner.

4.3.4.2.5 *Ex situ* Treatment

The processes examined here are soil reactor *ex situ* chemical treatment. Due to the large area involved, this technology would likely only be used in small areas, or to produce clean materials for other uses.

4.3.4.3 Remedial Alternatives for Fields Requiring Between 20% and 50% Reduction

There are 13 fields in this category as shown in Table 4-4. For eight of these fields toxaphene is the critical contaminant, for two fields the critical contaminant is DDTx. Dieldrin and DDE are the critical contaminants for the two and one fields respectively. These 13 fields comprise a total area of approximately 1,813 acres. Twelve of these fields are located in Unit 2, two fields are located at the east boundary, and one at the north boundary of the NSRA. Two fields are located bordering the north-east shore of Lake Apopka.

4.3.4.3.1 No Action

The “no action” alternative demands that the fields are kept in a dry condition to avoid the contact of surface water with contaminated soil/sediment, in this way preventing the establishment of fish habitat that may attract bird populations. This alternative prevents the realization of a critical element for the overall restoration of Lake Apopka.

4.3.4.3.2 Limited Action

The limited action alternative is similar to the no action alternative mentioned above with the distinction that it would include monitoring programs including soil sampling and the implementation of remedial actions. Though monitoring does not prevent exposure to contaminants, it could be used in combination with other remedial actions to evaluate the short-term and long-term effects of these actions.

4.3.4.3.3 Isolation/Containment

Several technologies were examined here: construction of bermed areas that would preclude flooding the field or part of the field, soil covers, soil layer inversion, vertical blending and horizontal blending.

No fields are considered here for isolation from flooding since there are other options within this category of technologies that could be implanted in order to achieve the CTL proposed in Table 3-2 without making fields unavailable for flooding.

Using the methodology describe above, the fields covered in this subsection would be suitable for either soil layer inversion, or vertical soil blending given that the these technologies would at most result in a 45 and 30% reduction, respectively, which would be sufficient to meet the CTL.

Horizontal blending of soil between fields can be an option for those fields located contiguous to "clean" fields. Ten such fields are part of the 13 fields examined in this subsection.

4.3.4.3.4 *In situ* Treatment

The technologies considered here are landfarming, which consists or tilling the upper foot of soil with the addition of chemical and/or biological amendments, and bioremediation with the addition of amendments necessary for aerobic-anaerobic dechlorination. Treatment to achieve 20% or greater reduction could be done on portions of these fields needed for quicker flooding, but may not be warranted unless such acceleration of the schedule avoids maintenance and monitoring costs.

4.3.4.3.5 *Ex situ* Treatment

The processes examined here are soil reactor *ex situ* chemical treatment. While this alternative is technically possible, the economic benefit is unlikely compared to *in situ* options, unless the equipment is already mobilized elsewhere on-site.

4.3.4.4 Remedial Alternatives for Fields Requiring Less Than 20% Reduction

There are seven fields in this category as shown in Table 4-4. Toxaphene is the critical contaminant for all but one field for which DDE is the critical contaminant. Four of these fields are extensive fields located just south of the McDonald Canal Road, two fields border Lake Apopka, and one is located at the east boundary of the NSRA. These seven fields represent a total area of approximately 1,328 acres.

4.3.4.4.1 No Action

The "no action" alternative demands that the fields are kept in a dry condition to avoid the contact of surface water with contaminated soil/sediment, in this way preventing the establishment of fish habitat that may attract bird populations. This alternative prevents the realization of a critical element for the overall restoration of Lake Apopka.

4.3.4.4.2 Limited Action

The limited action alternative is similar to the no action alternative mentioned above with the distinction that it would include monitoring programs including soil sampling and the implementation of remedial actions. Though monitoring does not prevent exposure to contaminants, it could be used in combination with other remedial actions to evaluate the short-term and long-term effects of these actions.

4.3.4.4.3 Isolation/Containment

Several technologies were examined here: construction of bermed areas that would preclude flooding the field or part of the field, soil covers, soil layer inversion, vertical blending and horizontal blending.

No fields are considered here for isolation from flooding since there are other options within this category of technologies that could be implanted in order to achieve the CTL proposed in Table 3-2 without making fields unavailable for flooding.

Using the methodology describe above, the fields covered in this subsection would be suitable for either soil layer inversion, or vertical soil blending given that the these technologies would result in a 45 and 30% reduction, respectively, quite sufficient to meet the CTL.

Horizontal blending of soil between fields can be an option for those fields located contiguous to “clean” fields. Five such fields are part of the seven fields described in this subsection.

4.3.4.4.4 *In situ* Treatment

The technologies considered here are landfarming, which consists or tilling the upper foot of soil with the addition of chemical and/or biological amendments, and bioremediation with the addition of amendments necessary for aerobic-anaerobic dechlorination. Treatment to achieve 20% or less reduction could be done on portions of these fields needed for quicker flooding, but may not be warranted unless such acceleration of the schedule avoids maintenance and monitoring costs.

4.3.4.4.5 *Ex situ* Treatment

The processes examined here are soil reactor *ex situ* chemical treatment. Due to the large area involved, this technology would likely only be used in small areas, or to produce clean materials for other uses.

5.0 Detailed Analysis of Remedial Alternatives

This section presents a detailed description and analysis of the remedial alternatives that address the contaminated soil at NSRA. Section 5.2 presents remedial alternatives for OCP contaminated soil at the NSRA. A detailed analysis is performed to provide decision makers with sufficient information to identify appropriate remedial alternatives for OCP contaminated soil at NSRA. The detailed analysis has been conducted using CERCLA Section 121, the NCP, and USEPA Remedial Investigation (RI)/FS guidance (USEPA, 1988) as a basis, but allowing for some flexibility to better address the requirements of the NSRA.

5.1 Screening Criteria

The in-depth evaluation of each remedial alternative includes the following:

- A detailed description of the alternative, emphasizing the application of the technology or actions; and
- An analysis of the alternative against the modified CERCLA criteria as explained in Section 2.1.

The modified criteria against which the alternatives are screened are the following (see Table 5-1):

- Protection to the avian populations that will make the Lake Apopka NSRA their permanent or temporary habitat;
- Compliance with the regulatory requirements established by the USFWS with regard to the NSRA;
- Long-term effectiveness and permanence;
- Short-term effectiveness;
- Implementability;
- Cost; and
- Stakeholder's acceptance.

The modifying criterion, stakeholder's acceptance, is more appropriately evaluated after the comment period. It is anticipated that the stakeholder's acceptance will be used in conjunction with the remedial alternative comparison presented in Section 6.0 to select the appropriate remedial alternatives for the OCP contaminated soils at NSRA.

A final consideration in developing this evaluation procedure came from the findings of the technology screening, which indicated that one or more technologies (e.g., soil flipping, vertical blending, bioremediation) are not currently proven to reliably achieve more than a 45-50% reduction in exposure concentrations. Other technologies, e.g., enhanced bioremediation, can achieve greater percentage reductions, but greater percentage reductions are achieved more slowly, and may require multiple treatment cycles, at greater cost. It appears that an ability to achieve more than 50% reduction was limited to only a few, higher cost, alternatives. Therefore, fields requiring more than a 50% reduction could impose significant feasibility limitations.

Table 5-1. Criteria for Evaluation of Remedial Alternatives

Factors	Criteria to Consider
Protection to the Avian Populations	How risks are eliminated, reduced, or controlled. Short-term effects
Compliance with Regulatory Requirements	Compliance with chemical-specific requirements Compliance with location-specific requirements Compliance with action-specific requirements
Long-Term Effectiveness and Permanence	Magnitude of residual risk Adequacy of controls Reliability of controls
Short-Term Effectiveness	Protection of the avian populations during remedial action Protection to the community during remedial action Protection to the workers during remedial action. Environmental effects Time until RAO is achieved.
Implementability	Ability to apply technology Reliability of technology Ease of undertaking additional remedial action, if necessary Coordination with other agencies
Cost	Capital cost Long term monitoring, operations, and maintenance cost (O&M)

5.2 Detailed Analysis of Remedial Alternatives

This section presents the detailed description and analysis of remedial alternatives that address the soil contamination at the Lake Apopka NSRA. The remedial alternatives that were developed for the fields requiring remedial action were discussed in Sections 4.3.3 through 4.3.4. In order to make this FS a more efficient document, the detailed analysis of the remedial alternatives together with the evaluation against the six criteria is presented by alternative rather than by remediation levels, as was the case in Section 4.3.4. and 4.3.5. Each alternative is presented as it is applied to a specific type of field. In this way, there will be less recurrence of similar or identical paragraphs. Table 5-2 presents a summary of the detailed analysis of the alternatives taking into account the percent reduction required.

5.2.1 No Action

Typically, the no action alternative is defined as doing no response and no long-term monitoring of the contaminated soil. However, as discussed earlier, the District is currently implementing programs to maintain the area drained of surface water. Because this is an ongoing action, the continued implementation of this program will be retained as a component of the no action alternative.

In accordance with the NCP, the no action alternative is used as a baseline for comparison against alternatives that incorporate remedial actions. The no action alternative would include the following components:

- Continue drainage programs
- Periodic site reviews

As stated above, the District is implementing programs that maintain the drainage of the NSRA, minimizing the extent to which contaminated soil comes in contact with surface water. In order to implement this program, the District must maintain levees, canals, access roads and pumping equipment, in addition to periodically monitoring the site to determine the need for drainage.

Periodic site reviews, including surface and groundwater monitoring, may be required in order to establish whether the soil contamination is not affecting any other medium, and to ensure that the Florida surface water and drinking water standards are met. The costs associated with this component are not included.

5.2.1.1 Technical Criteria Analysis

This subsection provides the technical criteria analysis of the no action alternative compared against the six criteria in Table 5-1. Table 5-2 provides a summary of the detailed analysis of the remedial alternatives.

5.2.1.1.1 Protection of Avian Populations

No action risks to the avian populations are reduced and controlled so long as the fields remain drained thus allowing limited contact of surface water with contaminated soil, and therefore limited potential for fish in the avian food chain to uptake OCPs.

5.2.1.1.2 Compliance with Regulatory Requirements

Provided the contaminated areas do not come in contact with the surface water, the District will be in compliance with the ESA, MBTA and the BGEPA. Periodic monitoring, will in the same way, determine whether the District is in compliance with the SDWA.

Location-specific regulatory requirements are not met with this alternative, since this action does not comply with the Lake Apopka Restoration Act, the Surface Water Improvement and Management Act (SWIM) and the CWA.

Action-specific regulatory requirements do not apply to the no action alternative.

Table 5-2. Summary of Detailed Analysis of Remedial Activities

Alternative	Protective of Avian Populations	Compliance with Regulatory Requirements	Long-term Effectiveness and Permanence	Short-term Effectiveness	Implementability	Cost (K$/acre)
No action	Yes	No	No	Yes	Yes	Moderate
Limited Action	Yes	Only for fields requiring < 20% reduction	Only for fields requiring < 20% reduction	Yes	Yes	Moderate
Isolation/Containment						
Island Construction	Yes	Yes	Yes	Yes	Yes	9.4
Berm Containment	Yes	Yes	Yes	Yes	Limited Acreage	7.3
Soil Cover	Requires demonstration	Requires demonstration	Requires demonstration	Yes	Yes	24.4
Soil Layer Inversion	Pilot study recommended for fields requiring > 20% reduction	Pilot study recommended for fields requiring > 20% reduction	Pilot study recommended for fields requiring > 20% reduction	Pilot study recommended for fields requiring > 20% reduction	Yes	2.6
Vertical Blending	Only for fields requiring < 75% reduction provided limited acreage is involved, or fields requiring < 50% reduction	Only for fields requiring < 75% reduction provided limited acreage is involved, or fields requiring < 50% reduction	Only for fields requiring < 75% reduction provided limited acreage is involved, or fields requiring < 50% reduction	Only for fields requiring < 75% reduction provided limited acreage is involved, or fields requiring < 50% reduction	Only for fields requiring < 75% reduction provided limited acreage is involved, or fields requiring < 50% reduction	2.7
Horizontal Blending	Yes	Yes	Yes	Yes	Limited Acreage	6.1
***In situ* treatment**						
Landfarming	Yes	Yes	Yes	Yes	Yes	18.0
Bioremediation	Yes	Yes	Yes	Yes	Yes	23.0
***Ex situ* treatment**						
Soil Reactor *ex situ* treatment	Yes	Yes	Yes	Yes	Yes	34.7
Excavate & Landfill	Yes	Yes	Yes	Yes	Yes	118.6

Source: MACTEC, 2004

Prepared by/Date: MLJ 9/10/04
Checked by/Date: WAT 9/10/04

5.2.1.1.3 Long-Term Effectiveness and Permanence

This action is effective in reducing exposure to piscivorous birds, but only as the result of continued pumping to keep the NSRA dry. Adequate and reliable controls and drainage program implementation will need to be maintained in order to maintain fields in a dry state. Consequently, this action is not a permanent solution. The magnitude of the residual risk is addressed under this alternative only as it relates to the natural attenuation that will take place with time.

5.2.1.1.4 Short-Term Effectiveness

The no action alternative meets short-term effectiveness criteria. The drainage of the fields has been performed for a number of years now since the bird mortality event and protection to the avian population, community and workers has been achieved with no adverse environmental effects. However, with the no action alternative, the RAOs will not be achieved.

5.2.1.1.5 Implementability

The no action alternative has been implemented since the bird mortality event, along with the field drainage program.

5.2.1.1.6 Cost

There is no capital cost associated with this alternative. The long term monitoring, operations, and maintenance costs, including the cost of perpetual drainage of the farm fields, is relatively high, but has not been quantified.

5.2.2 Limited Action

The limited action alternative consists of long-term monitoring activities, physical barriers, and administrative actions to reduce the potential for exposure to the contaminated media. Limited action could also include public information programs, providing a database of information about the site, and evaluating changes in site conditions over time. The limited action alternatives differs from the no action alternative primarily by incorporation of long term monitoring of soil concentrations to identify when concentrations have naturally attenuated to such an extent that flooding of individual fields may be possible, i.e., this alternative includes MNA.

5.2.2.1 Technical Criteria Analysis

This subsection provides the technical criteria analysis of the limited action alternative compared against the six criteria in Table 5-1.

5.2.2.1.1 Protection of Avian Populations

Risks to the avian populations are eliminated, reduced and controlled so long as the fields remain drained, allowing no chance for surface water to come in contact with contaminated soil so long as concentrations of COPCs remain above the target levels.

5.2.2.1.2 Compliance with Regulatory Requirements

Provided the contaminated areas do not come in contact with the surface water, the District will be in compliance with the ESA, MBTA and the BGEPA. Periodic monitoring, will in the same way, determine whether the District is in compliance with the SDWA.

Location-specific regulatory requirements are not met with this alternative, since this action does not comply with the Lake Apopka Restoration Act, the Surface Water Improvement and Management Act (SWIM) and the CWA. It is plausible that MNA may be effective in the long term in fields that exceed the target levels by less than 30%, and therefore may eventually achieve compliance with these Florida statutes.

Action-specific regulatory requirements do not apply to the limited action alternative.

5.2.2.1.3 Long-Term Effectiveness and Permanence

The incorporation of monitoring into the Limited Action alternative implies implementation of MNA. Whereas, available non-site-specific research indicates the half lives of the COPCs in the environment are approximately 2 to 20 years, this action may be effective in the long term, although effectiveness has not been demonstrated, and is expected to require a long term monitoring period of more than 30 years.

5.2.2.1.4 Short-Term Effectiveness

The no action alternative meets short-term effectiveness criteria. The drainage of the fields has been performed for a number of years now since the bird mortality event and protection to the avian populations, community and workers as been achieved with no adverse environmental effects. However, with the no action alternative, the RAOs will not be achieved.

5.2.2.1.5 Implementability

The no action alternative has been implemented since the bird mortality event, along with the field drainage program.

5.2.2.1.6 Cost

There is no capital cost associated with this alternative. The long term monitoring, operations, and maintenance costs, including the cost of perpetual drainage of the farm fields, is relatively high, but has not been quantified.

5.2.3 Isolation/Containment

A number of technologies were considered under this option. Of these, the retained technologies were island construction above flooding levels, berm containment to prevent soil flooding of certain areas, soil cover, deep plowing soil layer inversion, vertical blending of soils and horizontal blending of soils.

5.2.3.1 Island/Peninsula Construction Above the Flooding Level

This remedial alternative consists of constructing a limited number of on-site landfill like vaults in areas where adjacent roads, dikes, or the elevation of the area afford construction of an enclosure. Contaminated soil will be excavated and placed in the vault. A geomembrane cap may be installed on top of the contaminated material to provide a barrier between the material and the environment, and the surface covered with clean soil for re-vegetation. Fields considered for this alternative are those requiring 75% or greater reduction to achieve the remediation target level and are located near the east boundary of the NSRA. A total of three fields were identified for which this remedial alternative could be applied.

These small area fields, located at or near roads are candidates for isolating the 0-12 inch contaminated surface soils by building "islands" above the proposed flooded level. The island earthworks would be constructed using 623 scrapers and D-8 dozers in such a way as to minimize soil movement. These sites are assumed accessible to equipment without further actions. Roads, canals and/or ditch features would be used to the extent possible to minimize the construction effort, and are not assumed to be a hindrance. No soil preparation of the currently vegetated fields is assumed required, but the soils must be de-watered and mowed to the extent necessary to allow reasonable equipment operation.

The island design layout would be computer optimized by the specific characteristics of each field. For cost estimation purposes, it is assumed that a four man crew would move soil from two adjacent six square acre sub-fields. Scrapers would stage soil and 5cubic yard/load bulldozers would move the soil no more than 400 ft to stockpiles for other dozers to complete the final stacking, shaping, contouring, and compacting of the island. The long narrow islands would be approximately 6-8 ft high X 100 ft width X 600 ft length. Assuming a rate of 2 acres per day, one island would require approximately 6 crew days, not including weather days or other delays. Deeper clean soils would be used to provide at least a six inch soil cover, and initial re-vegetation would include hydroseeding. The effort would include finishing the removal area to a flat grade and final surveying the site to confirm the removal of 1 ft.

Earthworks to isolate OCP contaminated soils is a permanent solution that provides complete protection from OCP exposure. This option would reduce the flooded area approximately 13% based on the assumed island height. The surrounding flooded area depth would be increased by 1 ft. Long-term inspection and maintenance of the islands to confirm the lack of exposed OCP soils would be required in perpetuity until monitoring has confirmed natural attenuation of the subsurface contamination. Placement of the materials is assumed to enhance natural attenuation but the rate is unknown. Further, the construction includes no coupling with bio-amendments spreading or mixing during placement.

Above water islands will be seeded for erosion control only initially. There likely would be benefits from tapering island slopes to deepened areas to create more littoral habitat if flooding was less than to island top. Vegetation on islands may require mowing to prevent shrubs and trees, which might have roots large enough to penetrate the cap. In later phased efforts, some islands might be allowed to grow trees adjacent to open water to attract birds looking for nesting sites.

5.2.3.2 Technical Criteria Analysis

This subsection provides the technical criteria analysis of the island/peninsula construction alternative compared against the six criteria in Table 5-1.

5.2.3.2.1 Protection of Avian Populations

This alternative would be protective of the avian populations, since it would prevent surface water from coming into contact with contaminated soil/sediment, and, as a consequence would prevent the establishment of a fish habitat. As islands/peninsulas develop vegetation, these areas provide suitable locations for rookeries, and would as such perhaps attract more fish-eating birds to the NSRA.

5.2.3.2.2 Compliance with Regulatory Requirements

Provided the contaminated areas do not come in contact with the surface water, the District will be in compliance with the ESA, MBTA and the BGEPA. Periodic monitoring, will in the same way, determine whether the District is in compliance with the SDWA.

This alternative slightly reduces the total area of restored wetlands, but does not significantly adversely affect compliance with Florida statutes intended to restore water quality of Lake Apopka.

This alternative will require permitting by FDEP and the US Army Corps of Engineers to comply with Section 404 of the CWA (dredge and fill) and other Florida requirements for construction within wetlands and/or floodplains. Whereas the action is interpreted to be in the public interest, MACTEC believes the alternative is permittable, but permit requirements may affect cost.

Action-specific regulatory requirements may apply during construction of the necessary controls. Non point source emissions of OCP-contaminated particulates by wind and stormwater erosion that could be generated during the required construction can be minimized with appropriate erosion controls. These controls would ensure compliance with Florida air pollution and water pollution control regulations.

5.2.3.2.3 Long-Term Effectiveness and Permanence

The isolation of contaminated soil within these island vaults is effective in preventing the contaminated soil from coming into contact with surface water. Monitoring and maintenance of the isolated areas will be required to ensure the integrity of the outer edge barrier.

5.2.3.2.4 Short-Term Effectiveness

The isolation of contaminated soils within these island vaults meets the short-term effectiveness criterion. The high contamination areas will remain dry, so the RAOs will not be completely achieved given that areas at the NSRA would remain un-flooded, and therefore contributing little to the restoration of Lake Apopka. This alternative is not expected to have any negative environmental effects, therefore the avian populations will not be affected during the remedial action. There would only be slight exposures to workers performing the remedial action.

5.2.3.2.5 Implementability

Island construction can be performed using standard construction technologies. This option must include adequate erosion controls and maintenance. This alternative will require CWA Section 404 (dredge and fill) permitting, but it is assumed the risk assessment (RA) is permittable because the overall restoration program is in the public interest.

5.2.3.2.6 Cost

The overall cost for this action is estimated to be approximately $9,400 per acre. For purposes of this FS, this unit cost is assumed to be applicable regardless of the overall size of the application. Details of the basis of this cost estimate are provided in Appendix B.

5.2.4 Berm Containment of Non-Flooded Areas

This remedial alternative consists of implementing construction activities necessary to prevent flooding those fields which require a high percent reduction (75% and above), located at the boundary of the NSRA and therefore may be at a higher elevation. A total of two fields were identified for which this remedial alternative could be applied, both are currently part of the FBs proposed to be flooded to 0.5 ft.

5.2.4.1 Technical Criteria Analysis

This subsection provides the technical criteria analysis of the berming only isolation alternative compared against the six criteria in Table 5-1.

5.2.4.1.1 Protection of Avian Populations

This alternative would be protective of the avian populations, since it would prevent surface water from coming into contact with contaminated soil/sediment, and, as a consequence would prevent the establishment of a fish habitat.

5.2.4.1.2 Compliance with Regulatory Requirements

Provided the contaminated areas do not come in contact with the surface water, the District will be in compliance with the ESA, MBTA and the BGEPA. Periodic monitoring, will in the same way, determine whether the District is in compliance with the SDWA.

This alternative slightly reduces the total area of restored wetlands, but does not significantly adversely affect compliance with Florida statutes intended to restore water quality of Lake Apopka.

This alternative will require permitting by FDEP and the US Army Corps of Engineers to comply with Section 404 of the CWA (dredge and fill) and other Florida requirements for construction within wetlands and/or floodplains. Whereas the action is interpreted to be in the public interest, MACTEC believes the alternative is permittable, but permit requirements may affect cost.

Action-specific regulatory requirements may apply during construction of the necessary controls. Non point source emissions of OCP-contaminated particulates by wind and stormwater erosion that could be generated during the required construction can be minimized with appropriate erosion controls. These controls would ensure compliance with Florida air pollution and water pollution control regulations.

5.2.4.1.3 Long-Term Effectiveness and Permanence

The isolation of contaminated soil using berms is effective in preventing the contaminated soil from coming into contact with surface water within the limited portions of the site where it has been considered, specifically at higher elevations, near roads or other barriers, in FBs with planned water depth less than 0.5 ft. In other areas, use of earthen berms will not be sufficient to prevent groundwater seepage and inundation of the bermed area. Monitoring and maintenance of the berms will be required to ensure their integrity. Rainwater and runoff would require maintenance of temporary pumping equipment and structure maintenance to prevent ponding behind berms.

5.2.4.1.4 Short-Term Effectiveness

The isolation of contaminated soils by berming meets the short-term effectiveness criterion. The high contamination areas will remain dry, so the RAOs will not be completely achieved given that areas at the NSRA would remain un-flooded, and therefore contributing little to the restoration of Lake Apopka. This alternative is not expected to have any negative environmental effects, therefore the avian populations will not be affected during the remedial action. There would only be slight exposures to workers performing the remedial action.

5.2.4.1.5 Implementability

Berm construction can be performed using standard construction technologies. This option must include adequate erosion controls and maintenance. This alternative will require CWA Section 404 (dredge and fill) permitting, but it is assumed the RA is permittable because the overall restoration program is in the public interest. This alternative, however, is viable only in limited areas within the NSRA.

5.2.4.1.6 Cost

The cost of this alternative is estimated to be $7,300 per acre. For purposes of this FS, this unit cost is assumed to be applicable regardless of the overall size of the application. Details regarding the basis of this cost estimate are provided in Appendix B.

5.2.5 Soil Cover

The soil cover alternative has been considered for the same fields as the earthwork options to prevent flooding. In general, this alternative consists of the placement of a layer of clean soil at least six inches thick over contaminated soils to provide permanent isolation of the non-leachable OCPs. The cover material would then be compacted over the contaminated soil and the banks to the extent necessary for and surfaces would be sloped for stabilization and erosion control. Dredge material from Lake Apopka might be used where testing confirms adequate cover soil characteristics. A vertical section would be constructed around the perimeter of the area, to a depth of approximately 2 feet below land surface. The cover area would depend on the size of the non-flooded area defined in a field.

The soil cover alternative is considered in areas where the fields are located in upland areas at the boundaries of the NSRA or generally with higher levels of contamination requiring problematic reductions for other technologies. These areas are considered candidates for isolation by placement of a soil cover prior to flooding. This action requires that the surface is prepared by mowing of chopping, and that clean soil from elsewhere on the property is excavated and transported to the field to be covered, spread in a finished layer thickness of one ft, and compacted. This action can be performed by standard construction equipment. Sufficient soil is assumed available nearby either from fields not requiring treatment, or from deeper layers of fields where the surface layer has been removed as part of other remedial action options. For the seventeen fields included in the minimum treatment, this option is suggested only for the three fields (231 acres total) requiring the highest (34-68 percent) reduction that exceeds proven soil inversion reduction capabilities (approximately 30 percent). If any appreciable time period occurs between completion and flooding, re-vegetation and maintenance of the site is recommended.

The effectiveness of this alternative is critically dependent on two assumptions:

1. The COPCs are virtually immobile in site soils and sediments; and
2. The soil cover will not erode appreciably under the project future land use.

Both these assumptions appear to be valid, however, wide scale implementation of this alternative should not be implemented without extended pilot testing to verify these assumptions.

5.2.5.1 Technical Criteria Analysis

This subsection provides the technical criteria analysis of the soil cover alternative compared against the six criteria in Table 5-1.

5.2.5.1.1 Protection of Avian Populations

If the alternative is effective (to be demonstrated by an extended pilot test), it would be protective of the avian populations since it would prevent surface water from coming into contact with contaminated soil/sediment. This alternative is expected to be effective because the COPCs have been shown to be immobile in site soils.

5.2.5.1.2 Compliance with Regulatory Requirements

Under the effectiveness assumptions previously stated, the alternative complies with all identified regulatory requirements.

Action-specific regulatory requirements may apply during construction of the necessary controls. Non point source emissions of OCP-contaminated particulates by wind and stormwater erosion that could be generated during the required construction can be minimized with appropriate erosion controls. These controls would ensure compliance with Florida air pollution and water pollution control regulations.

5.2.5.1.3 Long-Term Effectiveness and Permanence

Construction of a soil cover for some of these areas will have effective and permanent results provided these areas are properly constructed and maintained. The incorporation of monitoring into this alternative may be necessary to assure that this is the case. Monitoring should also be implemented to follow the natural attenuation that is likely to take place over time.

5.2.5.1.4 Short-Term Effectiveness

The construction of a soil cover alternative meets short-term effectiveness criteria. Maintaining the contaminated soil from coming in contact with surface water is the primary objective of this remedial action and can be effectively accomplished by means of this alternative. Protection to the avian population, community and workers can been achieved with no adverse environmental effects.

5.2.5.1.5 Implementability

This alternative would be moderately difficult to implement on soils with high organic content. The low-density soils may not support optimum compaction of the cover. If the area is flooded, the soils will swell and shift slightly.

5.2.5.1.6 Cost

The estimated cost for this alternative is $24,400 per acre. The basis for this cost estimate is provided in Appendix B.

5.2.6 Soil Layer Inversion

This alternative has been considered for those fields requiring approximately 30% reduction or less based on the effectiveness demonstrated by this technology. Deep plowing is a physical treatment alternative that involves the inversion of entire layers of soils by use of special mechanical means (moldboard plow). Limited testing of this alternative has been conducted in the NSRA.

Soil inversion or flipping is an inherently attractive, presumably low cost range option for large areas. Proper soil inversion involves multi-step preparation and special plowing, using moldboard and offset disk plows. This action has been used worldwide to invert entire soils layers. In Australia, layers 1-3 meters in depth are being inverted at a reported cost of $1,000 to $3,000 per hectare to restore moisture profiles in arid regions for pasture restoration (Australian Ministry of the Environment web site). In the US, The USDA National Soil Tilth Laboratory, Ames, Iowa has reported use of the technique (under flooded conditions) to seal contaminated sediments below clean bottom material following floods. A Pilot program is reportedly currently being designed by Allen Machine and Equipment, Roscoe, Texas for 0-2 ft depth soil inversion of Everglade’s soils containing chlordane for the SFWMD.

Adequate equipment and preparation are absolutely critical to achieve the desired depth of the turn or “flip”. To accomplish a minimum 24 inch depth turn needed in the NSRA fields, offset plow disks of 38 to 54 inches may be required. For moldboard plow use, the size and curvature of the blades requires custom design, and the tractor or dozer pulling the plow must have adequate horsepower to be capable of constant speed without excessive slippage. Spinning the tractor tires or failure to maintain speed can and will result in failure to reach and sustain the specified depth under even the wettest conditions.

The technique has been already tested by the District for several weeks in September 2003 on a two acre test plot in the NSRA with somewhat mixed and less than anticipated results. Plow manufacturers maintain flipping can be accomplished with 95-98 percent efficiency, even under NSRA muck characteristics. However, initial testing was confirmed to provide only an estimated 32 ± 8 percent OCP reduction. The demonstration already performed in the NSRA was evaluated and found to be equipment limited, especially considering the extreme and unanticipated moisture conditions. Since the achieved reduction was adequate for much of the NSRA minimum treatment areas (1,975 of 2,207 acres and 15 of 17 fields), the soil inversion option is a candidate for much of the NSRA. If further, more rigorous testing confirms results closer to theoretical results this option may be applicable to all of the sites.

5.2.6.1 Technical Criteria Analysis

This subsection provides the technical criteria analysis of the soil layer inversion alternative compared against the six criteria in Table 5-1.

5.2.6.1.1 Protection of Avian Populations

This alternative will be protective if its use is restricted to fields that exceed the target levels by a small percentage (e.g., 30% based on available data).

5.2.6.1.2 Compliance with Regulatory Requirements

Provided the soil that comes in contact with the surface water meets the LTL or HTL as established in Table 3-2, the District will be in compliance with the ESA, MBTA and the BGEPA. Periodic monitoring, will in the same way, determine whether the District is in compliance with the SDWA and the CWA.

This action complies with the Lake Apopka Restoration Act.

There are no location-specific regulatory requirements that need to be taken into account.

Action-specific regulatory requirements may apply during the implementation of the alternative. Non point source emissions of OCP-contaminated particulates by wind and stormwater erosion that could be generated during the implementation can be minimized with appropriate erosion controls. These controls would ensure compliance with Florida air pollution and water pollution control regulations.

5.2.6.1.3 Long-Term Effectiveness and Permanence

This alternative is effective and permanent under the assumption that COPCs are virtually immobile in site soils, and would eventually naturally attenuate under anaerobic conditions.

5.2.6.1.4 Short-Term Effectiveness

This alternative is effectiveness in the short term if restricted to fields where concentrations do not exceed the target levels by more than 30%. Protection to the avian populations, community and workers can been achieved with no adverse environmental effects. It is possible that this technology can be effective and capable of achieving COPC reductions greater than 30%, however, greater percent reductions would have to be demonstrated via a properly designed pilot test.

5.2.6.1.5 Implementability

The limited testing of this alternative conducted in the NSRA indicates that implementation may be difficult in site soils. Nonetheless, MACTEC understands that these limitations can be overcome if the correct equipment is used.

5.2.6.1.6 Cost

The estimated cost of this alternative is approximately $2,600 per acre. The basis for this cost estimate is provided in Appendix B. Amortization of purchased equipment over larger acreage would significantly alter the costs. This estimate assumes no credit for salvage value of the equipment.

Cost Uncertainties and Pilot Scale

Calculations of cost include the capital equipment, mobilization, labor and fuel, and equipment spares. Despite experience with estimating productivity (acres per hour or day) for a given step or equipment, there are so many unknown factors that it wou1d be at best an approximation. A well equipped test over 75-100 acres is needed in the NSRA to gain confidence. The plow planned for use for the next pilot study will be a 5 bottom plow which has been cut back to a 3 bottom. Once the plow and the proper horsepower of the tractor are matched up and the slippage is under control, an average of two acres per hour (for Phase 3 inversion) is judged possible, barring other unforeseen circumstances. There are other unknowns, such as the presence of stumps, rocks, frequency and time lost due to instances of the tractor and plow stuck, efficiency of turns. Very little vertical profile data exists for much of the NSRA below the 0-1 ft depth. Additional service and maintenance equipment would also be needed to keep all the equipment operational.

If Phases 1 through 3 can be done without any type of root plowing, productivity of an average from 10 acres to 30 acres per day may be possible. Based on the likely site preparation steps, an overall cost of $1,500 to $2,600 per acre is used for FS costing. After a larger pilot effort is completed, firm estimates can be done based on sound data. Because of the size of the project it is anticipated the equipment could be purchased. Therefore, the actual cost will depend greatly on the total number of acres. Further, when the project is complete, cost could be reduced further by sale of the used equipment.

A pilot to refine this technique is estimated to require approximately 4 weeks to process approximately 75-100 acres using the above equipment and a crew of four to five experienced operators. Depending on the equipment furnished by the District (tractors) versus purchase of attachments, this pilot effort is estimated at $325,000-$410,000. Assuming adequate soil inversion, the pilot field(s) areas would require no further action. Deeper inversion depths to 3 ft are also possible.

5.2.7 Vertical Blending

Vertical blending involves complete mixing of the 0-12 inch and 12-24 inch depth intervals. Since the lower intervals contain ten percent or less OCP contamination than the surface layer, a theoretical 45 percent reduction in surface exposure concentration is possible. Deeper blending of 0-3 ft depth soils might be expected to achieve even higher reduction, possibly as high as 68%.

Vertical blending can be accomplished by several techniques using agricultural or forestry heavy equipment. The commonly accepted approach utilizes large offset disk plows and multiple pass working of the soil to effect the homogenization. The shallow tilling demonstration previously conducted in the NSRA is a partial example of tilling that resulted in a 21 +/- 8 percent reduction despite weekly tilling for six months. This method would benefit from use of much larger equipment with disks as large as 38 inches.

Historically, the NSRA tilling has primarily involved the upper 8 inches of soil. The presence of deeper roots, rocks, and even limestone could adversely impact soil inversion or deep tillage equipment. Because of the time and uncertainties involved in implementing this alternative, other methods were researched. An alternate approach investigated involves the use of diesel powered special towed reclamation equipment called the Rotoclear. This equipment is used in mining and forestry for pipeline and right-of-way clearing, reclamation services drainage reconstruction, topsoiling, revegetation, and rangeland improvement (Personal Communications, W. Erickson, 2004) One such HMI application involved the mixing of lime into the top four feet of acidic mine tailing soils.

Based on initial evaluation, Rotoclearing is a unique land clearing and habitat management tool that may be able to effectively aid in achieving site specific goals in portions of the NSRA. The Rotoclear machine, manufactured by Madge Rotoclear, Calgary Canada, uses a rotating drum with 56 cutting teeth to shred or chip into mulch, and mix. Drum sizes and weights are available; speeds may reach 350 rpms. The machine has incorporated up to 125 tons/acre of woody plant materials processed plant materials into soil to a maximum depth of 9 inches, but can be adjusted to a maximum depth of 18 inches. Larger drums would be required to reach lower depths

Uses have included mining, pipeline operations, pre-stripping brush incorporation, mulch substitute, soil amendment incorporation, and as an alternate revegetation method and for erosion repair. In forestry, uses have included mulching slash, windfall or stumps (below ground level) without burning, seedbed preparation, right-of-way management, road, powerline and pipeline easement development and maintenance. In waste remediation and hydrocarbon landfarming the Rotoclear is used to rapidly incorporate organics/nutrients and improve aeration. The technique provides a highly controlled method for improving/rejuvenating wildlife habitat associated with soil, alleviates compacted soils, Incorporates organic materials and amendments (18 inch maximum depth), and aerates soil stimulating microbial activity. (Personal Communications, Carlson, 2004, Habitat Management, Inc.; Madge Rotoclear Manufacturing, 2004).

The Rotoclear is pulled by a large farm type tractor or bulldozer (D-7 or D-8 size machine). Productivity is primarily dependent upon cover vegetation type, size, soil mixing depth, soil type and terrain. Rotoclear production rates reportedly range from approximately 0.5 acres per hour in heavier stands to 2.5+ acres per hour in low-density shrublands/grasslands. Because this equipment has not been used in the NSRA, and mixing efficiency may be moisture affected, field trials are necessary.

5.2.8 Technical Criteria Analysis

This subsection provides the technical criteria analysis of the vertical blending alternative compared against the six criteria in Table 5-1.

5.2.8.1 Protection of Avian Populations

This technology is protective in portions of the NSRA. The limits of its applicability relate to the concentrations of COPCs and the depth of the soil profile available for vertical blending. Consequently it is expected to be protective in areas where concentrations of COPCs exceed the target levels by less than 50%, and may also be effective in areas with slightly higher concentrations of COPCs if the thickness of the soil profile available for blending is more than 2 ft.

5.2.8.2 Compliance with Regulatory Requirements

This alternative complies with regulatory requirements in areas where it is effective, as discussed in the previous paragraph (protectiveness).

5.2.8.3 Long-Term Effectiveness and Permanence

This technology is effective and permanent in portions of the NSRA as previously described.

5.2.8.4 Short-Term Effectiveness

This technology is effective immediately in those portions of the NSRA where it may be applied, as previously described.

5.2.8.5 Implementability

This technology is readily implementable using commercially available modified rock trenching equipment. Such .equipment is currently being used in New Jersey on agricultural soils.

5.2.8.6 Cost

The estimated cost for vertical soil mixing is $2,700 per acre pending further information. The basis for this cost estimate is provided in Appendix B.

5.2.8.7 Horizontal Blending

Horizontal blending is a combination of minimum excavation – earthmoving and vertical blending techniques that takes into account specific NSRA field locations and conditions. This option is assumed to only applicable when adjacent fields have highly disparate OCP concentrations, and where a composite combination of the surface soils from the two would result in a product that meets the required minimum reduction for both. These conditions are size-volume and soil TOC dependent

5.2.8.8 Technical Criteria Analysis

This subsection provides the technical criteria analysis of the isolation/containment alternative compared against the six criteria in Table 5-1.

5.2.8.8.1 Protection of Avian Populations

This technology is protective in portions of the NSRA. The limits of its applicability relate to the availability of clean soil on an adjacent parcel.

5.2.8.8.2 Compliance with Regulatory Requirements

This alternative complies with regulatory requirements in areas where it is effective, as discussed in the previous paragraph (protectiveness).

5.2.8.8.3 Long-Term Effectiveness and Permanence

This technology is effective and permanent in portions of the NSRA as previously described.

5.2.8.8.4 Short-Term Effectiveness

This technology is effective immediately in those portions of the NSRA where it may be applied, as previously described.

5.2.8.8.5 Implementability

This technology is readily implementable using commercially available technologies.

5.2.8.8.6 Cost

The estimated cost for this alternative is $6,100 per acre. The basis for this cost estimate is provided in Appendix B.

5.2.9 *In Situ* Treatment

Landfarming and bioremediation are the retained technologies considered under this option. Both technologies are similar as relates to implementability, however depending on the organic content of the soil, OCP concentrations, and required percent reduction, one technology would be more suitable than the other.

5.2.9.1 Landfarming

Landfarming as an option envisioned for possible use in the NSRA, incorporates physical site preparation and tilling techniques with introduction of various bio and/or chemical treatment soil amendments (liquid fertilizers, buffers, etc.), and moisture control to initiate and accelerate *in situ* biodegradation of OCPs. The technology results in the destruction of COPC mass, and consequently is highly rated with respect to long term effectiveness and permanence.

5.2.9.2 Technical Criteria Analysis

This subsection provides the technical criteria analysis of the *in situ* treatment alternative compared against the six criteria in Table 5-1.

5.2.9.2.1 Protection of Avian Populations

This alternative, if properly implemented, is protective of the avian populations because it will reduce or eliminate exposure to the COPCs. If flooding cycles are part of the anaerobic-anobic treatment, care must be taken to control run-on and run-off impacting the avian food chain.

5.2.9.2.2 Compliance with Regulatory Requirements

This alternative is expected to be compliant with all regulatory requirements.

5.2.9.2.3 Long-Term Effectiveness and Permanence

This alternative, as all the other alternatives which incorporate reduction of COPC mass by treatment, is permanent and effective over the long term.

5.2.9.2.4 Short-Term Effectiveness

This alternative is effective in achieving the RAOs in the short term.

5.2.9.2.5 Implementability

This alternative is readily implemented with available technologies, however, pilot testing is required. For any of the treatments that amend the soil with nutrients or carbon source, there is a need to demonstrate that the NSRA soils truly are deficient or need optimization of either carbon or nutrients, and to verify the other environmental conditions at the NSRA such as oxidation reduction potential that may be limiting the natural attenuation of OCPs.

5.2.9.2.6 Cost

The estimated cost of this technology is $18,000 per acre, and is highly variable depending on degree of reduction needed, acreage, and time. The basis of this cost estimate is provided in Appendix B.

5.2.10 Bioremediation

5.2.10.1 *In Situ* Bioremediation (Daramend™)

5.2.10.1.1 Rationale

Pesticides persist in the environment because the conditions necessary for their biodegradation are not present or the microorganisms capable of their biodegradation may not be present at the contaminated site. At some sites the right consortia of microorganisms necessary for their biodegradation may be present, but biodegradation may not occur due to unsuitable environmental conditions such as nutrient shortage, unfavorable pH or toxic concentrations of the contaminants of interest or metals. Many laboratory and field studies have provided evidence that oxidized organic compounds such as chlorinated pesticides degrade rapidly under anaerobic conditions (Clark, 2003; Fracas, 2000; Allen, 1999; Adventus, 2004; Battelle, 2003; Portier, 1989). Numerous efforts have also demonstrated the efficacy of biostimulation of *in situ* biodegradation of oxidized organic compounds using commonly available products (USEPA, 2001; Neil, 2004; Lang, 2004). Examples of these processes include PLANTECO's Surface Application and Mobilization of Nutrient Amendments (SAMNA) approach [patent pending] which uses preferred amendments that include agricultural wastes and compost to treat contaminated soil and groundwater *in situ*. Typically, the amendments will also include bulking agents, such as grass, sawdust, peat and liquid carbon and electron sources. The liquid amendments also improve the accessibility (bioavailability) of the strongly sorbed DDT and PAHs to the soil microorganisms. Indigenous microorganisms consume the available oxygen and the amended soil quickly becomes anaerobic. Under anaerobic conditions, chlorinated pesticides have been shown to undergo reductive dechlorination and mineralization to CO2. Over the course of treatment, moisture, organic matter, inorganic compounds, pH and temperature are all monitored. SAMNA is similar to other competing bioremediation enhancing techniques (e.g., DARAMEND, XENOREM, SABRE) used for bioremediation of biodegradable organic compounds. *In situ* bioremediation of chlorinated pesticides in soils can be achieved in less than 24 months using SAMNA.

The maximum concentration of COPCs at the site in question is about an order of magnitude less than other sites where *in situ* bioremediation has been applied. The quantitation of the COPCs in g/kg of organic carbon would need to be converted to g/kg of soil to directly compare carbon normalized data with published data from other sites. Depth of treatment and degree of reduction in any *ex situ* treatment would be done on a field specific basis. Partially treated soils could either be blended with other soil, covered, or possibly simply left as a soil cap. However, testing of the treated soil would be required to verify that changes in organic carbon or other characteristics still allow use for capping.

Other chlorinated pesticides have been identified in the site soil. Baseline characterization of the site will precede treatability studies and pilot field tests where such data does not already exist. Application sequence includes:

Field Pilot Test (*In Situ* Bioremediation – approximately nine months)

- Treat one acre of site with selected amendment
- Establish restoration rate for selected amendment under field conditions
- Determine moisture application rate for the region of Florida
- Revegetate restored pilot test site with local indigenous plants

Design and Full Scale Implementation (*In Situ* Bioremediation)

- Use pilot-scale test data to design full-scale remedy plus cost
- Install technology on applicable portions of the entire site

- Use conventional earth moving equipment to amend the soil with selected amendment
- Install or provide water application system

Operation and Maintenance (*In Situ* Bioremediation)

- Biweekly maintenance of treated plots
- Monitor site moisture, irrigation, pH, temperature, inorganics, etc.
- Monitor changes in concentration of pesticides of concern quarterly
- Reapply amendment and till if need be for up to 24 months.

The proprietary technology, XENOREM that was used to treat DDT and toxaphene at the Helena Chemical Company and SMC Tampa, Florida sites consisted of some of the same products in PLANTECO's SAMNA technology, except that XENOREM involves dig and treat by composting while SAMNA is applied *in situ*. DARAMEND and SAMNA use different products, but their method of *in situ* application is similar.

Based on the information from several Superfund sites, a few generalizations can be made regarding which technologies have seen the most use or success for the remediation of a particular class of pesticides. The organophosphate pesticides, including malathion and parathion appear to be best degraded by aerobic treatment such as composting and land spreading. The organochloride pesticides, including chlordane, DDT and toxaphene appear to require a cycling of aerobic and anaerobic phases in order for remediation to be most successful. The anaerobic phase reductively dechlorinates these pesticides while the aerobicphase completes the mineralization of the compound. White-rot fungi have also shown to be promising in the remediation of organochlorides.

5.2.10.1.2 Application of *In Situ* DARAMEND Bioremediation on Pesticide Impacted Soils

Chlorinated organic compounds deposited to soil are bound, to varying degrees, as determined by their physical/chemical properties and those of the soil (e.g., pH, organic matter content and clay mineralogy). Biodegradation of chlorinated organic compounds in the environment is influenced by a complex variety of factors. When incorporated into a soil matrix the half-lives of these compounds will often be measured in years.

Adventus has developed a bioremediation technology suitable for application to soils impacted with chlorinated organic compounds. The technology, known as DARAMEND, enhances and promotes natural bioremediation rates by adjusting conditions in a soil matrix to stimulate biodegradation of target compounds. The key to the DARAMEND approach is the application of repeated and sequential anoxic and oxic conditions to the soil matrix (treatment cycles). Treatment results in the sequential reductive dechlorination and aerobic biodegradation of chlorinated organic compounds.

The general applicability of the technology has been verified by testing samples of soil collected from a number of sites throughout North America. To illustrate the effectiveness of DARAMEND treatment, two project summaries detailing results from field scale applications were evaluated. The technology has been patented for use on soils containing chlorinated organic pesticides and organic explosive compounds.

DARAMEND bioremediation is generally applied as a land treatment process. Soil and amendments are blended using a deep rotary tiller, driven by an agricultural tractor, with an effective penetration of two (2) feet. Tilling serves to incorporate amendments and homogenize and aerate the amended soil. The technology has been applied both to excavated soil placed in a land treatment unit and to surficial soil left in place (upper two (2) feet).

Standard DARAMEND bioremediation has been effective in reducing the concentration of DDT. To improve its effectiveness in degrading DDT metabolites, particularly DDD, the provider has made a number of improvements in the technology. DARAMEND has been applied to numerous sites impacted by various different chlorinated pesticides, including DDT and its metabolites, as well as other recalcitrant compounds such as toxaphene and chlordane. Most recently treatment was completed full-scale on the THAN Superfund Site in Montgomery, Alabama, where DDT, DDD and DDE concentrations were reduced substantially (Table 5-3).

Table 5-3. Influence of Standard DARAMEND, THAN Superfund Site, Montgomery, Alabama.

Parameter	Concentration (mg/kg)	
	Initial	**Final**
DDE	48.6	11
DDD	590	102
DDT	216	27
toxaphene	720	13

Source: Adventus, 2004.

Adventus' studies with the Generation III DARAMEND bioremediation have proven it to be superior to all of the preceding applications, particularly when treating recalcitrant chlorinated organic pesticides. Table 5-4 provides a summary of the interim results obtained during an ongoing bench scale study looking at a few different modifications to the standard technology. Clearly, the Generation III applications have substantially improved performance over the standard technology. Of particular interest is the dramatic reduction seen in DDD concentrations.

DDD and, to a lesser extent DDE, both biodegradation intermediates of DDT, are commonly observed to transiently accumulate during the bioremediation of DDT contaminated soils. DDD in particular is generally considered very recalcitrant and resistant to biodegradation. Although standard DARAMEND bioremediation is able to cause substantial reductions in all DDT biodegradation products, DDD has traditionally been the most difficult to remove and, in some cases, has been observed to accumulate using standard DARAMEND protocols. With the Generation III DARAMEND, we do not encounter this transient DDD accumulation, and we see rapid reduction of the DDD originally present in the impacted soil. Adventus theory is that although DDD will still result from the biodegradation of DDT, the conditions in the soil are such that DDD is also degraded very rapidly and does not result in any measurable transient accumulation.

Table 5-4. Influence of Standard and Generation III DARAMEND Bioremediation on DDE, DDD, DDT, and Toxaphene.

Parameter	Concentration (mg/kg)			
	Initial	**Standard**	**Gen. III (a)**	**Gen. III (b)**
DDE	0.3	0.16	<0.2	<0.2
DDD	1.65	3.12	0.22	0.16
DDT	14.46	1.58	<0.2	0.32
toxaphene	28.24	14.70	<0.3	<0.3

Source: Adventus, 2004.

Figure 5-1 compares the results between a Generation III DARAMEND treatment and a standard DARAMEND treatment on more heavily contaminated pesticide-impacted soil from an industrial site in Louisiana. Results show that the concentration of total pesticides was reduced by 95%, from 277 mg/kg to 12.6 mg/kg, after 105 days of treatment using the Generation III technology. During the same period, only an 80% reduction in soil pesticide concentrations was achieved with the standard DARAMEND treatment.

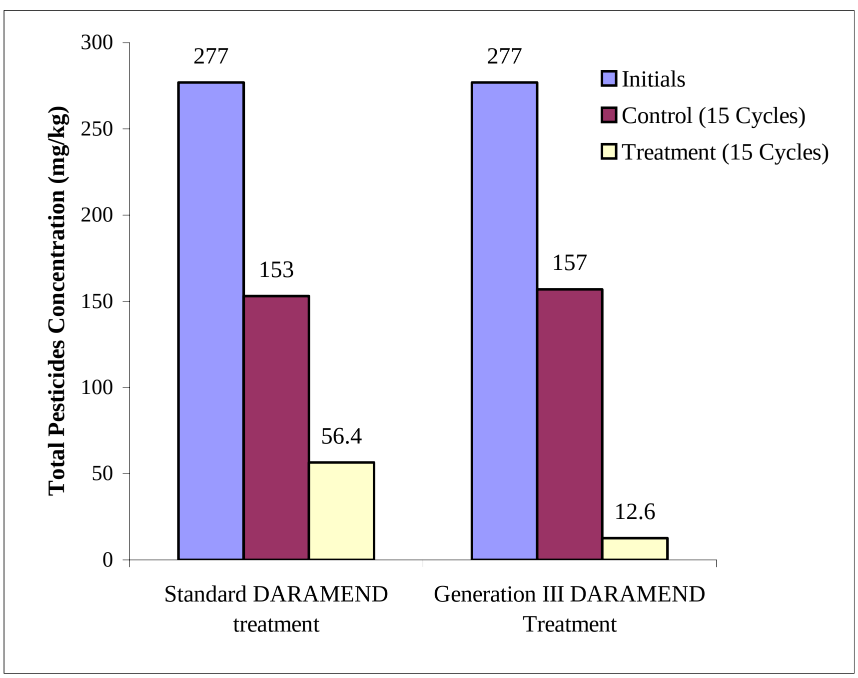


Figure 5-1. Influence of Generation III DARAMEND Bioremediation on Chlorinated Pesticides in Soil – Industrial Site, New Orleans, LA (Source: Adventus, 2004.)

5.2.10.1.3 Treatment Cost

In general, bioremediation treatment costs are determined on a price per ton basis. To convert to price per acre, we have assumed an average depth of one foot and a soil bulk density of 1.0 ton/cubic yard. We have assumed this bulk density due to the relatively high organic matter content (Appendix B). For a large project such as Apopka, it is reasonable to expect the unit price for treatment might range between $25 and $40 per ton ($40,300 to 64,500 per acre-ft), not including site delineation, site preparation, soil excavation (if required), confirmatory analysis, permitting or overall project management. Using the assumptions outlined above, each acre should contain approximately 1,613 tons of soil. Therefore, the cost estimate for typical source area full scale turnkey treatment ranges between about $23,000 and $36,000 per acre for removals as high as 99%.

5.2.10.1.4 Pilot Scale Demonstration

Prior to full scale treatment, an on-site pilot scale demonstration of the technology to verify its effectiveness with site soils would be performed on approximately 250 tons of surficial soil in place, assuming Adventus provides all amendments, equipment, and labor, would cost approximately $100,000 to $125,000. Pilot testing would be performed at worst case hotspots on the site.

Based on overall site conditions, landfarming or *in situ* bioremediation applications are potentially applicable on at least five to nine of fifteen fields totaling 793 to 922 acres. The cost of bioremediation to a depth of one foot is estimated to be $16,700 to $23,000 per acre to effect reductions needed as high as 68 percent. The presumably even lower cost for performing shorter, fewer, or less intense treatment cycles to provide less than 20 percent reduction are not well documented. The District intense tilling demonstration involving weekly tilling for six months achieved approximately 21 percent reduction, but did not involve a regime of amendments.

5.2.10.2 Technical Criteria Analysis

This subsection provides the technical criteria analysis of the *in situ* treatment alternative compared against the six criteria in Table 5-1.

5.2.10.2.1 Protection of Avian Populations

This alternative, if properly implemented, is protective of the avian populations because it will reduce or eliminate exposure to the COPCs.

5.2.10.2.2 Compliance with Regulatory Requirements

This alternative is expected to be compliant with all regulatory requirements.

5.2.10.2.3 Long-Term Effectiveness and Permanence

This alternative, as all the other alternatives which incorporate reduction of COPC mass by treatment, is permanent and effective over the long term.

5.2.10.2.4 Short-Term Effectiveness

This alternative is effective in achieving the RAOs in the short term.

5.2.10.2.5 Implementability

This alternative is readily implemented with available technologies.

5.2.10.2.6 Cost

The estimated cost of this technology is estimated to be $24,100 per acre, but will be less for fields only requiring lower percent reduction and fewer or shorter cycles due to differences in the COPC matrices. The basis of this cost estimate is provided in Appendix B.

5.2.11 *Ex Situ* Treatment

The only technology considered under this option is *ex situ* chemical treatment (Soilsavers AOP).

Soil Savers specializes in *ex situ* chemical oxidation of organic contaminants contained in earth materials and as a contractor/technology company their experience includes both bench experience and full scale applications. The chemical oxidation process relies on the Soil FX™ treatment system which is comprised of the Water FX™ reactor that produces hydroxyl rich water that is used in combination with a number of different oxidizers, catalysts, reducers, acid and bases that are selected based on the contaminant of concern, soil matrix, moisture content, organic content, and remediation goal. Figure 5-2 shows generic process flow chart which describes the treatment process as follows:

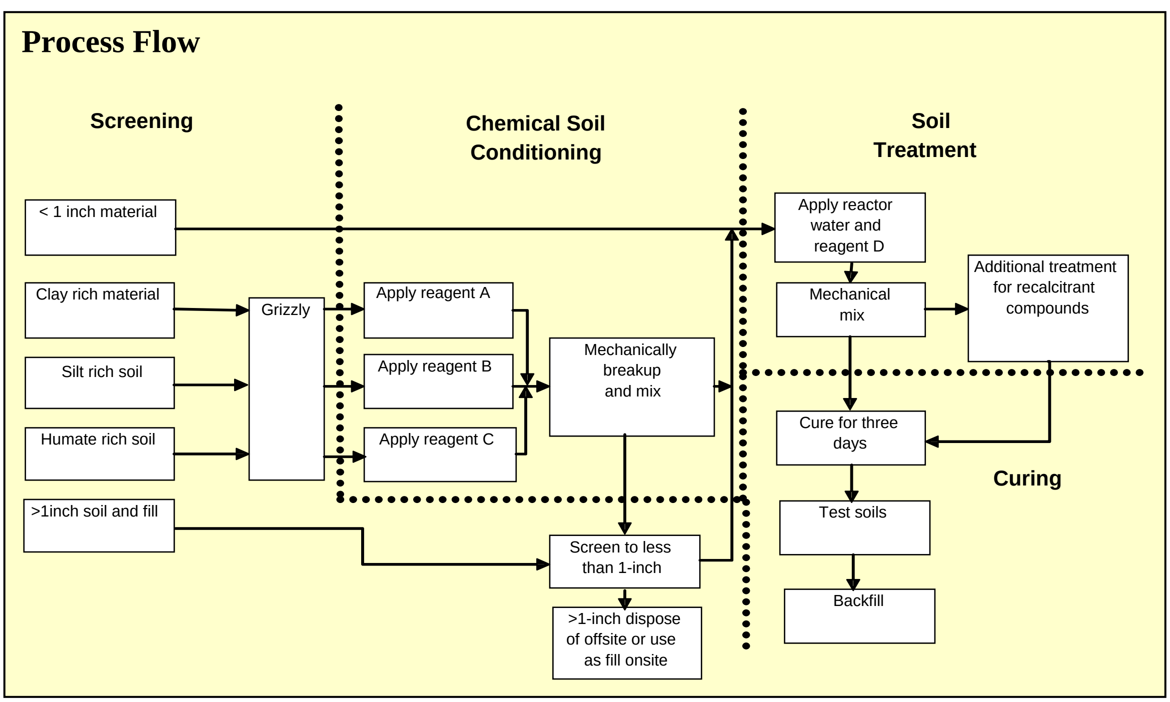


Figure 5-2. *Ex Situ* Chemical Treatment Process Schematic

Soil Savers has experience treating a variety of soil types ranging from sand and clay to dredge material with high TOC. Six case histories are available which demonstrate the process aility to treat a variety of contaminants in a variety of soil types.

The Soilsavers process has treated over 500,000 tons of soil using chemical oxidation on over 100 *ex situ* chemical oxidation treatment projects. Full scale treatments range from recalcitrant manufactured gas plant wastes (with compounds such as benzo-a-pyrene), creosote, gasoline, crude oil and fuel oil.

The Soil FX^{TM} Treatment System has been used to treat a wide variety of contaminants *ex situ* including a wide variety of PAHs.

Soil Savers' research and development department regularly conducts bench tests on contaminated soils. Table 5-5 summarizes treatment efficiencies for a variety of chemicals of regulatory concern based on bench scale data which included OCPs.

Table 5-5. Bench Scale Performance Data

Regulatory Constituent	Pretreatment Concentration	Post Treatment Concentration	Percent Reduction
1,2-dichloroethene	610	<4.4	>99%
2-methylnapthalene	43,000	40	>99.9%
4,4'-DDD	66	<6	>90%
4,4'-DDT	210	<6	>97%
aldrin	1,700	<190	>88.8%
benzo(a)pyrene	8,210	<190	>97%
benzo(g,h,i)perylene	6,070	<200	>97%
dibenzofuran	9,200	<37	>99%
dieldrin	160	<2	>99%
di-n-Butyl phthalate	3,300	300	91%
heptachlor	12,000	600	95%
heptachlor epoxide	200	430	79%
p-isoproplytoluene	700	170	98%
methoxychlor	130	<20	>84%
tetrachlorethene	4,500	43	99%
trichloroethene	180	<2.2	>88%
vinyl chloride	21	<2.2	>90%

Source: Soilsavers, 2004.
Note: All results in mg/kg

Soil Savers does not have documented full scale field experience treating the pesticides of concern at the Apopka project including DDT, DDE, dieldren, chlordane and toxaphene.

However the above bench scale results that document oxidation of all of the pesticides of concern except toxaphene. Table 5-5 summarizes the bench scale treatment of DDD, DDT and dieldrin with reductions in 90% to 99% range. These concentrations are lower than those present at Apopka but they do demonstrate ability to achieve high percentage reductions at low concentrations.

Table 5-6 presents bench test results from earlier work than presented in Table 5-5, with starting concentrations similar to those found at Apopka except for DDT which are on the low side in the bench test.

Table 5-6. FPM Pesticide Bench Results (mg/kg)

OCP	Pre Treat 1	Post Treat 1	Pre Treat 2	Post Treat 2
heptachlor	12,000	720	8,900	600
aldrin	1,700	<190	1,400	<190
heptachlor epoxide	1,900	430	2,000	560
dieldrin	9,000	2,900	7,300	3,900
4,4-DDE	2,600	800	2,200	990
4,4'-DDD	5,700	1,900	5,100	1,800
4,4 DDT	2,800	880	2,400	780
alpha chlordane	22,000	7,500	18,000	8,600
gamma chlordane	23,000	7,900	16,000	9,200

Source: Soilsavers, 2004.

Bench scale percent reductions range from 56% to 68% based on first round bench work. Subsequent bench tests and field applications have been achieving percent reductions greater than 90% and in many cases greater than 99% for recalcitrant compounds. The bench test process is used to determine the optimal combination of reagents relative to contaminant concentrations, remediation criteria and soil matrix.

Soil Savers does not have bench data for weathered toxaphene but is confident in its ability to oxidize this mixture. A brief review of the literature suggests that toxaphene will oxidize and is no more difficult to treat than many of the organic chemicals that Soil Savers has treated in the past. The real issue relates to the laboratory methodologies utilized to test the soils and a toxicological evaluation of the resulting treated soils. The process uses a variety of different oxidizers and reagents that can be modified for different environmental settings. For most all of the reagents microtox tests or other toxicological evaluations have been conducted on treated media. This issue is similar to the concerns regarding the proposed alum treatment when first considered. Bench tests would first address the most effective steps to oxidize the toxaphene and subsequent tests would evaluate the best combination of reagents versus the environmental issues.

The Apopka soil has a high TOC, high humate content and a moisture content of up to 40% by weight. Worst case percent reductions required to achieve the low dry weight wt criteria range from approximately 60% for dieldrin to 90% for DDT. The average required reduction is substantially less.

The total mass of contaminant requiring reduction will have a direct impact on the amount of oxidizer required and therefore the cost to treat. Based on experience treating a wide range of contaminants the per ton treatment cost (assuming the soil is excavated and stockpiled for treatment) is from a low of $12/ton up to $30/ton ($19,400 to $48,400 per acre assuming 1.0 tons/cu yd soil density) for the average percent reductions required on this project. This assumes that Soil Savers will dry the soil, screen out the large material, apply the reagents and stockpile the soil for testing by others. The difference in price is reagent cost. The greater the percent reduction and mass, the greater reagent doses required. Higher TOC will require more oxidizer to treat conversely the treatment criteria for soils high in TOC is also higher so the cost may not vary. Complicating the pricing is that Soil Savers has not been called upon to achieve low percent reductions (less than 75%). Typically 99% and greater reductions are required therefore through mixing; curing, drying and layered applications are required. In this case many of those steps may not be needed as the starting concentrations are relatively low and the percent reductions are low. The available pricing assumes all those steps are required, and does not reflect lower possible costs for less intense treatment.

The low percent reductions may also indicate the application could be used in an *in situ* variation by tilling the reagents into the soil as a high degree of mixing may not be required. In a tilling scenario, where others are operating the tilling/mixing equipment, the costs can range from $8/ton up to $20/ton ($12,900 to $32,300 per acre).

Soil Savers would need to conduct a bench testing program to determine the optimal treatment scenario accounting for the *ex situ* treatment versus tilling and particularly the dry weight versus TOC weighted remediation goal. There is an existing bench scale facility in McKinney, Texas capable of handling all of the bench work including evaluating alum in combination with oxidation.

5.2.12 Soilsavers AOP *Ex Situ* Chemical Treatment

5.2.12.1 Technical Criteria Analysis

This subsection provides the technical criteria analysis of the *ex situ* treatment alternative compared against the six criteria in Table 5-1.

5.2.12.1.1 Protection of Avian Populations

This alternative, if properly implemented, is protective of the avian populations because it will reduce or eliminate exposure to the COPCs.

5.2.12.1.2 Compliance with Regulatory Requirements

This alternative is expected to be compliant with all regulatory requirements.

5.2.12.1.3 Long-Term Effectiveness and Permanence

This alternative, as all the other alternatives which incorporate reduction of COPC mass by treatment, is permanent and effective over the long term.

5.2.12.1.4 Short-Term Effectiveness

This alternative is effective in achieving the RAOs in the short term.

5.2.12.1.5 Implementability

This alternative is readily implemented with available technologies.

5.2.12.1.6 Cost

The estimated cost of this technology is $28,000 to 34,700 per acre. The basis of this cost estimate is provided in Appendix B. Costs for lesser degrees of treatment have yet to be determined.

6.0 Comparative Analysis of Remedial Alternatives

Remedial alternatives for the NSRA soil contamination were developed and individually evaluated in Sections 4.0 and 5.0, respectively, using the seven technical evaluation criteria presented in Section 2.1. For comparative purposes, these criteria are grouped into the following categories:

- Threshold criteria
- Primary balancing criteria
- Modifying criterion

This section presents a comparison of remedial alternatives with respect to the threshold and primary balancing criteria. This comparison is intended to provide technical information to support selection of a preferred alternative. The modifying criterion consisting of stakeholder reviews (i.e., USFWS, FDEP) is more appropriately evaluated after review of this document. It is anticipated that the stakeholder's reviews will be accomplished at a later date.

6.1 Overall Approach to Comparative Analysis

Section 4.0, developed remedial alternatives to accomplish the RAOs identified for the soil contamination at NSRA. The threshold and primary balancing criteria identified above are used to streamline the comparison between alternatives, while ensuring compliance with the RAOs. Components of these criteria are described below.

6.1.1 Threshold Criteria

Because the selected alternatives must be protective to the avian populations, as well as comply with the regulatory requirements, the following threshold criteria are essential:

- Protection to the bird populations at will make the NSRA their permanent or temporary habitat
- Compliance with the regulatory requirements

An individual assessment of each alternative with respect to these criteria was presented in Section 5.1.

6.1.2 Primary Balancing Criteria

Primary balancing criteria consists of the following components:

- Long- term effectiveness and permanence
- Short-term effectiveness
- Implementability
- Cost

These criteria are used to provide an assessment of the permanence of each remedial alternative, while ensuring their implementability and cost-effectiveness. An individual assessment of each alternative with respect to these criteria was presented in Section 5.2. A comparative analysis of each of the alternatives using primary balancing criteria is presented in Section 6.2.

Comparative evaluation of cost will be based on the estimated cost per acre remediated. It is assumed that the upper foot of soil is to be remediated so 1 acre is equivalent to 1 acre-ft of soil which is approximately 900 tons.

6.2 Comparative Analysis

The following subsections present a comparison between alternatives for the 11 remedial alternatives capable of addressing the soils contamination at the NSRA using the six threshold and balancing criteria outlined above. Remedial alternatives are compared to each other in Section 6.2.1.

6.2.1 Comparative Analysis for Soil Remediation Alternatives at the NSRA

The alternatives discussed within this FS are identified as follows:

- **Alternative A -** No action
- **Alternative B -** Limited action
- **Alternative C -** Island/peninsula construction
- **Alternative D -** Bermed only containment of non-flooded areas
- **Alternative E -** Soil capping and/or cover
- **Alternative F -** Soil layer inversion
- **Alternative G -** Vertical blending
- **Alternative H -** Horizontal blending
- **Alternative I -** Land farming – shallow tilling with biological and/or chemical amendments
- **Alternative J -** Bioremediation – aerobic-anaerobic dechlorination
- **Alternative K -** Soil reactor *ex situ* chemical treatment
- **Alternative L** Excavation and off-site landfill disposal

6.2.1.1 Comparison of Threshold Criteria

The following comparison is made between remedial alternatives that could be implemented to remediate the soil contamination at the NSRA with respect to two criteria:

1) Protection for the bird populations that will make the NSRA their permanent or temporary habitat, and
2) Compliance with the regulatory requirements.

6.2.1.2 Protection of Bird Populations at the NSRA

Soil contamination at the NSRA has been proven to constitute a risk to piscivorous bird populations when the soil comes in contact with surface water supporting fish habitat. All the alternatives presented in this FS, including Alternatives A and B, are protective of the piscivorous bird populations at the NSRA. Alternatives A, B, C, and D, are protective because these alternatives consist primarily in maintaining the fields drained, and under this condition bird exposure to COPCs is mitigated. Bird exposure to OCPs is primarily through the ingestion of fish contaminated with OCPs, and maintaining the fields in a dry condition will prevent the establishment of a fish habitat. However, the dry field condition is inconsistent with the wetland restoration objectives for the NSRA.

The remaining alternatives are also protective to the piscivorous bird populations at the NSRA because a field will not be flooded unless it has met the remediation target level. As fields are remediated and re-flooded, a more precise remediation target level may be developed which will then become the remediation target level for the remainder of the fields.

6.2.1.3 Compliance with Regulatory Requirements

All the alternatives presented in this FS comply with the chemical-specific regulatory requirements which include the SDWA, the ESA, the MBTA, and the BGEPA. Alternatives A, B, C, and D, comply with the chemical-specific regulatory requirements given that under these alternatives the soil will remain dry and the contaminated areas will not come in contact with the surface water, the District will be in compliance with the ESA, MBTA and the BGEPA. Periodic monitoring, will in the same way, determine whether the District is in compliance with the SDWA. The remaining of the alternatives also comply with the chemical-specific regulatory requirements since fields will not be flooded unless it has been proven that the degree of treatment has reduced the OCP soil concentration to levels in which it will not pose a risk to the bird habitat.

Alternatives A, B, C, and D, do not comply with location-specific regulatory requirements; specifically, they do not comply with the Lake Apopka Restoration Act, and as a consequence they do not comply with the CWA that drives the Lake Apopka Restoration Act. Although alternatives C and D tend to be inconsistent with the objective of the Lake Apopka Restoration Act, it is anticipated that they would be applied over such a small portion of the NSRA that the effect of this inconsistency will be *de minimus.*

The remainder of the alternatives comply with the Lake Apopka Restoration Act since the fields will be flooded and will revert to wetlands, which is of primary importance in the restoration of Lake Apopka.

Action-specific regulatory requirements do not apply to alternatives A and B. Action-specific regulatory requirements will apply to all the other alternatives during construction and implementation of the alternatives. Non point source emissions of OCP-contaminated particulates by wind and stromwater erosion that could be generated during the required construction can be minimized with appropriate construction site and long-term erosion controls. Action-specific regulatory requirements can be complied with equally by all the alternatives.

6.2.1.4 Comparison of Primary Balancing Criteria

A comparison was made between the remedial alternatives with respect to the following balancing criteria:

1) Long-term effectiveness and permanence;
2) Short-term effectiveness;
3) Implementability; and
4) Cost.

These criteria are discussed for each alternative within Section 5.2.

6.2.1.5 Long-Term Effectiveness and Permanence

Long-term effectiveness of the various alternatives is decreased in proportion to the magnitude of the residual risk. Reduction and *ex situ* treatment remove the possibility of residual risk by verified COPC destruction. Bioremediation is permanent but slightly less effective because it reduces the residuals in proportion to the depth and extent of application only, although further and accelerated attenuation is expected with time because of soil layer mixing. Soil covers and islands might be less permanent and effective because of the possibility of erosion uncovering remaining untreated contamination. Dikes and berms that leave the soils uncovered except for re-vegetation are even more susceptible to failure and the possibility of periodic but infrequent flooding. Soil inversion and vertical blending may be equally permanent but adequate. Soil flipping would bury the OCPs beyond reach, while blending would only reduce the surface exposure to lower acceptable values. Blending would lower concentrations of OCPs so that they do exceed thresholds, especially if deeper mixing involving clean soils is accomplished.

Not all the alternatives have the same degree of adequacy and reliability. Island construction is not considered as applicable for deeper flooding blocks. Soil covers would typically provide less coverage of the COPCs than proper soil inversion and might be breached by erosion after even periodic storm flooding. Bermed and uncovered areas would not allow re-flooding. Once accomplished, bioremediation controls are adequate and reliable for long-term controls because the OCPs will have been dechlorinated, but the *in situ* alternative is subject to the variability involved in monitoring large areas to confirm with analytical certainty that desired concentrations have been reached, and that pockets or deeper contamination will not impact the food chain after re-flooding.

6.2.1.6 Short-Term Effectiveness

All of the alternatives can be protective of the avian populations during implementation because the impacted fields would be kept in a non-flooded condition until monitoring verifies the field specific reductions have been accomplished. None of the alternatives involve processes that would have significant emissions, or transport of residual waste that could have an impact on the surrounding community. Workers implementing the construction alternatives would be protected adequately from chemical exposure during equipment operation and servicing by common Level D OSHA protection. Mechanical and fall or other injury risk due to very large scale heavy equipment operation in hot, wet conditions with subsurface roots, etc. can be addressed with adequate safety programs. Alternatives requiring chemical handling and application will require additional protection according to established protocols.

Time to achieve the RAOs on a field level is significantly different for the alternatives according to the amount of multi-pass surface preparation, and the time required for the chemical-biological treatment processes to occur. Island and cover or berm alternatives may process several acres per day. Deep plowing or inversion equipment have plowed 30 to 50 acres per day under some conditions, but productivity is expected to be far less under NSRA conditions. Physical soil manipulation alternatives will require relatively little monitoring to verify completion. Chemical treatment would be fast and a unit might process 1-2 acres per day but require time for staging and re-placement of soils after a few days of curing and confirmation sampling. Bioremediation performed in varying intensity cycles would require the longest time. Bio-treatment cycle lengths of 1 to over 150 days have been utilized on other OCP sites, with number of cycles varying from a few to over a dozen. Bioremediation times for individual fields may range from six months to several years.

6.2.1.7 Implementability

Island, soil cover, and berm isolation techniques have no significant construction issues. Off-site landfill disposal of soils in subject to availability of landfill capacity.

Vertical blending and soil inversion have been commonly applied for bringing lower soils to the surface in Texas (Personal Communications, Allen, 2004), and in Australia to depths of 3 meters, and have even reportedly been implemented in the US under flooded conditions to seal contaminated sediments below clean sediment (Personal Communications, USDA, 2004). Implementability is a matter of site preparation and use of proper equipment. Reliability of deep plowing will suffer if roots and wet conditions do not allow a constant speed – turning depth, or if the concentrations at depth are not as low as anticipated. Large scale efficiency under NSRA wet muck field conditions is essentially unknown because the demonstrations have so far been limited.

Ease of undertaking additional remediation, if necessary, varies significantly for several alternatives. Islands, berms, and soil cover can be repaired or replaced. Soil inversion is a nearly one-time procedure that can probably not be repeated more than once, and the second attempt would require a deeper turning depth to bring up clean materials from 2 to 3 feet to the surface. However, such failure of inversion, if it occurs, can easily be followed by sequential tilling to depths as deep as 3-4 ft or more with offset plows having larger 42 to 54 inch disks.

Bioremediation has been documented by various processes, but is relatively complex to control versus time, and some processes have experienced problems with achieving complete DDTx dechlorination, or have required volume increases due to the use of bulking agents. Full-scale application performance data on large acreage versus time is lacking.

Although bioremediation and chemical treatments may be expected to be effective based on relevant full-scale experience, most documented successful applications of these technologies have addressed different soil types and/or have had different remedial objectives. Typically these technologies have been applied to soils more typical of uplands, with lower moisture and organic content. To address these conditions, the application often must add moisture or organic material. Implementation in the NSRA's marsh soils would have distinctly different soil preparation and amendment requirements. It is not clear if these factors would improve or adversely affect implementability. Also, successful documented applications of bio and chemical treatment technologies were conducted at higher initial concentration and had lower (more stringent) remediation targets. These unique features of the NSRA RAOs are expected to make implementability easier. In any case, however, these technologies have not been demonstrated in an application similar to the situation in the NSRA, and this represents a relative disadvantage for these technologies. The processes would need adjustment to treat wet NSRA high TOC content soils. Chemical treatment in an *ex situ* reactor would provide the most complete soil contact for treatment but is mass based and non-selective; chemical demand will be exerted by the soil TOC and OCPs. Chemical treatment will be the most efficient on the lowest TOC soils requiring the least OCP reduction. Stated another way, chemical treatment is certain to reduce TOC and therefore produce product with greater leachability. These soils may not be as desirable for the future wetland use of the NSRA. Such soils would, however, be acceptable as clean cover materials for non-flooded areas.

Coordination with other agencies is assumed to be required for any alternative or approach, particularly those requiring demonstration and later confirmation monitoring prior to re-flooding of phased portions of the NSRA. None of the retained alternatives discussed herein are considered to have unusual or significantly different coordination requirements. Based on the analytical difficulties already experienced for different methods, it is assumed that resolution of issues related to confirmatory monitoring frequency, number, spacing, and precision and accuracy will be needed to avoid the possibility of rejection for re-flooding or required re-treatment if field samples are above negotiated target levels.

6.2.1.8 Cost

Actual costs for broad acreage remediation using any of the construction methods or the biological treatment methods are not well documented. While overall project costs are driven almost entirely by target levels and size of the acreage to be treated, field level application costs of the individual alternatives are driven by the underlying per acre unit cost assumptions. These assumptions are subject to a high degree of uncertainty with regard to productivity. For example, deep plowing –soil inversion has the lowest unit cost, but daily productivity could vary nearly an order of magnitude. For vertical blending and mixing, the possibility of single pass processing using Rotoclearing or trenching equipment under wet conditions has not been determined. Processing rates considered reasonable, commercially available, and using adequate sized equipment were used in costing.

The supporting cost documentation is contained in Appendix B. The rationale and methodology for estimating alternative costs was simplified to unit cost inputs per acre to allow multiple alternative cost comparisons applied to large broad acreage fields. Typical construction and agricultural costs for site preparation, soil manipulation, soil movement, soil compaction and stabilization, and cover or re-vegetation operations were assembled from Means Construction Guide (2004), and RACER (1999), National Construction Estimator (2004), and the Alabama Cost Estimator (2002); agriculture costs only.Vendors provided estimates for bioremediation and chemical treatment. Based on the non-flooded but wet site conditions, discussions with the District, and correspondence with previous site demonstration equipment operators, each alternative unit cost was built based on the required steps. For example, most of the soil manipulation isolation alternatives include site preparation, mowing, and tilling steps.

Unit costs per acre were applied to fields considered to be candidates for an alternative based on the OCP concentration, %TOC, size, field location, flooding depth, and characteristics of the adjoining fields. For each field the composite unit costs per acre for candidate alternatives were multiplied by the field acreage to arrive at the various technology application costs. The minimum cost for each field was then used to assemble the reduction group costs.

At the field level, each alternative represents a stand-alone-technology application. There are numerous possible combinations not costed for coupling partial treatment applications with other alternatives to reach the stated goals. Coupling is particularly applicable to highest concentration fields requiring the most complete treatment. An option might be to process part of the surface soil with *in situ* bioremediation or chemical treatment, then blend the product with the remainder of the surface soils. Chemical treatment is known to be more economical for lower TOC content soils. In lower contaminated areas requiring limited treatment, vertical blending might be augmented with a less intensive form of *in situ* bioremediation to provide accelerated achievement of target levels.

These costs are for the comparative technology implementation only, assume adequate access, and non-flooded conditions without additional roads, canals, ditches, or pumping and controls beyond what is currently provided by the District. No additional costs have been added to cover procurement, construction oversight, or monitoring beyond that required for process control.

6.2.1.9 Summary of Comparative Analysis for the Remediation Alternative

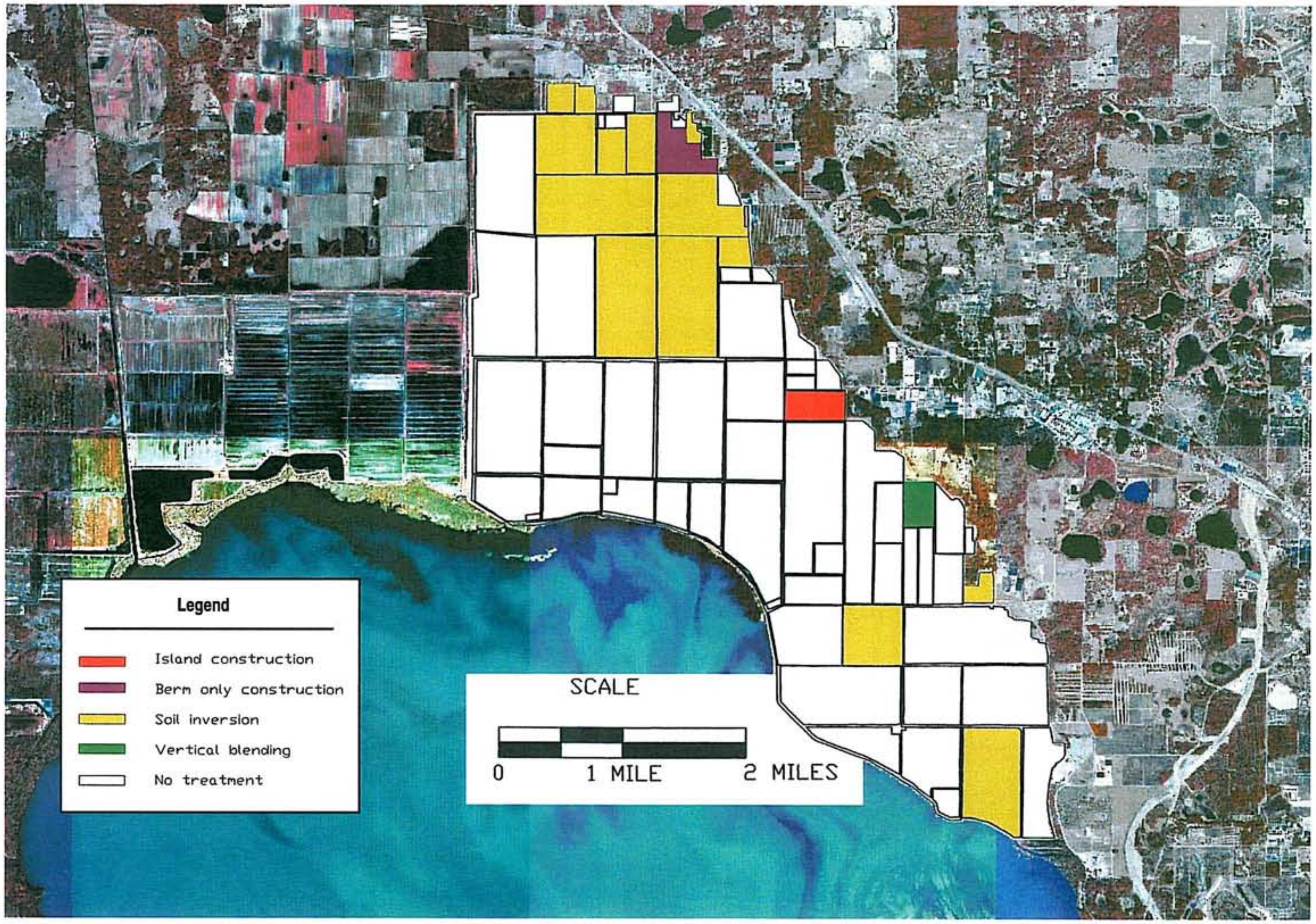
Table 6-1 presents a summary of the comparative analysis of the soil contamination remedial alternatives for the NSRA. The evaluation criteria presented within this table provide evaluation of the individual remedial alternatives in their ability to achieve the screening criteria. This summary table also supports the overall comparison of remedial alternatives to support the stakeholders acceptance process.

Figure 6-1 provides a map showing the field locations and corresponding lowest cost alternatives to meet the BETL. Figure 6-2 provides the same information for the more extensive area treatment neededto meet the CTL.

Table 6-2 presents minimum capital costs for the retained alternatives summarized by the percent reduction field groups. Not all alternatives are reasonably applicable to all fields, reduction levels.

As shown, the minimum cost estimated for BETL treatment of 2,207 acres in 17 fields is $6,740,000 or approximately $3,054 per acre. This minimum is based on unit costs and productivity considered conservative pending further phased demonstrations. For the CTL larger acreage of 6,915 acres, the minimum cost is estimated to be at least $61,907,000 or approximately $8,953,, per acre. The higher average cost is due to the need for higher degrees of treatment requiring higher cost technologies. If all the acreage could be treated with the lower average cost alternative following demonstrated proof of performance, the CTL minimum cost might be reduced significantly by as much as $27,767,400 to approximately $34,139,000.

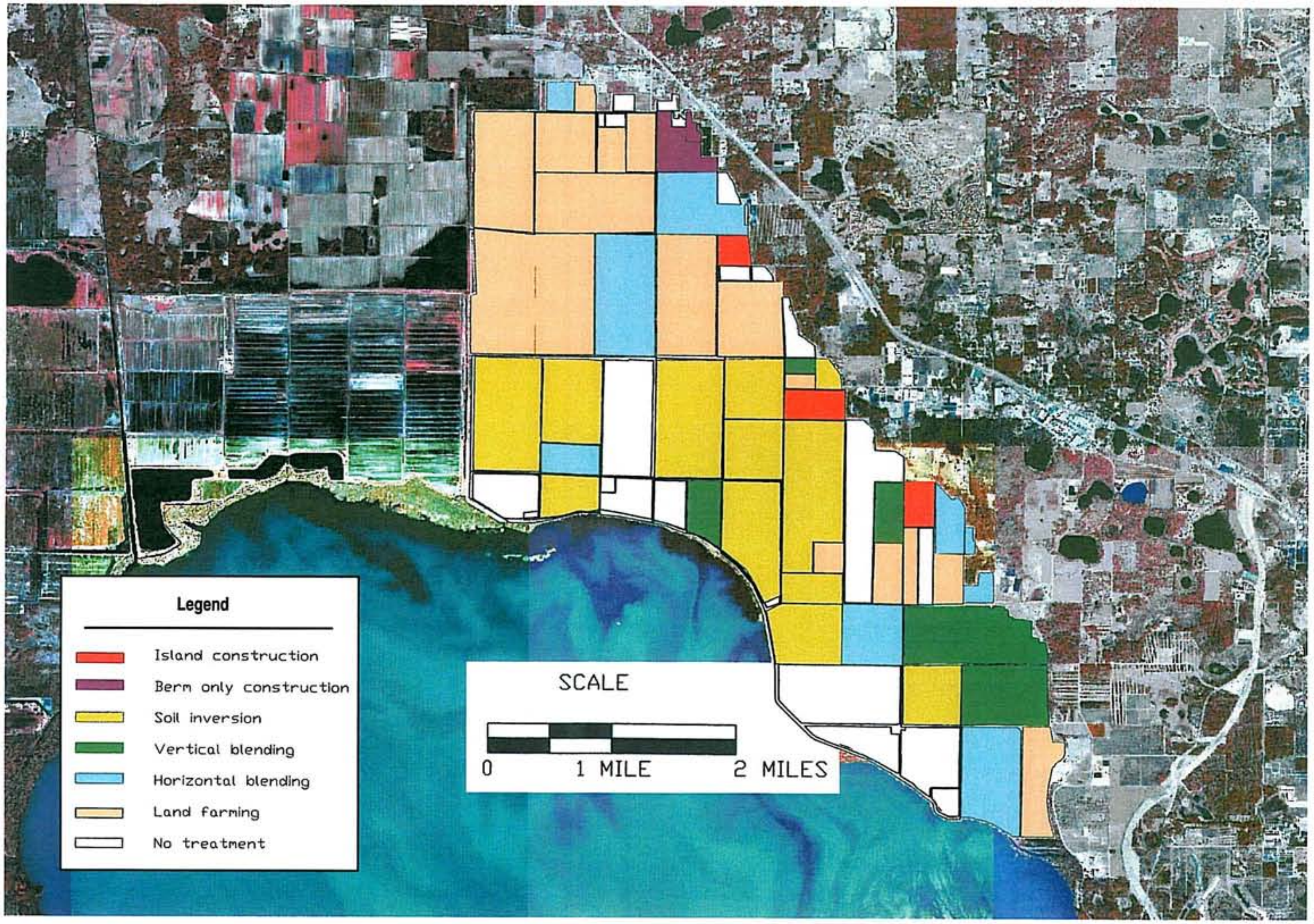
Appendix B provides a more detailed summation of the costs and potential savings if isolation (inversion or mixing) techniques can be improved and substituted for acreage requiring greater than 20% reduction. This difference highlights the critical need for a robust pilot program to determine actual unit cost per acre for planning purposes. With practice, and due to the economy of scale for this size project, overall much lower cost per acre is potentially possible.



Source: SJRWMD, 2004;
MACTEC, 2004.

Prepared/Date: MLJ 7/26/04
Checked/Date: WAT 7/27/04

Lake Apopka North Shore Restoration Area ZDWCD Units 1 and 2 SJRWMD, Lake & Orange Counties, FL	MACTEC	Lowest Cost Applicable Technologies to Meet the BETL PROJ. NO. 609604004 Figure 6-1



Source: SJRWMD, 2004;
MACTEC, 2004.

Prepared/Date: MLJ 7/26/04
Checked/Date: WAT 7/27/04

Lake Apopka North Shore Restoration Area ZDWCD Units 1 and 2 SJRWMD, Lake & Orange Counties, FL	MACTEC	Lowest Cost Applicable Technologies to Meet the CTL PROJ. NO. 609604004 Figure 6-2

Table 6-1. Alternatives Relative Comparison Summary

Evaluation Factors and Criteria	No Action A	Limited Action B	Island Construction C	Soil Cover D	Berms Only E	Soil Layer Inversion F	Vertical Blending G	Horizontal Blending H	*In Situ* Landfarming I	Bioremediation J	Chemical Treatment K	Excavation/ Landfill L
AVIAN POPULATION PROTECTION												
Risk Eliminated	1	1	1	1	1	1	2	2	2	2	1	1
Risk Reduced or controlled	1	1	1	1	1	1	1	1	1	1	1	1
Short-term Effects		1	1	1	2	1	1	1	1	1	1	1
COMPLIANCE WITH REGULATORY REQUIREMENTS												
Compliance with chemical-specific requirements	1	1	1	1	1	1	1	1	1	1	1	1
Compliance with location -specific requirements	NO	NO	NO	NO	1	1	1	1	1	1	1	1
Compliance with action -specific requirements	1	1	1	1	1	1	1	1	1	1	1	1
LONG-TERM EFFECTIVENESS-PERMANENCE												
Magnitude of Residual Risk	6	6	5	5	5	3	4	4	2	2	1	1
Adequacy of Controls	5	5	4	4	4	1	2	3	2	2	1	1
Reliability of Controls	2	2	1	3	3	1	2	2	2	2	1	1
SHORT-TERM EFFECTIVENESS												
Protection of Avian Pop. During Restoration	NA	NA	1	1	1	1	1	1	1	1	1	1
Protection of Community During Restoration	NA	NA	NA	1	1	1	1	1	1	1	1	1
Protection of Workers During Remedial Action	NA	1	1	1	1	1	1	1	1	1	1	1

Table 6-1. Alternatives Relative Comparison Summary

Evaluation Factors and Criteria	No Action A	Limited Action B	Island Construction C	Soil Cover D	Berms Only E	Soil Layer Inversion F	Vertical Blending G	Horizontal Blending H	*In Situ* Landfarming I	Bioremediation J	Chemical Treatment K	Excavation/ Landfill L
IMPLEMENTABILITY												
Ability to Apply Technology	1	NA	1	1	1	1	1	1	1	1	1	1
Reliability of Technology	1	1-Monitor	1	1	1	1	1	1	1	1	1	1
Ease of undertaking additonal Remedial Action if Needed	1	1	1	1	1	1	1	1	1	1	1	1
Coordination with Other Agencies	1	1	1	1	1	1	1	1	1	1	1	1
COST												
Capital	2	2	3	4	3	1	1	2	3	4	5	6
O&M	3	3	1	2	1	NA	NA	NA	1	NA	NA	NA
			LIMITED ACREAGE								LIMITED ACREAGE	LIMITED ACREAGE

Source: MACTEC, 2004

Prepared by/Date: MLJ 9/10/04

Checked by/Date: WAT 9/10/04

Notes:
Relative Ranking - 1 is most protective, effective, etc., higher values are less.
NA = Not Applicable

Table 6-2. NSRA Soil Restoration Overall Alternatives Cost Summary

Target Level Basis and Reduction Levels	Field Group Acreage	No. Fields	Minimum Cost $	Average $/Acre (Minimum)	Maximum Cost $	Comments
BEST ESTIMATE						
Reduction >50%	173	2	$1,421,606	$8,219.08	$17,628,314	Pilot Location to determine if lower cost options feasible
20% < Reduction < 50%	614	3	$1,608,333	$2,621.34	$14,182,027	
Reduction <20%	1,420	12	$3,710,077	$2,611.98	$35,792,592	Soil Inversion Demonstration required
Total to Achieve Best Estimate Target Levels	2,207	17	$6,740,016	$3,054.03	**$79,317,975**	
CONSERVATIVE ESTIMATE						
Reduction >75%	254	4	$2,068,772	$8,446.73		Soil Inversion Demonstration required
75% < Reduction >50%	3,529	22	$49,589,830	$14,051.02		
20% < Reduction < 50%	1,813	13	$6,779,596	$3,739.61		Demonstrate Vertical Blending
Reduction <20%	1,328	7	$3,468,472	$2,611.98		
Total to Achieve Conservative Estimate Target Levels	6,915	46	$61,906,670	$8,952.50		

Source: MACTEC, 2004

Prepared by/Date: EMK 9/10/04
Checked by/Date: WAT 9/10/04

Table 6-3. Lake Apopka NSRA Units 1 and 2 Soil Remediation –Earthmoving/Construction and Treatment Composite Unit Costs Summary

Alternative	Function	Remedial Action - Technology Description	Composite ($/acre Jul 2004 $) *
A	No Action	No Action	Administrative in perpetuity
B		Limited Action	Administrative + Monitoring
C	Isolation/Containment Technologies	Island construction (Non-flooded)	$9,381
D		Soil Cover Capping (Non-flooded)	$24,370
E		Berms or Dikes Alone (Non-flooded)	$7,294
F		Soil layer Inversion (0-2 ft)	$2,612
G		Vertical Soil Blending (0-2 ft)	$2,710
H		Horizontal Soil blending (0-1 ft adjacent fields)	$6,112
I	*In situ* Treatment	Landfarming - In situ biostimulation /augmentation	$17,982
J		Bioremediation-Anaerobic-aerobic reductive dechlorination	$22,982
K	*Ex Situ* Treatment	Soil reactor *in situ* Chemical Treatment (0-1 ft)	$34,719
L		Excavation and Off-site Landfill Disposal (0-1 ft)	$118,560

Source: MACTEC, 2004.

Prepared by/Date: EMK 9/10/04

Checked by/Date: WAT 9/10/04

* Includes soil clearing, preparation, vertical manipulation, movement, *in situ* or *ex situ* treatment, replacement, compaction, stabilization, and cover elements to the extent required for each different alternative - See Appendix B.
These costs are based on rates from the National Construction Estimator, 2004, Racer 1999 (Means) and the Alabama Cost Estimator, 2002 (agricultural costs) updated to July 2004 dollars.

7.0 Conclusions and Recommendations

7.1 Conclusions

The ZDWCD Units 1 and 2 consist of 70 farm field units, covering approximately 9,900 acres. Within this area, soils have been contaminated by historical use of OCPs. It has been determined that re-flooding these fields, in 1998, contributed to the death of 676 birds in 1998-1999, after the birds ate fish that accumulated pesticide residues in their tissues. The OCPs most likely to have contributed to the bird mortality event of 1998-1999 were chlordane (total), DDE, DDTx (sum of DDD, DDE, and DDT), dieldrin, and toxaphene. These are the COPCs.

These COPCs are very persistent and immobile in site soils from 0-12 inches in depth, due, in part to the high organic carbon content of the soils, which averages 36% by weight. The COPCs are strongly associated with soil organic carbon, and the steady state concentration of OCPs in bird tissue appears to be directly related to the carbon-normalized concentrations of the COPCs (e.g., mg of toxaphene per kg of organic carbon), not the rate of exposure.The District has developed a range of estimates of target levels for each of the COPCs in soil on a carbon-normalized basis. The BETL represents the Districts best estimate of a carbon-normalized concentration of each COPC in soil that could be left in place during wetland restoration without resulting in toxic effects to protected birds. *These concentration targets were prepared to assist MACTEC's analyses and are preliminary and subject to change.* Insofar as the District continues to conduct research on the relationship between levels of pesticides in soil and pesticide exposure by piscivorous birds, there is some uncertainty in the final soil target levels that will be selected as protective. Therefore, the District also requested that this FS consider CTLs that might be selected after completion of ongoing research. The range between the CTLs and BETLs represents a reasonable range of potential remedial action objectives for soils to protect piscivorous birds under the wetland restoration land use scenario.

The 70 farm field units were the basic building blocks used in this FS, representing an appropriate exposure unit for piscivorous birds, and an appropriate unit for considering alternative remedial actions. The District has previously established that concentrations within these fields are relatively homogeneous, but may be quite different from surrounding fields that had different owners. For each of the 70 farm field units, a best estimate and a conservative estimate of the carbon-normalized concentration of each of the COPCs was calculated. The best estimate exposure concentration is the average value observed on each field. The conservative estimate is the upper 95% confidence limit of the average, or the maximum concentration, whichever was smaller. Limited soil profile data indicates little contamination in the 12-24 inch or 24-36 inch depth soil intervals.

The uncertainty regarding potential remediation target levels, as well as the uncertainty in knowing exactly what concentrations exist in the NSRA now, were expressly considered by evaluating potential remedies across the above-described range of potential remediation levels and the range of potential exposure concentrations. The best estimate soil concentrations were compared to the BETLs to identify the most probable degree of remediation that may be required on each field. On the other hand, comparison of the conservative estimate of the concentration with the CTL is expected to produce an upper bound estimate of the magnitude of remediation that may be required in order to restore these lands to a wetland function.

A field by field comparison of best estimate soil concentrations to BETLs (see Table 4-3) indicated that 2,200 acres in 17 fields of the 9,900 acre study area exceeded the BETLs. Of these 2,200 acres, however, 1,500 exceeded the BETL by less than 20%. In the conservative analysis, however, it is possible that 6,900 acres in 46 fields exceed the CTLs, representing a worst case estimate of the acreage needing remediation (Table 4-4). It was further determined that toxaphene was the critical contaminant for more than 70% of the acreage requiring remediation under either the best estimate or worst case scenarios. In other words, toxaphene exceeds its target level by a greater ratio than the other COPCs, and requires the greatest percentage reduction to achieve target levels in more than 70% of the fields requiring remediation. Chlordane was not identified as the critical contaminant on any field.

The FS identified 24 remedial technologies and process options that might be applicable to one or more fields on the site. After an initial screening, these were assembled into 12 remedial alternatives (Table 6-1). These alternatives included no action; a limited action alternative relying principally on MNA; several alternatives whose objective was to physically isolate the COPCs by soil manipulation to prevent exposure by birds (without removing the COPCs from the NSRA); and alternatives that would destroy the contaminant mass by biological treatment, either *in* or *ex situ*. The initial screening step clarified that some lower cost technologies may be available that would be capable of remediating some fields (e.g., the fields with relatively low percentage reductions required), but could not be relied on to remediate all the fields, particularly those where much higher percentage reduction of COPC concentrations were required.

It was assumed that any of the alternatives could be applied independently or in varying degrees to any of the farm field units requiring remediation, and that there was no need to select only one remedial alternative. The alternatives were evaluated on a field by field basis. To accomplish this efficiently, the fields were separated into groupings based on the percentage reduction in concentration required for the critical contaminant. Location-specific factors were also considered: fields at higher elevations near the land-side boundaries of NSRA may be easier to isolate than fields at lower elevations that would be inundated 2 or more feet under water.

A few fields are so contaminated that the only cost effective solution may be to isolate them, by building islands or peninsulas, or constructing earthen berms, that could prevent surface water from coming in contact with the contaminated soils and prevent formation of fish habitat. Such alternatives would reduce the acreage of wetland habitat that can be created in the NSRA, but the portion of the total NSRA area included in these high concentration fields is small enough (less than 2 percent) that excluding them from the wetlands would not significantly adversely affect the wetland and Lake Apopka restoration project. These fields could also be treated by *in situ* bioremediation or *ex situ* treatment technologies, thereby regaining their acreage as potential wetlands, though at a considerably greater cost.

It was determined that attractive low cost alternatives may be applicable to a great majority of the acreage. These include soil layer inversion, and vertical blending (tilling), either of which may be enhanced by the addition of amendments that promote COPC degradation. While these technologies appear to be attractive, with the potential to remediate most of the contaminated area, they have not yet been demonstrated to be effective in achieving contaminant concentration reductions much greater than 30%, in limited testing conducted in the NSRA. Even at this level of treatment, they may be useful over large portions of the NSRA. They present a reasonable promise, however, of achieving even greater applicability, and, given their low cost per acre, further pilot testing of these alternatives definitely represents a worthwhile investment.

The more intensive and expensive alternatives (amendments, *ex situ* and *in situ* treatments) would likely be removed from further initial implementation based upon estimated costs, at least pending further testing on the far less costly alternatives. If the less costly alternatives do not prove to be successful, the more costly alternatives could be investigated further. The use of inversion and blending alternatives would not preclude the use of further biological treatment or excavation.

Assuming that the BETLs are sufficiently conservative, and that best estimate concentration levels are accurate, the total cost to remediate Units 1 and 2 of the NSRA, using a combination of technologies (Figure 6-1), is estimated to be $6,700,000. On the other hand, if it is subsequently determined that the BETLs are not sufficiently protective, and the CTLs were adopted, the estimated minimum remediation cost for Units 1 and 2 of the NSRA could be as high as $62,000,000 (Figure 6-2 and Table 6-2). Potential cost savings of at least $976,000 are projected if pilot tests are successful, and further savings are increased in proportion to the acreage treated by lower unit cost isolation techniques, and the degree to which inversion or blending isolation can be further proven for higher percent reduction. If CTL level treatment of 6915 acres is needed, there is an enormous potential savings incentive of approximately $42,400,000, provided isolation can be applied to the 3529 acres of fields needing 50% to 75% reduction. In any case MACTEC is fairly confident of the range of potential remediation costs. It should also be noted that these alternative cost estimates are in 2004 dollars but do not include other or related District internal costs associated with management of the NSRA program.

It is clear there is some uncertainty in the overall estimated cost. This is caused, primarily, by uncertainty in the ultimate target levels. It is expected that this uncertainty will be reduced or eliminated by flooding areas with relatively low concentrations, monitoring the outcome, and using this information to refine the estimated remediation levels.

It is anticipated that wetland restoration at the site should proceed in phases, with the least contaminated areas re-flooded first, then monitored to verify that the OCP levels in that section did not cause adverse effects, then proceed to re-flood areas with somewhat higher concentrations if adverse effects of the earlier phases are minimal. Using this process, tentative estimates of acceptable soil concentrations can be verified in the field. This experimental approach has been initiated by monitoring fish tissue and bird eggshell thinning on the Duda Farms property, a portion of the NSRA that was reflooded in 2002. On that parcel, concentrations of toxaphene in fish tissue have consistently been much less than the threshold concentration of 4.3 mg/kg, wet weight, which is consistent with the low soil concentrations that were observed on that parcel, but also consistent with the bioaccumulation factors that support the BETLs. These results suggest that the District bioaccumulation factors are consistent with full scale re-flooding results, and thus the BETLs are more accurate than the CTLs, and may be sufficiently conservative to guide remediations.

7.2 Recommendations

This sequential approach has already been initiated by re-flooding Duda Farms, and the District expects to continue by re-flooding another area with relatively little contamination, the Sand Farm to the north of the Duda Farms. Based on the analysis conducted in this FS, the next recommended area for re-flooding is FB 1, followed by FBs 2, 3, and 4. There are no fields within FBs 1 through 4 that exceed the BETLs. These could be reflooded, with monitoring, restoring 2,200 acres of wetland near the lake’s north shore.

On a parallel track, pilot studies may be conducted to determine the most cost-effective methods for remediating 400 acres at Lust Farms X ZSE-A and Zellwin Farms X ZSE-I parcels in FB 6. These are the only two parcels in FB 6 that exceed the BETLs and they represent only 30% of its area. Accelerated testing of remediation technologies on these fields would permit the accelerated restoration of an additional 1,300 acres in FB 6.These fields would be most appropriate for pilot testing the soil layer inversion technology, and/or other promising technologies. Once these technology demonstrations are completed, and taken to full scale, FB 6 would be next in sequence for flooding, contingent on the results of continuing monitoring in Duda Farms, and FBs 1 through 4. Figure 7-1 shows this phased approach. Rigorous and well-maintained pilot testing should be considered for the following technologies:

- Soil layer inversion,
- Vertical blending and

- Use of either of these technologies in combination with the addition of amendments that would stimulate biodegradation.

MACTEC intends to begin working on a letter report which would better define pilot testing or treatability study parameters for these technologies.

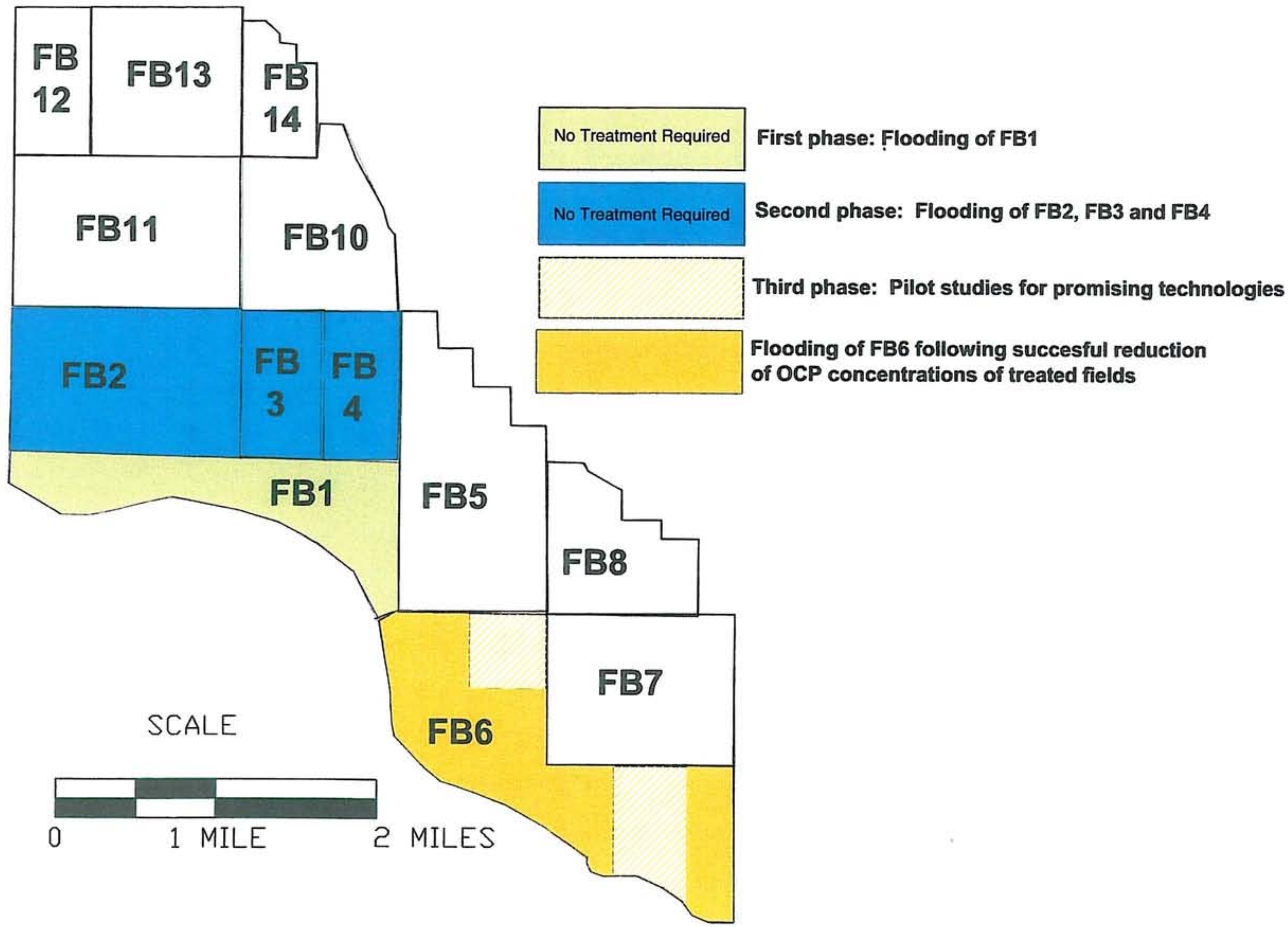
An area of possible promise especially for use as an interim measure, is water management. Water is currently being pumped to keep fields drained. However, water level and duration manipulations could also be utilized in flooded fields: to minimize habitat for the most sensitive species (e.g. flood field at depth too deep for wood storks), and prevent or minimize fish colonization or bioaccumulation of OCPs in fish to critical levels through intermittent drawdowns. Such manipulations would be orchestrated to minimize adverse exposure through timing/scheduling, duration, and depth changes. Although pumping would still be necessary, these types of habitat manipulations still provide some water recharge benefit. These processes could be used in concert with stated technologies of berm or ditch and canal construction or perhaps more appropriately as an interim measure for select FBs while pilot testing and other activities proceed.

Temporary flooding would need to be managed in a way not to increase the water and phosphorus loading back to the lake. In addition, the flooding and especially drying of fields would be a significant attractor for many birds and especially wood storks. High water levels can discourage birds, but even well timed drawdowns could attract piscivorous birds to the site. Changing water levels would have to be done with care on any fields where unacceptable risk from OCPs still exists, to insure adequate risk management during implementation.

This tactic of re-flooding areas with relatively low concentrations, monitoring, pilot testing remedial technologies in FBs with small fractions of their area requiring remediation, and thereafter remediating such FBs, could quickly restore 3,500 acres, or 35% of the study area to wetland function.

FB 6 was selected as the most promising area for pilot and full scale testing of remedial approaches primarily because the portion of the flood block that may require remediation is small (approximately 30%). Thus, a limited investment in remedial action can generate a large benefit in wetland restoration acreage. This principle should be useful in guiding subsequent field remediation sequencing schedules.

Finally, MACTEC recommends that the District discuss this process and recommended sequence with the USFWS, NRCS, FDEP and other stake holders.



Source: SJRWMD, 2004.

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Lake Apopka North Shore Restoration Area ZDWCD Units 1 and 2 SJRWMD, Lake & Orange Counties, FL	MACTEC	Recommended Remediation Actions Based on BETL (Remediation Sequence for Accelerated Flooding) PROJ. NO. 609604004 Figure 7-1

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Appendix A

Soil Data Used in Feasibility Study and Supporting Documentation

Owner Acreage

OWNERXALUM	ACRES
Bates X Z1N-E	6.352
Baumgardt X SFN-C	11.290
Clarence Beall X ZNC-B	150.972
Clarence Beall X ZNW-B	75.371
Clarence Beall X ZSC-A	61.570
Clonts Farm X ZSE-B	298.606
Clonts Farm X ZSE-C	100.413
Clonts Farm X ZSE-G	152.052
Clonts Farm X ZSE-H	28.542
Crakes & Son, Inc. X ZNC-B	156.145
Crakes & Son, Inc. X ZNE-A1	19.603
Crakes & Son, Inc. X ZNE-A2	76.687
Crakes & Son, Inc. X ZNE-C	73.932
Crakes & Son, Inc. X ZNE-D	58.624
Crakes & Son, Inc. X ZSW-B	94.714
General Impex X Z1N-G	24.466
Grinnell Farms, Inc. X Z1N-D	56.731
Grinnell Farms, Inc. X Z1N-E	11.822
Grinnell Farms, Inc. X Z1S-E	40.591
Hensel & Rodgers X Z1N-A	306.203
Long Farms, Inc. X Z1N-C	159.357
Long Farms, Inc. X Z1S-E	45.278
Long Farms, Inc. X ZNE-A1	19.117
Long Farms, Inc. X ZNE-A2	356.644
Long Farms, Inc. X ZNE-D1	64.537
Long Farms, Inc. X ZNE-D2	47.085
Long Farms, Inc. X ZNE-E	73.439
Long Farms, Inc. X ZNE-F	29.723
Long Farms, Inc. X ZNE-F	10.389
Long Farms, Inc. X ZSE-A	181.786
Lust Farms X ZNE-A	39.893
Lust Farms X ZNE-B	263.618
Lust Farms X ZNE-C	75.425
Lust Farms X ZNE-D	50.787
Lust Farms X ZSC-C	242.009
Lust Farms X ZSE-A	156.729
Lust Farms X ZSE-D	316.043
Lust Farms X ZSE-F	222.705
Marsell X Z1N-E	11.298
Marsell X Z1N-E	2.034
Marsell X Z1S-E	21.502
NAPA X Z1N-B	34.135
Progressive Growers (Rice) X Z1N-B	1.278
Rice X Z1N-D2	13.644
Rice X Z1N-D1	4.760
Robert Potter & Sons, Inc. X Z1N-F	307.969
Shaffer X Z1S-E	11.916
Shortz X Z1N-B1	24.043
Shortz X Z1N-B2	15.771
Smith X ZNE-A	29.283
Stroup Farms X ZNE-A	75.694

Table take from
units look-up table

Stroup Farms X ZSC-B	78.596
Stroup Farms X ZSE-E	148.245
Stroup Farms X ZSW-C	80.696
Zellwin Farms X SFN-C	76.822
Zellwin Farms X SFN-D	66.777
Zellwin Farms X Z1N-D	75.071
Zellwin Farms X Z1N-E	96.277
Zellwin Farms X Z1N-G	198.201
Zellwin Farms X Z1S-A	329.036
Zellwin Farms X Z1S-B	308.098
Zellwin Farms X Z1S-C	314.405
Zellwin Farms X Z1S-D	307.701
Zellwin Farms X Z1S-E	214.079
Zellwin Farms X ZNC-A	332.688
Zellwin Farms X ZNW-A	321.842
Zellwin Farms X ZNW-B	211.451
Zellwin Farms X ZNW-C	250.462
Zellwin Farms X ZSE-I	246.960
Zellwin Farms X ZSE-J	143.455
Zellwin Farms X ZSW-A	112.876
Zellwood Drainage District X ZSW-C	9.589

Raw Data Table

OwnerXAlum	Flooding Block	SiteName	Total Chlordane ug/kg	DDE ug/kg	DDE Code	DDTx ug/kg	DDTx Code	Dieldrin ug/kg	Dieldrin Code	Toxaphene ug/kg	ToxapheneCode	TOC %
Crakes & Son, Inc. X ZNE-A1	FB5	ZEFE0579	760	2100		3260		190	U	7500		25.499
Crakes & Son, Inc. X ZNC-B	FB4	ZEFE0583	560	1300		1760	U	140	U	8600		23.127
Crakes & Son, Inc. X ZNE-A2	FB5	ZEFE0596	2480	9600		37100		600	U	30000		52.184
Lust Farms X ZNE-B	FB5	ZEFE0624	960	2100		3020	U	240	U	21000		29.65
Crakes & Son, Inc. X ZNE-C	FB5	ZEFE0629	44	150		204	U	11	U	135	U	1.1267
Lust Farms X ZNE-B	FB5	ZEFE0660	960	2800		3825	U	235	U	21000		29.65
Lust Farms X ZNE-C	FB5	ZEFE0692	380	1100		3200		230	JN	13000		24.906
Stroup Farms X ZNE-A	FB5	ZEFE0721	1320	4400		5060	UU	330	U	17000		37.952
Lust Farms X ZNE-B	FB5	ZEFE0723	760	2200		2900	U	190	U	13000		21.941
Long Farms, Inc. X ZNE-D1	FB8	ZEFE0732	353	930		1225	U	85	U	4600		23.72
Crakes & Son, Inc. X ZNE-A1	FB5	ZES0580	480	2000		5400		125	U	7800		39.138
Crakes & Son, Inc. X ZNE-A1	FB5	ZES0581	760	2700		8800		185	U	14000		49.812
Long Farms, Inc. X ZNE-A1	FB5	ZES0582	1560	5300		14100		385	U	23000		46.847
Crakes & Son, Inc. X ZNE-A2	FB5	ZES0584	340	1300		2550		330	JN	7100		46.254
Long Farms, Inc. X ZNE-A1	FB5	ZES0585	296	1100		2550		210	JN	7100		30.836
Crakes & Son, Inc. X ZNE-A2	FB5	ZES0586	850	3000		8400		580		19000		38.545
Crakes & Son, Inc. X ZNE-A2	FB5	ZES0587	4800	16000		79200	U	1200	U	46000		52.777
Crakes & Son, Inc. X ZNE-A2	FB5	ZES0590	1200	4500		19500		670	JN	27000		42.696
Crakes & Son, Inc. X ZNE-A2	FB5	ZES0591	4800	15000		70300		1200	U	42000		53.963
Long Farms, Inc. X ZNE-A2	FB5	ZES0592	520	1800		2890	P	690	JN	13000		38.545
Long Farms, Inc. X ZNE-A2	FB5	ZES0593	88	350		860		84		1400		50.998
Long Farms, Inc. X ZNE-A2	FB5	ZES0595	1240	5000		20800		315	U	22000		44.475
Lust Farms X ZNE-B	FB5	ZES0597	970	3100		9400		120	U	17000		37.359
Lust Farms X ZNE-B	FB5	ZES0598	680	2100		7890	P	175	U	45000		52.777
Long Farms, Inc. X ZNE-A2	FB5	ZES0599	510	1400		3140		490	JN	16000		43.289
Long Farms, Inc. X ZNE-A2	FB5	ZES0600	132	490		1320		140	JN	2800		53.37
Long Farms, Inc. X ZNE-A2	FB5	ZES0601	440	1400		4800		360	JN	11000		51.591
Long Farms, Inc. X ZNE-A2	FB5	ZES0602	440	1900		5500		730	JN	18000		53.37
Lust Farms X ZNE-B	FB5	ZES0603	2560	7400		13300		650	U	50000		44.475
Lust Farms X ZNE-B	FB5	ZES0604	372	1400		4110	P	95	U	14000		50.405
Long Farms, Inc. X ZNE-A2	FB5	ZES0606	124	550		1390		160	JN	2700		54.556
Long Farms, Inc. X ZNE-A2	FB5	ZES0609	1240	5400		11900		1700	JN	42000		50.998
Lust Farms X ZNE-B	FB5	ZES0611	530	3500		10810		320	JNP	27000		52.184
Lust Farms X ZNE-B	FB5	ZES0612	1680	5100		19090	P	415	U	54000		49.812
Long Farms, Inc. X ZNE-A2	FB5	ZES0613	760	4100		9100		1400	JN	22000	Q	51.591
Long Farms, Inc. X ZNE-A2	FB5	ZES0614	680	3000		9700		640	JN	13000		50.998
Lust Farms X ZNE-B	FB5	ZES0616	890	4500		6790		520	JN	20000		43.289
Lust Farms X ZNE-B	FB5	ZES0617	1080	3500		13500		270	U	46000		52.184
Lust Farms X ZNE-B	FB5	ZES0618	460	1600		4600		105	U	15000		52.777
Lust Farms X ZNE-B	FB5	ZES0619	480	1300		4200		120	U	8200		50.998

OwnerXAlum	Flooding Block	SiteName	Total Chlordane ug/kg	DDE ug/kg	DDE Code	DDTx ug/kg	DDTx Code	Dieldrin ug/kg	Dieldrin Code	Toxaphene ug/kg	ToxapheneCode	TOC %
Long Farms, Inc. X ZNE-A2	FB5	ZES0622	720	3300		9100		650	JN	21000		46.254
Long Farms, Inc. X ZNE-A2	FB5	ZES0623	600	2800		7500		740	JN	16000		49.812
Lust Farms X ZNE-B	FB5	ZES0626	1530	2800		8100		325	U	39000		52.777
Lust Farms X ZNE-B	FB5	ZES0627	2220	2900		7600		650		31000		43.289
Crakes & Son, Inc. X ZNE-D	FB8	ZES0630	1440	5600		15600		360	U	22000		47.44
Crakes & Son, Inc. X ZNE-D	FB8	ZES0631	1520	6200		31700		375	U	22000		45.068
Long Farms, Inc. X ZNE-E	FB8	ZES0632	400	1400		3740		90	U	17000		43.882
Long Farms, Inc. X ZNE-A2	FB5	ZES0633	324	1400		2200	P	650	JN	14000		51.591
Long Farms, Inc. X ZNE-A2	FB5	ZES0634	910	4400		12400		1800	JN	41000		52.777
Long Farms, Inc. X ZNE-A2	FB5	ZES0636	1160	2300		4340		900	JN	30000		51.591
Lust Farms X ZNE-B	FB5	ZES0638	1040	2100		5300		205	U	37000		51.591
Crakes & Son, Inc. X ZNE-C	FB5	ZES0639	1240	2800		8100		310	U	17000		52.184
Crakes & Son, Inc. X ZNE-C	FB5	ZES0640	1000	2800		7700		250	U	14000		47.44
Crakes & Son, Inc. X ZNE-D	FB8	ZES0641	1580	7600		21700		980	JN	24000		49.219
Crakes & Son, Inc. X ZNE-D	FB8	ZES0642	1360	4700		15600		340	U	14000		51.591
Long Farms, Inc. X ZNE-E	FB8	ZES0643	680	3000		7900		105	U	18000		32.022
Long Farms, Inc. X ZNE-E	FB8	ZES0644	316	1100		2820	P	80	U	17000		36.173
Long Farms, Inc. X ZNE-A2	FB5	ZES0645	680	2200		3490	P	630	JN	20000		48.626
Long Farms, Inc. X ZNE-A2	FB5	ZES0646	440	2000		5000		600	JN	18000		49.812
Long Farms, Inc. X ZNE-A2	FB5	ZES0647	440	2000		4150		780	JN	20000		51.591
Lust Farms X ZNE-B	FB5	ZES0649	1180	2200		5500	P	550	JN	28000		52.184
Crakes & Son, Inc. X ZNE-C	FB5	ZES0650	856	2000		4940		560		16000		48.033
Crakes & Son, Inc. X ZNE-D	FB8	ZES0652	680	2700		6400		340	JN	15000		51.591
Crakes & Son, Inc. X ZNE-D	FB8	ZES0653	760	2700		7700		195	U	21000		45.661
Long Farms, Inc. X ZNE-E	FB8	ZES0654	1000	2800		7800		480	P	31000		50.405
Long Farms, Inc. X ZNE-E	FB8	ZES0655	880	3200		9000		225	U	25000		52.777
Long Farms, Inc. X ZNE-A2	FB5	ZES0657	650	2400		5000	P	150	U	35000		50.405
Long Farms, Inc. X ZNE-A2	FB5	ZES0659	930	2000		4100		125	U	21000		50.405
Lust Farms X ZNE-B	FB5	ZES0661	1160	4200		5950		285	U	25000		43.289
Lust Farms X ZNE-B	FB5	ZES0662	700	1800		4300	P	400	JN	25000		50.998
Crakes & Son, Inc. X ZNE-C	FB5	ZES0663	930	2000		5400		600	JN	20000		51.591
Long Farms, Inc. X ZNE-D2	FB8	ZES0665	1060	4000		5665	U	1000	JN	37000		48.033
Lust Farms X ZNE-D	FB8	ZES0666	494	1600		2930		100	U	9200		45.661
Long Farms, Inc. X ZNE-E	FB8	ZES0667	1190	3200		8500		285	U	42000		42.103
Long Farms, Inc. X ZNE-E	FB8	ZES0668	590	2100		5000	P	350	JN	18000		52.184
Long Farms, Inc. X ZNE-F	FB8	ZES0669	880	2600		8100		220	U	25000		28.464
Long Farms, Inc. X ZNE-A2	FB5	ZES0670	356	1400		1905	U	85	U	15000		47.44
Lust Farms X ZNE-A	FB5	ZES0671	720	3200		14200		470	JN	25000		52.184
Lust Farms X ZNE-A	FB5	ZES0672	620	2000		4180		410	JN	18000		52.777
Lust Farms X ZNE-B	FB5	ZES0673	1150	2500		3720	U	560	JN	23000		40.917

OwnerXAlum	Flooding Block	SiteName	Total Chlordane ug/kg	DDE ug/kg	DDE Code	DDTx ug/kg	DDTx Code	Dieldrin ug/kg	Dieldrin Code	Toxaphene ug/kg	Toxaphen eCode	TOC %
Lust Farms X ZNE-B	FB5	ZES0675	1440	3300		6120		750	JN	34000		48.626
Lust Farms X ZNE-C	FB5	ZES0676	670	1400		2160		420	JN	15000		47.44
Crakes & Son, Inc. X ZNE-C	FB5	ZES0677	920	2700		4010		230	U	9400		35.58
Long Farms, Inc. X ZNE-D2	FB8	ZES0678	700	2300		4700		460	JN	19000		46.254
Long Farms, Inc. X ZNE-E	FB8	ZES0680	1030	3100		8100		235	U	26000		44.475
Long Farms, Inc. X ZNE-F	FB8	ZES0681	480	1500		3750	P	115	U	12000		41.51
Long Farms, Inc. X ZNE-A2	FB5	ZES0685	690	1800		3450	JP	105	U	17000		50.998
Lust Farms X ZNE-A	FB5	ZES0686	1360	3500		8200		340	U	52000		52.777
Lust Farms X ZNE-B	FB5	ZES0688	848	1200		2150		410		13000		45.661
Lust Farms X ZNE-C	FB5	ZES0690	1200	2100		4120	P	600	JN	26000		49.812
Long Farms, Inc. X ZNE-D2	FB8	ZES0693	700	2600		4370		810	JN	23000		37.952
Long Farms, Inc. X ZNE-D2	FB8	ZES0694	2440	2800		15900		600	U	35000		51.591
Long Farms, Inc. X ZNE-D1	FB8	ZES0696	150	450		930		32	U	3200		10.674
Long Farms, Inc. X ZNE-D1	FB8	ZES0697	725	1900		4530		95	U	17000		35.58
Mulford Hickerson c/o Peat Hu	FB8	ZES0698	11.6	43		55.2	U	2.9	U	145	U	2.5499
Long Farms, Inc. X ZNE-A2	FB5	ZES0701	507	3200		4100		730		12000		43.289
Stroup Farms X ZNE-A	FB5	ZES0703	400	1800		7500		510	JN	13000		50.405
Stroup Farms X ZNE-A	FB5	ZES0704	610	2600		5800		1000	JN	23000		51.591
Lust Farms X ZNE-B	FB5	ZES0705	1090	2400		3635	U	620	JN	18000		46.254
Lust Farms X ZNE-B	FB5	ZES0706	1260	2800		7500		590	JN	33000		52.184
Lust Farms X ZNE-C	FB5	ZES0707	560	1300		1580	UU	140	U	9200		37.952
Lust Farms X ZNE-D	FB8	ZES0710	308	940		1620	P	75	U	6800		37.952
Long Farms, Inc. X ZNE-D1	FB8	ZES0711	758	2100		5600		890		28000		41.51
Long Farms, Inc. X ZNE-D1	FB8	ZES0712	445	1900		4940		590	JN	19000		27.278
Long Farms, Inc. X ZNE-D1	FB8	ZES0713	850	2200		4890	P	135	JN	23000		39.138
Stroup Farms X ZNE-A	FB5	ZES0719	560	2100		4460		630	JN	18000		49.812
Lust Farms X ZNE-B	FB5	ZES0724	980	3200		4950	P	145	U	22000		41.51
Lust Farms X ZNE-B	FB5	ZES0725	480	1900		3680		280	JN	18000		44.475
Lust Farms X ZNE-C	FB5	ZES0727	195	610		910	P	100	JN	5200		38.545
Long Farms, Inc. X ZNE-D2	FB8	ZES0728	790	2500		4800		580	JN	23000		39.138
Long Farms, Inc. X ZNE-D2	FB8	ZES0729	710	1800		3280	P	410	JN	20000		37.952
Long Farms, Inc. X ZNE-D1	FB8	ZES0731	506	1800		3100		95	U	8700		37.952
Long Farms, Inc. X ZNE-F	FB8	ZES0733	570	2500		5600		420	JN	14000		38.545
Long Farms, Inc. X ZNE-F	FB8	ZES0735	1040	2700		9600		260	U	42000		34.987
Lust & Long Precooler X ZNE-I	FB8	ZES0737	10.4	2.6	U	7.8	UUU	2.6	U	130	U	0.593
Long Farms, Inc. X ZNE-A1	FB5	ZES0981	590	3300		7200		940		25000		37.952
Long Farms, Inc. X ZNE-A1	FB5	ZES0982	342	3200		11200		570		31000		42.696
Smith X ZNE-A	FB5	ZES0983	223	1500		4080		160		11000		30.836
Smith X ZNE-A	FB5	ZES0984	232	2000		4870		190		14000		36.173
Smith X ZNE-A	FB5	ZES0985	133	700		2080		96		8000		34.987

OwnerXAlum	Flooding Block	SiteName	Total Chlordane ug/kg	DDE ug/kg	DDE Code	DDTx ug/kg	DDTx Code	Dieldrin ug/kg	Dieldrin Code	Toxaphene ug/kg	ToxaphenCode	TOC %
Smith X none	FB5	ZES0986	14.8	14		21.5	UU	3.75	U	185	U	3.9731
NAPA X Z1N-B	NFB	ZNS0076	47.8	580		765		110		860		4.015
Shortz X Z1N-B1	NFB	ZNS0077	121.8	2400		4700		180		1200		19.25
Progressive Growers (Rice) X Z	NFB	ZNS0078	10.4	2.55	U	7.65	UUU	2.55	U	130	U	0.605
Shortz X Z1N-B2	NFB	ZNS0079	800	2200		5300	U	200	U	3100		36.3
Grinnell Farms, Inc. X Z1N-E	FB14	ZNS0080	11.2	40		94.8	U	2.8	U	140	U	3.19
Grinnell Farms, Inc. X Z1N-E	FB14	ZNS0081	100	390		586		25	U	250	U	29.15
Hensel & Rodgers X Z1N-A	FB12	ZNS0082	11.6	2.9	U	8.7	UUU	2.9	U	145	U	1.21
Hensel & Rodgers X Z1N-A	FB12	ZNS0083	188.8	43		48.7	UU	58		145	U	0.935
Hensel & Rodgers X Z1N-A	FB12	ZNS0084	12.7	170		286		11		140	U	1.485
Long Farms, Inc. X Z1N-C	FB13	ZNS0085	26.4	130		191		2.7	U	300		1.045
Long Farms, Inc. X Z1N-C	FB13	ZNS0087	278	2200		7700		190	JN	15000		14.3
Long Farms, Inc. X Z1N-C	FB13	ZNS0089	16	330		428		4	U	200	U	22.55
Rice X Z1N-D2	FB13	ZNS0090	14.4	45		60.6	U	3.6	U	180	U	9.9
Rice X Z1N-D1	FB13	ZNS0092	12.4	68		88.05	U	3.05	U	155	U	6.05
Rice X Z1N-D1	FB13	ZNS0093	14	310		440		3.5	U	460	JN	21.45
Zellwin Farms X Z1N-D	FB13	ZNS0094	770	4400		12500		540	JN	26000		34.1
Zellwin Farms X Z1N-E	FB14	ZNS0095	1560	4900		17600		385	U	29000		19.25
Bates X Z1N-E	FB14	ZNS0097	33.2	750		1858.5		8.5	U	1600		51.7
Marsell X Z1N-E	FB14	ZNS0098	1440	2000		7760	U	360	U	5200		38.5
Hensel & Rodgers X Z1N-A	FB12	ZNS0099	10.8	37		42.5	UU	8.8		135	U	1.815
Hensel & Rodgers X Z1N-A	FB12	ZNS0100	164	860		1600		37		670		3.08
Long Farms, Inc. X Z1N-C	FB13	ZNS0101	361	1700		5800		210	JN	12000		9.35
Long Farms, Inc. X Z1N-C	FB13	ZNS0102	625	1800		5900		490	JN	32000		25.85
Long Farms, Inc. X Z1N-C	FB13	ZNS0103	13.2	28		34.7	UU	3.35	U	165	U	7.15
Grinnell Farms, Inc. X Z1N-D	FB13	ZNS0104	794	2800		10730		220	JN	26000		44
Zellwin Farms X Z1N-D	FB13	ZNS0105	1368	4000		8700		860	JN	39000		40.7
Zellwin Farms X Z1N-E	FB14	ZNS0106	2030	5700		11300		490	U	50000		28.6
Zellwin Farms X Z1N-E	FB14	ZNS0107	2530	7000		19700		1300	JN	79000		41.8
Marsell X Z1N-E	FB14	ZNS0108	22.4	380		890		22		740		22
Marsell X Z1N-E	FB14	ZNS0109	1440	5700		15255	U	355	U	7800		30.8
Hensel & Rodgers X Z1N-A	FB12	ZNS0112	10.4	17		22.2	UU	2.6	U	130	U	0.66
Hensel & Rodgers X Z1N-A	FB12	ZNS0113	12	150		164.05	U	3.05	U	150	U	1.65
Hensel & Rodgers X Z1N-A	FB12	ZNS0114	49.4	540		666		12		530		1.705
Long Farms, Inc. X Z1N-C	FB13	ZNS0116	800	1500		4000		600	JN	17000		17.05
Long Farms, Inc. X Z1N-C	FB13	ZNS0117	1240	2600		4490		315	U	14000		14.3
Long Farms, Inc. X Z1N-C	FB13	ZNS0118	272	820		1090	U	70	U	2400		5.005
Robert Potter & Sons, Inc. X Z1	FB13	ZNS0120	1040	2100		5200		870	JN	39000		47.3
Zellwin Farms X Z1N-D	FB13	ZNS0121	1062	3200		5240		500	JNP	30000		31.9
Zellwin Farms X Z1N-E	FB14	ZNS0123	2670	3400		10500		650	U	58000		44

OwnerXAlum	Flooding Block	SiteName	Total Chlordane ug/kg	DDE ug/kg	DDE Code	DDTx ug/kg	DDTx Code	Dieldrin ug/kg	Dieldrin Code	Toxaphene ug/kg	ToxaphenеCode	TOC %
Zellwin Farms X Z1N-G	FB14	ZNS0124	36.4	220		427		9	U	570	JN	5.225
Zellwin Farms X Z1N-E	FB14	ZNS0125	120	420		1050		29.5	U	2600		1.76
Hensel & Rodgers X Z1N-A	FB12	ZNS0127	43.4	190		246		5.5	U	470		6.05
Hensel & Rodgers X Z1N-A	FB12	ZNS0128	11.6	51		56.9	UU	2.95	U	145	U	1.595
Hensel & Rodgers X Z1N-A	FB12	ZNS0129	24.8	420		562		14	JN	500		3.41
Robert Potter & Sons, Inc. X Z1	FB13	ZNS0130	240	860		1270	U	130	JN	3500		4.29
Robert Potter & Sons, Inc. X Z1	FB13	ZNS0131	224	420		1220		150	JN	4900		4.4
Robert Potter & Sons, Inc. X Z1	FB13	ZNS0132	1320	2100		3970	PP	1200	JN	43000		46.2
Robert Potter & Sons, Inc. X Z1	FB13	ZNS0133	432	1100		2060		330	JN	17000		38.5
Robert Potter & Sons, Inc. X Z1	FB13	ZNS0134	1800	2100		5800		800	JN	41000		47.3
Zellwin Farms X Z1N-G	FB14	ZNS0135	930	2500		4740		800		43000		46.2
Zellwin Farms X Z1N-G	FB14	ZNS0136	610	1800		3550		520		29000		42.9
General Impex X Z1N-G	FB14	ZNS0137	24.8	830		1136	U	6	U	1000		13.2
Hensel & Rodgers X Z1N-A	FB12	ZNS0139	22.5	430		567		16		140	U	1.375
Hensel & Rodgers X Z1N-A	FB12	ZNS0140	31.6	560		680		5.5	U	410		1.705
Hensel & Rodgers X Z1N-A	FB12	ZNS0141	13.8	230		283		3.1	U	155	U	1.815
Robert Potter & Sons, Inc. X Z1	FB13	ZNS0142	368	1300		2390		310	JN	1900		4.95
Robert Potter & Sons, Inc. X Z1	FB13	ZNS0143	480	1400		3050		610	JN	16000		26.4
Robert Potter & Sons, Inc. X Z1	FB13	ZNS0144	2470	3700		8750	U	2400	JN	79000		44
Robert Potter & Sons, Inc. X Z1	FB13	ZNS0145	552	1900		3300	P	540	JNP	25000		40.15
Robert Potter & Sons, Inc. X Z1	FB13	ZNS0146	760	1300		3360		490	JN	22000		39.6
Zellwin Farms X Z1N-G	FB14	ZNS0147	1030	1300		2430	U	400	JN	36000		46.75
Zellwin Farms X Z1N-G	FB14	ZNS0148	980	3200		6500		900		46000		45.1
Zellwin Farms X Z1N-G	FB14	ZNS0149	600	2300		2590	UU	145	U	12000		20.35
Zellwin Farms X Z1N-G	FB14	ZNS0150	560	2200		3085	U	135	U	10000		20.35
Zellwin Farms X Z1S-A	FB11	ZNS0151	1690	2600		4090	P	1100	JN	36000		26.4
Hensel & Rodgers X Z1N-A	FB12	ZNS0152	20.2	330		381		2.75	U	340		2.915
Zellwin Farms X Z1S-B	FB11	ZNS0154	434	1100		1840	P	160	JNP	16000		20.35
Zellwin Farms X Z1S-B	FB11	ZNS0155	372	1000		1170	UP	130	JNP	5900		35.2
Zellwin Farms X Z1S-B	FB11	ZNS0157	550	1000		1560	P	120	JNP	12000		19.8
Zellwin Farms X Z1S-C	FB11	ZNS0158	834	1400		2850	P	550	JN	27000		42.9
Zellwin Farms X Z1S-C	FB11	ZNS0159	608	1100		1445	U	360	JN	12000		26.4
Zellwin Farms X Z1S-D	FB10	ZNS0161	1580	1900		2865	U	740	JN	37000		42.35
Zellwin Farms X Z1S-D	FB10	ZNS0162	1620	2200		4000	P	860	JN	49000		40.15
Grinnell Farms, Inc. X Z1S-E	FB10	ZNS0164	1490	5000		14805	U	305	U	33000		46.2
Grinnell Farms, Inc. X Z1S-E	FB10	ZNS0165	21.2	98		223.5	U	5.5	U	580		0.935
Zellwin Farms X Z1S-A	FB11	ZNS0167	900	2200		3190	P	760	JN	25000		29.7
Zellwin Farms X Z1S-A	FB11	ZNS0168	335	830		940	UU	300	JN	7700		9.9
Zellwin Farms X Z1S-B	FB11	ZNS0169	131	340		466	PP	19	U	3800		40.7
Zellwin Farms X Z1S-B	FB11	ZNS0170	584	1300		1990	P	190	JNP	17000		29.7

OwnerXAlum	Flooding Block	SiteName	Total Chlordane ug/kg	DDE ug/kg	DDE Code	DDTx ug/kg	DDTx Code	Dieldrin ug/kg	Dieldrin Code	Toxaphene ug/kg	ToxaphenеCode	TOC %
Zellwin Farms X Z1S-C	FB11	ZNS0171	792	1500		3060	P	250	JNP	30000		30.8
Zellwin Farms X Z1S-C	FB11	ZNS0172	1150	1800		5800	P	300	JNP	50000		45.65
Zellwin Farms X Z1S-C	FB11	ZNS0173	744	1300		2270	P	250	JNP	19000		24.2
Zellwin Farms X Z1S-D	FB10	ZNS0174	888	1400		1930	U	400	JN	19000		38.5
Zellwin Farms X Z1S-D	FB10	ZNS0175	1000	2800		5080		930		37000		45.1
Grinnell Farms, Inc. X Z1S-E	FB10	ZNS0176	1990	6700		20125	U	425	U	49000		45.1
Grinnell Farms, Inc. X Z1S-E	FB10	ZNS0178	344	1700		2510		85	U	5500		31.9
Shaffer X Z1S-E	FB10	ZNS0182	12.8	3.15	U	9.45	UUU	3.15	U	160	U	5.06
Zellwin Farms X Z1S-A	FB11	ZNS0183	33.9	130		161.5	U	30	JN	1100		3.41
Zellwin Farms X Z1S-A	FB11	ZNS0184	285	900		1160	P	260	JN	6100		5.28
Zellwin Farms X Z1S-B	FB11	ZNS0185	98	310		620		51	JNP	4400		11.55
Zellwin Farms X Z1S-B	FB11	ZNS0186	640	1500		3290		280	JNP	26000		19.8
Zellwin Farms X Z1S-C	FB11	ZNS0187	932	1500		3650	P	95	U	33000		41.8
Zellwin Farms X Z1S-C	FB11	ZNS0188	1410	2100		4250	P	130	U	41000		36.3
Zellwin Farms X Z1S-C	FB11	ZNS0189	866	1800		2730	PP	340	JNP	21000		36.3
Zellwin Farms X Z1S-D	FB10	ZNS0191	146	340		420	U	59	JNP	3700		22.55
Zellwin Farms X Z1S-D	FB10	ZNS0192	1160	1800		2690	U	590	JN	31000		41.25
Zellwin Farms X Z1S-D	FB10	ZNS0193	849	1700		2440	U	380	P	22000		34.1
Marsell X Z1S-E	FB10	ZNS0195	76	19.5	U	58.5	UUU	19.5	U	950	U	50.05
Zellwin Farms X Z1S-E	FB10	ZNS0196	1920	5700		20600		485	U	22000		34.65
Zellwin Farms X Z1S-A	FB11	ZNS0197	760	1200		1310	UU	420	JN	13000		31.9
Zellwin Farms X Z1S-A	FB11	ZNS0198	780	1100		1270	UU	480	JN	15000		45.65
Zellwin Farms X Z1S-A	FB11	ZNS0199	97.8	240		265	PU	86	JN	2200		20.9
Zellwin Farms X Z1S-A	FB11	ZNS0200	346	770		845	UU	230	JN	6100		15.95
Zellwin Farms X Z1S-B	FB11	ZNS0202	1024	990		2090	P	95	U	18000		40.7
Zellwin Farms X Z1S-C	FB11	ZNS0203	102	280		402	P	12.5	U	2000		5.39
Zellwin Farms X Z1S-C	FB11	ZNS0205	932	1700		5100		75	U	32000		44
Zellwin Farms X Z1S-C	FB11	ZNS0206	666	1900		2980	P	300	JNP	18000		34.1
Zellwin Farms X Z1S-D	FB10	ZNS0207	1210	2000		2740	U	600	JN	32000		37.4
Zellwin Farms X Z1S-D	FB10	ZNS0208	562	980		1550	U	350	JN	16000		44.55
Zellwin Farms X Z1S-D	FB10	ZNS0209	458	1100		1575	U	180	JNP	8900		25.3
Zellwin Farms X Z1S-E	FB10	ZNS0211	3040	6500		22100		750	U	34000		48.95
Zellwin Farms X Z1S-E	FB10	ZNS0212	448	2500		4880		79	JN	3500		46.2
Long Farms, Inc. X Z1S-E	FB10	ZNS0214	16	62		70	UU	4	U	200	U	22
Zellwin Farms X Z1S-A	FB11	ZNS0215	545	910		1007	UU	200	JN	11000		35.2
Zellwin Farms X Z1S-A	FB11	ZNS0216	830	1700		2180	PP	280	JNP	12000		34.1
Zellwin Farms X Z1S-A	FB11	ZNS0217	1045	1500		1670	UU	760	JN	21000		34.65
Zellwin Farms X Z1S-B	FB11	ZNS0218	630	1000		1940	P	240	JNP	22000		38.5
Zellwin Farms X Z1S-B	FB11	ZNS0219	1210	1300		2980	P	270	JNP	30000		39.6
Zellwin Farms X Z1S-B	FB11	ZNS0220	1008	1500		2700	P	100	JNP	24000		33

OwnerXAlum	Flooding Block	SiteName	Total Chlordane ug/kg	DDE ug/kg	DDE Code	DDTx ug/kg	DDTx Code	Dieldrin ug/kg	Dieldrin Code	Toxaphene ug/kg	Toxaphen eCode	TOC %
Zellwin Farms X Z1S-C	FB11	ZNS0221	930	2300		4900	P	125	U	35000		39.6
Zellwin Farms X Z1S-C	FB11	ZNS0222	820	2200		3900	P	400	JNP	25000		43.45
Zellwin Farms X Z1S-D	FB10	ZNS0223	1820	2400		4055	P	860	JN	51000		45.1
Zellwin Farms X Z1S-D	FB10	ZNS0224	950	1700		2465	U	410	JN	18000		37.4
Zellwin Farms X Z1S-E	FB10	ZNS0225	452	1300		1470	UU	85	U	8400		45.1
Zellwin Farms X Z1S-E	FB10	ZNS0226	223	720		785	UU	32.5	U	4900		44
Zellwin Farms X Z1S-E	FB10	ZNS0227	181.9	800		1001		26	JNP	1600		29.15
Zellwin Farms X Z1S-E	FB10	ZNS0228	721	2700		3720		120	JN	3400		48.4
Long Farms, Inc. X Z1S-E	FB10	ZNS0229	337.9	670		1252		11	JN	700		23.1
Zellwin Farms X Z1S-A	FB11	ZNS0231	1227	1500		1670	UU	380	JNP	22000		42.35
Zellwin Farms X Z1S-B	FB11	ZNS0233	410	650		1200	P	130	JNP	11000		29.7
Zellwin Farms X Z1S-C	FB11	ZNS0235	420	900		2060		140	JNP	13000		21.45
Zellwin Farms X Z1S-C	FB11	ZNS0237	920	2600		4250	P	380	JNP	22000		27.5
Zellwin Farms X Z1S-D	FB10	ZNS0238	770	1600		2130	U	350	JN	12000		39.05
Zellwin Farms X Z1S-E	FB10	ZNS0240	47.2	440		484.5	U	22	JN	820	JN	33.55
Stroup Farms X ZNE-A	FB5	ZSFE0740	27.6	88		130	U	7	U	345	U	33.801
Lust Farms X ZNE-C	FB5	ZSFE0749	1530	5100		7190	P	810		45000		34.394
Clonts Farm X ZSE-B	FB6	ZSFE0815	188	760		853	UU	46.5	U	1600		16.604
Clonts Farm X ZSE-B	FB6	ZSFE0819	920	2100		2570	UU	235	U	3300		42.103
Stroup Farms X ZSE-E	FB7	ZSFE0825	800	2900		3300	UU	490	JN	14000		30.836
Lust Farms X ZSE-D	FB7	ZSFE0831	532	1600		2400		380	JN	9400		28.464
Lust Farms X ZSE-F	FB7	ZSFE0837	159	350		870		83	JN	4800		13.046
Clonts Farm X ZSE-C	FB6	ZSFE0891	840	2500		2920	UU	210	U	6000		31.429
Clonts Farm X ZSE-B	FB6	ZSFE0899	216	980		1370		130	JN	2600		11.267
Lust Farms X ZSE-F	FB7	ZSFE0904	1000	1800		8050	U	250	U	13000		29.65
Lust Farms X ZSE-F	FB7	ZSFE0909	470	1700		3520		320	JN	14000		23.72
Clonts Farm X ZSE-G	FB6	ZSFE0940	640	1900		2815	U	145	U	7500		27.871
Zellwin Farms X ZSE-I	FB6	ZSFE0954	485	960		1270	U	240	JN	9600		17.197
Zellwin Farms X ZSE-J	FB6	ZSFE0967	900	1900		2910	U	420	JNP	15000		23.72
Zellwin Farms X ZSE-I	FB6	ZSFE0975	364	780		910	UU	180	JNP	5200		20.162
Clonts Farm X ZSE-C	FB6	ZSFE0989	560	1700		2100	U	130	U	5500		23.72
Long Farms, Inc. X ZSE-A	FB6	ZSS0741	296	900		1160	U	250	JN	5200		37.952
Long Farms, Inc. X ZSE-A	FB6	ZSS0743	246	840		1480	P	420	JN	8700		37.952
Lust Farms X ZSE-A	FB6	ZSS0744	710	1500		3360		590	JN	26000		49.219
Lust Farms X ZSE-A	FB6	ZSS0745	418	1200		1700	P	490	JN	10000		14.232
Lust Farms X ZSE-A	FB6	ZSS0746	450	1600		2470		390	JN	20000		30.243
Lust Farms X ZSE-A	FB6	ZSS0747	380	1800		1990	UU	95	U	240	U	18.976
Lust Farms X ZSE-D	FB7	ZSS0750	750	2200		3420	P	530	JN	26000		43.882
Lust Farms X ZSE-D	FB7	ZSS0751	236	760		1005	U	55	U	5200		34.394
Lust Farms X ZSE-D	FB7	ZSS0752	960	2400		5500		550	JN	32000		52.777

OwnerXAlum	Flooding Block	SiteName	Total Chlordane ug/kg	DDE ug/kg	DDE Code	DDTx ug/kg	DDTx Code	Dieldrin ug/kg	Dieldrin Code	Toxaphene ug/kg	Toxaphene eCode	TOC %
Lust Farms X ZSE-D	FB7	ZSS0755	274	740		1520		160	JN	7100		32.615
Lust Farms X ZSE-D	FB7	ZSS0757	10.4	9.2		17.75	UP	2.65	U	130	U	0.593
Long Farms, Inc. X ZSE-A	FB6	ZSS0759	780	1300		1520	UU	340	JN	9500		48.626
Long Farms, Inc. X ZSE-A	FB6	ZSS0760	756	1400		2370		390	JN	12000		49.219
Long Farms, Inc. X ZSE-A	FB6	ZSS0762	376	1100		2950		570	JN	15000		50.998
Long Farms, Inc. X ZSE-A	FB6	ZSS0763	1120	2200		4730	JP	1000	J	24000		52.184
Lust Farms X ZSE-A	FB6	ZSS0764	538	1200		2870		490	JN	19000		52.184
Lust Farms X ZSE-A	FB6	ZSS0765	1270	2600		7200	J	125	U	30000		49.812
Lust Farms X ZSE-A	FB6	ZSS0767	1510	2800		7000	P	1100	JN	150000		41.51
Lust Farms X ZSE-D	FB7	ZSS0770	840	2400		4400	P	205	U	37000		27.278
Lust Farms X ZSE-D	FB7	ZSS0771	850	2100		4180		440	JN	25000		49.812
Lust Farms X ZSE-D	FB7	ZSS0772	700	1800		3970	JP	540	J	20000		49.812
Lust Farms X ZSE-D	FB7	ZSS0773	225	520		930	P	140	JNP	3800		23.127
Lust Farms X ZSE-D	FB7	ZSS0774	600	1700		4900		310	JN	23000		48.626
Lust Farms X ZSE-D	FB7	ZSS0775	580	1900		6200		145	U	23000		48.033
Lust Farms X ZSE-D	FB7	ZSS0776	294	800		2000		70	U	7800		13.046
Lust Farms X ZSE-D	FB7	ZSS0778	16.8	30		38.3	UU	4.15	U	210	U	21.941
Long Farms, Inc. X ZSE-A	FB6	ZSS0781	341	1000		2090		440	JN	15000		51.591
Long Farms, Inc. X ZSE-A	FB6	ZSS0782	292	1000		1920		320	JN	9700		52.184
Lust Farms X ZSE-A	FB6	ZSS0783	900	2000		5100		860	JN	33000		51.591
Lust Farms X ZSE-A	FB6	ZSS0784	390	1200		2570		460	JN	11000		50.405
Lust Farms X ZSE-A	FB6	ZSS0785	376	1700		3030		350	JN	8000		45.661
Lust Farms X ZSE-D	FB7	ZSS0788	650	1800		3220		330	JN	28000		49.219
Lust Farms X ZSE-D	FB7	ZSS0789	520	1500		2150		120	U	20000		46.254
Lust Farms X ZSE-D	FB7	ZSS0790	840	2100		4250		490	JN	30000		40.324
Lust Farms X ZSE-D	FB7	ZSS0791	872	1300		2950		390	JN	15000		45.661
Lust Farms X ZSE-D	FB7	ZSS0792	810	2000		4340		660	JN	23000		46.847
Lust Farms X ZSE-D	FB7	ZSS0793	785	1300		3260	J	85	U	18000		50.998
Lust Farms X ZSE-D	FB7	ZSS0794	580	1400		3930		145	U	23000		50.405
Lust Farms X ZSE-D	FB7	ZSS0795	560	2300		6400		135	U	17000		34.987
Lust Farms X ZSE-D	FB7	ZSS0796	296	1000		2980		75	U	7600		18.976
Long Farms, Inc. X ZSE-A	FB6	ZSS0797	790	1800		2465	U	420	JN	13000		46.847
Long Farms, Inc. X ZSE-A	FB6	ZSS0798	512	1500		2720		600	JN	17000		46.847
Long Farms, Inc. X ZSE-A	FB6	ZSS0799	1250	2700		5300	P	1300		26000		50.405
Long Farms, Inc. X ZSE-A	FB6	ZSS0800	260	810		1670		400	JN	9600		49.219
Lust Farms X ZSE-A	FB6	ZSS0802	1180	2800		8200		980		32000		47.44
Lust Farms X ZSE-A	FB6	ZSS0804	452	1300		2610	P	260	JN	18000		27.278
Lust Farms X ZSE-D	FB7	ZSS0805	620	1400		2600	P	400	JN	23000		36.766
Lust Farms X ZSE-D	FB7	ZSS0806	570	1700		2650		130	JN	22000		32.615
Lust Farms X ZSE-D	FB7	ZSS0809	610	1600		2510	P	380	JN	17000		48.033

OwnerXAlum	Flooding Block	SiteName	Total Chlordane ug/kg	DDE ug/kg	DDE Code	DDTx ug/kg	DDTx Code	Dieldrin ug/kg	Dieldrin Code	Toxaphene ug/kg	Toxaphene Code	TOC %
Lust Farms X ZSE-D	FB7	ZSS0810	383	870		1580	P	270	JN	19000		46.847
Lust Farms X ZSE-D	FB7	ZSS0811	1148	1800		4600	P	650		24000		48.626
Lust Farms X ZSE-D	FB7	ZSS0812	574	1500		3140	P	300		13000		37.952
Lust Farms X ZSE-D	FB7	ZSS0813	870	1800		5400		160	U	16000		39.731
Lust Farms X ZSE-D	FB7	ZSS0814	1480	2300		6840		370	U	20000		27.871
Clonts Farm X ZSE-B	FB6	ZSS0816	176	1000		1174	U	91	JN	1200		40.324
Clonts Farm X ZSE-B	FB6	ZSS0817	176	820		1004	U	91	JNP	1700		48.626
Clonts Farm X ZSE-B	FB6	ZSS0820	520	2000		2465	U	135	JN	2800		42.103
Clonts Farm X ZSE-B	FB6	ZSS0822	480	2200		2800	U	560		4600		41.51
Stroup Farms X ZSE-E	FB7	ZSS0826	480	2600		3680	P	500		9500		33.801
Stroup Farms X ZSE-E	FB7	ZSS0830	580	2300		3570	P	510		9700		34.987
Lust Farms X ZSE-F	FB7	ZSS0832	1210	2100		4120	P	610	JN	25000		42.696
Lust Farms X ZSE-F	FB7	ZSS0833	910	2300		6800		710	JN	20000		50.998
Lust Farms X ZSE-F	FB7	ZSS0834	1150	1900		4280	P	530	JN	22000		37.359
Lust Farms X ZSE-F	FB7	ZSS0835	530	1600		2830	P	310		12000		29.057
Lust Farms X ZSE-F	FB7	ZSS0836	1130	2900		7500		890	JN	34000		49.812
Clonts Farm X ZSE-B	FB6	ZSS0838	84	900		1046	P	180		1200	JN	49.812
Clonts Farm X ZSE-B	FB6	ZSS0840	308	950		1100	UU	75	U	3100		49.219
Clonts Farm X ZSE-B	FB6	ZSS0841	400	2000		2465	U	440		6100		49.812
Clonts Farm X ZSE-B	FB6	ZSS0842	228	920		1115	U	160	JN	1400		40.917
Clonts Farm X ZSE-B	FB6	ZSS0843	520	2000		2645	U	540		5400		45.068
Clonts Farm X ZSE-B	FB6	ZSS0844	352	1300		1890	U	490	JN	4900		43.289
Clonts Farm X ZSE-B	FB6	ZSS0845	680	2100		2925	U	680	JN	8400		39.731
Stroup Farms X ZSE-E	FB7	ZSS0846	870	3700		5240	P	770	JN	15000		36.766
Stroup Farms X ZSE-E	FB7	ZSS0847	700	2300		5110		640	JN	17000		46.847
Stroup Farms X ZSE-E	FB7	ZSS0848	550	2100		3810		640	JN	13000		42.103
Stroup Farms X ZSE-E	FB7	ZSS0849	268	1200		1525	U	220	JN	2300		35.58
Stroup Farms X ZSE-E	FB7	ZSS0850	340	1500		3210		320	JN	4900		37.952
Lust Farms X ZSE-F	FB7	ZSS0851	102	210		372	P	56	JN	2800		5.93
Lust Farms X ZSE-F	FB7	ZSS0852	620	1800		2900		580	JN	18000		50.405
Lust Farms X ZSE-F	FB7	ZSS0853	500	1500		3190		470	JN	14000		50.998
Lust Farms X ZSE-F	FB7	ZSS0854	165	600		1200		150	JN	6700		36.173
Lust Farms X ZSE-F	FB7	ZSS0855	1130	2100		5600	P	670	JN	28000		46.254
Clonts Farm X ZSE-B	FB6	ZSS0856	800	3400		3800	UU	200	U	2600		39.138
Clonts Farm X ZSE-B	FB6	ZSS0857	560	2300		2755	U	135	U	4800		47.44
Clonts Farm X ZSE-B	FB6	ZSS0858	560	1900		2180	UU	140	U	3800		47.44
Clonts Farm X ZSE-B	FB6	ZSS0859	300	1500		1755	U	380		4100		48.033
Clonts Farm X ZSE-B	FB6	ZSS0860	520	2500		3040	U	610		6500		43.882
Clonts Farm X ZSE-B	FB6	ZSS0861	368	1700		2190	U	430	JN	2500		27.871
Clonts Farm X ZSE-B	FB6	ZSS0862	520	1900		2505	U	640	JN	6000		29.65

OwnerXAlum	Flooding Block	SiteName	Total Chlordane ug/kg	DDE ug/kg	DDE Code	DDTx ug/kg	DDTx Code	Dieldrin ug/kg	Dieldrin Code	Toxaphene ug/kg	Toxaphen eCode	TOC %
Stroup Farms X ZSE-E	FB7	ZSS0864	480	2700		4270		530		10000		34.987
Stroup Farms X ZSE-E	FB7	ZSS0865	550	2000		3490		430	JN	12000		45.068
Stroup Farms X ZSE-E	FB7	ZSS0866	770	2700		5000		620	JN	17000		40.324
Lust Farms X ZSE-F	FB7	ZSS0868	308	1200		1545	U	210	JN	4900		42.696
Lust Farms X ZSE-F	FB7	ZSS0870	890	1700		2680	P	410	JN	17000		48.033
Lust Farms X ZSE-F	FB7	ZSS0871	600	1800		3130	P	490		16000		38.545
Lust Farms X ZSE-F	FB7	ZSS0873	720	1600		4190		320	JN	9400		8.302
Clonts Farm X ZSE-B	FB6	ZSS0874	268	1700		1965	U	65	U	1700		46.847
Clonts Farm X ZSE-B	FB6	ZSS0875	332	1400		1570	UU	85	U	1100		41.51
Clonts Farm X ZSE-B	FB6	ZSS0876	520	2100		2370	UU	135	U	4000		42.103
Clonts Farm X ZSE-B	FB6	ZSS0877	560	2100		2550	U	380	JN	3200		30.243
Clonts Farm X ZSE-B	FB6	ZSS0880	650	3700		4830	U	810		7700		31.429
Stroup Farms X ZSE-E	FB7	ZSS0881	288	1400		2020	U	70	U	6800		8.895
Stroup Farms X ZSE-E	FB7	ZSS0882	540	2000		3180		500	JN	11000		39.138
Stroup Farms X ZSE-E	FB7	ZSS0884	600	1900		2940		440	JN	14000		48.626
Lust Farms X ZSE-F	FB7	ZSS0886	670	2000		3150	P	540		18000		47.44
Lust Farms X ZSE-F	FB7	ZSS0888	890	2300		4410		950	JN	27000		47.44
Lust Farms X ZSE-F	FB7	ZSS0889	399	1200		2920		300	JN	12000		45.661
Lust Farms X ZSE-F	FB7	ZSS0890	128	370		1012	U	32	U	2400		2.9057
Clonts Farm X ZSE-C	FB6	ZSS0892	442	1500		1755	U	150	JN	2100		33.801
Clonts Farm X ZSE-C	FB6	ZSS0893	132	270		310	UU	63	JN	500	U	37.952
Clonts Farm X ZSE-B	FB6	ZSS0896	13.6	11		17.8	UU	3.4	U	170	U	7.116
Clonts Farm X ZSE-C	FB6	ZSS0898	688	1500		2030	U	460	JN	10000		32.022
Clonts Farm X ZSE-G	FB6	ZSS0900	534	1300		1745	U	370	JN	12000		36.173
Clonts Farm X ZSE-G	FB6	ZSS0901	468	1200		1650	U	310	JN	9100		34.987
Clonts Farm X ZSE-G	FB6	ZSS0902	352	1300		1570	U	200	JN	5500		35.58
Clonts Farm X ZSE-G	FB6	ZSS0903	426	1500		2035	U	480	JN	3000		37.952
Zellwin Farms X ZSE-I	FB6	ZSS0907	1770	3800		7400		1500	JN	38000		37.359
Zellwin Farms X ZSE-I	FB6	ZSS0908	1630	2400		5200	P	920		49000		35.58
Zellwin Farms X ZSE-J	FB6	ZSS0910	1120	2000		5300		870	JN	25000		20.162
Clonts Farm X ZSE-C	FB6	ZSS0912	572	1300		1470	UU	290	JN	4000		39.138
Clonts Farm X ZSE-C	FB6	ZSS0914	428	1000		1350	U	230	JN	4000		26.685
Clonts Farm X ZSE-C	FB6	ZSS0915	378	900		1200	U	200	JN	3300		54.556
Clonts Farm X ZSE-G	FB6	ZSS0916	410	1100		1432	P	300	P	4600		31.429
Clonts Farm X ZSE-G	FB6	ZSS0917	154	480		604.5	U	60	JN	1200		27.278
Clonts Farm X ZSE-G	FB6	ZSS0918	502	1500		2055	U	500		5800		37.952
Clonts Farm X ZSE-G	FB6	ZSS0919	305	1100		1445	U	270	JN	2600		33.801
Zellwin Farms X ZSE-I	FB6	ZSS0920	13.6	54		68.45	U	3.45	U	170	U	2.9057
Zellwin Farms X ZSE-I	FB6	ZSS0922	77	210		277.5	U	55	JNP	1100		16.011
Zellwin Farms X ZSE-I	FB6	ZSS0924	1340	2600		5130		1000	JN	44000		33.801

OwnerXAlum	Flooding Block	SiteName	Total Chlordane ug/kg	DDE ug/kg	DDE Code	DDTx ug/kg	DDTx Code	Dieldrin ug/kg	Dieldrin Code	Toxaphene ug/kg	ToxaphenCode	TOC %
Zellwin Farms X ZSE-J	FB6	ZSS0925	1380	3500		11200		1100	JN	63000		43.289
Zellwin Farms X ZSE-J	FB6	ZSS0926	640	2500		6800		550	JN	8300		46.847
Clonts Farm X ZSE-C	FB6	ZSS0927	176	650		737	UU	200	JN	3100		24.906
Clonts Farm X ZSE-C	FB6	ZSS0928	397	1500		1700	UU	430		4300		31.429
Clonts Farm X ZSE-G	FB6	ZSS0929	404	1300		1605	U	230	JN	7200		33.208
Clonts Farm X ZSE-G	FB6	ZSS0930	470	1400		1780	U	200	JN	4000		30.243
Clonts Farm X ZSE-G	FB6	ZSS0931	800	3500		4550	U	720	JN	6600		40.324
Zellwin Farms X ZSE-I	FB6	ZSS0933	2000	5100		6990	U	1800	JN	42000		32.022
Zellwin Farms X ZSE-I	FB6	ZSS0936	1270	2100		5400		960	JN	37000		46.254
Zellwin Farms X ZSE-J	FB6	ZSS0937	937	1500		4500		560	JN	39000		45.661
Zellwin Farms X ZSE-J	FB6	ZSS0938	1730	5000		15000		1200	JN	31000		43.289
Zellwin Farms X ZSE-J	FB6	ZSS0939	244	750		1190		130	JN	3200		21.941
Clonts Farm X ZSE-G	FB6	ZSS0942	520	2000		2510	U	130	U	4500		34.987
Zellwin Farms X ZSE-I	FB6	ZSS0946	1360	2700		5000		1100	JN	30000		39.731
Zellwin Farms X ZSE-I	FB6	ZSS0947	478	1200		1625	U	330	JN	5500		41.51
Zellwin Farms X ZSE-I	FB6	ZSS0948	1430	2600		5300	P	1200		47000		47.44
Clonts Farm X ZSE-G	FB6	ZSS0951	47	150		185	U	31	JN	710		4.9219
Clonts Farm X ZSE-G	FB6	ZSS0952	800	2600		3000	UU	200	U	5400		29.65
Clonts Farm X ZSE-H	FB6	ZSS0953	54	260		330	U	31	JN	470		5.2184
Zellwin Farms X ZSE-I	FB6	ZSS0955	1400	2800		3900	P	870	P	20000		37.952
Zellwin Farms X ZSE-I	FB6	ZSS0956	996	1700		2620	P	560		19000		46.847
Zellwin Farms X ZSE-I	FB6	ZSS0957	1510	2900		4640	P	1200	JN	40000		8.302
Zellwin Farms X ZSE-J	FB6	ZSS0959	1190	1800		3750	P	820		24000		29.65
Zellwin Farms X ZSE-J	FB6	ZSS0960	1620	3000		6390	P	180	U	16000		48.033
Clonts Farm X ZSE-H	FB6	ZSS0961	45	190		234.5	U	38	JN	550		7.116
Zellwin Farms X ZSE-I	FB6	ZSS0963	1420	2700		4060		1100	JN	21000		46.254
Zellwin Farms X ZSE-I	FB6	ZSS0965	736	1600		2450	P	420		36000		46.254
Zellwin Farms X ZSE-I	FB6	ZSS0966	1380	2400		3415	U	1100	JN	24000		43.289
Zellwin Farms X ZSE-J	FB6	ZSS0968	1630	2400		3920		1300	JN	14000		42.696
Zellwin Farms X ZSE-J	FB6	ZSS0969	958	1400		2300		860	JN	12000		42.103
Zellwin Farms X ZSE-I	FB6	ZSS0970	332	1100		1230	UU	160	JN	1600		19.569
Zellwin Farms X ZSE-I	FB6	ZSS0971	1176	1600		2500	P	800	P	11000		42.696
Zellwin Farms X ZSE-J	FB6	ZSS0973	1736	1100		2210	PP	1000	P	14000		48.626
Zellwin Farms X ZSE-I	FB6	ZSS0974	15.2	14		21.7	UU	3.85	U	190	U	10.674
Zellwin Farms X ZSE-J	FB6	ZSS0978	1560	3300		6510		1300	JN	24000		46.254
Zellwin Farms X ZSE-J	FB6	ZSS0979	48	11.5	U	34.5	UUU	11.5	U	600	U	55.742
Zellwin Farms X ZSE-J	FB6	ZSS0980	23.6	77		353	U	6	U	295	U	46.254
Zellwin Farms X Z1S-A	FB11	ZWFE0314	328	860		1200	P	200	JN	8000		16.011
Zellwin Farms X ZNW-A	FB2	ZWFE0315	172	550		763.5	U	43.5	U	4900		33.208
Zellwin Farms X ZNW-A	FB2	ZWFE0320	288	880		1310	U	70	U	8800		32.615

OwnerXAlum	Flooding Block	SiteName	Total Chlordane ug/kg	DDE ug/kg	DDE Code	DDTx ug/kg	DDTx Code	Dieldrin ug/kg	Dieldrin Code	Toxaphene ug/kg	ToxapheneCode	TOC %
Zellwin Farms X ZNW-B	FB2	ZWFE0325	297	770		1190		120	JN	6800		18.976
Zellwin Farms X ZNW-C	FB2	ZWFE0329	434	1100		1530	U	150	JNP	5500		17.79
Crakes & Son, Inc. X ZNC-B	FB4	ZWFE0336	192	770		1220	P	48.5	U	3400		29.057
Zellwin Farms X ZNW-A	FB2	ZWFE0387	204	710		930	U	50	U	7800		27.871
Zellwin Farms X ZNW-B	FB2	ZWFE0392	268	950		1175	U	65	U	4200		12.453
Zellwin Farms X ZNC-A	FB3	ZWFE0397	480	1500		2410		115	U	14000		17.79
Zellwin Farms X ZNW-A	FB2	ZWFE0406	144	450		659	P	85	JN	5800		30.243
Zellwin Farms X ZNC-A	FB3	ZWFE0424	275	820		1045	U	310	JN	4600		23.72
Crakes & Son, Inc. X ZNC-B	FB4	ZWFE0429	600	1900		2630	U	420	JN	11000		43.882
Zellwin Farms X ZNW-A	FB2	ZWFE0476	200	780		980	P	50	U	5000		19.569
Zellwin Farms X ZNW-C	FB2	ZWFE0481	268	900		1155	U	190	JN	5000		25.499
Zellwin Farms X ZNC-A	FB3	ZWFE0507	271	1200		1525	U	520	JN	3400		31.429
Zellwin Farms X ZNC-A	FB3	ZWFE0513	470	1600		2055	U	420	JN	4000		29.057
Clarence Beall X ZNC-B	FB4	ZWFE0517	580	1600		2325	U	890	JN	5800		26.685
Zellwin Farms X ZSW-A	FB1	ZWFE0518	100	510		785.5	U	70	JN	1300		17.79
Zellwin Farms X ZSW-A	FB1	ZWFE0540	136	150		218	UU	34	U	1700	U	37.952
Crakes & Son, Inc. X ZSW-B	FB1	ZWFE0545	264	1100		1415	U	65	U	2800		29.65
Clarence Beall X ZSC-A	FB1	ZWFE0549	344	1500		1670	UU	210	JN	2700		39.731
Long Farms, Inc. X ZNE-A2	FB5	ZWFE0570	1190	4100		4670	UU	285	JN	14000		19.569
Zellwin Farms X ZNW-A	FB2	ZWS0316	545	1300		2105	U	400	JN	21000		49.219
Zellwin Farms X ZNW-A	FB2	ZWS0317	204	710		1090	P	50	U	5500		31.429
Zellwin Farms X ZNW-A	FB2	ZWS0318	152	460		727	P	37.5	U	6100		36.766
Zellwin Farms X ZNW-A	FB2	ZWS0319	480	1300		2880	P	270	JN	20000		48.033
Zellwin Farms X ZNW-B	FB2	ZWS0322	265	1100		1590	P	45	U	7100		50.405
Zellwin Farms X ZNW-B	FB2	ZWS0323	530	1800		2520	U	290	JN	18000		46.847
Zellwin Farms X ZNW-B	FB2	ZWS0324	440	1600		1820	UU	110	U	9900		39.138
Zellwin Farms X ZNW-C	FB2	ZWS0326	500	1000		1365	U	250	JN	8200		30.243
Zellwin Farms X ZNW-C	FB2	ZWS0327	188	930		1256.5	U	46.5	U	840		3.558
Zellwin Farms X ZNW-C	FB2	ZWS0328	277	700		857.5	U	37.5	U	3300		43.289
Zellwin Farms X ZNC-A	FB3	ZWS0330	184	550		840		45.5	U	5100		10.674
Zellwin Farms X ZNC-A	FB3	ZWS0332	461	1100		1405	PU	95	U	14000		44.475
Zellwin Farms X ZNC-A	FB3	ZWS0334	440	1100		1370	UP	50	U	12000		48.626
Zellwin Farms X ZNC-A	FB3	ZWS0335	224	690		800	UU	55	U	5700		38.545
Crakes & Son, Inc. X ZNC-B	FB4	ZWS0337	13.2	7.5		14.1	UU	3.3	U	165	U	2.4906
Crakes & Son, Inc. X ZNC-B	FB4	ZWS0338	400	1500		3000		390	JN	19000		51.591
Crakes & Son, Inc. X ZNC-B	FB4	ZWS0339	1170	2700		6580		950	JN	30000		52.184
Zellwin Farms X ZNW-A	FB2	ZWS0340	552	1200		1800	U	320	JNP	18000		49.219
Zellwin Farms X ZNW-A	FB2	ZWS0341	443	1100		1855	U	340	JN	17000		45.661
Zellwin Farms X ZNW-A	FB2	ZWS0343	364	1100		1960	P	200	JN	17000		46.254
Zellwin Farms X ZNW-A	FB2	ZWS0344	57	170		235	U	30	JN	1500		9.488

OwnerXAlum	Flooding Block	SiteName	Total Chlordane ug/kg	DDE ug/kg	DDE Code	DDTx ug/kg	DDTx Code	Dieldrin ug/kg	Dieldrin Code	Toxaphene ug/kg	Toxaphen eCode	TOC %
Zellwin Farms X ZNW-B	FB2	ZWS0345	304	760		1125	U	75	U	3100		41.51
Zellwin Farms X ZNW-C	FB2	ZWS0348	227	1000		1310	P	38.5	U	6600		26.092
Zellwin Farms X ZNW-C	FB2	ZWS0350	251	850		1170	U	60	U	4400		37.359
Zellwin Farms X ZNC-A	FB3	ZWS0352	401	1400		2240	P	260	JN	25000		49.812
Zellwin Farms X ZNC-A	FB3	ZWS0353	440	1600		2230	P	280	JN	20000		46.254
Zellwin Farms X ZNC-A	FB3	ZWS0354	300	1300		2170	P	160	JN	10000		40.917
Zellwin Farms X ZNC-A	FB3	ZWS0355	454	1100		1410	U	290	JN	16000		43.882
Crakes & Son, Inc. X ZNC-B	FB4	ZWS0359	720	2300		5050	P	480	JN	25000		52.777
Zellwin Farms X ZNW-A	FB2	ZWS0361	316	1200		1630	P	80	U	12000		43.289
Zellwin Farms X ZNW-A	FB2	ZWS0364	346	910		1700	JP	290	JN	16000		43.882
Zellwin Farms X ZNW-A	FB2	ZWS0365	343	1000		1520	U	240	JN	13000		40.324
Zellwin Farms X ZNW-B	FB2	ZWS0367	600	1300		2260	U	150	U	15000		44.475
Zellwin Farms X ZNW-B	FB2	ZWS0369	450	1600		2740		340	JN	17000		44.475
Zellwin Farms X ZNW-C	FB2	ZWS0370	76	270		307	UU	18.5	U	840		5.5149
Zellwin Farms X ZNW-C	FB2	ZWS0371	52	190		236	U	30	JN	1200		5.93
Zellwin Farms X ZNW-C	FB2	ZWS0372	430	1400		1860	U	280	JN	7000		39.731
Zellwin Farms X ZNW-C	FB2	ZWS0373	360	1500		1990	U	300	JN	7400		40.917
Zellwin Farms X ZNC-A	FB3	ZWS0374	332	1100		1480	P	85	U	12000		31.429
Zellwin Farms X ZNC-A	FB3	ZWS0376	418	1500		2220	P	260	JN	19000		48.626
Zellwin Farms X ZNC-A	FB3	ZWS0378	351	870		1040	UU	85	U	9200		36.766
Crakes & Son, Inc. X ZNC-B	FB4	ZWS0380	300	1200		1685	U	75	U	5200		46.847
Crakes & Son, Inc. X ZNC-B	FB4	ZWS0381	560	1900		3630	P	360	JN	21000		51.591
Zellwin Farms X ZNW-A	FB2	ZWS0382	13.2	12		18.6	UU	3.3	U	165	U	4.6254
Zellwin Farms X ZNW-A	FB2	ZWS0384	369	970		1505	U	330	JN	18000		44.475
Zellwin Farms X ZNW-A	FB2	ZWS0385	320	1100		2150	P	50	U	18000		48.033
Zellwin Farms X ZNW-A	FB2	ZWS0386	207	640		969	U	130	JNP	6400		26.685
Zellwin Farms X ZNW-B	FB2	ZWS0388	296	910		1205	U	75	U	4000		31.429
Zellwin Farms X ZNW-B	FB2	ZWS0389	480	1100		1530	U	120	U	7000		43.289
Zellwin Farms X ZNW-B	FB2	ZWS0391	22.4	61		72	UU	5.5	U	140	U	2.3127
Zellwin Farms X ZNW-C	FB2	ZWS0393	61	280		360	P	51		1400		5.93
Zellwin Farms X ZNW-C	FB2	ZWS0396	260	1000		1290	U	60	U	3400		29.65
Zellwin Farms X ZNC-A	FB3	ZWS0398	402	1400		2040	P	200		9100		32.022
Zellwin Farms X ZNC-A	FB3	ZWS0399	450	2000		2890	P	105	U	16000		40.917
Zellwin Farms X ZNC-A	FB3	ZWS0400	511	1500		2190	P	340		12000		43.289
Zellwin Farms X ZNC-A	FB3	ZWS0401	284	690		830	UU	70	JNP	7600		48.033
Crakes & Son, Inc. X ZNC-B	FB4	ZWS0403	332	1400		1970	P	85	U	4600		34.394
Crakes & Son, Inc. X ZNC-B	FB4	ZWS0404	520	1900		3250	P	440	JN	16000		50.998
Zellwin Farms X ZNW-A	FB2	ZWS0408	278	1100		1950	P	300		15000		45.661
Zellwin Farms X ZNW-A	FB2	ZWS0409	348	940		1560	P	220	JN	22000		37.952
Zellwin Farms X ZNW-A	FB2	ZWS0410	472	1300		2180	JP	430	JN	22000		49.219

OwnerXAlum	Flooding Block	SiteName	Total Chlordane ug/kg	DDE ug/kg	DDE Code	DDTx ug/kg	DDTx Code	Dieldrin ug/kg	Dieldrin Code	Toxaphene ug/kg	Toxaphen eCode	TOC %
Zellwin Farms X ZNW-A	FB2	ZWS0411	415	1100		1725	U	350	JN	17000		42.103
Zellwin Farms X ZNW-A	FB2	ZWS0412	480	1300		1830	U	120	U	15000		33.208
Zellwin Farms X ZNW-B	FB2	ZWS0413	620	2000		3380	P	690	JN	22000		41.51
Zellwin Farms X ZNW-B	FB2	ZWS0414	200	490		639.5	U	49.5	U	2300		22.534
Zellwin Farms X ZNW-B	FB2	ZWS0415	213	720		1430		380		6900		33.208
Zellwin Farms X ZNW-C	FB2	ZWS0417	268	810		1065	U	150	JN	5900		34.394
Zellwin Farms X ZNW-C	FB2	ZWS0418	164	480		651	U	94	JN	2500		33.208
Zellwin Farms X ZNC-A	FB3	ZWS0419	291	950		1185	U	240	JN	7700		27.278
Zellwin Farms X ZNC-A	FB3	ZWS0421	650	1500		2420	P	740	JN	19000		48.033
Zellwin Farms X ZNC-A	FB3	ZWS0423	556	1400		2000	JNPP	900		14000		45.068
Clarence Beall X ZNC-B	FB4	ZWS0425	500	1900		2415	U	1100	JN	5300		33.208
Clarence Beall X ZNC-B	FB4	ZWS0426	590	1700		2610		1300	JN	8900		38.545
Zellwin Farms X ZNW-A	FB2	ZWS0430	467	1100		1880	U	380	JN	18000		33.801
Zellwin Farms X ZNW-A	FB2	ZWS0431	284	750		1210	JP	250	JN	14000		45.661
Zellwin Farms X ZNW-A	FB2	ZWS0432	346	1100		1710	U	280	JN	14000		34.987
Zellwin Farms X ZNW-A	FB2	ZWS0433	366	1400		2320	P	410	JN	17000		46.847
Zellwin Farms X ZNW-B	FB2	ZWS0436	640	1900		3540	P	560	JN	21000		46.847
Clarence Beall X ZNW-B	FB2	ZWS0438	510	1900		2460	U	390	JN	5900		26.685
Zellwin Farms X ZNW-C	FB2	ZWS0440	192	730		908	U	170	JN	3600		19.569
Zellwin Farms X ZNC-A	FB3	ZWS0442	650	2000		2580	U	1100	JN	15000		41.51
Zellwin Farms X ZNC-A	FB3	ZWS0443	690	1900		3060		1000	JN	22000		48.626
Zellwin Farms X ZNC-A	FB3	ZWS0445	413	1600		1950	U	550	JN	9100		39.138
Zellwin Farms X ZNC-A	FB3	ZWS0446	353	850		1100	U	450	JN	9500		48.033
Clarence Beall X ZNC-B	FB4	ZWS0447	414	1600		2115	U	930	JN	9300		25.499
Clarence Beall X ZNC-B	FB4	ZWS0448	460	1700		2840	P	1000	JN	6900		45.661
Clarence Beall X ZNC-B	FB4	ZWS0450	700	3300		7260	P	1300	JN	7600		49.812
Zellwin Farms X ZNW-A	FB2	ZWS0451	379	1200		2090	P	350	JN	15000		45.661
Zellwin Farms X ZNW-A	FB2	ZWS0452	375	1100		1990	P	350	JN	18000		40.917
Zellwin Farms X ZNW-A	FB2	ZWS0453	360	1100		1950	P	90	U	16000		45.661
Zellwin Farms X ZNW-A	FB2	ZWS0454	284	930		1150	UP	70	U	10000		36.173
Clarence Beall X ZNW-B	FB2	ZWS0456	640	2600		3220	U	510	JN	8400		41.51
Clarence Beall X ZNW-B	FB2	ZWS0458	91	710		950		200		2300		15.418
Zellwin Farms X ZNW-C	FB2	ZWS0460	480	1700		2205	U	460	JN	9700		41.51
Zellwin Farms X ZNW-C	FB2	ZWS0461	204	790		1020	U	180	JN	4200		22.534
Zellwin Farms X ZNC-A	FB3	ZWS0462	52	220		263	U	40		690		4.2696
Zellwin Farms X ZNC-A	FB3	ZWS0463	406	1400		2180		940	JN	4600		40.324
Zellwin Farms X ZNC-A	FB3	ZWS0464	422	1400		1765	U	460	JN	6900		41.51
Zellwin Farms X ZNC-A	FB3	ZWS0465	520	2000		2440	U	630	JN	8600		42.696
Zellwin Farms X ZNC-A	FB3	ZWS0467	400	1100		3205	U	360	JN	5300		28.464
Clarence Beall X ZNC-B	FB4	ZWS0468	487	1600		2180	U	1200	JN	7400		37.952

OwnerXAlum	Flooding Block	SiteName	Total Chlordane ug/kg	DDE ug/kg	DDE Code	DDTx ug/kg	DDTx Code	Dieldrin ug/kg	Dieldrin Code	Toxaphene ug/kg	ToxapheneCode	TOC %
Clarence Beall X ZNC-B	FB4	ZWS0469	680	2400		4820		1700	JN	12000		49.812
Clarence Beall X ZNC-B	FB4	ZWS0470	520	1800		2720	U	910	JN	4500		38.545
Zellwin Farms X ZNW-A	FB2	ZWS0471	132	520		769	P	140	P	5400		45.661
Zellwin Farms X ZNW-A	FB2	ZWS0472	188	780		1146.5	U	46.5	U	2700		30.836
Zellwin Farms X ZNW-A	FB2	ZWS0473	417	980		1470	U	300	JN	15000		42.696
Zellwin Farms X ZNW-A	FB2	ZWS0474	338	1100		1665	U	270	JN	14000		36.173
Zellwin Farms X ZSW-A	FB1	ZWS0475	11.6	64		78.95	U	2.95	U	145	U	2.3127
Crakes & Son, Inc. X ZSW-B	FB1	ZWS0477	280	910		1210	U	70	U	3400		32.022
Crakes & Son, Inc. X ZSW-B	FB1	ZWS0479	68	240		314.5	U	17.5	U	690		1.8976
Clarence Beall X ZNW-B	FB2	ZWS0480	1320	5500		6780	U	720	JN	17000		24.313
Zellwin Farms X ZNW-C	FB2	ZWS0482	68	210		279	U	42	JN	2000		20.162
Zellwin Farms X ZNW-C	FB2	ZWS0484	61	330		453	JNP	57	P	1600		17.79
Zellwin Farms X ZNC-A	FB3	ZWS0485	160	430		590.5	U	40.5	U	830		7.709
Zellwin Farms X ZNC-A	FB3	ZWS0489	386	1400		1820	U	280	JNP	3300		30.836
Clarence Beall X ZNC-B	FB4	ZWS0490	826	2000		3080	JNP	1600		5500		34.987
Clarence Beall X ZNC-B	FB4	ZWS0491	600	1800		2625		1100	JN	5300		39.138
Clarence Beall X ZNC-B	FB4	ZWS0492	530	1500		2950	JNP	1500		8300		39.731
Clarence Beall X ZNC-B	FB4	ZWS0493	590	2000		2635	U	910	JN	17000		42.103
Zellwin Farms X ZSW-A	FB1	ZWS0496	164	440		721.5	U	90	JN	2100		20.755
Zellwin Farms X ZSW-A	FB1	ZWS0497	400	2000		3035	U	410	P	11000		39.138
Crakes & Son, Inc. X ZSW-B	FB1	ZWS0499	156	500		648.5	U	38.5	U	1200		21.348
Crakes & Son, Inc. X ZSW-B	FB1	ZWS0500	660	1800		3450		145	U	8000		46.254
Crakes & Son, Inc. X ZSW-B	FB1	ZWS0501	560	2100		2645	U	135	U	6400		40.917
Crakes & Son, Inc. X ZSW-B	FB1	ZWS0502	400	1300		1700	U	100	U	5800		39.138
Zellwood Drainage District X Z:	FB1	ZWS0503	230	2400		3520		290	JN	5500		44.475
Stroup Farms X ZSW-C	FB1	ZWS0505	650	2600		3095	U	630	P	11000		46.847
Stroup Farms X ZSW-C	FB1	ZWS0506	810	2300		2690	UU	195	U	12000		49.219
Clarence Beall X ZSC-A	FB1	ZWS0508	940	3500		4660		1100	JN	6400		48.033
Clarence Beall X ZSC-A	FB1	ZWS0509	308	2100		2770		500		5900		44.475
Stroup Farms X ZSC-B	FB1	ZWS0511	750	1900		2160	UU	1100	JN	6800		40.324
Stroup Farms X ZSC-B	FB1	ZWS0512	660	2900		3510	U	1300	JN	9000		30.836
Lust Farms X ZSC-C	FB1	ZWS0514	770	1400		2510		960	JN	19000		50.998
Lust Farms X ZSC-C	FB1	ZWS0515	1670	4000		8100		3300	JN	26000		49.812
Lust Farms X ZSC-C	FB1	ZWS0516	480	1200		2110		600	JN	7700		40.917
Zellwin Farms X ZSW-A	FB1	ZWS0521	440	1900		3110	U	110	U	7600		44.475
Crakes & Son, Inc. X ZSW-B	FB1	ZWS0523	264	1300		2365	U	65	U	3700		7.116
Crakes & Son, Inc. X ZSW-B	FB1	ZWS0524	920	2400		4360		430	JN	7600		47.44
Crakes & Son, Inc. X ZSW-B	FB1	ZWS0525	324	610		1990	U	80	U	4500		44.475
Crakes & Son, Inc. X ZSW-B	FB1	ZWS0526	224	650		915	U	55	U	1200		17.197
Clarence Beall X ZSC-A	FB1	ZWS0531	384	1200		1585	U	370	JN	4300		49.219

OwnerXAlum	Flooding Block	SiteName	Total Chlordane ug/kg	DDE ug/kg	DDE Code	DDTx ug/kg	DDTx Code	Dieldrin ug/kg	Dieldrin Code	Toxaphene ug/kg	ToxaphenеCode	TOC %
Stroup Farms X ZSC-B	FB1	ZWS0534	514	1300		1490	UU	500	JN	3700		42.696
Lust Farms X ZSC-C	FB1	ZWS0535	478	1200		2070		700	JN	16000		41.51
Lust Farms X ZSC-C	FB1	ZWS0536	840	1500		3220		1100	JN	22000		52.184
Lust Farms X ZSC-C	FB1	ZWS0537	760	1400		3220		950		20000		48.626
Lust Farms X ZSC-C	FB1	ZWS0538	660	1300		2210		740	JN	15000		47.44
Zellwin Farms X ZSW-A	FB1	ZWS0541	680	2000		2585	U	175	U	5600		45.661
Crakes & Son, Inc. X ZSW-B	FB1	ZWS0543	345	1400		1990		85	U	3800		40.917
Crakes & Son, Inc. X ZSW-B	FB1	ZWS0544	212	810		1075	U	55	U	265	U	32.022
Stroup Farms X ZSW-C	FB1	ZWS0546	14	21		28.1	UU	3.55	U	175	U	8.895
Stroup Farms X ZSW-C	FB1	ZWS0547	640	1800		2060	UU	130	JNP	7200		47.44
Clarence Beall X ZSC-A	FB1	ZWS0550	426	2000		2430	P	490	P	6000		49.219
Clarence Beall X ZSC-A	FB1	ZWS0551	272	1100		1230	UU	65	U	1400		48.626
Lust Farms X ZSC-C	FB1	ZWS0554	512	780		1210		550	JN	12000		48.626
Lust Farms X ZSC-C	FB1	ZWS0555	720	1700		2940		1200	JN	23000		49.812
Lust Farms X ZSC-C	FB1	ZWS0557	524	1000		1720		690	JN	12000		49.219
Lust Farms X ZSC-C	FB1	ZWS0558	184	710		986	UP	130	JN	6600		4.0324
Stroup Farms X ZSC-B	FB1	ZWS0559	288	1700		1840	UU	290	P	1600		45.068
Lust Farms X ZSC-C	FB1	ZWS0561	442	740		1120	P	470	JN	8400		47.44
Lust Farms X ZSC-C	FB1	ZWS0562	682	1100		1950		700	JN	17000		49.812
Lust Farms X ZSC-C	FB1	ZWS0563	584	990		2040		690	JN	15000		50.405
Lust Farms X ZSC-C	FB1	ZWS0566	372	730		1055	UP	390	JN	10000		48.626
Lust Farms X ZSC-C	FB1	ZWS0567	400	310		1810	U	100	U	17000		49.812
Lust Farms X ZSC-C	FB1	ZWS0571	432	1400		1725	UP	200	JNP	6600		43.289
Lust Farms X ZSC-C	FB1	ZWS0572	282	770		890	UU	140	JNP	4800		39.731
Lust Farms X ZSC-C	FB1	ZWS0574	536	1400		1590	UU	550	JN	12000		32.022
Lust Farms X ZSC-C	FB1	ZWS0575	396	1000		1260	UP	250	JN	8200		43.289
Lust Farms X ZSC-C	FB1	ZWS0576	256	640		740	UU	130	JN	4400		45.661
Lust Farms X ZSC-C	FB1	ZWS0577	170	540		620	UU	93	JN	2100		42.103
Zellwood Drainage District X Z:	FB1	ZWS0578	12.4	3.1	U	9.3	UUU	3.1	U	155	U	1.4232

* Total chlordane is the sum of alpha-chlordane, gamma-chlordane, heptachlor and heptachlor epoxide
No code included for total chlordane because it is a summation

Statistical Table

OWNER X ALUM	ACRES	CN CHLORDANE	CN DDE	CN DDTX	CN DIELDRIN	CN TOXAPHENE	CN CHLORDANE	CN DDE	CN DDTX	CN DIELDRIN	CN TOXAPHENE	CN CHLORDANE	CN DDE	CN DDTX	CN DIELDRIN	CN TOXAPHENE	CN CHLORDANE	CN DDE	CN DDTX	CN DIELDRIN	CN TOXAPHENE	CN CHLORDANE	CN DDE	CN DDTX	CN DIELDRIN	CN TOXAPHENE
		EC	EC	EC	EC	EC	UCL 95	UCL 95	UCL 95	UCL 95	UCL 95	AVERAGE	AVERAGE	VERAGE	/ERAGE	AVERAGE	STD.ERR.	TD.ERR.	TD.ERR.	D.ERR.	STD.ERR.	ST.ER/AVE	ST.ER/AVE	T.ER/AVE	T.ER/AVE	ST.ER/AVE
Lust Farms X ZNE-A	39.893	899	5518	16890	989	60180	1465	8065	33197	1437	117109	899	5518	16890	989	60180	195	876	5610	154	19583	0.216	0.159	0.332	0.156	0.325
Lust Farms X ZNE-B	263.618	1710	4311	10340	744	31349	1710	4311	10340	744	31349	1442	6518	14625	1124	59183	157	634	1520	109	4607	0.109	0.097	0.104	0.097	0.078
Lust Farms X ZNE-C	75.425	2021	9289	14804	1656	86273	2021	9289	14804	1656	86273	1194	5237	9026	1061	50763	400	1963	2799	288	17200	0.335	0.375	0.310	0.272	0.339
Lust Farms X ZNE-D	50.787	653	3504	6417	438	20148	1091	5326	10228	514	24106	529	2990	5343	417	19033	123	514	1074	21	1116	0.233	0.172	0.201	0.051	0.059
Lust Farms X ZSC-C	242.009	1013	4572	7500	2048	45877	1013	4572	7500	2048	45877	790	3279	5528	1547	34331	130	752	1147	292	6714	0.164	0.229	0.207	0.189	0.196
Lust Farms X ZSE-A	156.729	1600	6282	12553	1902	122603	1600	6282	12553	1902	122603	1244	5097	10351	1449	73874	197	655	1218	251	26958	0.159	0.129	0.118	0.173	0.365
Lust Farms X ZSE-D	316.043	1161	4590	10531	1037	54175	1161	4590	10531	1037	54175	1008	4027	8973	893	47115	91	332	920	85	4168	0.090	0.082	0.102	0.095	0.088
Lust Farms X ZSE-F	222.705	1862	6840	17185	1619	56173	1862	6840	17185	1619	56173	1425	5368	12794	1339	47650	254	854	2547	163	4943	0.178	0.159	0.199	0.122	0.104
Long Farms, Inc. X Z1N-C	159.357	2907	14630	36488	2806	98314	2907	14630	36488	2806	98314	2033	10442	24750	1830	67664	464	2224	6232	518	16274	0.228	0.213	0.252	0.283	0.241
Long Farms, Inc. X Z1S-E	45.278	1251	2900	5420	48	3030	3406	7546	14405	68	5180	644	1591	2887	42	2424	607	1309	2533	6	606	0.944	0.823	0.877	0.134	0.250
Long Farms, Inc. X ZNE-A1	19.117	1589	11313	30098	2436	72606	1589	11667	32506	2436	79376	918	7768	20893	1534	52650	277	1611	4798	373	11043	0.302	0.207	0.230	0.243	0.210
Long Farms, Inc. X ZNE-A2	356.644	982	6910	15789	1683	45960	982	6910	15789	1683	45960	774	5467	12370	1368	38819	122	844	2001	184	4180	0.157	0.154	0.162	0.135	0.108
Long Farms, Inc. X ZNE-D1	64.537	1345	5879	14445	1617	60961	1345	5879	14445	1617	60961	1102	5124	11319	1050	45136	123	381	1578	286	7985	0.112	0.074	0.139	0.273	0.177
Long Farms, Inc. X ZNE-D2	47.085	1853	7260	21192	2168	70089	1853	7260	21192	2168	70089	1442	6118	14257	1683	59669	199	553	3360	235	5047	0.138	0.090	0.236	0.139	0.085
Long Farms, Inc. X ZNE-E	73.439	1293	7249	19320	1017	69208	1293	7249	19320	1017	69208	988	5727	15187	799	55441	158	791	2147	113	7152	0.160	0.138	0.141	0.141	0.129
Long Farms, Inc. X ZNE-F	40.112	1546	9134	28457	1546	120045	1694	9578	31492	1722	120714	1130	6738	19865	1169	68276	233	1174	4804	229	21667	0.207	0.174	0.242	0.196	0.317
Long Farms, Inc. X ZSE-A	181.786	1091	3444	6489	1415	34171	1091	3444	6489	1415	34171	809	2865	5280	1111	28228	156	320	669	169	3288	0.193	0.112	0.127	0.152	0.116
Lust & Long Precooler X ZNE-F		877	877	2631	877	43845						877	877	2631	877	43845										
Zellwin Farms X Z1N-D	75.071	2752	12903	36657	2113	95823	3325	13807	42519	2276	106874	2432	10921	24820	1755	88704	307	993	6089	179	6250	0.126	0.091	0.245	0.102	0.070
Zellwin Farms X Z1N-E	96.277	3874	25455	77253	3761	181204	3874	25647	77253	3761	181204	3543	18744	52318	3369	158803	151	3146	11367	179	10212	0.043	0.168	0.217	0.053	0.064
Zellwin Farms X Z1N-G	198.201	1536	9057	13861	1680	88248	1536	9057	13861	1680	88248	1207	6544	10939	1270	65527	166	1268	1474	207	11464	0.138	0.194	0.135	0.163	0.175
Zellwin Farms X Z1S-A	329.036	2668	7597	10156	2480	73679	2668	7597	10156	2480	73679	2079	5676	7505	1822	56961	331	1081	1491	370	9403	0.159	0.190	0.199	0.203	0.165
Zellwin Farms X Z1S-B	308.098	1928	4597	8689	761	73378	1928	4597	8689	761	73378	1526	3651	6678	597	56572	222	523	1113	91	9297	0.146	0.143	0.167	0.152	0.164
Zellwin Farms X Z1S-C	314.405	2212	5682	10961	988	83201	2212	5682	10961	988	83201	1958	5014	9789	838	72987	144	378	663	85	5781	0.073	0.075	0.068	0.102	0.079
Zellwin Farms X Z1S-D	307.701	2297	4996	8167	1578	81189	2297	4996	8167	1578	81189	1897	4348	6917	1292	65036	224	362	698	159	9017	0.118	0.083	0.101	0.123	0.139
Zellwin Farms X Z1S-E	214.079	1943	10010	31997	1740	41669	1943	10010	31997	1740	41669	1169	6162	16664	870	23156	402	1999	7965	452	9618	0.344	0.324	0.478	0.519	0.415
Zellwin Farms X ZNC-A	332.688	738	4114	6200	1220	33305	738	4114	6200	1220	33305	665	3699	5471	1032	28939	43	245	431	111	2581	0.064	0.066	0.079	0.107	0.089
Zellwin Farms X ZNW-A	321.842	507	2587	4230	617	35090	507	2587	4230	617	35090	461	2390	3901	550	31701	27	117	195	40	2011	0.059	0.049	0.050	0.072	0.063

OWNER X ALUM	ACRES	CN CHLORDANE	CN DDE	CN DDTX	CN DIELDRIN	CN TOXAPHENE	CN CHLORDANE	CN DDE	CN DDTX	CN DIELDRIN	CN TOXAPHENE	CN CHLORDANE	CN DDE	CN DDTX	CN DIELDRIN	CN TOXAPHENE	CN CHLORDANE	CN DDE	CN DDTX	CN DIELDRIN	CN TOXAPHENE	CN CHLORDANE	CN DDE	CN DDTX	CN DIELDRIN	CN TOXAPHENE
		EC	EC	EC	EC	EC	UCL 95	UCL 95	UCL 95	UCL 95	UCL 95	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	STD.ERR.	STD.ERR.	STD.ERR.	STD.ERR.	STD.ERR.	ST.ER/AVE	ST.ER/AVE	ST.ER/AVE	ST.ER/AVE	ST.ER/AVE
Zellwin Farms X ZNW-B	211.451	704	4100	6225	895	32924	704	4100	6225	895	32924	602	3429	5282	719	26440	58	379	533	100	3670	0.096	0.111	0.101	0.139	0.139
Zellwin Farms X ZNW-C	250.462	882	6450	8916	890	20405	882	6450	8916	890	20405	657	4415	6057	686	17809	130	1177	1653	118	1501	0.198	0.267	0.273	0.172	0.084
Zellwin Farms X ZSE-I	246.960	3757	9546	15664	3657	117306	3757	9546	15664	3657	117306	2637	6816	11258	2512	79048	650	1583	2556	664	22189	0.247	0.232	0.227	0.264	0.281
Zellwin Farms X ZSE-J	143.455	2736	6883	17101	2419	71712	2736	6883	17101	2419	71712	2145	5365	12641	1862	52116	335	860	2524	316	11092	0.156	0.160	0.200	0.169	0.213
Zellwin Farms X ZSW-A	112.876	553	4334	6698	737	19053	553	4334	6698	737	19053	408	3130	4834	510	13769	73	607	941	114	2666	0.179	0.194	0.195	0.224	0.194
Clonts Farm X ZSE-B	298.606	668	5439	7193	1111	11912	668	5439	7193	1111	11912	569	4627	6095	909	9872	58	477	645	119	1198	0.102	0.103	0.106	0.131	0.121
Clonts Farm X ZSE-C	100.413	1155	5424	7167	1123	19057	1155	5424	7167	1123	19057	894	4106	5412	862	13974	141	712	947	141	2745	0.158	0.173	0.175	0.164	0.196
Clonts Farm X ZSE-G	152.052	958	5509	7553	1105	20080	958	5509	7553	1105	20080	827	4578	6256	929	16549	74	527	734	100	1999	0.090	0.115	0.117	0.108	0.121
Clonts Farm X ZSE-H	28.542	537	4982	6573	594	9007	915	9084	12100	701	11273	430	3826	5015	564	8368	107	1156	1558	30	639	0.248	0.302	0.311	0.053	0.076
Crakes & Son, Inc. X ZNC-B	156.145	782	4383	8111	1036	38373	782	4383	8111	1036	38373	603	3580	6404	784	29586	98	440	934	138	4809	0.162	0.123	0.146	0.176	0.163
Crakes & Son, Inc. X ZNE-A1	19.603	1490	8236	17666	1490	29413	1743	9145	19074	1737	34442	955	6255	14750	957	25816	271	994	1487	268	2967	0.284	0.159	0.101	0.280	0.115
Crakes & Son, Inc. X ZNE-A2	76.687	3898	25665	120950	3876	79599	3898	25665	120950	3876	79599	2463	16274	71114	2514	58393	695	4549	24139	660	10272	0.282	0.280	0.339	0.263	0.176
Crakes & Son, Inc. X ZNE-C	73.932	1631	9654	16887	1579	35226	1631	9654	16887	1579	35226	1349	6702	13810	1303	30758	137	1430	1490	134	2164	0.102	0.213	0.108	0.103	0.070
Crakes & Son, Inc. X ZNE-D	58.624	1718	13724	52134	1757	48815	1718	13724	52134	1757	49534	1314	10210	34469	1334	41026	196	1702	8556	205	4121	0.149	0.167	0.248	0.154	0.100
Crakes & Son, Inc. X ZSW-B	94.714	1035	7631	12761	979	22653	1035	7631	12761	979	22653	769	5255	8506	721	15835	149	1326	2375	144	3806	0.194	0.252	0.279	0.200	0.240
Stroup Farms X ZNE-A	75.694	1294	8998	15072	1930	44793	1294	8998	16000	1930	48123	668	4936	10110	1199	30669	285	1852	2685	333	7957	0.427	0.375	0.266	0.278	0.259
Stroup Farms X ZSC-B	78.596	1297	8698	10919	4144	28100	1444	8698	10919	4144	28100	895	5233	6533	2190	14567	227	1432	1812	807	5592	0.253	0.274	0.277	0.369	0.384
Stroup Farms X ZSE-E	148.245	1045	8328	12886	1521	40561	1045	8328	12886	1521	40561	883	6755	10732	1338	32806	91	885	1211	103	4362	0.104	0.131	0.113	0.077	0.133
Stroup Farms X ZSW-C	80.696	875	5550	6873	1328	24381	1107	6384	8145	1328	28228	647	3563	4604	691	16743	190	1166	1463	263	4745	0.294	0.327	0.318	0.381	0.283
Clarence Beall X ZNC-B	150.972	1098	5493	9264	3477	25323	1098	5493	9264	3477	25323	929	5023	8147	3133	21032	94	262	623	192	2395	0.101	0.052	0.077	0.061	0.114
Clarence Beall X ZNW-B	75.371	2471	20291	26280	2732	62774	2471	20291	26280	2732	62774	1204	10153	13304	1737	31796	524	4189	5361	411	12799	0.435	0.413	0.403	0.237	0.403
Clarence Beall X ZSC-A	61.570	889	5636	7371	1589	13063	889	5636	7371	1589	13063	585	4091	5285	993	9532	147	748	1011	289	1710	0.252	0.183	0.191	0.291	0.179
Hensel & Rodgers X Z1N-A	306.203	4392	18516	25579	1629	24587	4392	18516	25579	1629	24587	2152	13106	17914	951	20860	1268	3062	4339	383	2110	0.589	0.234	0.242	0.403	0.101
Robert Potter & Sons, Inc. X Z1N-	307.969	1761	12736	24883	3687	103045	1761	12736	24883	3687	103045	1435	8533	17600	2730	81424	178	2300	3985	524	11832	0.124	0.270	0.226	0.192	0.145
Grinnell Farms, Inc. X Z1N-D	56.731	1477	6364	24386	500	59091						1477	6364	24386	500	59091										
Grinnell Farms, Inc. X Z1N-E	11.822	176	1338	3060	176	8777	183	1487	4921	183	21305	174	1296	2535	174	5246	2	42	525	2	3531	0.012	0.032	0.207	0.012	0.673
Grinnell Farms, Inc. X Z1S-E	306.203	2550	14856	45565	1885	108647	2587	15098	46763	1901	110309	1526	10372	27658	1229	64837	438	1953	7894	278	18788	0.287	0.188	0.285	0.226	0.290
Marsell X Z1N-E	13.332	2338	18506	50682	2305	25325	3447	23343	64878	3385	32512	1420	8476	25273	1425	14065	698	5114	13624	674	6346	0.491	0.603	0.539	0.473	0.451
Marsell X Z1S-E	21.502	76	78	234	78	3796						76	78	234	78	3796										

Statistical Table

OWNER X ALUM	ACRES	CN CHLORDANE	CN DDE	CN DDTX	CN DIELDRIN	CN TOXAPHENE	CN CHLORDANE	CN DDE	CN DDTX	CN DIELDRIN	CN TOXAPHENE	CN CHLORDANE	CN DDE	CN DDTX	CN DIELDRIN	CN TOXAPHENE	CN CHLORDANE	CN DDE	CN DDTX	CN DIELDRIN	CN TOXAPHENE	CN CHLORDANE	CN DDE	CN DDTX	CN DIELDRIN	CN TOXAPHENE
		EC	EC	EC	EC	EC	UCL 95	UCL 95	UCL 95	UCL 95	UCL 95	AVERAGE	AVERAGE	VERAGE	/ERAGE	AVERAGE	STD.ERR.	'D.ERR.	;TD.ERR.	'D.ERR.	STD.ERR.	ST.ER/AVE	ST.ER/AVE	T.ER/AVE	T.ER/AVE	3T.ER/AVE
NAPA X Z1N-B	34.135	922	14446	19054	2740	21420						922	14446	19054	2740	21420										
Smith X ZNE-A	29.283	418	5529	13463	525	38703	479	7278	18055	680	46523	347	4131	10880	440	32414	45	1082	2468	83	4854	0.131	0.262	0.227	0.188	0.150
Smith X none		186	352	730	189	9313						186	352	730	189	9313										
Shortz X Z1N-B1	24.043	540	12468	24416	935	6234						540	12468	24416	935	6234										
Shortz X Z1N-B2	15.771	1102	6061	15152	1102	8540						1102	6061	15152	1102	8540										
Rice X Z1N-D2	13.644	73	455	648	73	3636						73	455	648	73	3636										
Rice X Z1N-D1	4.760	102	1445	2051	101	5124	226	2015	3019	222	10409	68	1285	1779	67	3634	35	161	273	34	1490	0.517	0.125	0.153	0.511	0.410
Zellwood Drainage District X ZSW	9.589	436	5396	7915	652	21782	522	14196	19636	1036	38484	411	2916	4611	544	17074	24	2480	3304	108	4708	0.059	0.851	0.717	0.199	0.276
General Impex X Z1N-G	24.466	94	6288	8652	91	7576						94	6288	8652	91	7576										
Shaffer X Z1S-E	11.916	126	125	374	125	6324						126	125	374	125	6324										
Progressive Growers (Rice) X Z1I	1.278	860	843	2529	843	42975						860	843	2529	843	42975										
Bates X Z1N-E	6.352	32	1451	3611	33	3095						32	1451	3611	33	3095										
Mulford Hickerson c/o Peat Hummus Corp X		227	1686	2279	227	11373						227	1686	2279	227	11373										
																						0.209	0.210	0.226	0.192	0.196

Indicates only one sample in block

	OWNER X ALUM		ACRES	CN CHLORDANE EC	CN DDE EC	CN DDTX EC	N DIELDRI EC	TOXAPHE EC	CHLORDA UCL 95	CN DDE UCL 95	CN DDTX UCL 95	N DIELDRI UCL 95	TOXAPHE UCL 95	CHLORDA AVERAGE	CN DDE AVERAGE	CN DDTX AVERAGE	N DIELDRI AVERAGE	TOXAPHENE AVERAGE	CN CHLORDA STD.ERR.	CN DDE STD.ERR.	CN DDTX STD.ERR.	N DIELDRI STD.ERR.	TOXAPHENE STD.ERR.	CN CHLORDA ST.ER/AVE	CN DDE T.ER/AVE	CN DDTX T.ER/AVE	N DIELDRI T.ER/AVE	TOXAPHENE T.ER/AVE
1	Lust Farms X ZNE-A	Lust Farms X ZNE-A	39.893	1288	6632	27211	1288	98528	1465	8065	33197	1437	117109	899	5518	16890	989	60180	195	876	5610	154	19583	0.216463	0.158773	0.332148	0.155865	0.325410
2	Lust Farms X ZNE-B	Lust Farms X ZNE-B	263.618	1710	4311	10340	744	31349	1710	4311	10340	744	31349	1442	6518	14625	1124	59183	157	634	1520	109	4607	0.108882	0.097200	0.103908	0.097279	0.077845
3	Lust Farms X ZNE-C	Lust Farms X ZNE-C	75.425	2021	9289	14804	1656	86273	2021	9289	14804	1656	86273	1194	5237	9026	1061	50763	400	1963	2799	288	17200	0.335286	0.374808	0.310090	0.271657	0.338824
4	Lust Farms X ZNE-D	Lust Farms X ZNE-D	50.787	653	3504	6417	438	20148	1091	5326	10228	514	24106	529	2990	5343	417	19033	123	514	1074	21	1116	0.233236	0.171759	0.201050	0.051335	0.058612
5	Lust Farms X ZSC-C	Lust Farms X ZSC-C	242.009	1013	4572	7500	2048	45877	1013	4572	7500	2048	45877	790	3279	5528	1547	34331	130	752	1147	292	6714	0.164213	0.229170	0.207465	0.188564	0.195569
6	Lust Farms X ZSE-A	Lust Farms X ZSE-A	156.729	1600	6282	12553	1902	122603	1600	6282	12553	1902	122603	1244	5097	10351	1449	73874	197	655	1218	251	26958	0.158509	0.128563	0.117699	0.172958	0.364918
7	Lust Farms X ZSE-D	Lust Farms X ZSE-D	316.043	1161	4590	10531	1037	54175	1161	4590	10531	1037	54175	1008	4027	8973	893	47115	91	332	920	85	4168	0.089823	0.082446	0.102484	0.094930	0.088472
8	Lust Farms X ZSE-F	Lust Farms X ZSE-F	222.705	1862	6840	17185	1619	56173	1862	6840	17185	1619	56173	1425	5368	12794	1339	47650	254	854	2547	163	4943	0.178006	0.159040	0.199093	0.121506	0.103739
9	Long Farms, Inc. X Z1N-C	Long Farms, Inc. X Z1N-(	159.357	2907	14630	36488	2806	98314	2907	14630	36488	2806	98314	2033	10442	24750	1830	67664	464	2224	6232	518	16274	0.228340	0.212973	0.251801	0.282899	0.240512
10	Long Farms, Inc. X Z1S-E	Long Farms, Inc. X Z1S-I	45.278	1251	2900	5420	48	3030	3406	7546	14405	68	5180	644	1591	2887	42	2424	607	1309	2533	6	606	0.943510	0.822881	0.877202	0.134021	0.250000
11	Long Farms, Inc. X ZNE-A1	Long Farms, Inc. X ZNE-,	19.117	1589	11313	30098	2436	72606	1589	11667	32506	2436	79376	918	7768	20893	1534	52650	277	1611	4798	373	11043	0.302129	0.207420	0.229662	0.243029	0.209743
12	Long Farms, Inc. X ZNE-A2	Long Farms, Inc. X ZNE-,	356.644	982	6910	15789	1683	45960	982	6910	15789	1683	45960	774	5467	12370	1368	38819	122	844	2001	184	4180	0.157335	0.154414	0.161766	0.134671	0.107667
13	Long Farms, Inc. X ZNE-D1	Long Farms, Inc. X ZNE-I	64.537	1345	5879	14445	1617	60961	1345	5879	14445	1617	60961	1102	5124	11319	1050	45136	123	381	1578	286	7985	0.111629	0.074421	0.139377	0.272932	0.176906
14	Long Farms, Inc. X ZNE-D2	Long Farms, Inc. X ZNE-I	47.085	1853	7260	21192	2168	70089	1853	7260	21192	2168	70089	1442	6118	14257	1683	59669	199	553	3360	235	5047	0.137899	0.090377	0.235648	0.139498	0.084580
15	Long Farms, Inc. X ZNE-E	Long Farms, Inc. X ZNE-I	73.439	1293	7249	19320	1017	69208	1293	7249	19320	1017	69208	988	5727	15187	799	55441	158	791	2147	113	7152	0.160213	0.138067	0.141366	0.141464	0.129001
16 (1)	Long Farms, Inc. X ZNE-F	Long Farms, Inc. X ZNE-I	40.112	1546	9134	28457	1546	120045	1694	9578	31492	1722	120714	1130	6738	19865	1169	68276	233	1174	4804	229	21667	0.206612	0.174176	0.241852	0.195556	0.317336
17	Long Farms, Inc. X ZSE-A	Long Farms, Inc. X ZSE-,	181.786	1091	3444	6489	1415	34171	1091	3444	6489	1415	34171	809	2865	5280	1111	28228	156	320	669	169	3288	0.192754	0.111857	0.126762	0.151934	0.116470
18 (2)	Lust & Long Precooler X ZNE-F			877	877	2631	877	43845						877	877	2631	877	43845										
19	Zellwin Farms X			1312	5371	7495	1249	49966						1312	5371	7495	1249	49966										
20	Zellwin Farms X Z1N-D	Zellwin Farms X Z1N-D	75.071	2752	12903	36657	2113	95823	3325	13807	42519	2276	106874	2432	10921	24820	1755	88704	307	993	6089	179	6250	0.126296	0.090919	0.245314	0.102150	0.070461
21	Zellwin Farms X Z1N-E	Zellwin Farms X Z1N-E	96.277	3874	25455	77253	3761	181204	3874	25647	77253	3761	181204	3543	18744	52318	3369	158803	151	3146	11367	179	10212	0.042610	0.167863	0.217265	0.053127	0.064305
22	Zellwin Farms X Z1N-G	Zellwin Farms X Z1N-G	198.201	1536	9057	13861	1680	88248	1536	9057	13861	1680	88248	1207	6544	10939	1270	65527	166	1268	1474	207	11464	0.137630	0.193808	0.134788	0.162913	0.174945
23	Zellwin Farms X Z1S-A	Zellwin Farms X Z1S-A	329.036	2769	7789	10391	2577	75663	2769	7789	10391	2577	75663	2138	5699	7505	1866	57499	352	1167	1611	397	10140	0.164713	0.204759	0.214608	0.212507	0.176348
24	Zellwin Farms X Z1S-B	Zellwin Farms X Z1S-B	308.098	1928	4597	8689	761	73378	1928	4597	8689	761	73378	1526	3651	6678	597	56572	222	523	1113	91	9297	0.145735	0.143336	0.166628	0.151843	0.164345
25	Zellwin Farms X Z1S-C	Zellwin Farms X Z1S-C	314.405	2212	5682	10961	988	83201	2212	5682	10961	988	83201	1958	5014	9789	838	72987	144	378	663	85	5761	0.073407	0.075421	0.067763	0.101686	0.079209
26	Zellwin Farms X Z1S-D	Zellwin Farms X Z1S-D	307.701	2297	4996	8167	1578	81189	2297	4996	8167	1578	81189	1897	4348	6917	1292	65036	224	362	698	159	9017	0.117929	0.083173	0.100885	0.123354	0.138641
27	Zellwin Farms X Z1S-E	Zellwin Farms X Z1S-E	214.079	1943	10010	31997	1740	41669	1943	10010	31997	1740	41669	1169	6162	16664	870	23156	402	1999	7965	452	9618	0.343630	0.324474	0.477975	0.519243	0.415348
28	Zellwin Farms X ZNC-A	Zellwin Farms X ZNC-A	332.688	738	4114	6200	1220	33305	738	4114	6200	1220	33305	665	3699	5471	1032	28939	43	245	431	111	2581	0.064329	0.066224	0.078716	0.107294	0.089178
29	Zellwin Farms X ZNW-A	Zellwin Farms X ZNW-A	321.842	507	2587	4230	617	35090	507	2587	4230	617	35090	461	2390	3901	550	31701	27	117	195	40	2011	0.059453	0.048816	0.050094	0.072330	0.063447
30	Zellwin Farms X ZNW-B	Zellwin Farms X ZNW-B	211.451	704	4100	6225	895	32924	704	4100	6225	895	32924	602	3429	5282	719	26440	58	379	533	100	3670	0.095638	0.110609	0.100977	0.138825	0.138812
31	Zellwin Farms X ZNW-C	Zellwin Farms X ZNW-C	250.462	882	6450	8916	890	20405	882	6450	8916	890	20405	657	4415	6057	686	17809	130	1177	1653	118	1501	0.198278	0.266603	0.272932	0.171632	0.084271
32	Zellwin Farms X ZSE-I	Zellwin Farms X ZSE-I	246.960	3757	9546	15664	3657	117306	3757	9546	15664	3657	117306	2637	6816	11258	2512	79048	650	1583	2556	664	22189	0.246520	0.232275	0.227017	0.264426	0.280707
33	Zellwin Farms X ZSE-J	Zellwin Farms X ZSE-J	143.455	2736	6883	17101	2419	71712	2736	6883	17101	2419	71712	2145	5365	12641	1862	52116	335	860	2524	316	11092	0.156067	0.160213	0.199688	0.169491	0.212840
34	Zellwin Farms X ZSW-A	Zellwin Farms X ZSW-A	112.876	553	4334	6698	737	19053	553	4334	6698	737	19053	408	3130	4834	510	13769	73	607	941	114	2666	0.179285	0.193997	0.194589	0.224136	0.193637
35	Clonts Farm X ZSE-B	Clonts Farm X ZSE-B	298.606	668	5439	7193	1111	11912	668	5439	7193	1111	11912	569	4627	6095	909	9872	58	477	645	119	1198	0.101639	0.103044	0.105840	0.130760	0.121382
36	Clonts Farm X ZSE-C	Clonts Farm X ZSE-C	100.413	1155	5424	7167	1123	19057	1155	5424	7167	1123	19057	894	4106	5412	862	13974	141	712	947	141	2745	0.157598	0.173389	0.175028	0.163570	0.196404
37	Clonts Farm X ZSE-G	Clonts Farm X ZSE-G	152.052	958	5509	7553	1105	20080	958	5509	7553	1105	20080	827	4578	6256	929	16549	74	527	734	100	1999	0.089603	0.115057	0.117304	0.107779	0.120761
38	Clonts Farm X ZSE-H	Clonts Farm X ZSE-H	28.542	537	4982	6573	594	9007	915	9084	12100	701	11273	430	3826	5015	564	8388	107	1156	1558	30	639	0.248143	0.302170	0.310661	0.053228	0.076336
39	Crakes & Son, Inc. X ZNC-B	Crakes & Son, Inc. X ZN(	156.145	782	4383	8111	1036	38373	782	4383	8111	1036	38373	603	3580	6404	784	29588	98	440	934	138	4809	0.162382	0.122773	0.145833	0.175642	0.162533
40	Crakes & Son, Inc. X ZNE-A1	Crakes & Son, Inc. X ZNI	19.603	1490	8236	17666	1490	29413	1743	9145	19074	1737	34442	955	6255	14750	957	25816	271	994	1487	268	2967	0.283503	0.158930	0.100847	0.280149	0.114943
41	Crakes & Son, Inc. X ZNE-A2	Crakes & Son, Inc. X ZNI	76.687	3898	25665	120950	3876	79599	3898	25665	120950	3876	79599	2463	16274	71114	2514	58393	695	4549	24139	660	10272	0.282130	0.279508	0.339441	0.262611	0.175902
42	Crakes & Son, Inc. X ZNE-C	Crakes & Son, Inc. X ZNI	73.932	1631	9654	16887	1579	35226	1631	9654	16887	1579	35226	1349	6702	13810	1303	30758	137	1430	1490	134	2164	0.101541	0.213376	0.107929	0.102578	0.070359
43	Crakes & Son, Inc. X ZNE-D	Crakes & Son, Inc. X ZNI	58.624	1718	13724	52134	1757	48815	1718	13724	52134	1757	49534	1314	10210	34469	1334	41026	196	1702	8556	205	4121	0.148997	0.166723	0.248229	0.153664	0.100453
44	Crakes & Son, Inc. X ZSW-B	Crakes & Son, Inc. X ZSV	94.714	1035	7631	12761	979	22653	1035	7631	12761	979	22653	769	5255	8506	721	15835	149	1326	2375	144	3806	0.193612	0.252374	0.279191	0.199917	0.240348
45	Stroup Farms X ZNE-A	Stroup Farms X ZNE-A	75.694	1294	8998	15072	1930	44793	1294	8998	16000	1930	48123	668	4936	10110	1199	30669	285	1852	2685	333	7957	0.427380	0.375139	0.265549	0.277704	0.259451
46	Stroup Farms X ZSC-B	Stroup Farms X ZSC-B	78.596	1297	8698	10919	4144	28100	1444	8698	10919	4144	28100	895	5233	6533	2190	14567	227	1432	1812	807	5592	0.253179	0.273569	0.277336	0.368763	0.383871
47	Stroup Farms X ZSE-E	Stroup Farms X ZSE-E	148.245	1045	8328	12886	1521	40561	1045	8328	12886	1521	40561	883	6755	10732	1338	32806	91	885	1211	103	4362	0.103652	0.131015	0.112890	0.076997	0.132952
48	Stroup Farms X ZSW-C	Stroup Farms X ZSW-C	80.696	875	5550	6873	1328	24381	1107	6384	8145	1328	28228	647	3563	4604	691	16743	190	1166	1463	263	4745	0.293728	0.327095	0.317698	0.380847	0.283425
49	Clarence Beall X ZNC-B	Clarence Beall X ZNC-B	150.972	1098	5493	9264	3477	25323	1098	5493	9264	3477	25323	929	5023	8147	3133	21032	94	262	623	192	2395	0.101153	0.052244	0.076526	0.061382	0.113890
50	Clarence Beall X ZNW-B	Clarence Beall X ZNW-B	75.371	2471	20291	26280	2732	62774	2471	20291	26280	2732	62774	1204	10153	13304	1737	31796	524	4189	5361	411	12799	0.435088	0.412605	0.402994	0.236583	0.402543
51	Clarence Beall X ZSC-A	Clarence Beall X ZSC-A	61.570	889	5636	7371	1589	13063	889	5636	7371	1589	13063	585	4091	5285	993	9532	147	748	1011	289	1710	0.252093	0.182840	0.191230	0.290743	0.179445
52	Hensel & Rodgers X Z1N-A	Hensel & Rodgers X Z1N	306.203	4392	18516	25579	1629	24587	4392	18516	25579	1629	24587	2152	13106	17914	951	20860	1268	3062	4339	383	2110	0.589366	0.233660	0.242185	0.402962	0.101149
53	Robert Potter & Sons, Inc. X Z1N-F	Robert Potter & Sons, Inc	307.969	1761	12736	24883	3687	103045	1761	12736	24883	3687	103045	1435	8533	17600	2730	81424	178	2300	3985	524	11832	0.124248	0.269565	0.226431	0.191816	0.145313
54	Grinnell Farms, Inc. X Z1N-D	Grinnell Farms, Inc. X Z1	56.731	1477	6364	24386	500	59091						1477	6364	24386	500	59091										
55	Grinnell Farms, Inc. X Z1N-E	Grinnell Farms, Inc. X Z1	11.822	176	1338	3060	176	8777	183	1487	4921	183	21305	174	1296	2535	174	5246	2	42	525	2	3531	0.011588	0.032405	0.206963	0.011588	0.673055
56	Grinnell Farms, Inc. X Z1S-E	Hensel & Rodgers X Z1N	306.203	2550	14856	45565	1885	108647	2587	15098	46763	1901	110309	1526	10372	27658	1229	64837	438	1953	7894	278	18788	0.287028	0.188250	0.285421	0.226049	0.289776
57 (3)	Marsell X Z1N-E	Marsell X Z1N-E	13.332	2338	18506	50682	2305	25325	3447	23343	64878	3385	32512	1420	8476	25273	1425	14065	698	5114	13624	674	6346	0.491355	0.603346	0.539086	0.473194	0.451175
58	Marsell X Z1S-E	Marsell X Z1S-E	21.502	76	78	234	78	3796						76	78	234	78	3796										
59	NAPA X Z1N-B	NAPA X Z1N-B	34.135	922	14446	19054	2740	21420						922	14446	19054	2740	21420										
60	Smith X ZNE-A	Smith X ZNE-A	29.283	418	5529	13463	525	38703	479	7278	18055	680	46523	347	4131	10880	440	32414	45	1082	2468	83	4854	0.130556	0.262008	0.228868	0.187892	0.149737
61 (4)	Smith X none			186	352	730	189	9313						186	352	730	189	9313										

62	Shortz X Z1N-B1	Shortz X Z1N-B1	24.043	540	12468	24416	935	6234						540	12468	24416	935	6234										
63	Shortz X Z1N-B2	Shortz X Z1N-B2	15.771	1102	6061	15152	1102	8540						1102	6061	15152	1102	8540										
64	Rice X Z1N-D2	Rice X Z1N-D2	13.644	73	455	648	73	3636						73	455	648	73	3636										
65	Rice X Z1N-D1	Rice X Z1N-D1	4.760	102	1445	2051	101	5124	226	2015	3019	222	10409	68	1285	1779	67	3634	35	161	273	34	1490	0.516939	0.125041	0.153356	0.510956	0.409913
66	Zellwood Drainage District X ZSW-C	Zellwood Drainage Distric	9.589	436	5396	7915	652	21782	522	14196	19636	1036	38484	411	2916	4611	544	17074	24	2480	3304	108	4708	0.059467	0.850602	0.716550	0.198966	0.275720
67	General Impex X Z1N-G	General Impex X Z1N-G	24.466	94	6288	8652	91	7576						94	6288	8652	91	7576						0	0	0	0	0
68	Shaffer X Z1S-E	Shaffer X Z1S-E	11.916	126	125	374	125	6324						126	125	374	125	6324										
69	Progressive Growers (Rice) X Z1N-E	Progressive Growers (Ric	1.278	860	843	2529	843	42975						860	843	2529	843	42975										
70	Bates X Z1N-E	Bates X Z1N-E	6.352	32	1451	3611	33	3095						32	1451	3611	33	3095										
71 (5)	Mulford Hickerson c/o Peat Hummus	Corp X ZNE-F		227	1686	2279	227	11373						227	1686	2279	227	11373										
																								0.205557	0.206165	0.222414	0.188817	0.192464

Indicates only one sample in block

(1) There are two different values for this plot, used the summation of the two as the value

(2) There is not acreage value for this owner x alum block

(3) There are two different values for this plot, used the summation of the two as the value

(4) There is no acreage value for this combination of owner x block

(5) There is no acreage value for this owner x alum block

172.964

Owner X Alum

		Flooding Block		Critical	% Reduction Needed			Portion of Flooding Block Exceeding Criteria		
OWNER X ALUM	Acres	FB	Depth	Contaminant	Low		High	Low		High
Stroup Farms X ZSC-B	79	FB1	3	Dieldrin	0%	-	40%			
Lust Farms X ZSC-C	242	FB1	3	Toxaphene	0%	-	31%			
Crakes & Son, Inc. X ZSW-B	95	FB1	3	DDE	0%	-	12%			
Zellwin Farms X ZSW-A	113	FB1	3							
Stroup Farms X ZSW-C	81	FB1	3							
Clarence Beall X ZSC-A	62	FB1	3							
Zellwood Drainage District X ZSW-C	10	FB1	3							
Flooding Block Total	**680**					<	**415**		<	**61%**
Grinnell Farms, Inc. X Z1S-E	41	FB10	1	DDTx	18%	-	75%			
Zellwin Farms X Z1S-E	214	FB10	1	DDTx	0%	-	65%			
Zellwin Farms X Z1S-D	308	FB10	1	Toxaphene	3%	-	61%			
Long Farms, Inc. X Z1S-E	45	FB10	1							
Marsell X Z1S-E	22	FB10	1							
Shaffer X Z1S-E	12	FB10	1							
Flooding Block Total	**907**				**614**	-	**828**	**68%**	-	**91%**
Zellwin Farms X Z1S-C	314	FB11	2	Toxaphene	13%	-	62%			
Zellwin Farms X Z1S-A	329	FB11	2	Toxaphene	0%	-	58%			
Zellwin Farms X Z1S-B	308	FB11	2	Toxaphene	0%	-	57%			
Flooding Block Total	**952**				**314**	-	**952**	**33%**	-	**100%**
Hensel & Rodgers X Z1N-A	306	FB12	0.5	DDE	0%		64%			
Flooding Block Total	**306**								<	**100%**
Robert Potter & Sons, Inc. X Z1N-F	308	FB13	0.5	Toxaphene	22%	-	69%			
Long Farms, Inc. X Z1N-C	159	FB13	0.5	DDTx	9%	-	69%			
Zellwin Farms X Z1N-D	75	FB13	0.5	DDTx	9%	-	69%			
Grinnell Farms, Inc. X Z1N-D	57	FB13	0.5	DDTx	7%	-	54%			
Rice X Z1N-D2	14	FB13	0.5							
Rice X Z1N-D1	5	FB13	0.5							
Flooding Block Total	**618**				**599**	-	**599**	**97%**	-	**97%**
Zellwin Farms X Z1N-E	96	FB14	0.5	DDTx	57%	-	85%			
Marsell X Z1N-E	13	FB14	0.5	DDTx	11%	-	78%			
Zellwin Farms X Z1N-G	198	FB14	0.5	Toxaphene	4%	-	64%			
Grinnell Farms, Inc. X Z1N-E	12	FB14	0.5							
General Impex X Z1N-G	24	FB14	0.5							
Bates X Z1N-E	6	FB14	0.5							
Flooding Block Total	**350**				**308**	-	**308**	**88%**	-	**88%**
Clarence Beall X ZNW-B	75	FB2	3	DDE	0%	-	67%			

		Flooding Block			% Reduction Needed			Portion of Flooding Block Exceeding Criteria		
Zellwin Farms X ZNW-A	322	FB2	3	Toxaphene	0%	-	10%			
Zellwin Farms X ZNW-B	211	FB2	3	Toxaphene	0%	-	4%			
Zellwin Farms X ZNW-C	250	FB2	3							
Flooding Block Total	**859**						**609**		**<**	**71%**
Zellwin Farms X ZNC-A	333	FB3	2	Toxaphene	0%	-	5%			
Flooding Block Total										
Clarence Beall X ZNC-B	151	FB4	2	Dieldrin	0%	-	28%			
Crakes & Son, Inc. X ZNC-B	156	FB4	2	Toxaphene	0%	-	18%			
Flooding Block Total	**307**									
Crakes & Son, Inc. X ZNE-A2	77	FB5	1.5 TO 2	DDTx	68%	-	91%			
Lust Farms X ZNE-C	75	FB5	1.5 TO 2	Toxaphene	0%	-	63%			
Long Farms, Inc. X ZNE-A1	19	FB5	1.5 TO 2	DDTx	0%	-	62%			
Lust Farms X ZNE-A	40	FB5	1.5 TO 2	Toxaphene	0%	-	47%			
Crakes & Son, Inc. X ZNE-A1	20	FB5	1.5 TO 2	DDTx	0%	-	36%			
Crakes & Son, Inc. X ZNE-C	74	FB5	1.5 TO 2	DDTx	0%	-	33%			
Long Farms, Inc. X ZNE-A2	357	FB5	1.5 TO 2	Toxaphene	0%	-	31%			
Stroup Farms X ZNE-A	76	FB5	1.5 TO 2	Toxaphene	0%	-	29%			
Lust Farms X ZNE-B	264	FB5	1.5 TO 2							
Smith X ZNE-A	29	FB5	1.5 TO 2							
Smith X none		FB5	1.5 TO 2							
Flooding Block Total	**1030**				**77**	**-**	**737**	**7%**	**-**	**72%**
Lust Farms X ZSE-A	157	FB6	2	Toxaphene	14%	-	74%			
Zellwin Farms X ZSE-I	247	FB6	2	Toxaphene	20%	-	73%			
Zellwin Farms X ZSE-J	143	FB6	2	Toxaphene	0%	-	56%			
Long Farms, Inc. X ZSE-A	182	FB6	2	Toxaphene	0%	-	8%			
Clonts Farm X ZSE-B	299	FB6	2							
Clonts Farm X ZSE-C	100	FB6	2							
Clonts Farm X ZSE-G	152	FB6	2							
Clonts Farm X ZSE-H	29	FB6	2							
Flooding Block Total	**1309**				**404**		**729**	**31%**	**-**	**56%**
Lust Farms X ZSE-F	223	FB7	2	Toxaphene	0%	-	44%			
Lust Farms X ZSE-D	316	FB7	2	Toxaphene	0%	-	42%			
Stroup Farms X ZSE-E	148	FB7	2	Toxaphene	0%	-	22%			
Flooding Block Total	**687**				**0**		**687**		**<**	**100%**
Crakes & Son, Inc. X ZNE-D	59	FB8	2	DDTx	34%	-	78%			
Long Farms, Inc. X ZNE-F	40	FB8	2	Toxaphene	7%	-	74%			
Long Farms, Inc. X ZNE-D2	47	FB8	2	Toxaphene	0%	-	55%			
Long Farms, Inc. X ZNE-E	73	FB8	2	Toxaphene	0%	-	54%			

		Flooding Block			% Reduction Needed			Portion of Flooding Block Exceeding Criteria		
Long Farms, Inc. X ZNE-D1	65	FB8	2	Toxaphene	0%	-	48%			
Lust & Long Precooler X ZNE-F	68	FB8	2	Toxaphene	0%	-	28%			
Lust Farms X ZNE-D	51	FB8	2							
Mulford Hickerson c/o Peat Hummus Corp X ZNE-F	120	FB8	2							
Flooding Block Total	**454**				**99**	**-**	**284**	**22%**	**-**	**62%**
Shortz X Z1N-B1	24	NFB		DDTx	7%	-	54%			
NAPA X Z1N-B	34	NFB		DDE	7%	-	54%			
Progressive Growers (Rice) X Z1N-B	1	NFB		Toxaphene	0%	-	26%			
Shortz X Z1N-B2	16	NFB		DDTx	0%	-	25%			

Appendix B
Costing

Soil Density Variability

Appendix B - APOPKA NSRA SOIL DENSITY VARIATION TONS/CY and COST

ESTIMATED $/TON	0-1 FT DEPTH CY/ACRE	TON/ACRE 0.4	0.5	0.55	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5	1.6
	1														
$5	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$6	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$7	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$8	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$9	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$10	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$11	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$12	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$13	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$14	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$15	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$16	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$17	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$18	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$19	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$20	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$21	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$22	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$23	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$24	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$25	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$26	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$27	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$28	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$29	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$30	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$31	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$32	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$33	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$34	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$35	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$36	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$37	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$38	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$39	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$40	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$41	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$42	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$43	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$44	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$45	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$46	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$47	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$48	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$49	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$50	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$51	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$52	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$53	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$54	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$55	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$56	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$57	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$58	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$59	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$60	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$61	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$62	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$63	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$64	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$65	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$66	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$67	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$68	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$69	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$70	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$71	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$72	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$73	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$74	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581
$75	1613	645	807	887	968	1129	1291	1452	1613	1775	1936	2097	2259	2420	2581

ESTIMATED $/TON	$/ACRE 0.4	0.5	0.55	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5	1.6
$5	$3,227	$4,033	$4,437	$4,840	$5,647	$6,453	$7,260	$8,067	$8,873	$9,680	$10,487	$11,293	$12,100	$12,907
$6	$3,872	$4,840	$5,324	$5,808	$6,776	$7,744	$8,712	$9,680	$10,648	$11,616	$12,584	$13,552	$14,520	$15,488
$7	$4,517	$5,647	$6,211	$6,776	$7,905	$9,035	$10,164	$11,293	$12,423	$13,552	$14,681	$15,811	$16,940	$18,069
$8	$5,163	$6,453	$7,099	$7,744	$9,035	$10,325	$11,616	$12,907	$14,197	$15,488	$16,779	$18,069	$19,360	$20,651
$9	$5,808	$7,260	$7,986	$8,712	$10,164	$11,616	$13,068	$14,520	$15,972	$17,424	$18,876	$20,328	$21,780	$23,232
$10	$6,453	$8,067	$8,873	$9,680	$11,293	$12,907	$14,520	$16,133	$17,747	$19,360	$20,973	$22,587	$24,200	$25,813
$11	$7,099	$8,873	$9,761	$10,648	$12,423	$14,197	$15,972	$17,747	$19,521	$21,296	$23,071	$24,845	$26,620	$28,395
$12	$7,744	$9,680	$10,648	$11,616	$13,552	$15,488	$17,424	$19,360	$21,296	$23,232	$25,168	$27,104	$29,040	$30,976
$13	$8,389	$10,487	$11,535	$12,584	$14,681	$16,779	$18,876	$20,973	$23,071	$25,168	$27,265	$29,363	$31,460	$33,557
$14	$9,035	$11,293	$12,423	$13,552	$15,811	$18,069	$20,328	$22,587	$24,845	$27,104	$29,363	$31,621	$33,880	$36,139
$15	$9,680	$12,100	$13,310	$14,520	$16,940	$19,360	$21,780	$24,200	$26,620	$29,040	$31,460	$33,880	$36,300	$38,720
$16	$10,325	$12,907	$14,197	$15,488	$18,069	$20,651	$23,232	$25,813	$28,395	$30,976	$33,557	$36,139	$38,720	$41,301
$17	$10,971	$13,713	$15,085	$16,456	$19,199	$21,941	$24,684	$27,427	$30,169	$32,912	$35,655	$38,397	$41,140	$43,883
$18	$11,616	$14,520	$15,972	$17,424	$20,328	$23,232	$26,136	$29,040	$31,944	$34,848	$37,752	$40,656	$43,560	$46,464
$19	$12,261	$15,327	$16,859	$18,392	$21,457	$24,523	$27,588	$30,653	$33,719	$36,784	$39,849	$42,915	$45,980	$49,045
$20	$12,907	$16,133	$17,747	$19,360	$22,587	$25,813	$29,040	$32,267	$35,493	$38,720	$41,947	$45,173	$48,400	$51,627
$21	$13,552	$16,940	$18,634	$20,328	$23,716	$27,104	$30,492	$33,880	$37,268	$40,656	$44,044	$47,432	$50,820	$54,208
$22	$14,197	$17,747	$19,521	$21,296	$24,845	$28,395	$31,944	$35,493	$39,043	$42,592	$46,141	$49,691	$53,240	$56,789
$23	$14,843	$18,553	$20,409	$22,264	$25,975	$29,685	$33,396	$37,107	$40,817	$44,528	$48,239	$51,949	$55,660	$59,371
$24	$15,488	$19,360	$21,296	$23,232	$27,104	$30,976	$34,848	$38,720	$42,592	$46,464	$50,336	$54,208	$58,080	$61,952
$25	$16,133	$20,167	$22,183	$24,200	$28,233	$32,267	$36,300	$40,333	$44,367	$48,400	$52,433	$56,467	$60,500	$64,533
$26	$16,779	$20,973	$23,071	$25,168	$29,363	$33,557	$37,752	$41,947	$46,141	$50,336	$54,531	$58,725	$62,920	$67,115
$27	$17,424	$21,780	$23,958	$26,136	$30,492	$34,848	$39,204	$43,560	$47,916	$52,272	$56,628	$60,984	$65,340	$69,696
$28	$18,069	$22,587	$24,845	$27,104	$31,621	$36,139	$40,656	$45,173	$49,691	$54,208	$58,725	$63,243	$67,760	$72,277
$29	$18,715	$23,393	$25,733	$28,072	$32,751	$37,429	$42,108	$46,787	$51,465	$56,144	$60,823	$65,501	$70,180	$74,859
$30	$19,360	$24,200	$26,620	$29,040	$33,880	$38,720	$43,560	$48,400	$53,240	$58,080	$62,920	$67,760	$72,600	$77,440
$31	$20,005	$25,007	$27,507	$30,008	$35,009	$40,011	$45,012	$50,013	$55,015	$60,016	$65,017	$70,019	$75,020	$80,021
$32	$20,651	$25,813	$28,395	$30,976	$36,139	$41,301	$46,464	$51,627	$56,789	$61,952	$67,115	$72,277	$77,440	$82,603
$33	$21,296	$26,620	$29,282	$31,944	$37,268	$42,592	$47,916	$53,240	$58,564	$63,888	$69,212	$74,536	$79,860	$85,184
$34	$21,941	$27,427	$30,169	$32,912	$38,397	$43,883	$49,368	$54,853	$60,339	$65,824	$71,309	$76,795	$82,280	$87,765
$35	$22,587	$28,233	$31,057	$33,880	$39,527	$45,173	$50,820	$56,467	$62,113	$67,760	$73,407	$79,053	$84,700	$90,347
$36	$23,232	$29,040	$31,944	$34,848	$40,656	$46,464	$52,272	$58,080	$63,888	$69,696	$75,504	$81,312	$87,120	$92,928
$37	$23,877	$29,847	$32,831	$35,816	$41,785	$47,755	$53,724	$59,693	$65,663	$71,632	$77,601	$83,571	$89,540	$95,509
$38	$24,523	$30,653	$33,719	$36,784	$42,915	$49,045	$55,176	$61,307	$67,437	$73,568	$79,699	$85,829	$91,960	$98,091
$39	$25,168	$31,460	$34,606	$37,752	$44,044	$50,336	$56,628	$62,920	$69,212	$75,504	$81,796	$88,088	$94,380	$100,672
$40	$25,813	$32,267	$35,493	$38,720	$45,173	$51,627	$58,080	$64,533	$70,987	$77,440	$83,893	$90,347	$96,800	$103,253
$41	$26,459	$33,073	$36,381	$39,688	$46,303	$52,917	$59,532	$66,147	$72,761	$79,376	$85,991	$92,605	$99,220	$105,835
$42	$27,104	$33,880	$37,268	$40,656	$47,432	$54,208	$60,984	$67,760	$74,536	$81,312	$88,088	$94,864	$101,640	$108,416
$43	$27,749	$34,687	$38,155	$41,624	$48,561	$55,499	$62,436	$69,373	$76,311	$83,248	$90,185	$97,123	$104,060	$110,997
$44	$28,395	$35,493	$39,043	$42,592	$49,691	$56,789	$63,888	$70,987	$78,085	$85,184	$92,283	$99,381	$106,480	$113,579
$45	$29,040	$36,300	$39,930	$43,560	$50,820	$58,080	$65,340	$72,600	$79,860	$87,120	$94,380	$101,640	$108,900	$116,160
$46	$29,685	$37,107	$40,817	$44,528	$51,949	$59,371	$66,792	$74,213	$81,635	$89,056	$96,477	$103,899	$111,320	$118,741
$47	$30,331	$37,913	$41,705	$45,496	$53,079	$60,661	$68,244	$75,827	$83,409	$90,992	$98,575	$106,157	$113,740	$121,323
$48	$30,976	$38,720	$42,592	$46,464	$54,208	$61,952	$69,696	$77,440	$85,184	$92,928	$100,672	$108,416	$116,160	$123,904
$49	$31,621	$39,527	$43,479	$47,432	$55,337	$63,243	$71,148	$79,053	$86,959	$94,864	$102,769	$110,675	$118,580	$126,485
$50	$32,267	$40,333	$44,367	$48,400	$56,467	$64,533	$72,600	$80,667	$88,733	$96,800	$104,867	$112,933	$121,000	$129,067
$51	$32,912	$41,140	$45,254	$49,368	$57,596	$65,824	$74,052	$82,280	$90,508	$98,736	$106,964	$115,192	$123,420	$131,648
$52	$33,557	$41,947	$46,141	$50,336	$58,725	$67,115	$75,504	$83,893	$92,283	$100,672	$109,061	$117,451	$125,840	$134,229
$53	$34,203	$42,753	$47,029	$51,304	$59,855	$68,405	$76,956	$85,507	$94,057	$102,608	$111,159	$119,709	$128,260	$136,811
$54	$34,848	$43,560	$47,916	$52,272	$60,984	$69,696	$78,408	$87,120	$95,832	$104,544	$113,256	$121,968	$130,680	$139,392
$55	$35,493	$44,367	$48,803	$53,240	$62,113	$70,987	$79,860	$88,733	$97,607	$106,480	$115,353	$124,227	$133,100	$141,973
$56	$36,139	$45,173	$49,691	$54,208	$63,243	$72,277	$81,312	$90,347	$99,381	$108,416	$117,451	$126,485	$135,520	$144,555
$57	$36,784	$45,980	$50,578	$55,176	$64,372	$73,568	$82,764	$91,960	$101,156	$110,352	$119,548	$128,744	$137,940	$147,136
$58	$37,429	$46,787	$51,465	$56,144	$65,501	$74,859	$84,216	$93,573	$102,931	$112,288	$121,645	$131,003	$140,360	$149,717
$59	$38,075	$47,593	$52,353	$57,112	$66,631	$76,149	$85,668	$95,187	$104,705	$114,224	$123,743	$133,261	$142,780	$152,299
$60	$38,720	$48,400	$53,240	$58,080	$67,760	$77,440	$87,120	$96,800	$106,480	$116,160	$125,840	$135,520	$145,200	$154,880
$61	$39,365	$49,207	$54,127	$59,048	$68,889	$78,731	$88,572	$98,413	$108,255	$118,096	$127,937	$137,779	$147,620	$157,461
$62	$40,011	$50,013	$55,015	$60,016	$70,019	$80,021	$90,024	$100,027	$110,029	$120,032	$130,035	$140,037	$150,040	$160,043
$63	$40,656	$50,820	$55,902	$60,984	$71,148	$81,312	$91,476	$101,640	$111,804	$121,968	$132,132	$142,296	$152,460	$162,624
$64	$41,301	$51,627	$56,789	$61,952	$72,277	$82,603	$92,928	$103,253	$113,579	$123,904	$134,229	$144,555	$154,880	$165,205
$65	$41,947	$52,433	$57,677	$62,920	$73,407	$83,893	$94,380	$104,867	$115,353	$125,840	$136,327	$146,813	$157,300	$167,787
$66	$42,592	$53,240	$58,564	$63,888	$74,536	$85,184	$95,832	$106,480	$117,128	$127,776	$138,424	$149,072	$159,720	$170,368
$67	$43,237	$54,047	$59,451	$64,856	$75,665	$86,475	$97,284	$108,093	$118,903	$129,712	$140,521	$151,331	$162,140	$172,949
$68	$43,883	$54,853	$60,339	$65,824	$76,795	$87,765	$98,736	$109,707	$120,677	$131,648	$142,619	$153,589	$164,560	$175,531
$69	$44,528	$55,660	$61,226	$66,792	$77,924	$89,056	$100,188	$111,320	$122,452	$133,584	$144,716	$155,848	$166,980	$178,112
$70	$45,173	$56,467	$62,113	$67,760	$79,053	$90,347	$101,640	$112,933	$124,227	$135,520	$146,813	$158,107	$169,400	$180,693
$71	$45,819	$57,273	$63,001	$68,728	$80,183	$91,637	$103,092	$114,547	$126,001	$137,456	$148,911	$160,365	$171,820	$183,275
$72	$46,464	$58,080	$63,888	$69,696	$81,312	$92,928	$104,544	$116,160	$127,776	$139,392	$151,008	$162,624	$174,240	$185,856
$73	$47,109	$58,887	$64,775	$70,664	$82,441	$94,219	$105,996	$117,773	$129,551	$141,328	$153,105	$164,883	$176,660	$188,437
$74	$47,755	$59,693	$65,663	$71,632	$83,571	$95,509	$107,448	$119,387	$131,325	$143,264	$155,203	$167,141	$179,080	$191,019
$75	$48,400	$60,500	$66,550	$72,600	$84,700	$96,800	$108,900	$121,000	$133,100	$145,200	$157,300	$169,400	$181,500	$193,600

Source: MACTEC, 2004.

Costs of Fields and Treatments

soil required to make the following leaves
all 1:1 side slopes

hight of levee (ft	road width on top (ft)	volume of soil required per linear foot of levee (ft^3)	volume of soil required per linear foot of levee (yd^3)	volume to build perimeter per acre (yd^3)
3	10	39	1.44	1205.91
4	0	16	0.59	494.73
5	0	25	0.93	773.02
6	0	36	1.33	1113.15
7	0	49	1.81	1515.12
8	0	64	2.37	1978.93
9	0	81	3.00	2504.58
10	0	100	3.70	3092.07
3	15	54	2.00	1669.72
4	10	56	2.07	1731.56
5	10	75	2.78	2319.06
6	10	96	3.56	2968.39
7	10	119	4.41	3679.57
8	10	144	5.33	4452.59
9	10	171	6.33	5287.45
10	10	200	7.41	6184.15
3	20	69	2.56	2133.53
4	10	56	2.07	1731.56
5	10	75	2.78	2319.06
6	10	96	3.56	2968.39
7	10	119	4.41	3679.57
8	10	144	5.33	4452.59
9	10	171	6.33	5287.45
10	10	200	7.41	6184.15

Dike Cost Basis vs Size

A 1-ft dike is estimated to be half the cost of the 3 foot dike (my data has 3, 4, 5, and 6). The costs a

The dikes should be proposed to be built from the clean material and will most likely need to be a mi

1 foot 3 ft^3 of soil per foot of dike or 2,502 ft^3 of soil per acre or 92.67 yd^3 per acre
2 foot 10 ft^3 of soil per foot of dike or 8,340 ft^3 of soil per acre or 308.89 yd^3 per acre
3 foot 21 ft^3 of soil per foot of dike or 17,514 ft^3 of soil per acre or 648.67 yd^3 per acre
4 foot 36 ft^3 of soil per foot of dike or 30,024 ft^3 of soil per acre or 1,112 yd^3 per acre

Also these may need filter cloth @ 2.75 per yd^2 so:

1 foot 8 ft^2 per foot of dike or 741 yd^2 of filter cloth per acre
2 foot 9 ft^2 per foot of dike or 834 yd^2 of filter cloth per acre
3 foot 11.5 ft^2 per foot of dike or 1,066 yd^2 of filter cloth per acre
4 foot 14.5 ft^2 per foot of dike or 1,344 yd^2 of filter cloth per acre

SOIL INVERSION COST BASIS

RATE	1	20	2	125	AC/DAY	DAYS	2206 6915	HTL LTL			HALF PROD. 2	0.25	
CAPITAL EQUIPMENT	MOB/DEMOB	LABOR	FUEL	PER DIEM	PRODUCTIVITY	DAYS	ACRES		TOTAL	$/AC AVG	X 2	+ CONTINGENCY	TOTAL $
810800	70000	176480	441200	27575	10	221	2206		$1,526,055	$692	$1,383.55	$1,729	$3,815,138
810800	70000	345750	864375	54023	16	432	6915		$2,144,948	$310	$620.38	$775	$5,362,371
810800	70000	352960	882400	55150	5	441	2206		$2,171,310	$984	$1,968.55	$2,461	$5,428,275
810800	70000	691500	1728750	108047	8	864	6915		$3,409,097	$493	$986.00	$1,233	$8,522,742

4 semi-loads EQUIPMENT FOR MOB/DEMOB

emk 7-29-04 Based on communications with J. Allen, Allen Machine & Equipment
Contractor multi-step process assumed to be 95-98 percent effective for flipping.

PILOT PROGRAM ESTIMATE 3-4 weeks 75-100 ac 16-18HR DAYS WITH 5 MAN CREW

187500	70000	24000	60000	3750	10	30	75	$345,250
250000	70000	24000	60000	3750	16	30	100	$407,750
187500	70000	24000	60000	3750	5	30	75	$345,250
250000	70000	24000	60000	3750	8	30	100	$407,750

Bio and Soilsavers $/acre

	$/ton																						
ton/ac	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
800	6400	7200	8000	8800	9600	10400	11200	12000	12800	13600	14400	15200	16000	16800	17600	18400	19200	20000	20800	21600	22400	23200	24000
900	7200	8100	9000	9900	10800	11700	12600	13500	14400	15300	16200	17100	18000	18900	19800	20700	21600	22500	23400	24300	25200	26100	27000
1000	8000	9000	10000	11000	12000	13000	14000	15000	16000	17000	18000	19000	20000	21000	22000	23000	24000	25000	26000	27000	28000	29000	30000
1100	8800	9900	11000	12100	13200	14300	15400	16500	17600	18700	19800	20900	22000	23100	24200	25300	26400	27500	28600	29700	30800	31900	33000
1200	9600	10800	12000	13200	14400	15600	16800	18000	19200	20400	21600	22800	24000	25200	26400	27600	28800	30000	31200	32400	33600	34800	36000
1300	10400	11700	13000	14300	15600	16900	18200	19500	20800	22100	23400	24700	26000	27300	28600	29900	31200	32500	33800	35100	36400	37700	39000
1400	11200	12600	14000	15400	16800	18200	19600	21000	22400	23800	25200	26600	28000	29400	30800	32200	33600	35000	36400	37800	39200	40600	42000
1500	12000	13500	15000	16500	18000	19500	21000	22500	24000	25500	27000	28500	30000	31500	33000	34500	36000	37500	39000	40500	42000	43500	45000
1600	12800	14400	16000	17600	19200	20800	22400	24000	25600	27200	28800	30400	32000	33600	35200	36800	38400	40000	41600	43200	44800	46400	48000
1700	13600	15300	17000	18700	20400	22100	23800	25500	27200	28900	30600	32300	34000	35700	37400	39100	40800	42500	44200	45900	47600	49300	51000
1800	14400	16200	18000	19800	21600	23400	25200	27000	28800	30600	32400	34200	36000	37800	39600	41400	43200	45000	46800	48600	50400	52200	54000
1900	15200	17100	19000	20900	22800	24700	26600	28500	30400	32300	34200	36100	38000	39900	41800	43700	45600	47500	49400	51300	53200	55100	57000
2000	16000	18000	20000	22000	24000	26000	28000	30000	32000	34000	36000	38000	40000	42000	44000	46000	48000	50000	52000	54000	56000	58000	60000

Lake Apopka Earthmoving - Construction Unit Cost
Cost

Element	Activity	Unit	C Unit Cost	D Unit Cost	E Unit Cost	F Unit Cost	G Unit Cost	H Unit Cost	I Unit Cost	J Unit Cost	K Unit Cost	Unit Cost	L Unit Cost
1	Drum Chopping-Marsh Dozer	ac	29.98	29.98	29.98	29.98	29.98	29.98	29.98	29.98	29.98	29.98	29.98
2	Marsh and Upland -Tractor/Skidder	ac	46	46	46	46	46	46	46	46	46	46	46
3	Medium Site Clearing	ac	619	619	619	619	619	619	619	619	619	619	619
4	Mowing-batwing	ac	10	10	10	10	10	10	10	10	10	10	10
5	Mowing - service	ac	30	30	30	30	30	30	30	30	30	30	30
6	Mowing - slope	ac	40	40	40	40	40	40	40	40	40	40	40
7	Clear light brush no grubbing	ac	281	281	281	281	281	281	281	281	281	281	281
8	Clear and Grub Light trees	ac	1,790	1,790	1,790	1,790	1,790	1,790	1,790	1,790	1,790	1,790	1,790
9	Stack light brush and Chip	ac	896	896	896	896	896	896	896	896	896	896	896
10	Presribed Burn	ac	18	18	18	18	18	18	18	18	18	18	18
11	Silt Fence 36 inch	ac	2,502	2,502	2,502	2,502	2,502	2,502	2,502	2,502	2,502	2,502	2,502
12	Dike construction 2 ft high	ac	3,336	3,336	3,336	3,336	3,336	3,336	3,336	3,336	3,336	3,336	3,336
13	Dike construction 4 ft high	ac	5,004	5,004	5,004	5,004	5,004	5,004	5,004	5,004	5,004	5,004	5,004
14	Rotoclear scarification	ac	600	600	600	600	600	600	600	600	600	600	600
15	Soil Flipping / Plowing	ac	350	350	350	2,500	2,500	350	350	350	350	350	2,500
16	Deep Tilling (2 ft)	ac	600	600	600	1,700	1,700	600	600	600	600	600	1,700
17	Shallow Tilling (1 ft)	ac	350	350	350	350	350	350	350	350	350	350	350
18	Rough Grade w/ D-7 Dozer	ac	11,036	11,036	11,036	11,036	11,036	11,036	11,036	11,036	11,036	11,036	11,036
19	Rock/Soil Screening Plant	hr	229	229	229	229	229	229	229	229	229	229	229
20	Amendment spreading	ac	72	72	72	72	72	72	72	72	72	72	72
21	Routine Upland surface 1-ft excavation	cu yd	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800
22	D-9N Dozer excavation	ac	6,970	6,970	6,970	6,970	6,970	6,970	6,970	6,970	6,970	6,970	6,970
23	Scraper Excavation	ac	4,776	4,776	4,776	4,776	4,776	4,776	4,776	4,776	4,776	4,776	4,776
24	Load soil and Haul	ac	12,907	12,907	12,907	12,907	12,907	12,907	12,907	12,907	12,907	12,907	111,958
25	spread dumped fill w/ compaction	ac	1,902	1,902	1,902	1,902	1,902	1,902	1,902	1,902	1,902	1,902	1,902
26	spread dumped fill w/o compaction	ac	1,162	1,162	1,162	1,162	1,162	1,162	1,162	1,162	1,162	1,162	1,162
27	5 ton static roller	ac	5,550	5,550	5,550	5,550	5,550	5,550	5,550	5,550	5,550	5,550	5,550
28	7 ton vibratory roller	ac	3,872	3,872	3,872	3,872	3,872	3,872	3,872	3,872	3,872	3,872	3,872
29	25.5 ton vib sheepsfoot roller	ac	951	951	951	951	951	951	951	951	951	951	951
30	w/ crushed rock	cy	11	11	11	11	11	11	11	11	11	11	11
31	w/ lime slurry	ac	39,464	39,464	39,464	39,464	39,464	39,464	39,464	39,464	39,464	39,464	39,464
32	w/ cement	ton	20	20	20	20	20	20	20	20	20	20	20
33	40 mil PVC	ac	18,732	18,732	18,732	18,732	18,732	18,732	18,732	18,732	18,732	18,732	18,732
34	1 foot bentonite cap	ac	80,154	80,154	80,154	80,154	80,154	80,154	80,154	80,154	80,154	80,154	80,154
35	Hydroseeding	ac	2,250	2,250	2,250	2,250	2,250	2,250	2,250	2,250	2,250	2,250	2,250
	Process Subs								15,000	20,000	12,800	80,000	
	BETL Potential Total Field Area	ac	244	173	542	1975	2034	752	1024	289	248	173	248
	Total Prep & Process Subs Lookup	$/acre	**$9,381**	**$24,370**	**$7,294**	**$2,612**	**$2,710**	**$6,112**	**$17,982**	**$22,982**	**$34,719**	**$101,919**	**$118,578**

= included in $ / acre composite unit cost.

Table 6-1 Alternatives Relative Comparison Summary

Evaluation Factors and Criteria	No Action A	Limited Action B	Island Construction C	Soil Cover D	Berms Only E	Soil Layer Inversion F	Vertical Blending G	Horizontal Blending H	In Situ Landfarming I	Bioremediation J	Ex Situ Chemical Treatment K	Excavation/ Landfill Disposal L
AVIAN POPULATION PROTECTION												
Risk Eliminated	1	1	1	1	1	1	2	2	2	2	1	1
Risk Reduced or controlled	1	1	1	1	1	1	1	1	1	1	1	1
Short-term Effects		1	1	1	2	1	1	1	1	1	1	1
COMPLIANCE WITH REGULATORY REQUIREMENTS												
Compliance with chemical-specific requirements	1	1	1	1	1	1	1	1	1	1	1	1
Compliance with location -specific requirements	NO	NO	NO	NO	1	1	1	1	1	1	1	1
Compliance with action -specific requirements	1	1	1	1	1	1	1	1	1	1	1	1
LONG-TERM EFFECTIVENESS-PERMANENCE												
Magnitude of Residual Risk	6	6	5	5	5	3	4	4	2	2	1	1
Adequacy of Controls	5	5	4	4	4	1	2	3	2	2	1	1
Reliability of Controls	2	2	1	3	3	1	2	2	2	2	1	1
SHORT-TERM EFFECTIVENESS												
Protection of Avian Pop. During Rstoration	NA	NA	1	1	1	1	1	1	1	1	1	1
Protection of Community During Restoration	NA	NA	NA	1	1	1	1	1	1	1	1	1
Protection of Workers During Remedial Action	NA	1	1	1	1	1	1	1	1	1	1	1
IMPLEMENTABILITY												
Ability to Apply Technology	1	NA	1	1	1	1	1	1	1	1	1	1
Reliability of Technology	1	1-Monitor	1	1	1	1	1	1	1	1	1	1
Ease of undertaking additonal Remedial Action if Needed	1	1	1	1	1	1	1	1	1	1	1	1
Coordination with Other Agencies	1	1	1	1	1	1	1	1	1	1	1	1
COST												
Capital	2	2	3	4	3	1	1	2	3	4	5	6
O&M	3	3	1	2	1	NA	NA	NA	1	NA	NA	NA
OVERALL ALTERNATIVE RANKING	26	26	25	30	30	19	23	25	24	24	21	22
	5	5	4	6	6	1	2	4	3	3	NA	NA
			LIMITED ACREAGE								LIMITED ACREAGE	LIMITED ACREAGE

Source: MACTEC, 2004.

Acres Est. $/Acre Basis										Total Field Area Prep Activities & Process Subs Lookup	ac $/acre	244 $9,381	173 $24,370	542 $7,294	1975 $2,612	2034 $2,710	752 $6,112	1024 $17,982	289 $22,982	248 $34,719	173 $101,919	248 $118,573
BEST ESTIMATE TARGET LEVEL - MINIMUM REMEDIAL ACTION COSTS										ALTERNATIVE		C	D	E	F	G	H	I	J	K		L
												Isolation/Containment Technologies						In situ Treatment		Ex Situ Treatment		
												Island construction	Soil Cover Capped soils	Berms alone to perched flooding	Soil layer inversion	Vertical blending	Horizontal blending	Landfarming -tilling with bio and/or chemical	Bioremediation-aerobic-anaerobic dechlorin	Soil reactor in situ chemical treatment (ISCO)	Low temperature thermal desorption	Excavate/Off-site Landfill Disposal
Order of Treatment	Block #	OWNER X ALUM	ACRES	FB	Depth	CN mg/kg	Critical Contaminant	% Reduction Low	High	Av. Conc. Critical Contaminant	% TOC											
1	41	Crakes & Son, Inc. X ZNE-A2	77	FB5	1.5 TO 2	10.7035	DDTx	68% -	91%	36375	47.74	719363	1868853					1378984	1782418	2662484	7815861	9093415
2	63	Zellwin Farms X Z1N-E	96	FB14	1	6.8365	DDTx	57% -	85%	12030	27.08		2346259	702243				1731251	2212036	3342639	9812454	11416384
4	24	Crakes & Son, Inc. X ZNE-D	59	FB8	2	4.6136	DDTx	34% -	78%	16450	48.43		1428660			158870		1054178	1347296	6267509		
8	56	Robert Potter & Sons, Inc. X Z1N-F	308	FB13	1	3.2609	Toxaphene	22% -	69%	26573	31.19				804409	834590		5637892	7077737			
1	2	Zellwin Farms X ZSE-I	247	FB6	2	3.7122	Toxaphene	20% -	73%	22939	31.99				645055	669257	1509375	4440630	5675030			
7	53	Grinnell Farms, Inc. X Z1S-E	41	FB10	1	4.0323	DDTx	18% -	75%	9600	31.03				108023	110001	248085	729907	932862	1409278		4813212
2	10	Lust Farms X ZSE-A	157	FB6	2	3.8798	Toxaphene	14% -	74%	29790	39.88				409373	424732	957890	2816298	3601843			
5	48	Zellwin Farms X Z1S-C	314	FB11	2	2.6329	Toxaphene	13% -	62%	25333	33.23				821220	852091		5653624	7225840			
14	64 (3)	Marsell X Z1N-E	13	FB14	1	4.4651	DDTx	11% -	78%	8207	30.43	125061		97243	34823	36129	81483	239736	306396			
12	62	Zellwin Farms X Z1N-D	75	FB13	1	3.2440	DDTx	9% -	69%	8813	35.57				196084	203441	458520	1348925	1725280			
10	58	Long Farms, Inc. X Z1N-C	159	FB13	1	3.2290	DDTx	9% -	69%	665	13.55				416237	431654	973961	2865554	3662330			
15	68	Shortz X Z1N-B1	24	NFB	tba	2.1607	DDE	7% -	46%	2400	19.25	225536			62800	65156		432341	552556			
3	13 (1)	Long Farms, Inc. X ZNE-F	40	FB8	2	3.7989	Toxaphene	7% -	74%	23250	35.88				104772	108703	245187	721293	921853			
11	59	Grinnell Farms, Inc. X Z1N-D	57	FB13	1	2.1581	DDTx	7% -	54%	10730	44.00				148150	153740		1020136	1303791			
13	69	NAPA X Z1N-B	34	NFB	tba	2.1561	DDE	7% -	54%	580	4.02	320294			89160	92505		613815	784490	1185132		4047871
9	55	Zellwin Farms X Z1N-G	198	FB14	1	2.7926	Toxaphene	4% -	64%	25224	32.41				517697	537121		3564046	4555051			
6	47	Zellwin Farms X Z1S-D	308	FB10	1	2.5693	Toxaphene	3% -	61%	25892	37.91				803709	833884		5533073	7071578			
		Total Acres	2207							Acres		148	232	110	1975	2034	732	2207	2207	248	173	248
										Alternative Cost		$1,390,163	$5,643,772	$799,486	$5,159,541	$5,511,994	$4,474,781	$39,684,881	$50,719,506	$8,599,544	$17,628,314	$29,370,662

	Acres										
	Est. $/Acre Basis										

Process Subs
Prep Activities & Process Subs Lookup

$/acre	$9,381	$24,370	$7,294	$2,612	$2,710	$6,112	15000 $17,982	$22,982	12800 $34,719	$116,578
ALTERNATIVE >>>	C	D	E	F	G	H	I	J	K	L
	Isolation/Containment Technologies						In situ Treatment		Ex situ Treatment	
	Bermed island construction	Soil Cover Capped soils	Berms alone to preclude flooding	Soil layer flipping	Vertical blending	Horizontal blending	Landfarming -tilling with bio and/or chemical	Bioremediation-aerobic-anaerobic dechlorinati	Soil reactor in situ chemical treatment (ISCO)	Low temperature thermal desorption

CONSERVATIVE TARGET LEVEL TREATMENT - MAXIMUM TREATMENT COSTS

	Block #	OWNER X ALUM	ACRES	Flooding Block FB	Depth	Critical Contaminant	% Reduction Low	High	Av. Conc. Crit. Cont	% TOC
1	41	Crakes & Son, Inc. X ZNE-A2	76.687	FB5	1.5 TO 2	DDTx	68% -	91%	36375	47.74
2	63	Zellwin Farms X Z1N-E	96.277	FB14	1	DDTx	57% -	85%	12030	27.08
3	24	Crakes & Son, Inc. X ZNE-D	58.624	FB8	2	DDTx	34% -	78%	16450	48.43
4	64 (3)	Mansell X Z1N-E	13.332	FB14	1	DDTx	11% -	78%	8207	30.43
5	53	Grinnell Farms, Inc. X Z1S-E	40.591	FB10	1	DDTx	18% -	76%	9600	31.03
6	10	Lust Farms X ZSE-A	156.729	FB6	2	Toxaphene	14% -	74%	29790	39.88
7	13 (1)	Long Farms, Inc. X ZNE-F	40.112	FB8	2	Toxaphene	7% -	74%	23250	35.88
8	2	Zellwin Farms X ZSE-I	246.950	FB6	2	Toxaphene	20% -	73%	22939	31.99
9	56	Robert Potter & Sons, Inc. X Z1N-F	307.969	FB13	1	Toxaphene	22% -	69%	26573	31.19
10	62	Zellwin Farms X Z1N-D	75.071	FB13	1	DDTx	9% -	69%	8813	35.57
11	58	Long Farms, Inc. X Z1N-C	159.357	FB13	1	DDTx	9% -	69%	665	13.55
12	33	Clarence Beall X ZNW-B	75.371	FB2	3	DDE	0% -	67%	2678	26.98
13	46	Zellwin Farms X Z1S-E	214.079	FB10	1	DDTx	0% -	65%	6910	41.25
14	55	Zellwin Farms X Z1N-G	198.201	FB14	1	Toxaphene	4% -	64%	25224	32.41
15	57	Hensel & Rodgers X Z1N-A	306.203	FB12	1	DDE	0% -	64%	269	2.09
16	17	Lust Farms X ZNE-C	75.425	FB5	1.5 TO 2	Toxaphene	0% -	63%	18900	38.84
17	43	Long Farms, Inc. X ZNE-A1	19.117	FB5	1.5 TO 2	DDTx	0% -	62%	5738	39.58
18	48	Zellwin Farms X Z1S-C	314.405	FB11	2	Toxaphene	13% -	62%	25333	33.23
19	47	Zellwin Farms X Z1S-D	307.701	FB10	1	Toxaphene	3% -	61%	25892	37.91
20	50	Zellwin Farms X Z1S-A	329.036	FB11	2	Toxaphene	0% -	57%	13708	25.80
21	49	Zellwin Farms X Z1S-B	308.098	FB11	2	Toxaphene	0% -	57%	15842	29.88
22	1	Zellwin Farms X ZSE-J	143.455	FB6	2	Toxaphene	0% -	56%	19353	40.28
23	16	Long Farms, Inc. X ZNE-D2	47.085	FB8	2	Toxaphene	0% -	55%	26167	43.49
24	23	Long Farms, Inc. X ZNE-E	73.439	FB8	2	Toxaphene	0% -	54%	24250	44.25
25	59	Grinnell Farms, Inc. X Z1N-D	56.731	FB13	1	DDTx	7% -	54%	10730	44.00
26	69	NAPA X Z1N-B	34.135	NFB		DDE	7% -	54%	580	4.02
27	14	Long Farms, Inc. X ZNE-D1	64.537	FB8	2	Toxaphene	0% -	48%	14786	30.84
28	20	Lust Farms X ZNE-A	39.893	FB5	1.5 TO 2	Toxaphene	0% -	68%	31667	52.58
29	68	Shortz X Z1N-B1	24.043	NFB		DDE	0% -	46%	2400	19.25
30	6	Lust Farms X ZSE-F	222.706	FB7	2	Toxaphene	0% -	44%	15266	35.58
31	9	Lust Farms X ZSE-D	316.043	FB7	2	Toxaphene	0% -	42%	17922	37.95
32	28	Stroup Farms X ZSC-B	78.596	FB1	3	Dieldrin	0% -	40%	798	39.73
33	44	Crakes & Son, Inc. X ZNE-A1	19.603	FB5	1.5 TO 2	DDTx	0% -	36%	5820	38.15
34	25	Crakes & Son, Inc. X ZNE-C	73.932	FB5	1.5 TO 2	DDTx	0% -	33%	6061	39.33
35	26	Long Farms, Inc. X ZNE-A2	356.644	FB5	1.5 TO 2	Toxaphene	0% -	31%	18316	48.32
36	27	Lust Farms X ZSC-C	242.009	FB1	3	Toxaphene	0% -	31%	12945	44.33
37	19	Stroup Farms X ZNE-A	75.694	FB5	1.5 TO 2	Toxaphene	0% -	29%	14338	44.71
38	39	Clarence Beall X ZNC-B	150.972	FB4	2	Dieldrin	0% -	28%	1188	38.59
39	7	Stroup Farms X ZSE-E	148.245	FB7	2	Toxaphene	0% -	22%	11157	38.85
40	42	Smith X ZNE-A	29.283	FB5	1.5 TO 2	Toxaphene	0% -	18%	11000	34.00
41	40	Crakes & Son, Inc. X ZNC-B	166.145	FB4	2	Toxaphene	0% -	18%	13103	39.90
42	32	Crakes & Son, Inc. X ZSW-B	94.714	FB1	3	DDE	0% -	12%	1163	30.80
43	35	Zellwin Farms X ZNW-A	321.842	FB2	3	Toxaphene	0% -	10%	12763	37.95
44	11	Long Farms, Inc. X ZSE-A	181.786	FB6	2	Toxaphene	0% -	8%	13725	47.84
45	38	Zellwin Farms X ZNC-A	332.688	FB3	2	Toxaphene	0% -	5%	10461	36.36
46	36	Zellwin Farms X ZNW-B	211.451	FB2	2	Toxaphene	0% -	4%	9639	34.63
		Total Acres	6916							

	C	D	E	F	G	H	I	J	K	L
1	$719,383	$1,868,853					$1,378,984	$1,782,418	$2,882,494	$9,093,415
2		$2,346,288	$702,243				$1,731,261	$2,213,639	$3,342,889	$11,418,384
3	$549,923	$1,428,860					$1,054,178	$1,347,288	$2,035,368	$6,881,636
4		$324,899	$97,243				$239,734	$306,394	$462,873	$1,560,858
5	$380,784	$989,198					$729,907	$932,862	$1,409,276	$4,813,217
6						$957,899	$2,818,298	$3,601,943	$5,441,471	$18,624,680
7						$245,157	$721,383	$921,963	$1,392,646	$4,756,413
8						$1,509,375	$4,440,830	$5,675,830	$8,574,199	$29,284,099
9							$5,537,892	$7,077,737	$10,692,370	$36,518,444
10							$1,349,925	$1,726,280	$2,606,399	$8,901,792
11							$2,865,564	$3,662,339	$5,532,713	$18,896,264
12						$460,654	$1,355,320	$1,732,175	$2,616,804	$8,937,300
13							$3,849,584	$4,919,959	$7,432,606	$25,385,126
14						$1,211,369	$3,564,049	$4,555,051	$6,881,337	$23,502,340
15							$5,506,136	$7,037,151	$10,631,056	$36,309,034
16							$1,356,291	$1,733,418	$2,618,679	$8,943,760
17							$343,762	$439,347	$663,723	$2,266,882
18						$1,921,587	$5,653,524	$7,225,649	$10,916,921	$37,281,614
19							$5,533,073	$7,071,678	$10,683,005	$36,486,895
20							$5,916,719	$7,561,899	$11,423,794	$39,016,933
21							$5,540,212	$7,080,702	$10,696,846	$36,533,740
22							$2,579,605	$3,296,880	$4,980,611	$17,010,851
23							$846,682	$1,082,107	$1,634,743	$5,583,300
24						$448,848	$1,320,579	$1,687,774	$2,549,727	$8,708,273
25							$1,020,136	$1,303,781	$1,969,643	$6,727,066
26						$208,627	$613,816	$784,480	$1,185,132	$4,047,671
27							$1,160,503	$1,483,186		$7,652,684
28							$717,355	$916,820		$4,730,445
29							$432,341	$552,558		$2,850,978
30					$603,526		$4,004,877	$5,118,202		$26,407,953
31					$856,470		$5,683,079	$7,263,294		$37,475,845
32					$212,994	$480,395	$1,413,312	$1,806,292		$9,319,781
33					$53,124		$352,501	$450,518		$2,324,491
34					$200,354	$451,859	$1,329,444	$1,699,104		$8,766,732
35				$931,547	$966,496	$2,179,744	$6,413,155	$8,196,335		$42,290,243
36				$632,123	$655,840		$4,351,801	$5,561,846		$28,697,016
37				$197,711	$205,128		$1,361,128	$1,739,588		$8,975,657
38				$394,336	$409,131		$2,714,778	$3,469,632		$17,902,008
39				$387,213	$401,741		$2,665,739	$3,406,954		$17,578,642
40				$76,487	$79,358	$178,973	$526,580	$673,001		$3,472,329
41				$407,848	$423,150		$2,807,799	$3,588,531		$18,515,410
42				$247,391	$256,673	$578,875	$1,703,148	$2,176,715		$11,231,026
43				$840,645	$872,185		$5,787,356	$7,396,566		$38,163,480
44				$474,821	$492,636	$1,111,043	$3,268,872	$4,177,802		$21,555,677
45				$868,974	$901,578		$5,982,380	$7,645,820		$39,449,581
46				$552,306	$573,024	$1,292,356	$3,802,306	$4,859,583		$25,073,802
Potential Acres	176	286	110	2301	3012	2166	6915	6915	3774	6915
Alternative Cost	$1,650,050	$6,957,869	$799,486	$6,011,401	$8,163,414	$13,236,723	$124,345,661	$158,920,736	$131,936,027	$819,970,792

Table 6-2 NSRA Soil Restoration Overall Alternatives Cost Summary

Target Level Basis and Reduction Levels	Field Group Acreage	No. Fields	Minimum Cost $	Average $/Acre (Minimum)	Maximum Cost $	Comments
BEST ESTIMATE						
Reduction >50%	173	2	$1,421,606	$8,219.08	$20,509,779	Pilot Location to determine if lower cost options feasible
20% < Reduction < 50%	614	3	$1,608,333	$2,621.34	$19,020,876	
Reduction <20%	1420	12	$3,710,077	$2,611.98	$39,787,320	Soil Inversion Demonstration required
Total to Achieve Best Estimate Target Levels	2207	17	$6,740,016	$3,054.03	$79,317,975	
CONSERVATIVE ESTIMATE						
Reduction >75%	245	4	$2,068,772	$8,446.73		Soil Inversion Demonstration required
75% < Reduction >50%	3529	22	$49,589,830	$14,051.02		
20% < Reduction < 50%	1813	13	$6,779,596	$3,739.61		Demonstrate Vertical Blending
Reduction <20%	1328	7	$3,468,472	$2,611.98		
Total to Achieve Conservative Estimate Target Levels	6915	46	$61,906,670	$8,952.50		

Source: MACTEC, 2004.

Minimum Treatment Table

FIELD ALTERNATIVE TREATMENT MATRIX

Block			Flooding Block		Critical	% Reduction			Av. Conc.		Isolation/Containment Technologies										Ex situ Treatment		
#	OWNER X ALUM	ACRES	FB	Depth	Contaminant	Low		High	Crit. Cont	% TOC	Bermed island construction	Capped soils	Surface sealing/compacting	Berms alone to perclude flooding	Soil layer flipping	Vertical blending	Horizontal blending	Soil removed used for berms or roads	Soil placed in existing canals and covered	Composting-Xenorem -Aerobic/Anaerobic	Soil reactor in situ chemical treatment (ISCO)	Low temperature thermal desorption	Excavate/Off-site Landfill Disposal
1	Lust Farms X ZNE-A	39.893	FB5	1.5 TO 2	Toxaphene	0%	-	47%	60180	52.58													
2	Lust Farms X ZNE-B	263.618	FB5	1.5 TO 2					59183	45.47													
3	Lust Farms X ZNE-C	75.425	FB5	1.5 TO 2	Toxaphene	0%	-	63%	50763	38.84													
4	Lust Farms X ZNE-D	50.787	FB8	2						41.81													
5	Lust Farms X ZSC-C	242.009	FB1	3	Toxaphene	0%	-	31%	34331	44.33													
6	Lust Farms X ZSE-A	156.729	FB6	2	Toxaphene	14%	-	74%	73874	39.88					2	1	3						
7	Lust Farms X ZSE-D	316.043	FB7	2	Toxaphene	0%	-	42%	47115	37.95													
8	Lust Farms X ZSE-F	222.705	FB7	2	Toxaphene	0%	-	44%	47650	35.58													
9	Long Farms, Inc. X Z1N-C	159.357	FB13	1	DDTx	9%	-	69%	24750	13.55					2	1							
10	Long Farms, Inc. X Z1S-E	45.278	FB10	1						22.55													
11	Long Farms, Inc. X ZNE-A1	19.117	FB5	1.5 TO 2	DDTx	0%	-	62%	20893	39.58													
12	Long Farms, Inc. X ZNE-A2	356.644	FB5	1.5 TO 2	Toxaphene	0%	-	31%	38819	48.32													
13	Long Farms, Inc. X ZNE-D1	64.537	FB8	2	Toxaphene	0%	-	48%	45136	30.84													
14	Long Farms, Inc. X ZNE-D2	47.085	FB8	2	Toxaphene	0%	-	55%	59669	43.49													
15	Long Farms, Inc. X ZNE-E	73.439	FB8	2	Toxaphene	0%	-	54%	55441	44.25													
16	Long Farms, Inc. X ZNE-F	40.112	FB8	2	Toxaphene	7%	-	74%	68276	35.88					2	1	3						
17	Long Farms, Inc. X ZSE-A	181.786	FB6	2	Toxaphene	0%	-	8%	28228	47.84													
18	Lust & Long Precooler X ZNE-F		FB8	2		0%	-	0%															

FIELD ALTERNATIVE TREATMENT MATRIX

Block			Flooding Block		Critical	% Reduction			Av. Conc.		Isolation/Containment Technologies										Ex situ Treatment		
#	OWNER X ALUM	ACRES	FB	Depth	Contaminant	Low		High	Crit. Cont	% TOC	Bermed island construction	Capped soils	Surface sealing/compacting	Berms alone to perclude flooding	Soil layer flipping	Vertical blending	Horizontal blending	Soil removed used for berms or roads	Soil placed in exisisting canals and covered	Composting-Xenorem -Aerobic/Anaerobic	Soil reactor in situ chemical treatment (ISCO)	Low temperature thermal desorption	Excavate/Off-site Landfill Disposal
19	Zellwin Farms X				Toxaphene	0%	-	37%	19	16.01													
20	Zellwin Farms X Z1N-D	75.071	FB13	1	DDTx	9%	-	69%	24820	35.57					2	1							
21	Zellwin Farms X Z1N-E	96.277	FB14	1	DDTx	57%	-	85%	158803	27.08	2	3		1							4	5	6
22	Zellwin Farms X Z1N-G	198.201	FB14	1	Toxaphene	4%	-	64%	65527	32.41				3	2	1							
23	Zellwin Farms X Z1S-A	329.036	FB11	2	Toxaphene	0%	-	58%	56961	25.80													
24	Zellwin Farms X Z1S-B	308.098	FB11	2	Toxaphene	0%	-	57%	56572	29.88													
25	Zellwin Farms X Z1S-C	314.405	FB11	2	Toxaphene	13%	-	62%	72987	33.23					1	2							
26	Zellwin Farms X Z1S-D	307.701	FB10	1	Toxaphene	3%	-	61%	6917	37.91					1	2							
27	Zellwin Farms X Z1S-E	214.079	FB10	1	DDTx	0%	-	65%	23156	41.25													
28	Zellwin Farms X ZNC-A	332.688	FB3	2	Toxaphene	0%	-	5%	28939	36.36													
29	Zellwin Farms X ZNW-A	321.842	FB2	3	Toxaphene	0%	-	10%	31701	37.95													
30	Zellwin Farms X ZNW-B	211.451	FB2	2	Toxaphene	0%	-	4%		34.63													
31	Zellwin Farms X ZNW-C	250.462	FB2	2					17809	25.03													
32	Zellwin Farms X ZSE-I	246.960	FB6	2	Toxaphene	20%	-	73%	79048	31.99					2	1	3						
33	Zellwin Farms X ZSE-J	143.455	FB6	2	Toxaphene	0%	-	56%		40.28													
34	Zellwin Farms X ZSW-A	112.876	FB1	3						29.73													
35	Clonts Farm X ZSE-B	298.606	FB6	2						38.63													
36	Clonts Farm X ZSE-C	100.413	FB6	2						33.56													
37	Clonts Farm X ZSE-G	152.052	FB6	2						31.76													
38	Clonts Farm X ZSE-H	28.542	FB6	2					8368	6.17													
39	Crakes & Son, Inc. X ZNC-B	156.145	FB4	2	Toxaphene	0%	-	18%	6404	39.90													
40	Crakes & Son, Inc. X ZNE-A1	19.603	FB5	1.5 TO 2	DDTx	0%	-	36%	14750	38.15													
41	Crakes & Son, Inc. X ZNE-A2	76.687	FB5	1.5 TO 2	DDTx	68%	-	91%	71114	47.74	2	3		1							4	5	6
42	Crakes & Son, Inc. X ZNE-C	73.932	FB5	1.5 TO 2	DDTx	0%	-	33%	13810	39.33													
43	Crakes & Son, Inc. X ZNE-D	58.624	FB8	2	DDTx	34%	-	78%	10210	48.43				3		1							
44	Crakes & Son, Inc. X ZSW-B	94.714	FB1	3	DDE	0%	-	12%	15835	30.80													
45	Stroup Farms X ZNE-A	75.694	FB5	1.5 TO 2	Toxaphene	0%	-	29%	1199	44.71													
46	Stroup Farms X ZSC-B	78.596	FB1	3	Dieldrin	0%	-	40%	14567	39.73													
47	Stroup Farms X ZSE-E	148.245	FB7	2	Toxaphene	0%	-	22%		36.85													
48	Stroup Farms X ZSW-C	80.696	FB1	3					691	38.10													
49	Clarence Beall X ZNC-B	150.972	FB4	2	Dieldrin	0%	-	28%	5023	38.59													
50	Clarence Beall X ZNW-B	75.371	FB2	3	DDE	0%	-	67%		26.98													
51	Clarence Beall X ZSC-A	61.570	FB1	3					4091	46.55													
52	Hensel & Rodgers X Z1N-A	306.203	FB12	1	DDE	0%	-	64%	20860	2.09													
53	Robert Potter & Sons, Inc. X Z1N-F	307.969	FB13	1	Toxaphene	22%	-	69%	17600	31.19					2	1	3						
54	Grinnell Farms, Inc. X Z1N-D	56.731	FB13	1	DDTx	7%	-	54%		44.00					2	1							