Northwest Wellfield Watershed Protection Plan

Miami-Dade County, Florida

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Prepared for the
South Florida Water Management District
C - 8797

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DERM

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

Page

LIST OF TABLES

Page

LIST OF FIGURES

Page

Northwest Wellfield Watershed Protection Plan

I. INTRODUCTION

The Northwest Wellfield is a major uncontaminated source of municipal drinking water for Miami-Dade County, Florida. The wellfield consists of fifteen wells that supply a current demand of 150 million gallons per day (MGD) and a planned future capacity of 225 MGD. It is located in an undeveloped area of the county situated between protected wetlands, but with rapidly encroaching development from the east and south. As with all water supplies within the county, the wellfield taps the county's only source of potable water, the Biscayne Aquifer, a water table aquifer with extremely high transmissivities (Fish and Stewart, 1991). Because the unconfined aquifer is highly vulnerable to contamination from the surface, the area surrounding the production wells is protected by a series of regulatory boundaries. Within the boundaries, potential sources of contamination are increasingly regulated and prohibited as proximity to the drinking water wells increases. Because the Northwest Wellfield was built to replace older wellfields contaminated by industrial pollutants and to meet future water demands, it is protected more stringently with an outer protection boundary that encompasses approximately 56 square miles (Figure 1).

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Most of the Northwest Wellfield Protection Area is also within a region of the county that provides half of the limestone mining resources used in the state each year. Since establishment of the current protection program in 1985, rockmining has expanded in this area, slowly converting groundwater resources into 600 acre, 60-foot deep lakes. Figure 2 shows the extent of existing and proposed future rockmining in the Lake Belt and Northwest Wellfield area. Over 5,600 acres of aquifer have been excavated with approximately 5,900 more acres permitted. The South Florida Rockmining Coalition is proposing to mine 8,400 additional acres, totaling almost 20,000 acres eventually mined out in the Lake Belt area. This would leave most of the Northwest Wellfield occupied by open water.

Because of the impact of this extensive mining on freshwater wetlands as well as potential impacts to drinking water quality, in 1992, the Florida Legislature created Section 373.4149(4), Florida Statutes, establishing the Northwest Dade County Freshwater Lake Plan Implementation

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Committee (committee). The Legislature directed the committee to develop a plan which " (a) Enhances the water supply for Dade County and the Everglades. (b) Maximizes efficient recovery of limestone while promoting the social and economic welfare of the community and protecting the environment; and (c) Educates various groups and the general public of the benefits of the plan." The Lake Belt Plan consists of two phases. The Phase I report and plan, which was completed and adopted by the Florida Legislature in 1997, provides the overall framework of the Lake Belt Plan and authorizes agencies to enter into agreements to implement the plan. In 1997, the Florida Legislature through 373.4149(7), Florida Statutes, directed the committee to develop PhaseII which shall "… (d) Provide for additional wellfield protection; (e) Provide measures to prevent the reclassification of the Northwest Miami-Dade County wells as groundwater under the direct influence of surface water; …" The Phase II report, due to be completed by December 31, 2000, develops a detailed master plan that considers land use, mitigation, water management, hydrologic impacts, land ownership and property rights, lake design, and wellfield protection.

Additionally, the Comprehensive Everglades Restoration Project (CERP) is planning a series of water supply improvements to be built over the next 20 to 50 years that will overlap into the Lake Belt and wellfield areas. Figure 3 shows proposed reservoirs, stormwater treatment areas, canal structures and other water management projects, some of which are located within the Northwest Wellfield protection area. The Phase II Master Plan is also analyzing these potential revisions to the water control/seepage features in order to be integrated with the CERP's overall design plans.

A. Purpose and Scope

In cooperation with the South Florida Water Management District (SFWMD), the Miami-Dade Department of Environmental Resources Management (DERM) initiated this study to assess the adequacy of the county's existing program to protect the Northwest Wellfield in conjunction with the Phase II Detailed Master Plan. The review process included assessment of:

- Contaminant transport
- Hydrologic changes due to removal of aquifer material
- Best Management Practices (BMPs) for hazardous materials use and storage by industry and for pesticide use for mosquito control and canal or corridor maintenance
- Defining what is a bona fide rockmining use that has a limited exemption from the hazardous materials prohibitions to allow use of fuels and lubricants set by the County's Wellfield Protection Ordinance
- Control of access to the watershed to prevent illegal dumping or accidental spills
- Identification of setback and berming requirements for lakes
- Identification of options to reduce ground and surface water interactions on lakes closest to the wellfield
- Identification of existing land uses
- Identification of appropriate recreational uses
- Monitoring of ground and surface water quality
- Ensuring that the drinking water source remains groundwater not under the influence of surface water.

Figure 3

Comprehensive Everglades restoration Project
Alternative D13R
North and Central Lake Belt Storage Areas

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Source: South Florida Water Management District

B. Study Area

The study area for this report is confined to the boundaries shown in Figure 2, which includes the majority of the Northwest Wellfield Protection Area. This study area is bounded by the Homestead Extension of the Florida Turnpike (HEFT) on the east, Krome Avenue on the west, Okeechobee Road on the north and NW 12th Street on the south. The West Wellfield, located just east of the southern portion of the Lake Belt planning area, will not be mined as extensively and, thus, will not be part of the study process. However, this does not preclude the possibility of applying the same wellfield protection improvements recommended for the Northwest Wellfield to the West Wellfield. The study area also omits the portion of the NWWF Protection Area that is east of the HEFT and within the Urban Development Boundary. For the purposes of this report "wellfield" shall mean the fifteen drinking water wells or production wells comprising the Northwest Wellfield. The "wellfield protection area" shall mean the entire area inside the outer protection boundary.

C. Study Process

The study process begins with a review of the background of the various elements of the county's wellfield protection program: adequacy of the existing regulation boundaries and the land use and zoning controls established by the Wellfield Protection Ordinance; regulatory and enforcement activities; and water management and monitoring as pertains to these boundaries. The effectiveness of the land use and enforcement program elements were assessed by surveying the existing uses, identifying potential and known environmental problems, and relating the information to the existing regulatory and enforcement activities in the study area. Assessment of the adequacy of the regulation boundaries as pertains to water management is ongoing.

Beginning in 1998, dye tracer projects were initiated to verify the adequacy of the existing protection zones under current conditions and to provide more specific hydrologic information for the area. Under different scenarios, food-grade dyes were released to the groundwater near the drinking water wells to gauge the velocity and flow path of groundwater under current pumping conditions. The findings of the dye tracer projects will be related to the existing travel-time based protection zones.

A previous report reviewed the water quality monitoring activities in the area and recommended improvements (DERM Technical Report, March 1999). The findings of that report were reviewed in context of additional information generated during this study. This information will be used to redesign the water quality monitoring program in terms of current land uses, future water management changes, and water quality objectives. An important consideration of water quality conditions in the wellfield area relates to the current classification of the wellfield as a groundwater supply. This issue is key to redesigning the existing monitoring program so that it detects changes in groundwater as pertains to surface water influences. The county's regional treatment facilities are designed for treating groundwater. Should the planned lake excavations render the wellfield as groundwater under direct influence (GWUDI) of surface water, the retrofit costs to those facilities will be considerable. The retrofits will be necessary because the risk from pathogenic organisms is higher in surface water than in groundwater.

The issues pertaining to pathogenic risk as well as other pollution risks to drinking water quality will be discussed in terms of risk avoidance and minimization options. These options are addressed in two categories. One set of options to minimize pollution risk to the wellfield relates

to more effective land use, regulatory, enforcement and stormwater controls. Another set of options relate to defining an adequate groundwater buffer (i.e. rockmining setback) to minimize risk to the drinking water supply under future hydrologic conditions. The final portion of this study process will present the risk avoidance and minimization options as action steps to augment protection to the Northwest Wellfield.

D. Background of Miami-Dade County's Wellfield Protection Program

The County's current Wellfield Protection Program was initiated in 1981 after studies conducted by the county and the U.S. Environmental Protection Agency (EPA) revealed that a significant majority (85%-90%) of public drinking water wells in the county had trace or more levels of industrial contaminants (EPA, 1976, DERM Technical Report 78-6). The severity of contamination was related to the amount of industrial and heavy commercial development sited around the various drinking water supplies. Therefore, the protection program was based on the principal of delineating "zones of protection" around the public drinking water wells within which new land uses would be controlled. These zones were computer generated by calculating the theoretical distance a water particle or pollutant will travel toward a well during a specific number of days as conceptually shown in Figure 4.

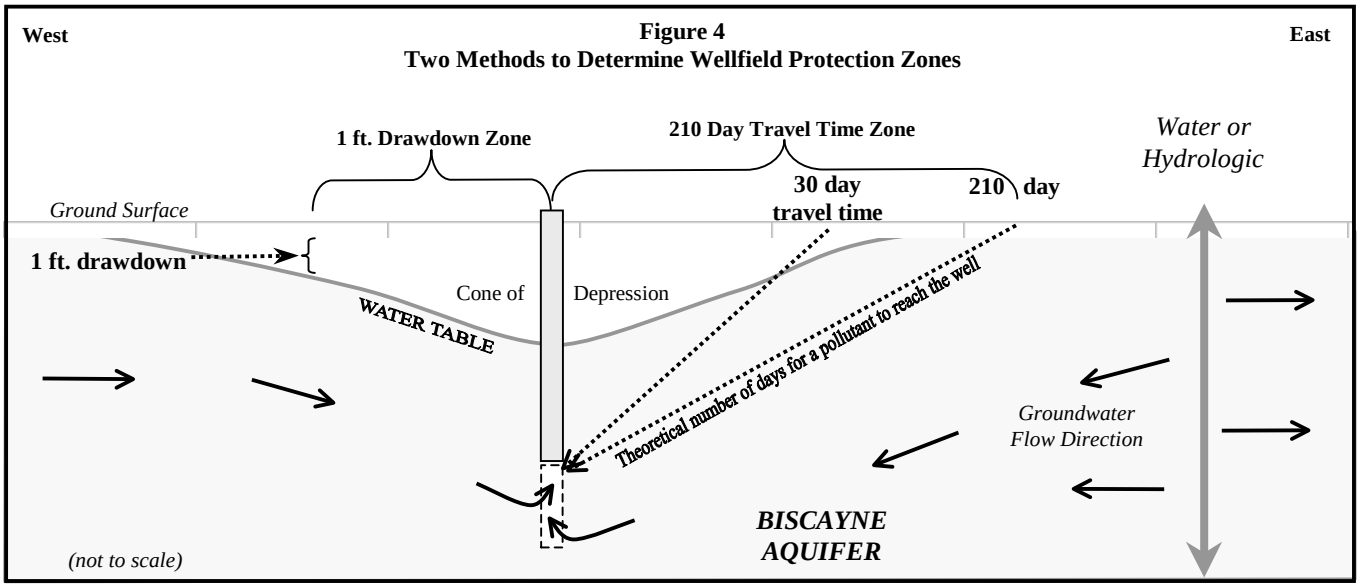
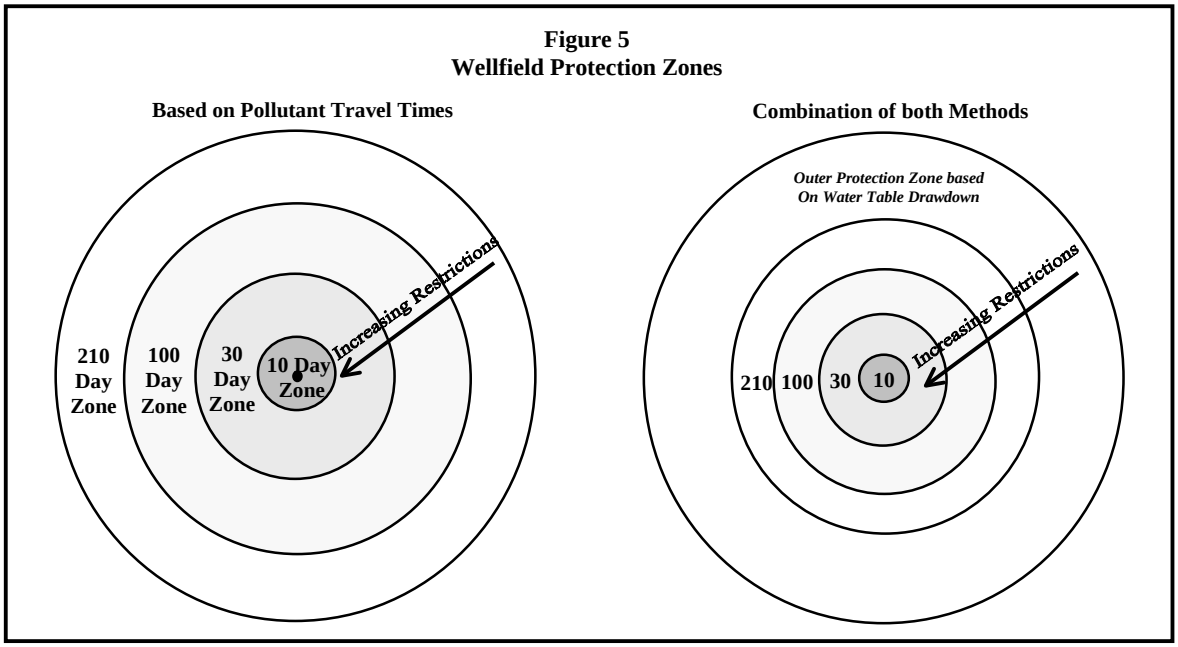


Figure 4
Two Methods to Determine Wellfield Protection Zones

The initial protection zones assigned to each public water supply were delineated on maps as 10, 30, 100 and 210-day travel time boundaries as shown in Figure 5. The "travel time" protection zones were based, in part, on very generalized survival times of bacteria and viruses in soils and groundwater (DERM Technical Report 80-4). The majority of pathogenic bacteria die off within an average of 10-30 days and viruses within 30-100 days. Because very soluble chemical pollutants travel farther than microbiological pollutants and a few viruses can survive more than 100 days, the 210-day zone was included. The 210-day zone is based on the worst-case condition of no rainfall infiltration to the aquifer to retard lateral transport of pollutants to a wellfield. The purpose of the zones is to regulate land uses with increasing stringency as the wellfield is approached. This recognizes the ever-increasing speed at which contaminants could

reach the wellfield as a result of drawdown from cumulative pumping action from the wells themselves along with normal lateral transport.

Figure 5
Wellfield Protection Zones



The largest of the public wellfields were protected more stringently with the creation of outer boundaries beyond the 210-day zones. The outer protection zones for the regional wellfields that existed in completely urbanized areas were based on 1-ft. drawdown as shown in Figures 4 & 5. The outer protection areas for the Alexander Orr complex of three wellfields and Hialeah/Preston complex of four wellfields are based on 1-ft. drawdowns. The outer protection areas for the Northwest and West wellfields were based on more conservative assumptions on the premise that minimizing risk to these wellfields is an important economic consideration for the county. Therefore, the outer boundary for the Northwest Wellfield Protection Area is based on ¼ ft. drawdown of the water table. The West Wellfield, located near the Bird Drive Basin, is based on 1/10 ft. drawdown. Figure 6 shows all of the protection zones around the current wellfields.

Land use policy within wellfield protection zones prohibits new uses of hazardous materials and prohibits generation of hazardous and liquid waste other than domestic sewage. However, uses that existed when the protection zones were created were allowed to remain as their current use. The risk to groundwater from these "grandfathered" uses of hazardous materials and waste is managed through permitting, inspections, sampling and enforcement activities. The risk from domestic sewage, which can contain pathogens of human health concern, is minimized by limiting density of new housing development or domestic waste generation within the zones closest to the wellfield. Other wellfield protection provisions include more stringent stormwater controls and construction criteria, prohibition of resources recovery facilities and requirements for existing grandfathered business to reduce hazardous material risk upon expansion. The specific wellfield protection rules are located in Chapter 24-12.1, Code of Miami-Dade County.

Figure 6

Wellfield Protection Areas
Miami-Dade County, Florida

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II. CURRENT CONDITIONS

A. The Existing Northwest Wellfield Protection Regulations

The existing Northwest Wellfield (NWWF) protection program is based on the Northwest Wellfield Protection Plan which was adopted by the Board of County Commissioners on November 26, 1985 (Resolution R-1541-85) after an inclusive, multi-year planning activity. After adoption of the Plan, numerous implementing actions were promptly taken by the County and the South Florida Water Management District (SFWMD). These actions included revisions to Chapter 24 of the Code of Miami-Dade County and the 'Comprehensive Development Master Plan (CDMP), construction of costly recharge canals and other hydrological modifications in the area, and air stripping water treatment facilities at the Hialeah and Preston water treatment plants, among other actions. These actions included more stringent land use controls, stormwater restrictions, and water quality monitoring. Of particular relevance to this report, the County's Wellfield Protection Program was updated on the basis of the best information and groundwater modeling tools available at the time.

The outer regulatory boundary established for the NWWF Protection Area is located where it was estimated that the surrounding water table will be drawn down ¼ ft. when the wellfield is pumping at 220 MGD. The travel-time protection boundaries within the outer boundary assume the same pumpage rate. The outer regulatory boundary includes a drought safety area, which extends approximately ½ mile east of the Snapper Creek Extension (SCE) canal. The SCE canal is the hydrologic divide, east of which groundwater generally flows eastward, away from the wells; however westward flow toward the wells will occur from the area east of the "divide" under drought conditions. The safety area east of the Turnpike was delineated to provide protection from three consecutive years characterized by average wet-season conditions and 6-month 20-year droughts during the dry seasons. Actual water level monitoring has verified that the improved Canal serves as an effective divide in all except very few dry periods. As mentioned earlier, this safety area east of the Turnpike is not part of the study area, as it falls outside of the designated Lake Belt area and it is hydrologically separated from the rest of the protection area the majority of the time.

Table 1 summarizes the county's wellfield protection program for the Northwest Wellfield. Highlighted in bold are provisions that are more stringent for the Northwest Wellfield as compared to the other wellfields in the county. Most of these provisions also apply within the West Wellfield protection area. It should be noted that the 100-ft. setback originates from state regulations requiring a separation of 100 feet between potable water wells and features such as septic tanks and other contamination sources. The County's Wellfield Protection Ordinance limits development on septic tanks in the Northwest Wellfield's protection area west of the Turnpike to 1 unit per 5 acres, but not development on public water and sewer. It is the CDMP Urban Development Boundary (UDB), aligned along the Turnpike, which currently prevents high-density commercial and residential zoning within the wellfield area and limits development of infrastructure such as sewerage and water distribution facilities. The NWWF Protection Plan advised against opening this recharge area to urban development. For this and other reasons, the CDMP provides that the area west of the Turnpike, south of Okeechobee Road and north of NW

Table 1

Chapter 24 Land Use Restrictions and Prohibitions for New Activities

ACTIVITY	Northwest Wellfield Protection Zones					
	100'	10 Day	30 Day	100 Day	210 Day	Outer
Residential Uses Served by Septic Tanks	P	**1 unit/5 acres** 10 day travel time between onsite well & septic tank				
Commercial Uses Served by Septic Tanks or On Site STPs	P	**P**	**P**	**P**	**P**	**P**
Residential Uses Served by Septic Tanks & Public Water (without sandy soils)	P	Limited by th UDB which controls urban infrastructure, otherwise: 0.4 units/acre	1.0 units/acre	1.7 units/acre	2.4 units/acre	2.4 units/acre
Uses Served by Sewers & Public Water not using hazardous materials	P	Limited by th UDB which controls urban infrastructure, otherwise: 850 GPD/acre	1,600 GPD/Acre	NR	NR	NR
Stringent Sewer Construction Criteria	P	Req.	Req.	Req.	Req.	Req.
Stormwater Disposal	P	Infiltra-tion	Infiltration & Seepage	Infiltration, seepage or overflow outfall		NR
Rockmining	P	P	P	40 ft. max. depth or 30 day additional buffer and land dedication		Security required
Non-Residential Uses Handling Hazardous Materials	P	P	P	P	P	P
Variances to Prohibitions	**Requires 4 out of 5 vote by Environmental Quality Control Board**					
Existing Uses Handling Haz. Mat. Must Reduce Risk Upon Expansion	P	Expansion is limited to 50% of grandfathered use and must demonstrate overall reduction in risk				
BU-3 And IU Zoning	P	**P**	**P**	**P**	**P**	**P**
Non-Residential Uses Served By Septic Tanks	P	P	P Excluding rockmining & ancillary uses	P	P	P
Underground Storage Tanks For Hazardous Materials	P	P	P	P	P	**P**
Pipelines Transporting Hazardous Materials	P	P	P	P	P	**P**
Liquid Waste Storage, Treatment Or Disposal Methods Other Than Septic Tanks & Public Sewers	P	P	P	P	P	P
Agriculture	P	Exempt, except for packinghouses with liquid waste and farmer owned vehicle maintenance operations.				
Resource Recovery And Management Facilities	P	P	P	P	P	P
P=Prohibited NR=Not Restricted Req.=Required R=Restricted UDB=Urban Development Boundary						
Bold highlighted refers to criteria more stringent in the Northwest and West Wellfields than older, urbanized wellfields						

12 Street shall not be urbanized. The comprehensive plan provides broad policy protection of the resource, while the development regulations provide additional protective conditions. Any decision to move the UDB into the wellfield area would allow for higher density zoning and development, within limits established in the Wellfield Protection Ordinance.

Exemptions from Hazardous Materials and Liquid Waste Prohibitions

The Northwest and West Wellfields are protected more stringently than other wellfields because these areas were relatively undeveloped when the protection zones were implemented which enabled the County to substantially reduce contamination risks that plague other wellfields in the county and caused others to be shut down entirely. Although the Northwest Wellfield area was undeveloped, approximately 1,200 acres were already zoned industrial. This zoning was repealed because this area was deemed poorly suited for urban development by the East Everglades Moratorium Study adopted in 1974 and the CDMP adopted in 1975. Down-zonings proceeded through the 1970's to implement the East Everglades study and CDMP. Removal of the zoning also served to reduce the perception that industrial development is acceptable in this wellfield area. Accommodations were made for rockmining because it was an established land use in the Northwest Wellfield area when the protection zones were created and the risks posed were significantly less than other development and believed to be acceptable, with the prescribed restrictions.

DERM operating permits are required for rockmining operations. As defined in Section 24-3(92) of the Miami-Dade County Environmental Protection Ordinance, "Rockmining shall mean the dredging or excavation of an area for the purpose of extracting subsurface materials. Rockmining shall also include ancillary property uses necessary for extracting and processing subsurface materials." Section 24-12.1(5) currently indicates that rockmining operations include 1) lake excavations, 2) concrete batch plants and 3) rock crushing and aggregate plants. However, Section 24-12.1(10), "Allowable Land Uses within the Northwest Wellfield" permits limestone quarrying, rock crushing and aggregate plants, but not concrete batch plants. Section 24-12.1(5) also provides a limited exemption from the prohibition of hazardous materials to allow the use of fuels and lubricants required for rockmining operations. In order to maintain the stationary and off-road vehicle/equipment at rockmining operations, hazardous and liquid wastes are generated. However, Section 24-12.1(4)(d) does not provide an exemption to rockmining operations for the liquid waste storage, disposal or treatment methods other than septic tanks, sanitary sewer lift stations, and public sanitary sewers. Following Chapter 24, rockmining operations must be either grandfathered or receive a variance form the Environmental Quality Control Board for use of hazardous materials other than fuels and lubricants, and for the generation of hazardous and liquid wastes. Chapter 24 will be amended to clarify the rockmining and ancillary uses allowed in the vicinity of the Northwest Wellfield and eliminate some apparent inconsistencies between certain sections of Chapter 24.

Rockmining Setbacks from Wellheads

Rockmining is prohibited within a certain setback distance from the wellheads. The purpose of this restriction is to provide some protection for the drinking water wells from the consequences of accidental spills associated with rockmining activities or even illegal intentional dumping of hazardous materials into rock pits. There are currently two setback options. The first option prohibits rockmining within the 30-day travel time boundary and restricts the excavation depth to 40 feet between the 30-day and the 210-day boundaries. The 40-ft. depth limitation was based on

the assumption that the majority of public water supply wells in the county withdrew groundwater at depths greater than 40 ft. This provides some vertical separation between groundwater discharges from the sides of the lake (0-40 ft.) and the depth of the aquifer (45-80 ft.) tapped by the drinking water wells. The second setback option removes the depth restriction if an additional 30-day travel time buffer is left unexcavated adjacent to the 30-day boundary for a total of 60-day travel time setback from the wellfield. The unexcavated portions of the property within the 30-day boundary (which is officially mapped) and the theoretical 60-day setback are bound by restrictive covenant to remain undeveloped. The 60-day setback distance has not been delineated on an official map nor codified as a specific distance from the wellfield.

Agricultural Exemptions

Agriculture is exempted from the wellfield protection provision that prohibits new uses of hazardous materials within the protection area. At the time of the Northwest Wellfield planning process during the early 1980's, there were no plans to expand agricultural activities in the Northwest Wellfield. It was the threat of industrial and commercial uses that prompted the special planning process for this wellfield. The county may not adopt laws, regulations, rules pertaining to pesticides except in the following instances as stated in Section 487.051 F.S.: "…local jurisdictions may adopt or enforce an ordinance pertaining to pesticides if that ordinance is in the area of occupational license taxes, building and zoning regulations, disposal or spillage of pesticides within a water well zone, or pesticide safety regulations relating to containment at the storage site." Additionally, during the 2000 Legislative Session, legislation was passed to modify the Florida Right-to-Farm Act, 823.14 F.S., to preempt local government regulation of agricultural activities when the activity is regulated through State best management practices (BMPs) or interim measures adopted under Chapter 120 F.S. At this time the state has not adopted BMPs applicable to wellfield protection areas. Agricultural operations that store hazardous materials (i.e. pesticides, fuels, fertilizers, etc.), grandfathered crop washing operations, and grandfathered farmer operated vehicle maintenance operations require DERM operating permits and inspections. No new farmer-operated vehicle/equipment maintenance facilities and crop washing operations are allowed in the Northwest and West Wellfield Protection Areas. Improper handling or disposals of agrichemical wastes that result in a nuisance condition or in ground or groundwater contamination also fall within the purview of county and state environmental regulations.

B. Environmental Setting of the Study Area

Figure 7 shows the existing land uses in the study area. Also shown are the wellfield protection zones and the Urban Development Boundary (UDB), which parallels the Turnpike and the Snapper Creek Extension (SCE) canal. The UDB defines the allowable westward extent of urban infrastructure including municipal water and sewer supplies, schools, parks and high-density zoning including but not limited to RU4 (residential), BU (business), and IU (industrial). In the portion of the NWWF Protection Area east of the UDB and outside of the study area, full density development is allowable with the exception of no new uses of hazardous materials or generation of hazardous wastes and BU3 and IU zoning.

Figure 7

Existing Land Uses in the Northwest Wellfield Study Area

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Major canals in the area include the L-30, the C-6 or Miami Canal, the NWWF Recharge Canal and the Snapper Creek Extension Canal (SCE). The L-30 canal is a southward conveyance canal for the county. Part of the water from L-30 is routed through a gated culvert under Krome

Avenue to the Recharge Canal, which sole function is to deliver water to the SCE Canal at NW 114th Street. Water deliveries to the SCE Canal are critical during the dry season to maintain a hydrologic divide along this canal from its beginning at NW 124th St. to the 12th St. structure. The "hydrologic divide" means the area where groundwater should cease to flow towards the wellfield from the east (Figure 4).

The study area includes the NWWF Protection Area west of the UDB and encompasses approximately 56 square mile sections or 36,000 acres. More than 60% of the study area, including nearly all land west of theoretical NW 147 Avenue, is vegetated freshwater wetlands, with the Pennsuco wetlands accounting for over 11,000 acres. Most of the existing lakes (5,300 acres) and land permitted for lake excavation (2,700 acres) are eastward of theoretical 147th Ave. Lakes and permitted excavations account for 45% of the land use between the Turnpike and NW 147 Avenue. The majority of other land activities in the study area are also located in this corridor, including the municipal water supply wells.

The production wells are aligned north to south between NW 90 and NW 58 Streets along theoretical 137th Ave. The production wells are at the western edge of a county-owned parcel of land comprised of 3 square mile sections. Within the wellfield property are the 15 well houses, a lime sludge lagoon, and a natural gas generator building that powers the pumps. There is a bathroom facility with onsite well and septic tank. A majority of the 1,800-acre wellfield property is undeveloped transitional wetlands. A lake, permitted prior to the wellfield protection ordinance, abuts the wellfield immediately on the north, entering the 10-day protection zone. Lakes also exist adjacent to or within the 100-day boundary on the south and east. A permit has been issued for excavation within the 100-day boundary on the southeast.

C. Specific Land Uses and Activities

The land uses and activities plotted on Figure 7 were surveyed using 1999 aerial photography and County databases current to year 2000 and then ground truthed by field inspections made in June and July 2000. Additionally, inspectors who frequently visit the area were interviewed for up-to-date information on compliance at permitted facilities and enforcement actions for un-permitted activities. The survey identified 50 separate properties with non-residential land use activities, 20 of which are allowable by the Department of Planning and Zoning or currently permitted by DERM, most of which are preexisting, grandfathered activities.

Examples of uses allowable by zoning regulations and not requiring DERM permits include agricultural uses such as pasture and homes on 5 acres or greater. DERM does review and approve the installation of on-site well and septic systems. Some of the existing 30 un-permitted uses may be allowable by zoning, but the properties were filled without a DERM Class IV permit so there are enforcement actions against the property owners. In wetlands, which predominate in the study area, DERM requires a Class IV permit for dredging and land filling. Class IV dredging permits are required of all rock miners. Class IV fill permits ensure that clean fill is used and that filling is done with proper stormwater retention so that surrounding sheet flow can be maintained when necessary. The DERM Class IV permit is issued in conjunction with the required zoning permits. A certificate of use and occupancy, a building permit, or operating permit further addresses the intended uses.

Land Activities West of NW 147 Avenue

West of the Wellfield, activities are very sparse and all are allowable uses. Most are located along Krome Avenue. A ten-acre container nursery, a private trailer park, and a county tourist park, each with on site septic tanks and a private community water supply, exist in the extreme northwest near Okeechobee Road. There are two communication towers further south on Krome, each with potable water supply and one with a septic tank. A communication tower is also located immediately west of the wellfield near the county property without water supply or septic tank.

The main activities west of NW 147 Avenue and north of NW 41st Street include a FPL transmission line and substation and two prison facilities (state and county). The prison facilities are connected by pump stations to a force main along NW 41st Street. The prison facilities and the FPL substation are not permitted by DERM to use or store hazardous materials. Past maintenance activities at the substation resulted in soil contamination. The contaminated soil was removed and the groundwater is being monitored to insure that there is no threat to the wellfield from groundwater contamination.

There is also an inactive rockmine lake to the north of the FPL substation. A recent inspection verified that, though rockmining is currently inactive, large diesel storage and waste oil tanks remain on site within secondary containment. Therefore, this site is a potential source of industrial contaminants within 1½ miles of the wellfield. Since the lake is inactive, a DERM operating permit has not been issued to a new owner. The owner has been advised to properly dispose of all waste oil and DERM will follow-up on status of the storage tanks.

Agricultural Operations

Current agricultural operations in the study area are relatively minor, as there are very limited use of pesticides and no observable vehicle maintenance activities. However, because nearly all the land in the area is zoned for either agriculture or for general usage, agriculture is the second most viable potential land usage after rockmining. Additionally, bonafide agricultural use provides a property tax reduction to those who apply to the Property Appraiser. Currently there are only 550 acres of land in the study area with agricultural exemption, all of which is devoted to cow or goat pasture. Two areas of pasture are located on rock mining property north of the wellfield along Okeechobee Road. Two more privately owned pasture areas are south of the wellfield along NW 12 Street. In addition to tax exempt pasture, agricultural uses in the study area include the one 10-acre tree nursery on Krome Avenue mentioned earlier and 2 abandoned nursery operations that are still home sites. These are located adjacent to the HEFT on NW 58 Street and NW 41 Street. Private residences are allowed on septic tanks (one per 5 acres) on land zoned for agriculture. None of these facilities requires a DERM agricultural facilities operating permit at this time.

Rock Mining Operations

Rockmining consortiums own approximately 57% of the study area, mostly in 640-acre tracts of land. There are 7 active mining operations. Four are full-scale operations that include rock crushing and aggregate separation, concrete batching, fuel and other hazardous materials storage, and/or equipment maintenance. Two of the large operations are north of the wellfield and two are south. These two operations account for all of the land activity north of the wellfield and east of NW 147 Avenue.

Several lakes are usually actively mined at each of the larger operations. Access to these is very limited, usually along private, unpaved roads with guardhouses at the road entrance. The unmined land is left fallow in most cases. As mentioned earlier, there are two pasture exceptions, one 8 acres and one 250 acres, where cattle have access to lakes.

The 3 smaller mining operations are southeast of the wellfield. The smaller operations generally mine in one lake and their ancillary activities involve much smaller quantities of hazardous materials. There are 4 concrete batch plants within the study area and 1 soil sorting facility operating independently of mining activity. Each is permitted for small quantity hazardous materials use and generation of hazardous materials including but not limited to waste oil. Each of these is also south or east of the wellfield.

Access to the smaller mines may or may not be restricted by locked gates. However, the independent operations are nearly always along public paved or unpaved right of way and so access is not guarded or restricted. Heavy truck traffic is associated with all of these properties. Trucks are generally carrying rock aggregate or concrete away from the facility. However, since each of the facilities use and store hazardous materials, trucks are also delivering these materials.

Other Industrial Facilities

The majority of activities in the study area are concentrated east and south of the wellfield. These include 10 of the permitted rockmining operations and independent ancillary uses as previously described. There is also a large tallow rendering plant that is grandfathered and permitted by DERM for fuel storage and truck fleet maintenance. Additionally 6 un-permitted truck and equipment maintenance operations, 9 un-permitted heavy equipment storage, 3 un-permitted concrete casting facilities, 2 un-permitted soil sorting operations, 6 un-permitted land filling, 3 miscellaneous non-industrial un-permitted uses, and scattered illegal dumping are occurring as of July, 2000.

The six truck and equipment maintenance facilities are located just 1 ½ miles from the wellfield adjacent to a rockmine lake at NW 58 Street and NW 122 Avenue. Each facility started business without the use of hazardous materials but recently has applied to the Environmental Quality Control Board (EQCB) for land use variances for use and storage of the hazardous materials. These facilities are currently not permitted by DERM because they are not permissible land uses within the wellfield. If the EQCB denies their requests for exemptions then DERM will initiate enforcement action to remove the illegal activities from the Northwest Wellfield protection area. The applicants will be heard by the EQCB in July and September 2000. There are also 2 concrete casting facilities in this area. Both have already been denied an EQCB variance but remain active. DERM is pursuing enforcement action to achieve compliance. The remaining un-permitted activities are in various stages of enforcement or remediation. Their potential for risk will be discussed later in the report.

Grandfathered Facilities, Permitting, Inspections, and Best Management Practices

The 12 facilities located within the wellfield protection area that are permitted for use and storage of fuels and lubricants were pre-existing rock mining or ancillary businesses at the time the Wellfield Protection Ordinance was passed. These businesses were “grandfathered” or allowed to remain in business with appropriate permits as long as permit conditions and best management practices are complied with to ensure minimization of pollution risk. Additionally, no new uses or business expansion would be allowed at the existing facilities unless risk was minimized. It

should also be noted that at one time there were some high-risk businesses such as asphalt batching that were not considered ancillary to rockmining that were required to shut down.

Each of the permitted facilities is inspected at least annually and for the larger operations as often as four times per year. A review of the photographs and records in the case files of these facilities show that house keeping and management practices have improved considerably since the early 1990's. This improvement is attributed to many of the facilities' own efforts for waste minimization as well as the number of inspections made by DERM and the competency of the field inspectors. DERM's constant presence in the area and the ability to administer enforcement actions are critical to the success of the Wellfield Protection Ordinance. DERM also holds public workshops geared to specific industries on best management practices (BMPs) and waste minimization options.

D. Potential and Known Environmental Problems

Figure 8 shows the location of known and potential sources of pollution by type of materials handled by the activities within the study area. At most of these locations domestic waste is treated by septic tanks. The exceptions are the state and county prison facilities that are served by municipal sewer along NW 41st Street. In addition to on-site domestic waste disposal, the major types of potential pollutants found in the study area include: 1) fuel and lubricants, 2) solvents, 3) animal wastes and agrichemicals and 4) other pollutants such as metals. There are also activities or features that can increase pollution risk within the study area such as 1) un-permitted land filling, 2) solid waste dumping, hazardous waste dumping and accidental spills along transportation corridors and 3) improper or insufficient stormwater retention along roadways. The following subsections futher discuss these pollution concerns.

Use of On-Site Domestic Waste Disposal Systems

Septic tanks are basically effective in treating domestic waste, not synthetic chemical and petrochemical waste products. Properly sized septic tank systems at private homes or the trailer parks are less of a pollution risk than septic tanks located at businesses using and generating industrial waste. Therefore county code prohibits land uses that generate liquid waste other than domestic sewage to be served by septic tanks. County inspectors have routinely found the septic tank systems being illegally used to dispose of non-domestic waste thereby causing groundwater contamination. Therefore businesses that are users of hazardous materials and/or generators of non-domestic wastes on septic tanks are generally considered to be high-risk potential sources of pollution in the study area. Each industrial facility permitted for septic tank use is inspected for that use to verify that there are no illegal uses of the domestic septic tank systems.

An exception to the potential for improper use of a domestic waste system is the WASD back-up power generation system located near the southernmost production well. The power supply for the system is natural gas, which is not a risk to groundwater quality as compared to gas or diesel operated systems. Lubricants and other products to repair or maintain the equipment are not stored on site. Therefore, although a bathroom is provided for the convenience of the

Figure 8

Known and Potential Environmental Problems in the Northwest Wellfield Study Area

Figure Removed for Security Purposes

employees, the risk to groundwater from this operation is negligible. Still, the septic tank is periodically sampled for industrial contaminants.

Use and Storage of Fuel and Lubricants

Seven facilities in the study area are permitted for large quantity use and above ground storage of fuels and lubricants and for blasting activities. Materials use and storage include but are not limited to diesel, waste oil, motor oil, hydraulic fluid, and antifreeze. Each facility is required to contain their above ground storage tanks with secondary containment and report any spills to DERM. Since the newer containment practices went into effect in the early 1980s, there have been no major fuel or oil spills at the permitted facilities. However, there is historical groundwater contamination by fuels at one site. This facility is in one of the state's Early Detection Incentive Programs and groundwater remediation should begin no later than 2001. The fuel spill is 4 miles north of the wellfield and has not migrated offsite, thus, the wellfield is currently not threatened by this contamination. This site will be considered in the future monitoring plan.

Use of Solvents

In terms of risk to groundwater from industrial pollution the un-permitted businesses clustered along NW 58th Street and NW 122nd Avenue are especially problematic because of proximity; they are 1½ miles from the drinking water wells and most of the activities are sited around two lakes. The potential risks to water quality are from the fuels, lubricants and synthetic chemical and petrochemical solvents used and stored at these businesses. Solvents as a group are some of the most transmissive of pollutants in the underground environment and the most ubiquitous of pollutants in local drinking water supplies. Un-permitted use of these chemicals is probably the greatest potential threat to the Northwest Wellfield. Currently, the existing monitoring wells in the study area are not sited at locations suitable to assess whether these facilities have localized groundwater contamination or that any contaminants are advancing towards the wellfield.

Animal Waste and Agrichemical Storage

Animal waste and agrichemical storage are low risk to the Northwest Wellfield at this time. However, in the future any expanded pasture operations could become a pathogenic threat to surface waters. Current farming operations include only one container nursery that is outside of the wellfield protection area, but in the study area. The existing pasturelands support no more than 10 animals per acre. Historic animal waste composting facilities have all ceased operation. There is one area where historic animal waste composting contributed to elevated groundwater ammonia. Ammonia is a greater contaminant issue for surface water than for groundwater and so this site will be considered for future monitoring.

Transportation Corridors

Transportation corridors are an issue for wellfield protection as they provide access for solid waste and hazardous materials. There is no railway or pipeline transport corridors transecting the study area, though railroads servicing rockmining operations do abut the study area at NW 12th Street and there is a 1 ½ mile northward spur off of the NW 12th Street railroad. Therefore, highways and roads are the only transport issues for the study area. In particular, roadways with truck traffic pose a threat to water quality due to the transport of hazardous materials or solid waste that might be spilled in an accident or illegally dumped.

The major roadways of concern to the Northwest Wellfield and the canals that abut them are depicted in Figures 7 and 8. They include Okeechobee Road and the Miami Canal (C-6) on the north, the Homestead Extension of Florida's Turnpike (HEFT) and the Snapper Creek Extension Canal on the east, Krome Avenue on the west and NW 12 Street on the south. The L-30 canal parallels Krome Avenue. However, there is no canal abutting NW 12 Street. The minor roadways of concern include NW 58 Street, NW 41 Street, NW 25 Street, and the Avenues north of NW 12 Street. All of these corridors experience varying volumes of heavy truck traffic, all of which have the potential to at least spill the fuel in their own tanks. The minor roadways add the additional potential hazard of illegal dumping.

Illegal Solid Waste Dumping

Illegal dumping of solid waste in remote areas is a constant problem throughout the county. The Miami-Dade Department of Solid Waste Management maintains a staff of ten inspectors assigned to curb the illegal dumping in western areas of the county. The inspectors are provided with ticketing authority and are partnered with the Miami-Dade County Police Department to arrest violators.

Information on illegal dumping incidents was obtained from the Department of Solid Waste Management records from 1996 - 1997 and from interviews with staff. It was not possible to extract the dumping violation records after this date because the subsequent case files were merged into county Police Department records and lumped under a general misdemeanor category. The collected incident data are plotted on Figure 8.

The dumping incidents are strongly related to paved and unpaved roads constructed to provide access to remote private properties. These roads have been platted and so can be legally constructed with proper permits. The southern portion of the study area north of NW 12 Street had approximately 75 documented incidents within a two-year period. Similar situations exist elsewhere in the Lake Belt area such as north of Okeechobee Road (approximately 100 incidents) and around the Bird Drive Basin area (not shown in Figure 7), particularly off of Tamiami Trail. As more ingress is provided in the wellfield area to provide access to property owners, the dumping could increase.

The dumping cases plotted on Figure 8 under-represent the magnitude of illegal dumping in the area, because in many cases it is impossible to trace the piles of waste to the perpetrators. The inspectors typically have to stake out an area subjected to heavy dumping and intercept the violators in the act. Other techniques are used such as inspecting any documents that are part of the waste material. Once it becomes apparent that an area is more heavily patrolled and arrests are being made, the illegal dumping activities shift to other remote locations accessible by vehicles. Although the waste is eventually cleaned up, most of the cost is at county expense. In late 1998 the County intensified the program by forming the Environmental Investigation Unit (EIU) incorporating the efforts of staff from the Department of Health, DERM, Team Metro and Housing Department.

Hazardous Materials on Roadways

The issues of hazardous materials transport and the possibility of contamination from a spill onto a roadway was thoroughly investigated by DERM (Technical Report 90-11) for all of Dade County's wellfield protection areas as part of the NWWF Protection Program initiative. The report recognized that even though the incidence of actual spills had been negligible within the

wellfield protection areas, prudence requires that every effort be made to prevent and remediate any spill that might occur. The two major recommendations of that 1990 report were 1) the formalization of an emergency response procedure for hazardous materials spills and roadside dumping and 2) investigation on effectiveness of stormwater retention on roadways in wellfield protection areas and especially those adjacent to surface water.

DERM completed a draft hazardous materials spill and roadside dumping emergency response plan in 1991. The plan is not limited to wellfield protection areas. However, it prioritizes the wellfield protection element. The plan was approved for use by DERM, WASD, Miami-Dade Fire Department and Florida DOT in 1992. This plan was recently reviewed to ensure that current issues concerning the Lake Belt are addressed. A deficiency concerning spill containment will be addressed in the next section.

In order to investigate the effectiveness of the implemented hazardous spills response procedures and to assess severity of the problem, DERM reviewed hazardous materials dumping reports (DERM), spill reports (US DOT HazMat Information Center), truck accidents (FL DOT), and DERM emergency response reports from 1990 to 2000. DERM has responded, on average, to 370 roadside dumping incidents per year for the entire County. These are generally 55-gallon drums containing unknown materials. DERM investigates the materials, which are generally waste oil, and hires an independent contractor to remove all hazardous materials.

Only 3.5% of total drum dumping incidents occurred within the study area. The hotspot in the study area is located along NW 25 Street just west of the Turnpike. None of these incidents involved spills. Less than 1% of all incidents for the entire county involved spills > 25 gallons. On average, DERM responds to only one major tanker spill per year; the product is generally diesel fuel.

To date, there has not been an accidental spill of hazardous materials on roads within the Northwest Wellfield Protection Area. While spill incidence and response statistics look favorable for the study area, trends in the number of truck accidents are increasing. This adds to the potential for a spill to occur. Florida DOT's truck accident data were reviewed for available years from 1994 – 1998. The highest volume of accidents consistently has been along Okeechobee Road, a total of 64 accidents on the relevant 4-mile segment. However, data are showing an increasing trend of accidents on the HEFT (72 accidents on 14 miles of roadway) and on Krome Avenue (56 accidents on 13 miles of roadway). The new interchange at NW 12th Street and the HEFT may also show an increase trend of accidents as the area becomes more developed.

Status of Stormwater Controls

Stormwater retention and pollution spill remediation for roadway improvements have been required and reviewed by DERM's Water Control Section and the South Florida Water Management District since 1990. Pollution control devices (Figure 9) that can intercept spills and allow time for cleanup prior to seepage into groundwater or overflow into surface water have been installed along the HEFT in the study area. The structures are operated manually; so immediate spill response is necessary for them to be operational. When the structures are closed, they hold volumes of spilled product from entering the stormwater retention area, allowing for product removal.

Figure 9

Pollution Control Structure

Typical for the Homestead Extension of the Florida Turnpike (HEFT)

- Control structure like this are located approximately 950 feet apart along the HEFT between NW 106th Street to NW 12th Street.

- Structures are located on the east side of the right-of-way in the swale between the roadway and the Snapper Creek Extension Canal.

- Structures can be closed manually to prevent a large accidental spill on the highway from entering the stormwater retention system. Overload of the retention system could result in surface and/or groundwater pollution.

These devices are effective for retention of floatable products. Since fuel is the most commonly spilled chemical, the pollution control devices add a significant measure of protection. Currently these devices exist approximately every 950 feet along the HEFT from NW 106 Street to NW 25 Street. The NW 12 Street exchange for the HEFT, which is currently under construction, will also include these devices. The devices have never been needed, but are inspected and lubricated annually by DERM. DERM's Emergency Response Plan recognizes the need for including these structures in spill responses along the Turnpike, but is currently deficient in including them in the emergency operating procedures section of the Plan.

The stormwater improvements to roadways have only been required since 1974. Before that time, positive drainage was allowed in all circumstances and many of the county's older roads do not retain even the first inch of stormwater runoff. To remedy this, in 1998, DERM's Stormwater Utility Section began mapping all positive outfalls and road drainage plans for the purpose of prioritizing road retrofits. In order to assess stormwater runoff conditions in the study area, a review was made of existing stormwater design as well as the County's Long and Short-Term Transportation Plan improvements for the same corridors.

Krome Avenue has virtually no stormwater engineering, which means it also has no direct drainage to the L-30 Canal. The Long-Range (2020) Transportation Plan has Krome Avenue designated for reconstruction and so it will be possible to address stormwater improvements at that time. The Okeechobee Road corridor is not designated for upgrade and this is problematical because there exist positive outfalls to the Miami Canal and no right of way on the south side of the road adjacent to the canal for stormwater drainage improvements. Considering that Okeechobee Road also has the highest truck accident rate, direct connections to the Miami Canal (C-6) should be made a priority for upgrade. Although the Miami Canal does not provide significant recharge to the wellfield under current conditions, it is hydrologically connected to the wellfield and provides significant recharge to older wellfields serving the Hialeah and Preston water treatment facilities. As already mentioned, stormwater drainage for the HEFT was upgraded in 1990 and future improvements will include hazardous spill retaining devices.

Herbicide and Pesticide Use

The regulation of pesticides use in Florida is handled exclusively by the state. But county policy is to encourage, whenever possible, non-chemical means for weed control within all wellfield areas. Weed control within the study area is conducted for wetland restoration, at a public park, canals and canal banks, County and FPL right-of-ways, and at private homes and businesses. Pest eradication in the area is principally for mosquito control upon request by the prison facility typically once or twice a year. Table 2 provides detailed information on weed and mosquito control methods currently being implemented in the study area.

Control of submerged and emergent weeds and canal bank vegetation is generally necessary for canals conveying water for flood control or recharge. Although there are several aquatic herbicides approved for use in drinking water reservoirs, the county maintains certain canals by mechanical means even though costs for mechanical maintenance are three times higher than chemical control. Presently the Miami Canal is maintained mechanically. The L-30, NWWF Recharge and Snapper Creek Extension (SCE) canals are primarily maintained through mechanical controls. Occasional chemical controls are used if needed.

Table 2

CURRENT WEED AND MOSQUITO CONTROL METHODS USED IN THE VICINITY OF THE NORTHWEST WELLFIELD MAY 2000

	CONTROL METHOD	CONTROLLER*	TREATMENT
WETLANDS: *Pennsuco Wetlands*	Chemical	SFWMD	No mechanical controls used. Melaleuca (<2" dia) are cut stump treated with a mixture of 25% Rodeo + 25% Arsenal + water using a hand held spray bottle. Melaleuca (>2" dia) are girdled and treated with a mixture of 25% Rodeo + 25% Arsenal + water using a hand held spray bottle. Dense stands of Melaleuca are treated with 3qts/acre Rodeo + 3qts/acre Arsenal + water using an aerial application. Brazilian pepper is treated with 10 % Garlon4 + mineral or vegetable oil using a basal bark application. Australian pines are treated the same as Brazilian pepper using 20% Garlon4.
Transitional Northeast Everglades	Mechanical		*No government owned properties in this area. Rockminers, in preparation for mining, remove Melaleuca and burn it.*
UPLANDS: *Milton E. Thompson Park*	Mechanical & Chemical	Miami-Dade Parks and Recreation Department, Natural Area Management	Melaleuca: Mature trees are cut stump treated with 25% Arsenal + 25% Rodeo. Few mature trees now exist. Small seedlings are hand pulled. Brazilian pepper is cut stump treated with Garlon 3A. Old World Climbing Fern is a new pest, treated with a foliar application of 3% Rodeo. Cattails are treated with Rodeo. No aquatic weed control is being implemented. Eventually a prescribed burn will be recommended.
EEL Sites (none in study area)			
Natural forest communities (none in study area)			
CANALS & CANAL BANKS:			
Recharge Canal	Mechanical	Miami-Dade Water & Sewer Department	The portion of the canal that lies between Krome Ave. and the FL Turnpike is maintained by a 2 man crew year round, without chemical controls as follows: Canal banks (tops & slopes) are mowed; Emergent weeds and grasses are pulled with a backhoe; No submerged or floating weeds; Right-of-ways are mowed which also control the Melaleuca.
Snapper Creek Extension	No Treatment	Miami-Dade Public Works Department	The portion of the canal that lies between NW 25th St and NW 58th St requires no maintenance at this time; no aquatic weeds are evident.
	Mechanical & Chemical	Miami-Dade Public Works Department	The portion of the canal that lies between SW 8th St and NW 25th St is maintained as follows: Canal banks (tops & slopes) are mowed, then occasionally treated with Rodeo as a follow-up control measure; Emergent weeds are treated with Rodeo; No submerged or floating weeds evident; Algae tough seldom present, is treated with Hydrothol 191+ Aquathol K or Reward + K-Tea.

Table 2 (Continued)

CURRENT WEED AND MOSQUITO CONTROL METHODS USED IN THE VICINITY OF THE NORTHWEST WELLFIELD MAY 2000

	CONTROL METHOD	CONTROLLER*	TREATMENT
ABUTTING CANALS & CANAL BANKS:			
L30 (Krome Ave.)	Chemical	SFWMD	No submerged or emergent weeds evident except for a few "Spatterdock" around the mouth of the control structures; Rodeo is used here if necessary. Canal banks require no maintenance since the grass and weeds tend to and die off in this area.
Miami Canal (Okeechobee Rd.)	Mechanical	SFWMD	Submerged and emergent weeds are removed using a towboat and plow.
Ditches & Ditch Banks: *(*none treated*)*			
Right-of-Ways			The only right-of-way maintained in this area runs along NW 12 St between 135 Ave and just east of the Fl Turnpike.
	Mechanical	Miami-Dade County Public Works	Mowed, except for those areas that are not accessible or have guardrails.
	Chemical	Miami-Dade County Public Works	Non-accessible areas and those areas around the guardrails are treated chemically. Rodeo is used when the area being treated is close to a water body where drift may occur. In all other cases, Roundup Pro or Garlon 3A is used.
FPL Right-of-Ways	Mechanical	FPL	Small trees/weeds are removed from low power distribution lines by cutting them manually. Large trees are cut stump treated with Garlon PM to prevent resprouting. Trees/weeds at transmission lines and substations are treated using a foliar application of .5% Arsenal & 1% Garlon PM or 1% Accord based on the area treated being wet or dry. Large trees are cut stump treated with Garlon PM .
Mosquito Control	Chemical	Miami-Dade County Public Works	Treat adult mosquitoes (no larvae) 1-2 x in the summer months at the prison, upon request. Malathion 95 or Fyfanon is applied by truck using a low volume sprayer.

* This information was provided by Glenn Persad and Francois La Roche, SFWMD, Gary Seamonson, Dade County Public Works, Roads and Bridges, Ed Lima, Dade County Public Works, Canal Maintenance, Cliff Phillips, Dade County Public Works, WASD, Ernesto Fernandez, Dade County Public Works, Mosquito Control, Joe Maguire, Dade County Parks and Recreation Department, NAM, and Burt Wartelll, FPL

The Recharge and SCE canals do not have a submerged vegetation problem because the dark color of the water impedes light penetration that would stimulate weed growth. Maintenance is mostly confined to canal banks and right-of-ways which, typically, are mowed. Where mowing is not possible, a Glyphosate product such as Rodeo™ or Roundup™ is used for spot treatment. This type of herbicide is environmentally safer than most others and quickly degrades to elemental substances.

Growth of submerged vegetation in the remote rock pits is impeded because phosphate levels in the water are low and because there is insufficient light penetration to the bottom. Weed control for aesthetic or access reasons around the lake perimeters is not necessary because access to the lakes is discouraged.

There have been broad-scale eradication projects for control of exotic plant species within the study area with the primary focus on Melaleuca. Brazilian pepper, Cattails, and Old World Climbing Fern are also controlled within the county-owned M.E. Thompson Park. Brazilian pepper and Australian pine are controlled inside the Pennsuco wetlands, partially to mitigate for the construction of the Recharge Canal.

The South Florida Water Management District, Natural Areas Management Section (NAM) of the Miami-Dade Parks and Recreation Department and the Exotic Pest Plant Council evaluated the techniques that employ the use of the higher risk herbicides, Arsenal and Garlon 4. The South Florida Water Management District is currently developing a long term monitoring plan for the Pennsuco wetlands and is considering the evaluation of water quality impacts of herbicide use. The NAM and Miami-Dade County Department of Solid Waste Management have been implementing a long term monitoring plan at M.E. Thompson Park since 1992. The Thompson Park study includes semi-annual sampling of soil, drinking water, surface water (including lake and standing water in treatment areas), and groundwater for the herbicides as well as other parameters. This study also included pre-application sampling. To date there have been no detections of herbicides.

The terrestrial right-of-ways in the wellfield area such as the power line easement and access roads are mowed, except where access is impeded. Most of the trees are trimmed or destroyed using foliar applications or stump treatments with chemicals. In some cases chemicals are used to remove woody vegetation. In these cases DERM staff participated in developing the protocol for weed control activities.

E. Enforcement and Remediation Activities

Enforcement actions taken to achieve compliance with DERM's environmental protection code may vary slightly depending upon the issues at hand. However, at permitted facilities, all facility operators are advised of any violations, potential problems, or concerns in writing through the issuance of field notices prior to initiating any formalized enforcement activities. Field notices specify the problems that have been identified and require corrective measures for bringing these facilities into compliance.

Typically, field notices are issued when a facility does not comply with the permit conditions on their operating permit, an inappropriate activity has been documented, unauthorized discharges occur, or there are general housekeeping concerns that would lead to potential problems. If there is no compliance within a specified time frame, formal enforcement action will be taken which

may result in the issuance of a "Notice of Violation", "Uniform Civil Violation Notice", "Final Notice Prior to Court", Civil or Criminal Court Action (which includes penalties) or a lien will be placed on the property. Presently, formal enforcement action involving cleanups associated with unauthorized discharges to the ground is generally given a shorter time frame for compliance when the facility is located inside wellfield protection areas than that for facilities located outside wellfield protection areas. Additionally, the time frame required for a cleanup and compliance will be dictated by proximity to the wellfield, the associated risk and the seriousness of the problem.

Enforcement activities were reviewed for the thirty-one (31) industrial type businesses that have been identified operating within the NWWF. Of these industrial operations, thirteen (13) are presently permitted by DERM, thirteen (13) are un-permitted, illegal operations and five (5) are un-permitted, potentially illegal operations that require further inspection.

The thirteen permitted facilities hold Industrial Waste Annual Operating Permits with specific permit conditions for each type of operation and are routinely inspected. A file review for these permitted businesses revealed that four are currently operating without any violations or housekeeping problems. The most frequent violations included small oil and diesel spills to the ground, liquid waste generation when prohibited, insufficient secondary containment for above ground storage tanks, insufficient submittal of waste disposal receipts, or not providing access to septic tank for sample collection. Other problems and concerns that have been documented at these businesses include spring loaded rainwater release valves wedged open, oily waste water left standing in secondary containment structures, lake filling with debris, placement of diesel operated generators and associated diesel tanks along the edges of rock mining lakes, improper storage of hazardous materials, improper disposal of hazardous wastes, and contamination of domestic septic tank systems with hazardous waste.

Eleven of the thirteen un-permitted businesses are currently under formal enforcement action for handling, storing, discharging, generating hazardous materials, hazardous waste, or liquid wastes without prior written approval from DERM. Seven of these facilities have requested hearings with the Environmental Quality Control Board (EQCB) to request variances for their operations. To date, three of these operations have been denied variances and two have withdrawn their request for variances. Additionally, two pre-cast / pre-stress operations were denied variances for their operations and were subsequently issued court orders to close.

Five facilities were recently identified operating inside the NWWF without approval from the Department. To date additional information is required on each, but they are potentially illegal operations and may require enforcement activities pending thorough inspections

F. Water Quality and Monitoring Activities

Source Classification of the Northwest Wellfield

The surface water treatment rule promulgated in 1989 by EPA requires that public water supplies derived from “groundwater under the direct influence of surface water” (GWUDI) receive the same treatment as water supplies derived directly from surface water (USEPA, 1992). The wellfield is not currently classified as being GWUDI. This was determined by testing the treated drinking water and individual production wells for “microscopic particulates” and specific microorganisms. WASD took 74 samples between March 1994 and June 1996. Initial testing

did reveal one production well exceeding the threshold for GWUDI and several others near the threshold. The well exceeding the threshold had faulty grouting which resulted in impacts from ponding stormwater around the well. The deficient well was rehabilitated by deepening the casing and correcting the faulty grouting. Several production wells near a lake immediately north of the wellfield were deepened to reduce pathogen risk. Current test results from 1998 - 2000 indicate all of the wells meet criteria under current hydrologic conditions. Because the wellfield is not GWUDI, the existing Hialeah and Preston water treatment facilities do not need to be retrofitted for treatment of surface water at this time.

Cryptosporidium and Giardia Sampling in the NWWF

DERM recently sampled surface and groundwater in the NWWF to determine concentration and distribution of *Giardia* cysts and *Cryptosporidium* oocysts at different distances from the wellfield (DERM Summary Report, 2000). In December 1999 samples were collected from 5 groundwater sites, 1 production well, and 2 surface sites and submitted to the Florida Department of Health Laboratory in Tampa, Florida. All were below detection limits that ranged from 0.45 – 5.29 /100 ml. Four more groundwater sites and 1 production well were sampled again in March 2000. These results were also below detection limits. The report recommends additional wet weather sampling. Researchers (Solo-Gabriel, 1998) collected water samples from the SCE canal and one rockmine lake in the study area for *Cryptosporidium* oocysts. The results were below the detection levels of 12 oocysts/100L.

Dye Tracer Projects

Several dye tracer projects were initiated in 1998 and continued through 2000 to assess groundwater velocities within the inner protection zones under current hydrologic conditions. A transect of wells aligned along theoretical NW 74th Street were used to inject and monitor the transport of red and yellow dyes towards the production wells. The purpose of these projects was to collect information on aquifer transport characteristics at various distances from the production well and at various depths.

Four preliminary dye tracer trials were initiated through 1998 and 1999 while wellfield pumpages were held more or less constant at 90 MGD (Figures 10 & 11). In the first trial, red dye was detected in production well #8 less than two days after release at a monitoring well located 450 feet east. The second and third dye releases were 1,800 feet east of production well #9. No dyes were detected in production well #9 after over 75 days of sampling. The fourth dye release was 879 feet east of production well #9. The initial detection of dye was 5.3 days after release and the mean dye travel time was 13.2 days.

A full-scale tracer test was started September 10, 1999 injecting two different dyes at different depths (Figure 12). The dye injection wells were 3,040 feet east of the wellfield. The intervening monitoring wells were sampled for both color dyes. The onset of the rainy season interfered with this project, essentially retarding dye transport. As dry season conditions set in, dye velocities increased.

Although this project is still ongoing, several conclusions are emerging from this project and the previous trials. The mean dye travel times are of the same order of magnitude as those predicted by the previous particle-tracking model used to generate the existing travel time boundaries.

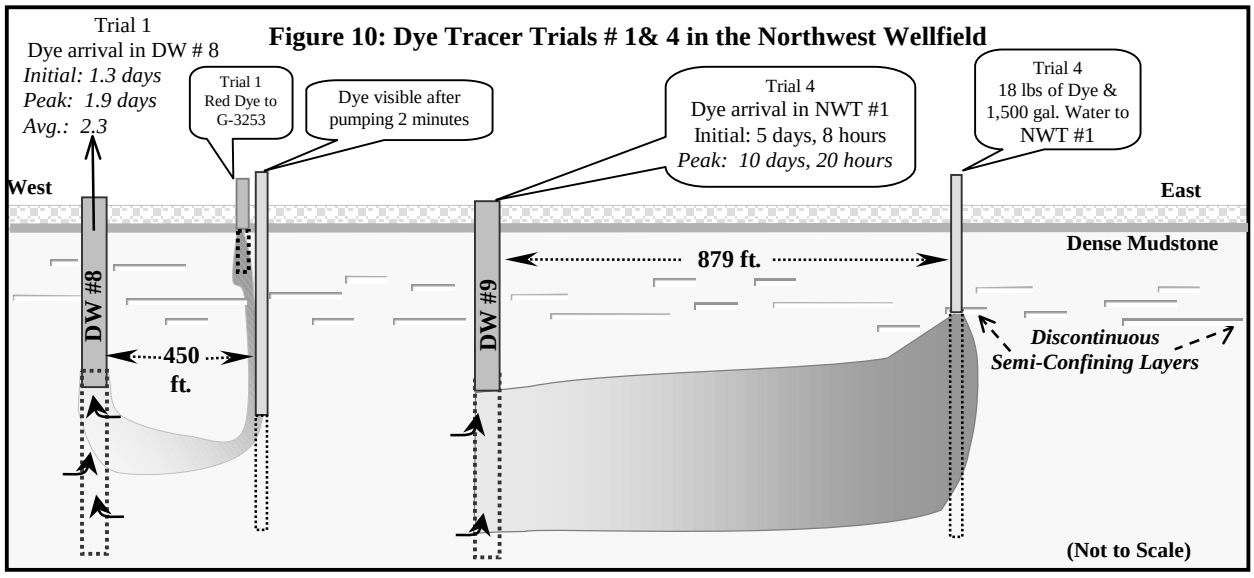


Figure 10: Dye Tracer Trials # 1& 4 in the Northwest Wellfield
Trial 1
Dye arrival in DW # 8
Initial: 1.3 days
Peak: 1.9 days
Avg.: 2.3
Trial 1
Red Dye to
G-3253
Dye visible after
pumping 2 minutes
Trial 4
Dye arrival in NWT #1
Initial: 5 days, 8 hours
Peak: 10 days, 20 hours
Trial 4
18 lbs of Dye &
1,500 gal. Water to
NWT #1
West
East
Dense Mudstone
DW #8
DW #9
450
ft.
879 ft.
Discontinuous
Semi-Confining Layers
(Not to Scale)

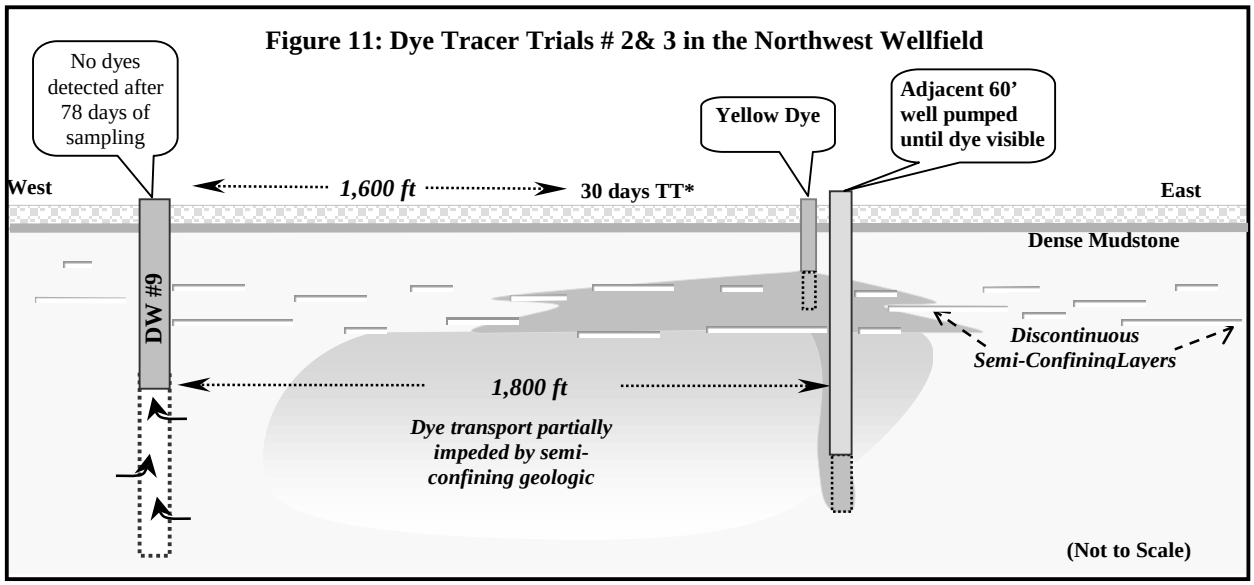
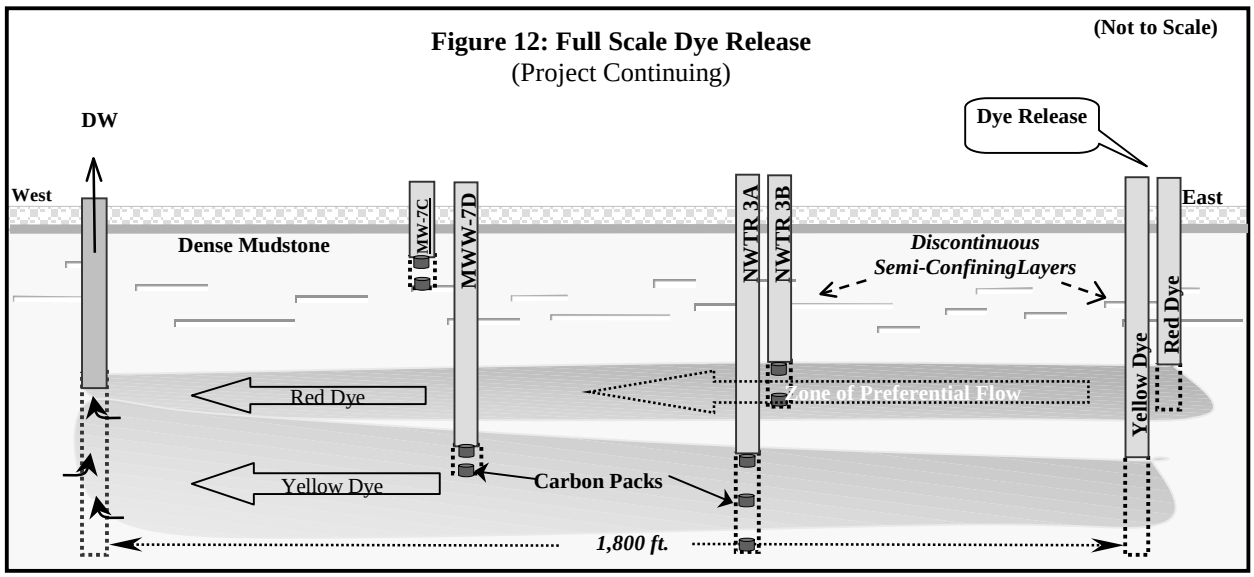


Figure 11: Dye Tracer Trials # 2& 3 in the Northwest Wellfield
No dyes
detected after
78 days of
sampling
Yellow Dye
Adjacent 60'
well pumped
until dye visible
West
1,600 ft
30 days TT*
East
Dense Mudstone
DW #9
Discontinuous
Semi-ConfiningLayers
1,800 ft
Dye transport partially
impeded by semi-
confining geologic
(Not to Scale)


(Not to Scale)
Figure 12: Full Scale Dye Release
(Project Continuing)
DW
Dye Release
West
East
Dense Mudstone
MW-7C
MWW-7D
NWTR 3A
NWTR 3B
Discontinuous
Semi-ConfiningLayers
Red Dye
Yellow Dye
Red Dye
Zone of Preferential Flow
Yellow Dye
Carbon Packs
1,800 ft.

Additionally, there appear to be two horizontal preferential flow paths to the wellfield, as originally predicted by lithologic data collected in 1986 (DERM Technical Report, 88-3). One preferential path occurs at 40-50 feet depth. Part of this may be the effect of the casing depths of 11 production wells (1-9, 11 and 12) at 46 ft., 3 production wells (13-15) at approximately 55 ft. and one (10) at 64 ft. Another transmissive zone occurs around 70 ft.

Historical Monitoring Program

The original water monitoring well network for the Northwest Wellfield was designed and installed in 1985 – 86 (DERM Technical Report 88-3). Five test wells, drilled from 90 –190' deep, defined stratigraphy, or the order and relative position of strata, for the area. Subsequently 29 two-depth well clusters and 13 single wells were sited and installed primarily to monitor groundwater migrating from the two major pollution threats to the wellfield. The Resources Recovery facility and an inactive landfill are both located between NW 71 Street and NW 58 Streets and NW 87 and 97 Avenues just 4 miles east of the wellfield. Water levels and water quality data were collected monthly from each well beginning in September 1986. Additional water level data were collected from continuous gages at an additional 12 canal and 12 groundwater sites. Additional surface water quality data were collected from one site in the Miami Canal and two sites in the Snapper Creek Extension canal.

By the end of 1987, sufficient water level data had been collected to depict wet and dry season conditions east and west of the Snapper Creek Extension (SCE) Canal. The new Recharge Canal and SCE Canal improvements were designed to act as a water divide so that even at the driest conditions, potential contaminants from the landfill area would remain eastward of the divide. The improvements to the SCE canal included deepening from 15 feet to 40 feet the segment of the canal from NW 120th Street to 74th Street. This provided more rapid recharge to the water production zone of the wellfield, at a 40-80 ft. depth, by bypassing semi-confining strata in the upper portion of the aquifer. The monitoring plan was designed to verify the water divide and detect migrating pollution. By 1993, sufficient water level and water quality data had been collected to determine that the hydrologic divide was being maintained the majority of the time by the canal improvements and that the wellfield was free of contaminants. The divide does move east of the HEFT under extreme drought conditions. At this time, water quality and water level monitoring was reduced to 4 times per year and the number of water level wells monitored was reduced.

The monitoring program has subsequently been scaled back twice more based on data assessment and DERM's recommendation to the Water Management District. Currently the monitoring program is a requirement of the water use permit issued by SFWMD for the wellfield pumpage. The current water quality program includes 3 annual samplings of 9 sites (two-depth clusters) and two production wells for a total of 20 wells. Four surface sites and 4 single wells are sampled annually. The program no longer samples wells around the county waste facilities because they are outside of the protection zone and because the waste facilities are monitored by a separate county program. Instead there is a transect of wells from Resources Recovery to the Snapper Creek Extension Canal to monitor for potential westward migration and there are two transects of wells from just west of the HEFT to the production wells to monitor for unknown sources of pollution. Water level wells have been scaled back to 30 sites and are also taken 3 times per year. The historical monitoring wells, current monitoring program wells, and production wells within the study area are depicted on Figure13. It should be noted that there are

many additional monitoring wells east of the study area. Parameters sampled are listed in Table 3.

TABLE 3: Parameters Currently Monitored in the NWWF Protection Area

Parameter	20 Wells Monitored Every 4 Months	4 Surface Sites and 4 Wells Monitored Annually
EPA 601 & EPA 602	Every 4 months	Annually
EPA 6270 or EPA 608	Every 2 years	Every 2 years
EPA 8081 or EPA 608	Every 3 years	Every 3 years
EPA 8270 or EPA 612	Every 3 years	Every 3 years
Phenols	Annually	Annually
Ammonia	Every 4 months	Annually
Chloride	Every 4 months	Annually
TDS and Color	Every 4 months	Annually
Metals (unfiltered Cd, Cr, Cu, Pb, Hg)	Annually	Annually
Cations (Ca, Na, Mg, K, SO4)	Every 2 years	Every 2 years
Nox-N, T-PO4	Every 3 years	Every 3 years

Figure 13

Monitoring Wells in the Northwest Wellfield Study Area

Figure Removed for Security Purposes

III. ISSUES

A. Reassessment of the Existing Protection Zones

The Northwest Wellfield's current travel-time boundaries (210, 100, 30 and 10 day) and the outer boundary west of the Turnpike were modeled in 1985 using a two dimensional finite difference model called PLASM, developed by Camp, Dresser, & McKee Inc. (CDM) and based on the Prickett-Lonnquist model. The wellfield pumpage was based at a projected average pumpage of 220 MGD at the NWWF and 30 MGD from the older wellfields located in Hialeah and Miami Springs. In 1993, the outer boundary east of the Turnpike was amended using CDM's DYNFLOW, a three-dimensional finite element model. The meteorologic and hydrologic assumptions were similar to those used in the PLASM model.

Although the earlier modeling accounted for canal recharge, the presence of lakes was not well defined, nor was the extent of future excavations considered. In 1998, ModFlow, a three-dimensional finite element model, was used to assess the effect of the existing lakes on particle travel times. The hydrological and meteorological assumptions were the same as in the earlier modeling, the only difference being the presence of the lakes. The preliminary scenarios indicated that the presence of lakes around the wellfield potentially increase particle transport velocities through the groundwater in the vicinity of the wellfield (DERM files). This means that the wellfield protection travel time boundaries generated by ModFlow scenarios extended further from the wellfield than the existing boundaries. This indicated a need to reassess the existing protection boundaries in context of the existing lakes and planned rockmining in the area.

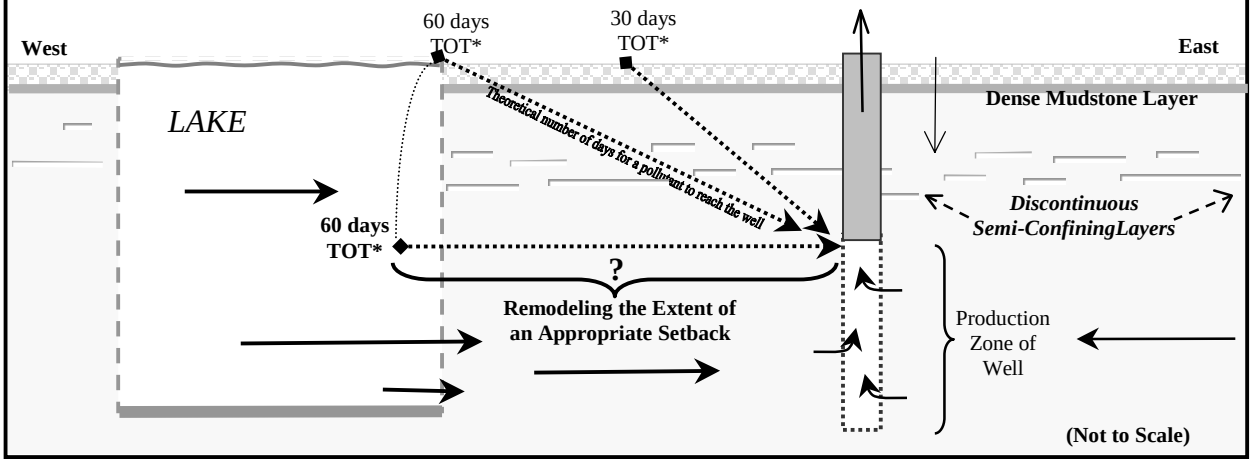
There are several factors that need to be defined for reassessing the current protection zones or modeling new zones. One factor is defining the distribution of aquifer properties relevant to the horizontal and vertical transport of water and potential pollutants. Lithologic data from various sources indicate the presence of semi-confining layers within the upper portion of the aquifer. The most significant is a layer of dense mudstone that occurs approximately 10 feet below ground surface. (Maurrasse, et al, 1976; Fish & Stewart, 1991; DERM Technical Report 88-3) Other semi-confining layers at greater depths have been described, but these do not appear to be as significant or continuous throughout the aquifer. The semi-confining layer and other layers of low transmissivity retard vertical transport from ground surface downward through the aquifer. Although these semi-confining layers are not necessarily continuous, in the aggregate they significantly retard downward movement of pollutions from the surface.

Two of the 4 preliminary dye tracer trials conducted to test transmissivity near the wellfield failed possibly because the dye release to a 25-ft. monitoring well, was above a semi-confining layer as shown in Figure 10. Detailed lithology available from an immediately adjacent 60-ft. well indicates the presence of three semi-confining layers within the upper thirty-foot profile of the aquifer. (DERM Technical Report 88-3) The dye was not detected in the nearest production well during the 78-day sampling period. Aquifer properties relevant to vertical (as well as horizontal) transport are of significance when simulating pollutant transport solely in a groundwater environment.

The existing protection boundaries for Miami-Dade's public water supplies are based on horizontal and vertical movement. However, when potential pollutants originate at the same depth as the production zone of the wellfield, horizontal transport properties within an aquifer become far more significant than vertical transport properties. This situation arises when lakes

adjacent to the production wells are as deep or deeper than the production zone of the wells. Lithologic data and the results of the tracer projects previously described indicate at least two zones of horizontal preferential flow towards the drinking water wells: one zone at 40-50 ft. and another at approximately 60-70 ft. This essentially implies that the aquifer is more porous at these depths, thus has less filtering capacity. (Figure 14) Determination of an adequate setback for rockmining that excavates down to the production zone of a wellfield should be based more on appropriate horizontal flow properties and may adequately be defined by two-dimensional modeling.

Figure 14
Schematic of Pollutant Transport Differences between Ground and Surface Water
[There will be less filtration of pollutants traveling horizontally from the lake edge than from ground surface.]



Another factor to consider in reassessing the inner protection zones is the differences in contaminant transport rates in surface water as opposed to groundwater. As previously stated, the current protection zones were modeled assuming transport only through aquifer material. However transport velocities are greater through surface water than through the aquifer because of factors such as wind effects and water currents. Factors related to surface water transport are not accounted for in groundwater transport models. There are 9 lakes entirely or partially within the 210-day zone (Figure 2). Three of those lakes extend into the 100-day zone and one intrudes into the 30-day and 10-day zones. Clearly, where lakes are present between the wellfield and the segments of the travel time boundaries, those segments are no longer relevant in terms of groundwater total time of travel (TOT) to the wellfield.

Figure 15 shows the travel time protection boundaries overlying the current, permitted and proposed lakes. In this scenario approximately 10% of the existing 210-day boundary and 30% of the 100-day boundary relate solely to groundwater transport. The remaining boundary segments encompass transport through ground and surface water, thus over estimate of travel time. This means that pollutant velocities are potentially much greater than represented by the travel time boundaries. A small segment of the 30-day (8%) and 10-day (3%) boundaries similarly over estimate the travel times.

Figure Removed for Security Purposes

Another weakness in the existing travel time boundaries is that the boundaries bisect properties and lakes in virtually all cases. This may result in one property or lake requiring two sets of wellfield regulatory criteria. It is unworkable to differentially protect a lake given the rapid mixing and dispersion that occurs in surface water. Model outputs never really determine the precise travel-time or drawdown boundary. They only estimate a region, which, on average, contains the particular boundary to an appropriate degree of certainty.

Several authors, including the EPA, have suggested that the determination of protection boundaries be based on a composite of several model scenarios (Kelson, et. al, 2000). Using this approach provides the opportunity to delineate the protection boundaries along features that are familiar to regulators and property owners. In other parts of the country, protection zones are aligned along practical features such canals and roads. Because lakes are a dominant feature in the Northwest Wellfield, protection boundaries should be assessed in terms of alignment along the right-of-ways separating lakes.

The presence of lakes in the vicinity of the wellfield increases the risk to the drinking water supply by two routes. The miles of increasing shoreline provide a route for pathogens, as well as

other pollutants, to enter the lakes either via stormwater runoff contaminated with pathogens, infected animals accessing the shorelines, or spills of contaminants near shorelines. A more direct route is via waterfowl flying in to use the lakes. Once in the lake, the pathogens/pollutants quickly disperse from the shoreline or middle of the lake. Depending on the specific gravity or other factors, the particular pathogen/pollutant will mix through the vertical extent of the lake and be drawn towards the wellfield. Water transport out of lakes and canals into the surrounding aquifer and towards the wellfield is primarily through the porous sides (Chin, 1991; Hydrologic Associates). The bottom of the rock pits is covered by an effective aquaclude of fine, calcium carbonate, clay-like lime-mud precipitate (DeGrove, 1991). Modern rockmining techniques now can excavate up to 85-ft. depths, well into the various preferential flow zones of the drinking water wells (40-80 ft.). The preferential flow zones are more porous, providing less attenuation, particularly for pathogens of human health concern.

B. Risk Management Issues Concerning Pathogens

A technical report (DERM Technical Report, 1984) associated with the 1985 Northwest Protection Plan expressed reservations about the microbial risk associated with the siting of lakes near the wellfield. Since then more has been learned about microbial pathogens typically found in surface waters and their risks to public drinking water supplies. Generally, disinfectant practices at water treatment plants are more effective against bacteria and viruses than against protozoans, nematodes and helminths. The cysts of many of these organisms are extremely resistant to environmental factors as well as most disinfectants. Nationally, more protozoan disease outbreaks have been associated with municipal drinking water supplies using surface waters than groundwater (Rosen, 2000). Although no disease outbreaks have occurred in Miami-Dade County that are attributable to municipal drinking water supplies, the extent of the lakes planned around the Northwest Wellfield area as well as the proximity of those lakes near the wellfield has raised concerns that the risk to the wellfield from pathogens will increase.

As lake acreages increase and as wellfield withdrawals increase to the planned future withdrawal rate of 225 MGD, there are two risk management issues to resolve to prevent reclassification of the wellfield as under the influence of surface water (UDI). One issue concerns determining how much aquifer material to leave unmined around the wellfield, namely determining a setback for the proposed lakes that will not result in a net increase in pathogenic risk to the wellfield and potentially trigger a reclassification of the wellfield as under direct influence of surface water. This requires more than just defining a 60-day setback distance for the wellfield using an appropriate model and incorporating that setback on a map. An assessment should be conducted as to the adequacy of a 60-day setback to filter potential pathogens to the degree that there is no net increase in risk to the wellfield under future hydrologic conditions. If necessary, risk assessments of greater setback distances should be assessed to establish an appropriate separation between the wellfield and future rockmining. No rockmining permits near the wellfield should be issued until the appropriate setback distance is determined.

The second risk management issue concerns identifying the sources of the pathogenic risk in the protection area and defining feasible source control options to reduce that risk to the lakes, canals and groundwater.

C. Pathogens of Concern to Drinking Water Supplies and Recreational Areas

Microorganisms that can be of concern in drinking water supplies include the following categories: bacteria, viruses, protozoans, fungi, algae, nematodes (roundworms) and helminths (flatworms). Although drinking water historically has been a common vehicle for the widespread transmission of pathogens, modern treatment requirements are effective for the majority of pathogens. For example, protozoans, such as *Naegleria* (causing meningoencephalitis) and *Entamoeba* (causing amoebic dysentery) are killed or inactivated during conventional treatment and maintenance of a disinfectant residual in the distribution system but others such as *Acanthamoeba* (possibly causing eye infections) are resistant (AWWA Research Foundation).

Other exceptions are microorganisms that during their life cycle form spores, cysts, or oocysts. These forms can survive for long periods in the environment and can be very resistant to conventional treatment practices at drinking water facilities. *Giardia*, *Cryptosporidium*, and relatives such as *Cyclospora* and *Microsporidium* can survive for months in some water environments (AWWA Research Foundation). *Cryptosporidium* can survive greater than six months in some water environments and is also resistant to conventional chlorination (Robertson, 1992; Rosen, 2000; AWWA Research Foundation). Additionally, there are other pathogens emerging as a concern to municipal drinking water supplies. One such pathogen is a bacteria, *Mycobacterium avium*, which is also chlorine resistant and, unlike *Giardia* and *Cryptosporidium* which need a host to reproduce, regrows in the environment (AWWA, 1999). The implication for the wellfield is that bacteria, such as *Mycobacterium*, are approximately an order of magnitude smaller than protozoans, thus not as well attenuated in the aquifer as the larger protozoans. This is why a risk assessment to determine an appropriate rockmine setback needs to assess pathogens of varying sizes and survival rates.

The health impacts of pathogens can range from mild to severe intestinal disorders with fever, cramping, nausea and headaches. Very young, old and immune compromised individuals are at special risk of death. Although most cases of intestinal illnesses, such as cryptosporidiosis, are probably due to direct contact with infected humans rather than drinking water, there have been major disease outbreaks associated with contaminated drinking or recreational waters (Rosen, 2000).

As shown in Table 4, *Giardia* outbreaks in surface water sources are three times more frequent than *Cryptosporidium* outbreaks. The literature indicates that *Giardia* is more prevalent in wildlife than *Cryptosporidium* and as a consequence LeChevallier (1991) and Wallis (1996) have found that *Giardia* is more frequently found in surface water than *Cryptosporidium*. The number of *Giardia* outbreaks from groundwater sources is 50% less than from surface water sources, in part, potentially due to the filtration capacity of the respective aquifer and more die-off because of slower transport rates. In contrast, *Cryptosporidium* oocysts are half the size of *Giardia* cysts and survive much longer in water environments. Rosen (2000), Robertson (1992) and Walker (1998) indicate that *Cryptosporidium* oocysts can survive more than 6 months. Chin (2000) indicates that *Giardia* cysts lose their viability in about 30 days at 20^{o} C (68^{o} F) and that *Cryptosporidium* oocysts survive an order of magnitude longer. These are contributing factors potentially explaining why the number of *Cryptosporidium* outbreaks in ground and surface waters is the same.

Table 4: Causes of waterborne disease outbreaks causing gastroenteritis 1989-1996[1]

(Adapted from Rosen, 2000, pg. 4)

Type of Organism	Agent	Number of outbreaks	Outbreaks associated with drinking water		Outbreaks associated with recreational water	
			surface	ground	natural	pool/park
Protozoa	*Giardia* sp.	27	12	6	4	5
	Cryptosporidium parvum	21	4	4	2	11
Bacteria	*Escherichia coli* 0157: H7	11		3	7	1
	Campylobacter jejuni	3	3			
	Salmonella sp.	2		1		1
	Leptospira grippotyphosa	1			1	
	Shigella sp.	19		8	11	
Human viruses	Hepatitis A	3				3
	Norwalk virus	1		1		
	Norwalk like virus	1				1
	Small round structured virus	1	1			
Unidentified cause	Many consistent with viral epidemiology	60	8	44	7	1
Other	Cyanobacteria-like bodies	1	1			

[1]Summary of results from studies by Herwaldt et al., 1991; Moore et al., 1998; and Levy et al., 1998.

When considering drinking water outbreaks from all causes, including bacteria, viruses and suspected viral sources, there appear to be more outbreaks from groundwater supplies (particularily for viruses) than from surface water supplies. A major factor is the preponderance of human pathogenic waste sources directly on top of water table aquifers such as septic tanks, stormwater infiltration systems, leaking sewer lines, and so forth releasing greater number of pathogens to groundwater as compared to surface water. Attenuation factors exist in both surface and groundwater that can substantially reduce the concentration of pathogens to less than the minimum that result in an infection. In the Northwest Wellfield minimizing the sources of the pathogens decreases the risk of all pathogens breaking through environmental attenuation factors in numbers sufficient to cause diseases.

Another factor related to more outbreaks in groundwater from known and suspect viral causes as compared to other types of pathogens is the minimum number necessary to cause an illness varies. In the case of some viruses, one organism is all that is theoretically necessary to infect a human. In the case of *Cryptosporidium*, 10-30 organisms are the minimum number to induce an infection in a human (Dupont et al., 1995; Rosen, 2000).

Size is another factor explaining why viral pathogens cause more outbreaks in groundwater supplies. The groundwater environment is simply more effective in mechanically filtering out

the larger pathogens. Thus viruses, approximately three orders of magnitude smaller than protozoans, are transported further and in greater numbers.

Finally, there are factors in surface water environments that reduce the number of bacterial and viral intestinal pathogens. Solar radiation, predatory protozoa and invertebrates, dilution, higher temperatures, adsorption and settling are some of the factors that kill or inactivate many bacterial and viral pathogens in surface waters (Rosen, 2000). What is not known from this table is which outbreaks were a result of a failure in the disinfection systems at the treatment facilities. As previously mentioned, bacteria and viruses, in general, are more sensitive to disinfection than protozoans. The candidate organisms to consider in a determination of an adequate rockmine setback should focus on those pathogens that are resistant to natural attenuation factors and resistant to disinfectants.

In addition to long survival times in the environment and resistance to conventional water treatment, waterborne pathogens of greatest concern to groundwater supplies are also those that are shed into the environment in fairly high numbers and highly infectious to humans or animals at relatively low doses (Rosen, 2000). *Cryptosporidium* oocysts, *Giardia* cysts and, possibly, *Mycobacterium avium* meet these criteria. Furthermore, unlike many human pathogens, they can be shed from one species of mammal and infect other species of mammals including humans (Dupont et al. 1995, Fayer et al. 1990).

D. Sources of Pathogenic Protozoans

Cryptosporidium has been isolated from newborn lambs, goat kids, foals and piglets as well as wild deer, feral hogs, coyotes, rats, birds, reptiles, and fish. The parasite is a particular problem for livestock producers because it lives in the intestines of many animals, particularly young calves used in the dairy and beef cattle industries. It is a major concern to the industry for its human and bovine health consequences. Oocysts can be shed in feces for several days by an infected animal, with up to 10 million oocysts per gram of feces (about 280 million per ounce) during the peak of shedding (Blewett, 1989; Goodgame et al., 1993; Xiao and Herd, 1994)

In addition to farm animals, pets also provide a reservoir for a number of pathogens including *Giardia lamblia*, *Cryptosporidium* and *Salmonella*. Horses are also known carriers of *Cryptosporidium* (Coleman, 1989; Johnson et al., 1997) and *Giardia* (Johnson et al., 1997). Salt Lake City has enacted strict regulations for companion animals in the Wasatch and Oquirrh Mountains that supply drinking water for the city after coliform counts indicated a potential pathogen problem was developing (Rosen, 2000).

Wildlife and farm animals are dispersed throughout the Lake Belt area. Both can contribute various pathogens to the natural ground and surface water environment in the Northwest Wellfield area, including flat and roundworms, protozoans, bacteria, and viruses. Agricultural practices and urban encroachment in this watershed area will amplify the total potential load to the lakes, canals and groundwater. Table 5 shows the distribution of *Cryptosporidium* oocysts from various types of surface water sources across the country. The data generally shows fewer oocysts in surface water remote from urban, agricultural and recreational activities. Therefore risk reduction measures in water shed protection programs around the country almost exclusively focus on limiting human activities including agricultural pasture which are major sources of pathogens of human health concern. However, to provide added protection to their drinking

water supplies, Seattle and City of New York have implemented waterfowl control measures in some of their suface water reservoirs. Graczyk (1996) as well as other researchers have implicated waterfowl as potential vectors of C. parvum. Because the study is attempting to enhance protection to the Northwest Wellfield under future hydrologic conditions, all reasonable options, including options to reduce pathogenic risk from wildlife, are being considered.

Table 5: Distribution of *Cryptosporidium* oocysts from various types of surface water sources

	Range	Mean	Single Value	Source
Midwest & East Coast Surface Water Sources	0.07 - 484 oocysts/liter	2.4-2.7 oocysts/liter (geometric)		LeChevallier and Norton 1995, LeChevallier et al. 1991)
Washington & Calf. Rivers	2 - 112 oocysts/liter	25 oocysts/liter		Ongerth and Stibbs 1987
Pristine Surface Water Sources	0.005 – 18 oocysts/liter			Madore et al. 1987
Irrigation canal Water through cattle pastures			5,800 oocysts/liter	Madore et al. 1987
River Water with Human Recreation			127 oocysts/liter	Madore et al. 1987

E. Options to Reduce Pathogenic/Pollutant Risk

The major challenge in protecting the wellfield is to minimize the potential sources of pathogens/pollutants, particularly to the surrounding lakes and unmined aquifer. The most conservative option is to avoid risk to the maximum extent. This implies prohibiting all land uses associated with pathogenic pollutants: farm animal operations, residential areas and associated commercial areas were pets are common as well as septic tanks, potentially leaking sewer lines, sewage treatment plants, landfill operations and indiscriminant dumping. Although many of these prohibitions exist on new uses, residential uses on 5 acres are allowed, rockmining and agriculture are allowable uses in the wellfield and other uses are grandfathered.

In the early 1980's, very little agriculture was present in the area and there were no major agricultural operations expected. Because this area was to be a regional water supply and a major water storage area, all industrial zoning was repealed to discourage development in this area. Now, agriculture and residential land use remain as the only other viable land use option in the protection area, besides rockmining. The county is generally preempted from exerting limitations on the use of farm chemicals by state statutes. Private land owners can expand farming operations within the study area, except where wetland restrictions prevail. This includes animal operations at the land surface and aquaculture: in above ground tanks, in-ground ponds and caged operations in the rock pits, all factors that can increase risk to drinking water quality. Additionally, much of this watershed consists of wetlands that will be undergoing biological enhancement to mitigate for loss of habitat. As this is intended to encourage wildlife access to shorelines, pathogenic risk from wildlife sources can be expected to increase.

The following sections discuss various options to reduce pathogenic/pollution risk to the wellfield. The most stringent is a risk avoidance option of eliminating as many sources of pathogens/pollution as possible. Short of this ideal, other measures will be discussed such as strengthening stormwater controls, requiring setbacks from shorelines, limiting access to lakes, preventing connectivity between canals and lakes, strengthening septic tank criteria, and so forth. Included is an option to limit wildlife around the lakes closest to the wellfield, a unique concept in wellfield and watershed protection.

Public Ownership of the Most Critical Areas

The most conservative protection for the wellfield is to eliminate all human activity around the unmined aquifer and lakes near the wellfield, except for the existing wellfield utility maintenance activities. This would entail purchase and transfer of private land into county ownership. This is a costly endeavor. Initial cost estimates to purchase private land around the wellfield is yet to be determined. Equally important is the final disposition of the lakes within the inner lake zone after excavation ceases. Placing lakes and surrounding land into public ownership would secure this area from public access. The shorelines could then be configured to minimize stormwater runoff and access by humans and animals.

At this time WASD is planning to purchase remnant parcels of private land within the 3 square miles of county owned property. Some of these parcels have virtually no land use options because they are less than the minimum 5 acres allowed for residential. The WASD acquisition program will eliminate the risk of animal operations contaminating the land surface in this area.

Once the inner lake and aquifer buffer areas are delineated, other parcels of land, particularly those west of the wellfield, could be at least prioritized for eventual transfer into public ownership through purchase or land transfer agreements. Sources of funding will be identified. Options involving land and development rights transfers should also be explored.

In the interim, existing stormwater regulations should be strengthened to manage any pathogenic or chemical pollution, particularly within the inner lake and aquifer buffer areas. Management strategies include stormwater controls, more stringent permitting and inspections, surveillance for illegal activities, and environmental monitoring.

Stormwater Management Controls

Stormwater runoff can be a major contributor of various pollutants, including pathogens from various sources. The SFWMD has stormwater permitting authority administered under Chapter 40E, F.A.C. Miami-Dade County, under a General Permit, has authority over developments, which fall within three thresholds:

1. developments less than 40 acres with overflow outfalls,
2. developments less than 320 acres without overflow outfalls, and
3. developments in environmentally sensitive areas.

According to County policy, stormwater runoff should be retained on site if possible. Within the 10 and 30-day wellfield protection zones, no offsite drainage is allowed. Outside the 30-day zone, at minimum, the first inch of stormwater runoff must be retained prior to outfall discharge to surface waters. Early studies indicated that approximately 90 percent of the bacteria, suspended solids and metals occur in the runoff from the first inch of rainfall. More restrictive protection was implemented in the Northwest Wellfield by requiring berming and backsloping

the SCE canal and the secondary canals connected to it. However county policy still allows for outfall discharge into the canals after retention of 1" of stormwater in the Northwest Wellfield area.

Because much of the wellfield area is relatively undeveloped, more land can be set aside to retain stormwater and eliminate the need for outfall discharge, particularly for lakes and unmined areas near the wellfield. Containment of stormwater on site would substantially reduce transport of pathogens and other pollutants to lakes needing more stringent protection. Because the Northwest Wellfield area is overlain with up to 10 feet of peaty muck soils, it is not uncommon to have several feet of floodwater in the area, which is slow to recede. Therefore, berms to the 100-year flood elevation should be required near the shorelines of the restricted access lakes. These berms should be backsloped a minimum of 4 foot for each 1 foot of berm height. To insure that there is adequate filtration of microorganisms, a ground cover should be provided along the berm and backslope area to retard stormwater infiltration to no more than ½ inch per hour. The ground cover should be a minimum 50-ft. width along the berm.

Another aspect of reducing shoreline pathogenic risk is to restrict access to the shoreline by the sources such as horses, agricultural animals, humans, pets, as well as wildlife. Excretion of wastes by infected animals and humans accessing the shoreline bypasses the stormwater control such as berming and backsloping. Although state regulations and statutes generally can preempt local regulations on farming activities which are regulated by State BMPs adopted under Chapter 120 F.S., local government regulations within wellfield protection areas including setbacks and fencing for farm animals are usually allowable. The right-of-way strips between the lakes (aquifer buffer strips), although too narrow for most activities can be attractive destination points for activities such as fishing and horseback riding. These aquifer buffer strips between the lakes in the inner lake protection zone should be likewise bermed and backsloped. Access to these buffer strips should be prohibited and security measures such as fencing required to restrict the public and feral and farm animal access to the inner lakes.

Canals

The canals that convey water outside of the wellfield protection area are subject to pollutant runoff not restricted by wellfield protection controls. A study testing for *Cryptosporidium* oocysts in various canals within Miami-Dade County detected oocysts in 2 of 9 canals and one lake tested during March 1996 (Solo-Gabriele, 1998). Those two canal sites were resampled in May 1997 along with the canal sediments. One site on the L-30 canal north of the Tamiami Trail had 25 and 175 oocysts/100 Liters detected in the water column samples and 74 and 237 oocyts/ml in the sediment samples. The second site, which drains agricultural and some urban land, along the C-103N canal had 113 and 52 oocysts/100 Liters detected in the water column samples and 115 and 114 oocyts/ml in the sediment samples. It is interesting to note that the canal with higher numbers of oocysts abuts and drains wetlands. Both reptiles and birds are highly represented within wetland wildlife populations. The eight sites in urban areas were below the level of detection (Solo-Gabriele, 1998). However, this does not mean that canals in urban areas are risk free. EPA's assessment of early sampling techniques have found poor recoveries and detection limits higher than the concentrations expected to cause disease (10-30 oocysts/100L) (Clancy, 1999). The researchers also found that more than half of the laboratories were unable to recover any oocysts when the samples were spiked with 800 oocysts. Therefore the non-detect water samples in the local study may have been false negatives.

The sediments in the Miami-Dade County study were tested only at the two positive sites (Solo-Gabriele, 1998). The number of oocysts was 100,000 times the number in the water samples. Distrubance of canal bottom sediments by conveyances of stormwater or mechanical removal of vegetation can resuspend the occysts. Therefore, it is important that there is no connectivity between the lakes and the canal system conveying water to the study area.

Design and Access of Littoral Areas by Wildlife

The Lake Belt Master Planning process is developing designs incorporating various littoral area configurations for biological enhancement of the lake perimeters. This includes attracting wildlife to these shorelines. For lakes near the wellfield, biologically enhanced shorelines are counterproductive to minimizing pathogen risk from wildlife waste. One option for minimizing risk to the lakes nearer the wellfield is to configure the littoral area to discourage wildlife from approaching the shorelines. Enough littoral area could be left for safety purposes for any maintenance workers in the area. Shoreline weed control may also be necessary to discourage bird populations. In the event that innovative littoral designs could provide some biological enhancement yet protect the lakes from animal waste, an assessment of these options will also be considered.

Septic Tanks and Sewers

For most disease outbreaks attributable to waterborne pathogens, the main contributor is usually water contaminated with human feces (Levy et al., 1998; Upton, 1999; Rosen, 2000). This typically includes wastes contributed by recreational swimming and boating. But sewer collection systems and septic tanks leaking to ground and surface water supplies have also been implicated. Wellfield protection provisions limit density and loading of septic tank systems and strengthen sewer construction requirements. Problems with these systems happen in the county when flooding occurs. Pathogens from septic tank systems (and from wastes deposited on ground surface) are lifted up and carried by the floodwaters. They can be quickly conveyed down the sides of poorly constructed private and public wells. Testing of private home wells in the aftermath of major flooding events has typically found contamination of home wells strongly related to ungrouted wells and lack of a protecting concrete pad around the wells. (DERM files) State regulations require septic tanks to be elevated to the 10-year flood criteria to minimize contamination of floodwaters by septic tank wastes. The septic tank that serves the bathroom facility at the wellfield meets the regulation by being situated on a clearly visible mound. Nonetheless, it is possible that the existing septic tank elevation criteria is not adequate under the changing hydrologic condition occurring and planned in the area. Increasing the required elevation for septic tanks from 10 to 20 years or more will provide more protection, particularly for the private wells in the area.

There is one sewer main that extends westward along NW 41 Street that services the State's and County's prison facilities. There are several sewage pump stations associated with this facility, but to date there are no recorded overflows or maintenance problems. As part of the operating permit DERM requires a standard operating procedure for maintenance that requires the reporting of overflows or maintenance problems. It is feasible that with power outages or with stormwater infiltration from serious flooding, overflows could occur at this facility. Any overflow could result in a risk of pathogen contamination near surface waters near the wellfield.

Compliance Monitoring and Enforcement

DERM has made a conscientious effort to restrict the land uses inside the NWWF, but it has been an ongoing management situation to prevent the establishment of illegal operations, to identify and stop prohibited activities at existing operations, and to close down illegal operations. Non-residential land uses, industrial operations and the types of activities associated with these land uses and operations are constantly changing. New land uses are always appearing in this area; these are typically smaller illegal operations. Also, businesses change location or the business changes names, owners, and activities. To stop prohibited activities and close an illegal operation, formal enforcement action is initiated. It is the Department's policy to aggressively deal with those facilities where discharges and contamination have been documented. However, to close all illegal operations without documented discharges or contamination, can take longer, sometimes years due to legal processes.

Recreation

Although the general public may believe that *Cryptosporidium* is most commonly linked to runoff from dairies and livestock cattle, many experts contend that its source can also include human wastes (especially children and workers at daycare centers) and pets. Some of the ways for humans to become contaminated include drinking and coming in contact with untreated water, swimming and water recreation, changing diapers, and some sexual activities. There has not been a documented outbreak of cryptosporidiosis in the county linked to municipal drinking water. County health data indicate most outbreaks of cryptosporidiosis are due to human-to-human contact. As shown in Table 4, a significant amount of water borne disease outbreaks occurs from contact with recreational waters. Although the Lake Belt Master Plan calls for public access lakes, plans are to prohibit any recreation in lakes near the wellfield. An issue is how many lakes near the wellfield should be eliminated from any recreational (and biological enhancement) opportunities. This will be determined by hydrologic modeling.

Some of the recommendations to reduce pathogenic and other pollution risk to the lakes closest to the wellfield should be extended to all of the lakes within the Northwest Wellfield Protection area. Surface water contaminated with pathogens also represents a health risk to recreational users who may accidentally swallow the water or have water enter the ear canal. Although recreational users will not be protected from more direct human-to-human contact in the water, they should be protected from needless exposure to pathogens and other pollutants from runoff from farming operations, roadways, residential areas and grandfathered activities. Therefore, the ban on overflow outfalls should be extended to the entire protection area. The 100-ft. setback for animal operations should be retained. Motorized boats should be also banned from all of the lakes in the wellfield protection area. Boats used for official purposes such as aquatic weed maintenance, biological surveys, and water quality monitoring should use electric motors. Swimming areas, which are potential sources of pathogens, should be sited as far as possible from the inner lake zone and isolated from other activities, such as launching areas for non-motorized watercraft. Water samples should be collected at swimming areas to monitor for buildup of enteric microorganisms.

IV. UPDATING THE PROTECTION PROGRAM FOR THE NORTHWEST WELLFIELD

A. Reassessing and Delineating the Protection Boundaries

The travel-time protection boundaries developed for the Northwest Wellfield were based primarily on groundwater hydrologic assumptions that are no longer valid given the extent of rockmining occurring in the area. To address the hydrologic and geologic changes occurring within the area, the protection zones will be revised to delineate two major protection zones: an outer protection zone containing lakes available for passive recreation and biological enhancement and an inner zone containing lakes and unmined aquifer more stringently protected. The two zones are shown conceptually in Figure 16.

Figure Removed for Security Purposes

County staff has received technical assistance from the South Florida Water Management District (SFWMD) and has contracted with an outside consultant to reassess and delineate the revised protection zones for the Northwest Wellfield. SFWMD staff is currently using various modeling tools in conjunction with the Comprehensive Everglades Restoration Plan (CERP). The CERP staff have constructed a simplified analytic element model of the groundwater flow system in the vicinity of the Northwest Wellfield to enable county staff to delineate time of travel (TOT) capture zones for entire lakes (Kelson, 2000). Scenarios will be generated simulating future hydrologic conditions, including increased water supply demands from the wellfield, lined reservoirs and rockmining build out. The analytic element model is being calibrated in a similar fashion as the regional models used for CERP, but with more detailed data from the county's wellfield protection monitoring program. If warranted and appropriate, outputs from the analytic

model will be compared to outputs from the SFWMD's ModFlow model used in the CERP process.

The outside consultant will be providing technical assistance in utilizing the analytic element model and evaluating whether additional model output is needed, such as that from the SFWMD's North Dade ModFlow model.

B. Assessment of the Rockming Setback

The adequacy of the 60-day rockmine setback for protecting the wellfield under future conditions will be assessed, including its adequacy for preventing the reclassification of the wellfield as GWUDI. For this purpose, the contracted consultants will be assisting the county in selecting the appropriate risk assessment modeling tools. A risk assessment model must account for aquifer properties similar to hydrologic models. Additional factors are considered such as organism size, specific gravity and die-off rates.

The logic in this type of modeling is to generate numbers of potential pathogens at the source, in this case lake water. Then using observed coefficients or algorithms for organism die-off, pathogen size and assumptions about aquifer properties, it is possible to model transport of the organism populations from the lake horizontally through the aquifer towards the wellfield. The numbers of pathogens that reach the drinking water well gives an indication of the attenuation capability of the aquifer under varying land use conditions. If it can be certain that the aquifer buffer and inner lake zone remain isolated, then lower organism population ranges could be used. If there is a chance that activities in this area will increase, then higher population ranges should be used.

The risk assessment modeling is to give an indication if the 60-day setback will be adequate under future conditions within an acceptable range of uncertainty. If not, then the risk assessment modeling will test other setback distances to determine which distance to be adequate to protect the wellfield. It is critical that establishment of an appropriate unmined buffer be determined expeditiously in order to respond to existing and future applications for rockmining in the vicinity of the wellfield.

C. Revised Wellfield Protection Strategies for the Inner Lake Protection Zone

The most stringent protection will be applied to the inner lake protection zone. These lakes will be closed to public access and not be biologically enhanced in order to minimize pathogenic risk to surface and groundwater closest to the wellfield. Properties within the inner lake protection zone, with particular attention to the unmined aquifer will be prioritized for transfer into public ownership. Other wellfield protection provisions will be uniformly applied within each zone as much as possible to simplify regulatory decisions.

The proposed wellfield protection program for the Northwest Wellfield is summarized in Table 6. The provisions that are more stringent than the current program are highlighted in bold. Most of the changes relate to stricter stormwater controls to protect the lakes from overland runoff and

Table 6

Recommended Program for New Uses in the Northwest Wellfield Protection Area

ACTIVITY	Northwest Wellfield Protection Zones				
	Inner Lake Protection Zone			Outer Zone	
	Setbacks			West of UDB	East of UDB
	100’	60-day*			
Rockmining/unlimited depth	P		Not Restricted		
Industrial Uses Ancillary to Active Rockmining (rock crushing and aggregate plants)	P	Not Restricted, only fuels and lubricants necessary to operate and maintain equipment			
Variances to Prohibitions	Requires 4 out of 5 vote by Environmental Quality Control Board				
BU3 and IU Zoning	P	P	P	P	P
Uses not Ancillary to Rockmining	P	P	P	P	P
Non-Residential Uses Handling Hazardous Materials and Generating Hazardous Waste	P	P	P	P	P
Underground Storage Tanks For Hazardous Materials	P	P	P	P	P
Pipelines Transporting Hazardous Materials	P	P	P	P	P
Liquid Waste Storage, Treatment Or Disposal Methods Other Than Septic Tanks & Public Sanitary Sewers	P	P	P	P	P
Resource Recovery And Management Facilities	P	P	P	P	P
Non Residential Uses on Septic Tanks	P	P	P Excluding rockmining and accompaning ancillary uses		
Existing Uses Handling Haz. Mat. Must Reduce Risk Upon Expansion	P	Req.	Req.	Req.	Req.
Residential Uses Served by Septic Tanks	P	1 unit/5 acres 10-day travel time between onsite well & septic tank			2 units/acre with zoning
Uses Served by Sewers & Public Water not using hazardous materials	P	**P**	**P**	**P**	NR
Residential Uses Served by Sewers & Public Water	P	**P**	**P**	**P**	NR
Stormwater Disposal	P	**Infiltration only at natural grade**		**Infilt. & seepage**	Infilt., seep. & overflow outfall
Berms and Backsloping at Lake and Canal Shorelines	R	**Req.**	**Req.**	**Req.**	R, for SCE Canal
100’ Setback from Surface Water for All Uses	R	**Req.**	**Req.**	**Req. except for Recreation**	Req., for SCE Canal
Littoral Area Enhancement	P	**Req.**	**Req.**	NR	NR
Weed Control	Mechanical and other non-chemical options preferred				
Agriculture	P	Exempt, except for packinghouses with liquid waste and farmer owned vehicle maintenance operations.			

P=Prohibited NR=Not Restricted Req.=Required R=Restricted UDB=Urban Development Boundary

Bold highlighted refers to criteria more stringent than the existing program

*****Rockmine setback distance conditional on determination of adequacy to protect the wellfield

outfall overflows. Also recommended is a prohibition of urban development west of the Turnpike codified within Chapter 24, Code of Metropolitan Dade County.

The groundwater contained within the unmined portion of the aquifer around the wellfield, which includes the 60-day setback, should be protected from pathogens associated with wastes deposited on ground surface and other pollutants. Transport of the pathogens/pollutants to the groundwater is facilitated not only by faulty well casing grouting and stormwater infiltration systems, but also by features such as in-ground ponds for aquaculture. Additionally, standing floodwaters near the wellfield are a suspected risk and are also being investigated by a tracer study. Therefore, with the exception of bonafide rockmining, all other excavations should be prohibited. This includes elimination of the 30-day/40 ft. depth rock mining option since there is no interest in this option from the rockmine interests. This would eliminate aquaculture interests in constructing shallow ponds between the current 30-day zone and the 60-day rockmine buffer. Other prohibitions include stormwater structures, such as French drains and slab-covered trenches, which are currently allowed outside of the 10-day boundary.

Stormwater ponding around the wellfield should be avoided by elevating the area in the vicinity of the well houses (to the existing 10-day zone, as an example) and along the alignment of the raw water transmission pipe along NW 74th Street. Excavation for the 96" pipe breached the confining layer 8-10 ft. below ground surface as evidenced by large pieces of the formation lying along the road. Appropriate fill material should be used along the wellfield and transmission pipe alignment to provide substantial filtration of stormwater percolating into the ground. The filled area should be contoured to divert the stormwater away from the wellfield pipeline. Because stormwater conveying away from the filled area may increase the risk of overland runoff towards the lakes, the required berms around the lakes abutting the unmined portion around the wellfield, or "aquifer buffer", should be designed to prevent overland runoff from entering these lakes under the most intense storm events.

The water quality and water level monitoring wells installed by the USGS and the county near the wellfield are suspect risks to the groundwater. Poor construction techniques, deterioration over time, and any potential effects of blasting around the wellfield may be responsible for well grout and casing damage. Wells not absolutely necessary for monitoring should be properly abandoned according to state regulations. Wells to be retained should be retrofitted to more stringent criteria or replaced by new wells. Each monitoring well or well cluster should be elevated above the 50 or 100-year flood criteria, surrounded by a concrete pad and secured by a locked meter box. The past and future potential effects of blasting on well integrity should also be studied.

D. Revised Wellfield Protection Strategies for the Outer Lake Protection Zone

The proposed outer protection zone encompasses lakes to be used for passive recreation and biological enhancement. This area includes the portion of the original outer protection boundary east of the Turnpike. This area east of the Turnpike is also included in the UDB. Most of the wellfield protection regulations for the outer boundary are uniformly applied with the exception of this area, as shown in Table 6. There are allowable land uses here that are not allowed west of the Turnpike including, two residences per acre on septic tanks, overflow outfalls after treatment of 1" of stormwater and urban development not using hazardous materials or generating

hazardous waste served by public water and sewer. However, these provisions are linked to the UDB placement process and not specifically linked to wellfield protection provisions. Conceivably, future action by the BCC to relocate the UDB into the study area would allow high-density urban development on water and sewer, but the environmental code would hold the residential density on septic tanks to 1 unit per 5 acres. A specific provision banning increased urban development in the Northwest Wellfield Protection Area west of the Turnpike should be incorporated into the environmental code.

There are state and federal regulations that preempt local regulatory efforts over certain activities. Bonafide agricultural activities and use of pesticides are examples where county control for drinking water protection is limited. In past legislative sessions various bills have been adopted to further exclude local control over various agricultural activities. This past legislative season aquaculture and general agricultural bills were initiated that would further curtail local control over agricultural activities regulated by State Best Management Practices. However, local authority is not preempted when State Best Management Practices for agricultural activities do not address wellfield protection. It is extremely problematic to have any animal farming and aquaculture operations within the Northwest Wellfield, particularly within the inner lake protection zone. The pathogenic risk associated with animal farming has been previously discussed.

Aquaculture operations attract avian and mammalian predators, which are potential carriers of pathogens. Even caged operations in large lakes are a concern in that they inadvertently support free-swimming fish, which, in turn, attract avian predators. Because past and future rockmining activities have caused this wellfield to be uniquely vulnerable to pathogenic risks, legislative actions should be pursued to ban animal and aquaculture operations, at a minimum, from the Northwest Wellfield's inner lake zone. Other activities, such as use of pesticides, should require DERM review to provide the user assistance in the selection of low risk options in eradicating the target pests or weeds.

E. Proposed Monitoring Program

The current monitoring program indicates that water quality in the study area is at background conditions. However, the monitoring wells are not sited to monitor the potential sources of pollution, and therefore show a bias. The program will be revised in light of the expanding surface water conditions and recent increase in land uses. Subsequent to this report, an updated monitoring plan will be designed and submitted for WASD and SFWMD review.

The current tracer tests are verifying the stratigraphy, or relative position of strata, determined by the original 5 test wells. However, the lithology of more wells is being investigated to broaden the understanding of stratigraphy throughout the wellfield protection area. The long-range goal is to install all new wells for the monitoring program to replace the older steel cased wells. In the short term, existing monitoring well depths from 10 –30 feet and from 40 – 90 feet can still supply the information needed. Water quality parameters newly of concern, including pathogens, can be added to the existing program wells until new wells are placed.

New wells will need to be placed adjacent to rock mine lakes in some instances. In this case, the depth of the lakes, as well as stratigraphy, will be considered for deciding screen intervals for the monitoring well. In the short term, surface sites in existing lakes will be added to the program to

monitor for pathogens. However, this can occur only if access is made available. It is anticipated that an ideal monitoring program will evolve over the next several years. It is also anticipated that due to ongoing lake expansion, that the program will require regular revision.

A review of known water quality data for the NWWF Protection Area was completed by DERM in March 1999. That report, "Northwest Miami-Dade County Lake Belt Water Quality Summary and Watershed Monitoring Plan", confirmed the existing high quality of water and also highlighted the differences that can be expected in water quality in canals, groundwater, and lake water. The report also made recommendations for additions to the wellfield monitoring program. The recommendations include that canals, rockmine lakes, and groundwater be sampled semi-annually for the following parameters in addition to those already sampled:

- Total Organic Carbon
- Nutrients: Compounds of Nitrogen and Phosphorus
- Chlorophyll A
- Biological Oxygen Demand
- Physical Parameters: Color, Dissolved Oxygen, Turbidity
- Bacteria: Total Coliform, Fecal Coliform, Fecal Streptococci
- *Cryptosporidium* parvum and *Giardia*

The objectives of sampling these parameters are to monitor the eutrophication process, pathogen potential, and impacts to groundwater. The report also recommends continuous water level measurements in selected rockmine lakes near the production wells to add to our hydrologic knowledge.

The following section lists the action steps to implement the recommended improvements to the existing Northwest Wellfield Protection Program.

V. WELLFIELD PROTECTION STRATEGIES AND ACTION STEPS

1. Delineate the travel time contours, watershed protection zone boundaries, and rockmine setbacks for the Northwest Wellfield

a. Utilizing an appropriate model, evaluate alternative watershed protection zone scenarios using various future lake, infrastructure, and buffer strip configurations.
Status: An analytic element model of the Northwest Wellfield is being prepared. A ModFlow model currently exists for the subject area. The availability and utility of these models will be investigated to determine their applicability in evaluating alternative watershed protection scenarios. (DERM)

b. Delineate the boundaries of the outer and inner, including the unmined aquifer buffer, protection zones using an appropriate model.
Status: An analytic element model of the Northwest Wellfield is being prepared. A ModFlow model currently exists for the subject area. The availability and utility of these models will be investigated to determine their applicability in assessing travel time and watershed protection zones. (DERM)

c. Evaluate the adequacy of the 60-day travel time rockmining setback for minimizing the risk from pathogens associated with surface water. This should include assessing the impact of full mine out of the area as projected in the Phase 1 Lake Belt master plan and CERP.
Status: The availability of an appropriate pathogenic risk assessment model will be investigated and, if available, will be used to delineate the aquifer buffer area. (EPA, DERM, WASD)

d. Conduct tracer studies to verify aquifer travel time distances.
Status: Tracer testing has been initiated and is undergoing evaluation. (DERM)

2. Identify protection strategies for the outer watershed protection zone boundary that will protect the Northwest Wellfield into the future.

a. Prohibit interconnections between canals and lakes.
Status: Chapter 24 to be amended.

b. Conduct routine surveillance within the outer watershed protection zone boundary to verify compliance with wellfield protection provisions. Add staff to ensure adequate attention to field, enforcement and planning actions.
Status: DERM has undeergon re-organization to assign staff for planning activities. DERM will evaluate methods to enhance existing compliance monitoring within the wellfield protection area and review on an annual basis, the adequacy of ongoing compliance monitoring.

c. For new projects and activities that could possibly affect the NWWF and not currently requiring DERM review and approval, establish formalized mechanisms to incorporate them into the DERM Plan Review process. This includes projects within the outer boundary or along canals conveying recharge to the wellfield such as aquatic and terrestrial weed control, road construction and improvements, and other infrastructure projects that have the potential to affect water quality.

Status: A study will be conducted identifying activities that should be reviewed by DERM and issued approval or comments. Procedural options to formalize the review process will be proposed.

d. Allow only passive recreation, no motorized boats, and a 100-ft. setback of animals from lakes.
Status: Chapter 24 to be amended.

e. Evaluate the appropriateness of uses currently allowed in the Northwest Wellfield by Chapter 24 in context of existing and future hydrologic conditions. Codify within Chapter 24 those uses that are consistent with protecting the Northwest Wellfield under future conditions.
Status: Chapter 24 to be amended.

3. Develop and implement provisions within the inner lake boundary which will provide maximum protection and avoid risks from pathogenic and chemical pollutants as follows:

a. Discharges of stormwater and wastewater to the lakes shall be prohibited.
Status: Chapter 24 to be amended (DERM)

b. The shorelines of lakes (lakes in progress and finished lakes) shall be bermed (minimum of 1 foot) to the 100-year flood elevation and backsloped (4 ft. for every 1 ft. of berm). A soil cover is to be provided which retards the infiltration rate to no more than ½ inch per hour for the berm and backslope including an additional setback distance from the shore to total 50 ft.
Status: Chapter 24 to be amended (DERM)

c. Security measures shall be required, such as fencing, in order to restrict the public and feral and farm animal access to the lakes.
Status: Explore regulatory options such as amending Chapter 24 or incorporating these as conditions of a Class IV permit.

d. Conduct a study to determine if elimination or modification of littoral areas will significantly reduce pathogen risk from wildlife.
Status: The feasibility of conducting such a study will be further investigated and, if appropriate, a scope of work will be developed. (DERM)

e. Prohibit recreational uses.
Status: Chapter 24 to be amended. (DERM)

f. Prohibit development along the shorelines of excavated lakes.
Status: Chapter 24 to be amended. (DERM)

g. Prohibit non-rockmining excavations.
Status: Chapter 24 to be amended. (DERM)

h. Only surface infiltration (swales) at natural grade will be allowed for stormwater management. Require that Class IV permits include stormwater management during mining and at lake completion.
Status: Chapter 24 to be amended. (DERM)

i. Upgrade the elevation requirement for septic tanks to 25-year flood criteria.
Status: Chapter 24 to be amended. (DERM)

j. Require a 100 ft. setback minimum from lakes and canals for all animal operations.
Status: Chapter 24 to be amended. (DERM)

k. Prohibit aquaculture operations in the lakes.
Status: Amend Chapter 24 or explore other regulatory options.

l. Specify interim and future land use options appropriate within the inner lake watershed protection zone boundary. Prioritize the most critical parcels for eventual public acquisition.
Status: (P&Z, WASD, DERM)

m. To preclude development, place in public ownership all land located within the aquifer buffer boundary.
Status: Upon delineation of the aquifer buffer boundary, mechanisms to place these lands in public ownership will be identified and investigated. WASD has approval to prioritize purchase of private properties near the wellfield. Two sources of funding that could be explored include EPA's Section 319 Non-Point Source Grant and the Drinking Water State Revolving Fund as part of the Source Water Assessment Program.

n. Prohibit rockmining within the aquifer buffer boundary
Status: Upon delineation of the aquifer buffer boundary, Chapter 24 will be amended.

4. The soils and semi-confining layers within the upper 30 ft. of the aquifer provide substantial protection from surface pollutants, including pathogens, and, therefore, the 30 day/40ft. rockmine setback shall be eliminated.
Status: Chapter 24 shall be amended.

5. Minimize localized surface water impacts to the drinking water wells by the following measures:

a. Repair damaged grouting surrounding the production wells and investigate the effects of blasting on well integrity.
Status: WASD has repaired the grouting on the most impacted wells and will be continuing inspections on the wellfield infrastructure.

b. Deepen wells affected by lake proximity.
Status: WASD has deepened production wells 15, 14, 13, 11 and 10.

c. Consider options for precluding surface water ponding in the vicinity of the wellheads
Status: WASD should evaluate various design options.

d. Consider options for minimizing localized impacts on drinking water wells from existing or permitted lakes including the feasibility of filling certain lakes with mining tailings, broken concrete pipes and other inert materials.
Status: WASD should evaluate various design options.

e. Assess the whether the monitoring wells in close proximity are conveying stormwater to the groundwater.
Status: DERM should abandon unnecessary wells and retrofit deficient wells.

6. **Evaluate the effectiveness of the current hazardous materials and liquid waste restrictions for protecting the wellfield into the future and identify and implement improvements.**

   a. Review existing rules and inspection records of grandfathered and currently allowable uses to determine their level of compliance with wellfield protection requirements and recommend revisions if necessary.
   Status: A preliminary review has been conducted and enforcement action initiated, where appropriate. Other findings will be referred to DERM's strategic planning process.

   b. Draft best management practices (BMPs) tailored to allowable land uses.
   Status: BMPs have been drafted and should be submitted for DERM staff review.

   c. Annually assess the compliance monitoring, permitting and cleanup programs to insure that illegal activities are precluded and that inspections and cleanups are rigorously conducted in the Northwest Wellfield Protection Area.
   Status: DERM's Remediation Section routinely reviews cleanup activities in wellfield protection areas and prepares a report for WASD.

   d. Review county, FPL, FDOT and other agencies road and canal maintenance activities and pesticide use practices in the area and recommend changes appropriate to protect a watershed area. (DERM)
   Status: Maintenance activities and pesticide use practices have been reviewed and recommendations developed. Determine the appropriate means to transmit these recommendations to the departments.

7. **Clarify the rockmining and ancillary uses allowed in the vicinity of the Northwest Wellfield.**

   Status: Chapter 24 to be amended.

8. **Minimize the risk to the West and Northwest Wellfields in the Lake Belt from spills resulting from the transportation of hazardous materials along major roads:**

   a. Update DERMs Emergency Response Plan for Hazardous Materials Accidents in wellfield protection areas to include the mechanism for closing existing pollution control structures along the Turnpike Extension by putting in place a mechanism by which the Emergency Response Plan is reviewed and updated annually.
   Status: A request has been submitted to update the Plan

   b. Improve stormwater retention capacity of major roadways in terms of retaining large capacity hazardous materials spills. The need for retrofitting Okeechobee Road should be conveyed to the FDOT and incorporated into the CERP planning process for the Miami Canal. (DERM, SFWMD, COE, FDOT)
   Status: Appropriate agencies should be notified in writing.

   c. Miami-Dade County DERM is part of the design and planning process on federal and state road expansion and repair projects requesting more stringent stormwater controls along critical roadways in wellfield protection areas.
   Status: Comments have been provided to the SFWMD pertaining to the upcoming widening of the HEFT. (DERM, FDOT, SFWMD)

d. Incorporate into the Comprehensive Everglades Restoration Plan process the issue of hazardous materials spills on roadways proximal to current and future surface water bodies.
Status: Submit comments to appropriate committees in the CERP process.

9. Update the existing wellfield protection monitoring program to account for future changes in the protection area.

a. Develop a new monitoring program that will incorporate parameters of public health concern and include lake sampling.
Status: A report has been completed evaluating the existing wellfield protection monitoring program and water quality data in the area from other programs. Recommendations include sampling the rockmine lakes, inclusion of additional parameters to monitor microorganisms, eutrophication processes, and impacts of lake mining on groundwater quality. A new monitoring program is being designed to monitor the wellfield as an integrated watershed as recommended in aforementioned evaluative report. This necessitates that new surface and groundwater sites be added to the program.

b. In order that groundwater and surface lakes sites are added to the program, access must be provided by the property owners or the leaseholders.
Status: Request permission from property owner.

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