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An Investigation of Water Quality Complaints in the Kingfisher Canal, Deerfield Beach, FL

Environmental Monitoring Division

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EXECUTIVE SUMMARY

The Department of Natural Resource Protection has received complaints that the discharge of polluted water from 24" and 72" diameter stormwater drainage pipes located at the western end of the Kingfisher Canal, Deerfield Beach, Florida, was polluting the waterway. In response to these complaints, DNRP conducted a water quality study to help determine the nature and extent of the problems that gave rise to the complaints.

The Kingfisher Canal and the stormwater drainage pipes were sampled and tested for a variety of water quality parameters. For comparison, the nearby Tern Waterway, similar in configuration to the Kingfisher Canal but without the large stormwater discharge pipes, was subjected to the same testing regimen. Sediment samples from both canals were also tested to evaluate the impact of long-term pollutant loading on sediment quality.

The results of the water quality testing indicated that with respect to bacteria and the oxidized forms of nitrogen, i.e., nitrite+nitrate, the water in the Kingfisher Canal was of significantly poorer quality than the Tern Waterway. Furthermore, pollutants discharged from the two stormwater pipes were suspected of contributing to the problem. High levels of bacteria and nutrients (nitrogen and phosphorus) in the flow from the 24" pipe suggested that the flow could contain waste from wild and/or domestic animals or possibly sanitary sewage as a result of cross-connections with the sanitary sewer system. The contribution from the 72" pipe was less clear because it is always at least partially submerged.

Sediments in the Kingfisher Canal were shown to contain elevated levels of petroleum hydrocarbons as compared to the Tern Waterway. The presence of petroleum hydrocarbons in the flow from the 24" pipe further implicate this discharge as a source of adverse impacts to the waterway.

Recommendations resulting from this study included (1) a comprehensive survey of facilities and land use in the drainage area should be conducted, (2) a remote camera should be used to examine the 24" pipe to reveal possible cross-connections, (3) the owners of the 72" and 24" outfalls to the Kingfisher Canal, Florida Department of Transportation (FDOT) and City of Deerfield Beach respectively, should install appropriate pollutant retardant mechanisms on the outfalls to reduce adverse impacts on surface water quality, and (4) the parties responsible for siltation of the waterway should remove excess buildup of sediments from the waterway.

I. INTRODUCTION

A. Background

The Broward County Department of Natural Resource Protection (DNRP) has received complaints of poor water quality at the extreme western end of the Kingfisher Canal in Deerfield Beach. The complaints included references to odors, floating fecal material and the discharge of dirty water to the canal from large pipes located near the western end of the canal.

In response to a complaint received February 5, 1997, a DNRP inspector visited the site that afternoon. The inspector observed 2 large pipes, 24" and 72" in diameter, in the seawall at the western end of the canal. A a yellow-hued liquid was seen flowing from the 24" pipe and discharging into the Kingfisher Canal. The inspector returned the following day, February 6, 1997, and collected samples of the discharge. He returned again on February 8, 1997 and surveyed the surrounding area. He found an above-ground grease tank located 20-25' from a storm drain next to a large retail establishment to the southwest of the Kingfisher Canal terminus. Grading and drainage plans provided by the City of Deerfield Beach indicated that this area drained into the 72" outfall into the Kingfisher Canal. There were signs of waste motor oil (stains and smaller containers) in and around the grease tank indicating that it was being used to dispose of waste motor oil. Samples of its contents were collected. The store's representative was advised to make the tank inaccessible to the public.

A warning notice was issued to the store's owner on February 19, 1997 for violation of the Broward County Natural Resource Protection Code for allowing the storage of hazardous materials (waste motor oil) in a waste food grease tank that did not have secondary containment. On March 11, 1997, DNRP was notified that the waste oil in the tank had been recycled and a new, locked tank was emplaced.

When the results of tests on the sample collected February 6, 1997 from the 24" pipe indicated the presence of petroleum hydrocarbons, a Warning Notice was also issued to the City of Deerfield Beach for allowing hazardous materials to enter the storm drain.

Following these initial actions, DNRP's Environmental Monitoring Division (EMD) initiated a water quality study to help determine the nature and extent of the problems that gave rise to the complaints.

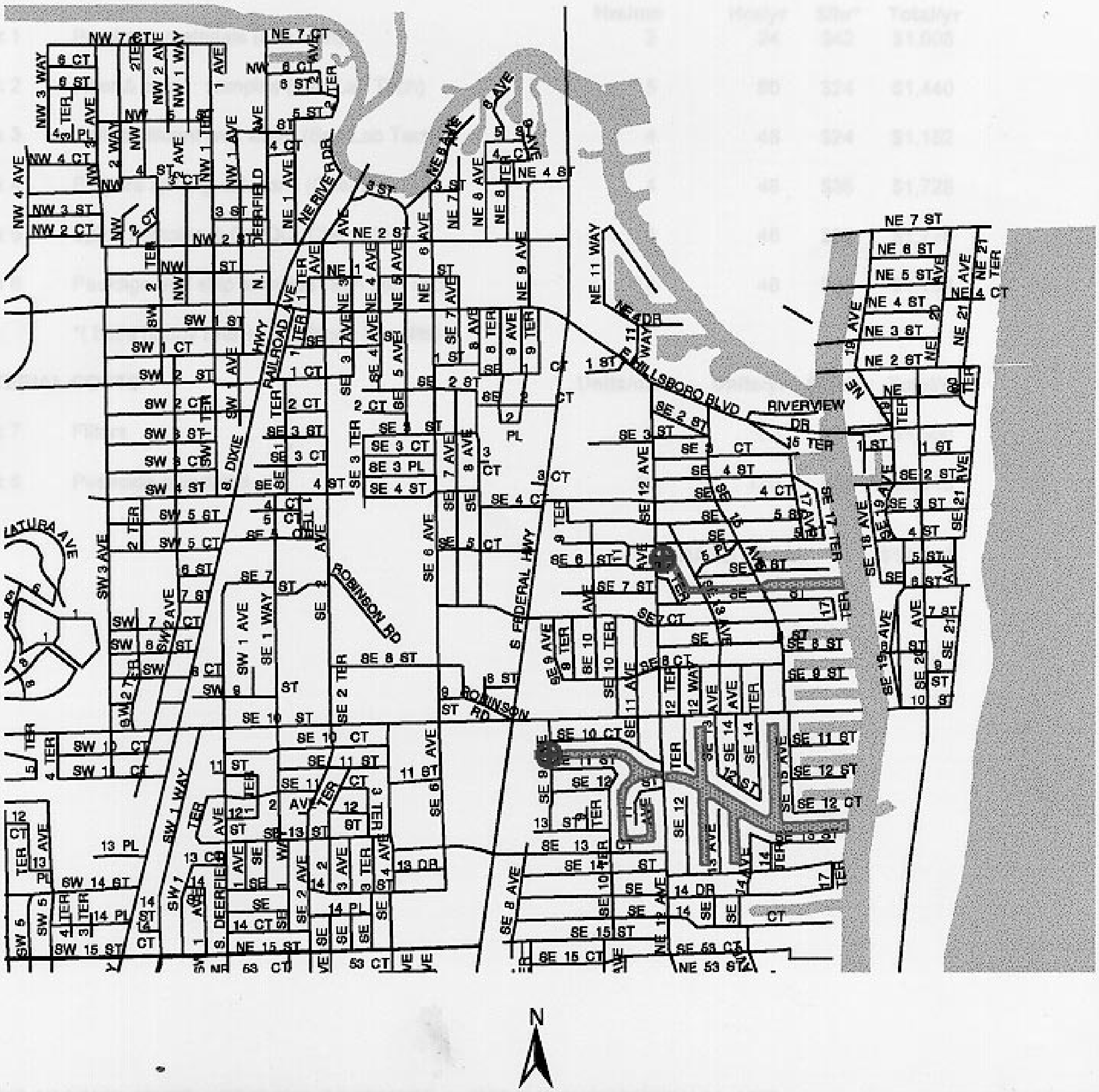
The study involved the sampling and analysis of the water column and sediment from the Kingfisher Canal as well as the discharge from the stormwater pipes at its western terminus. For comparison purposes, a similar dead-end canal known as the Tern Waterway, located approximately 1/2 mile north of the Kingfisher Canal, was subjected to the same sampling and testing. The study areas of both canals are generally very shallow. The Kingfisher Canal especially suffers from heavy siltation to the extent that the bottom is exposed at the lower tidal stages. While the Kingfisher Canal is considerably longer and also drains a number of finger canals, the primary difference at the western extremes of the canals was the existence of two large drainage pipes located at the western end of the Kingfisher Canal. There were no comparable drainage pipes near the western end of the Tern Waterway. Any apparent degradation in water quality in the area of study in the Kingfisher Canal versus the Tern Waterway would suggest that flow from the drainage pipes may be contributing to water quality problems.

Examination of the sediments in the two areas was included because water quality can vary over time. By contrast, sediments are a major repository of contaminants in surface water systems and play a significant part in influencing the fate and effects of potentially toxic substances (Seal et al., 1994).

B. Description of the study area

Figure 1 is a map of northeastern Broward County which encompasses the study area. The Kingfisher Canal branches west off the Intracoastal Waterway to the south of SE 12th Ct. in Deerfield Beach. It proceeds to the west approximately 2/3 mile and terminates at SE 9th Ave. Two short finger canals join the canal from the north and three from the south. The Tern Waterway branches off the Intracoastal to the south of SE 6th St., proceeds about 1/3 mile west and terminates at SE 12th Ave. There are no finger canals branching from this waterway. Both canals are located in residential neighborhoods served by municipal sanitary sewers.

FIGURE 1
Map of Northeastern Deerfield Beach



Broward County
Department of Natural Resource and Protection
Geographic Information Systems

0.25 0 0.25 0.5 Miles

II. METHODOLOGY

A. Sampling sites

Since the complaints were received from residents living near the dead-end portion of the canal, the sampling strategy targeted these areas. It should be noted that this study is restricted to the western reach of the Kingfisher Canal and Tern Waterway.

The two large pipes at the end of the Kingfisher Canal were identified by the Deerfield Beach Public Utilities Department as stormwater drainage pipes. One, a 72" reinforced concrete pipe, provides storm water relief to a major portion of the eastern half of the central/southern portion of Deerfield Beach (Viola, 1997). It is positioned in the seawall at such an elevation that it is always at least partially filled with canal water regardless of tidal stage. Because of this position, it is not possible to determine whether the canal is receiving any flow from the pipe unless the flow is quite large. This outfall was examined in 1992 in compliance with Broward County's National Pollutant Discharge Elimination System (NPDES) Stormwater permit. At that time, dry-weather flow was observed in the pipe up-gradient from the outfall, however, no water quality standard violations were found (DNRP, 1992).

The second pipe, a 24" reinforced concrete pipe is located just north of the 72" pipe. The drainage area leading to this pipe includes the large retail shopping area on the northeast corner of Federal Highway and SE 10th Street, Deerfield Beach. At lower tidal stages, the pipe is well above the surface of the water so that any flow from this pipe is easily discerned. Flow from this smaller pipe was regularly observed during this study and several samples were collected to characterize this water. Water in the larger 72" pipe was also tested.

B. Rainfall Data

References to rainfall in this report are based upon records maintained by the Broward County Office of Environmental Services water treatment plant 2A located at 1390 NE 51st St., Pompano Beach, Florida.

C. Sampling and Analysis Protocols

Water samples were collected by hand from just below the surface of the water directly into sample containers. Sediment samples were collected using a small shovel during the lower tidal stages. All samples were preserved according to U.S. Environmental Protection Agency (EPA) protocols and were transported on ice to the EMD laboratory within 6 hours. The EMD laboratory is approved by the Florida Department of Environmental Protection for all of the sampling and analysis methods performed in this study.

The test methods employed in this study appear in Table 1 (EPA, 1983; Greenberg, et al., 1992; FDEP, 1995).

TABLE 1
Test Methods

Parameter	Method	Matrix	Source
Specific Conductance	EPA 120.1	Water	Surf./Pipe
Salinity	SM 2520B	Water	Surface
pH	EPA 350.1	Water	Surface
Temperature	EPA 170.1	Water	Surface
Turbidity	EPA 180.1	Water	Surface
Ammonia	EPA 350.1	Water	Surface & pipes
Total Kjeldahl Nitrogen	EPA 351.2	Water	Surface & pipes
Total Phosphorus	EPA 365.4	Water	Surface & pipes
Nitrite plus Nitrate	EPA 353.2	Water	Surface & pipes
Total Nitrogen	EPA 351.2 + EPA 353.2	Water	Surface & pipes
Dissolved Oxygen	EPA 360.1	Water	Surface
Orthophosphate	EPA 365.1	Water	Surface & pipes
Fecal Coliform	SM 9222D	Water	Surface
Total Coliform	SM 9222B	Water	Surface
Hexane-Extractable Material, with/without Silica Gel Treatment	EPA 1664	Water	Pipe
Volatile Organic Hydrocarbons	EPA 8260	Water	Pipe
Polynuclear Aromatic Hydrocarbons	EPA 8270	Sediment	Sediment
Petroleum-Range Organics	FL-PRO	Sediment	Sediment
Percent Solids	EPA 160.3	Sediment	Sediment

The first 14 parameters listed in Table 1 are commonly used to evaluate surface water quality and standards exist for several of them (Broward County, 1994). Elevated levels of ammonia, nitrite, nitrate, ortho and total phosphorus may suggest contamination from fertilizers and/or sewage. Total coliform are indicators of bacterial contamination which may or may not have an animal source. The presence of elevated levels of fecal coliform in surface waters indicate wastes from warm-blooded animals including humans. The last five parameters in Table 1 are used to detect contamination from petroleum products. This study also included microscopic examination of pieces of floating material reported by residents as suspected fecal matter.

Statistical comparisons between sites were made using a Students t-test (Fitz-Gibbon and Morris, 1978).

II. RESULTS

A. Water Column Test Results

Table 2 presents the results of water column test results at the two sites. One sample per month was collected at each site (3 data points) during the 3-month study period. Sample times were in the early afternoon (1-3 pm). The results are expressed as the average, plus or minus one standard deviation. Statistics for total and fecal coliform are based upon log-transformed data in order to normalize positively-skewed bacteria data (Greenberg et al., 1992) and are presented in Table 2 and Figures 2 & 3.

TABLE 2
Water Quality Statistics

	Kingfisher Canal	Tern Waterway	Difference Significant?	Standard
Salinity	2.8±0.3 ppt	5.2±3.2 ppt	No	None
pH	7.3±0.2	7.5±0.4	No	>6.5 & <8.5
Dissolved Oxygen	4.4±1.8 mg/l	5.4±1.9 mg/l	No	Not <4 mg/l
Conductivity	5,070±517 us	9,120±5,300 us	No	None
Turbidity	4.7±1.8 NTU	6.2±5.1 NTU	No	Not >10 NTU
Ammonia	0.242±0.05 mg/l	0.201±0.03 mg/l	No	None
Total Kjeldahl N	0.827±0.20 mg/l	1.022±0.40 mg/l	No	None
Nitrite + Nitrate	0.197±0.03 mg/l	0.166±0.04 mg/l	Yes	None
Total Nitrogen	1.009±0.23 mg/l	1.192±0.51 mg/l	No	Not >1.5 mg/l
Orthophosphate	0.078±0.05 mg/l	0.072±0.02 mg/l	No	None
Total Phosphorus	0.124±0.05 mg/l	0.168±0.07 mg/l	No	Not >0.05 mg/l
Total Coliform	4.470±0.339 $\log_{10}$ CFU/100ml	3.215±0.464 $\log_{10}$ CFU/100ml	Yes	Not >2,400 CFU/100ml
Fecal Coliform	3.714±0.120 $\log_{10}$ CFU/100ml	3.092±0.408 $\log_{10}$ CFU/100ml	Yes	Not >800 CFU/100ml

FIGURE 2

Fecal Coliform Statistics

Fecal coliform levels at Kingfisher Canal and Tern Waterway. The vertical bar represents the 3-month mean (horizontal bar) +\- one standard deviation at each station.

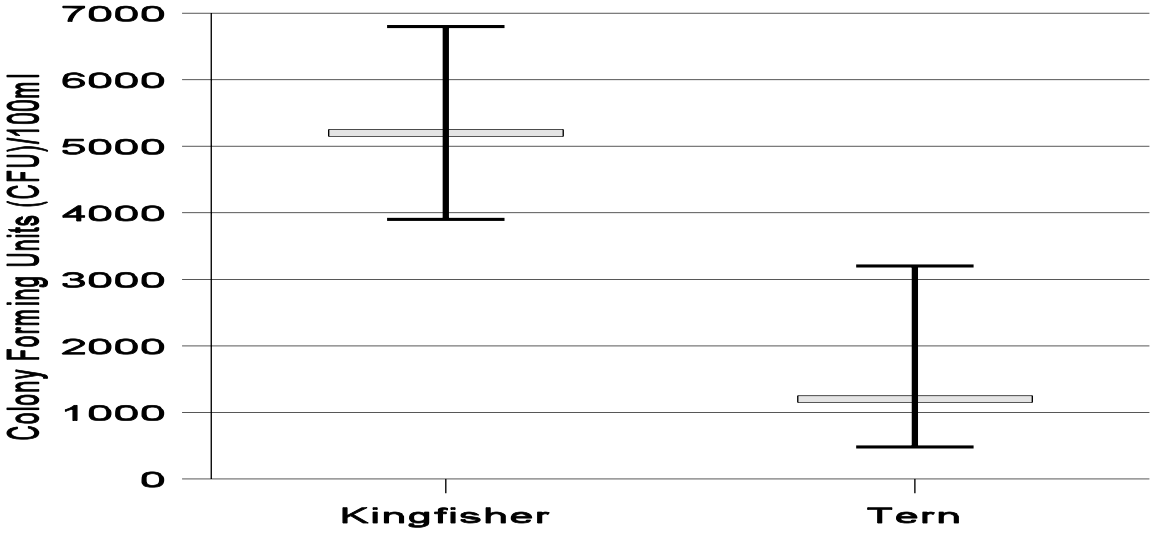
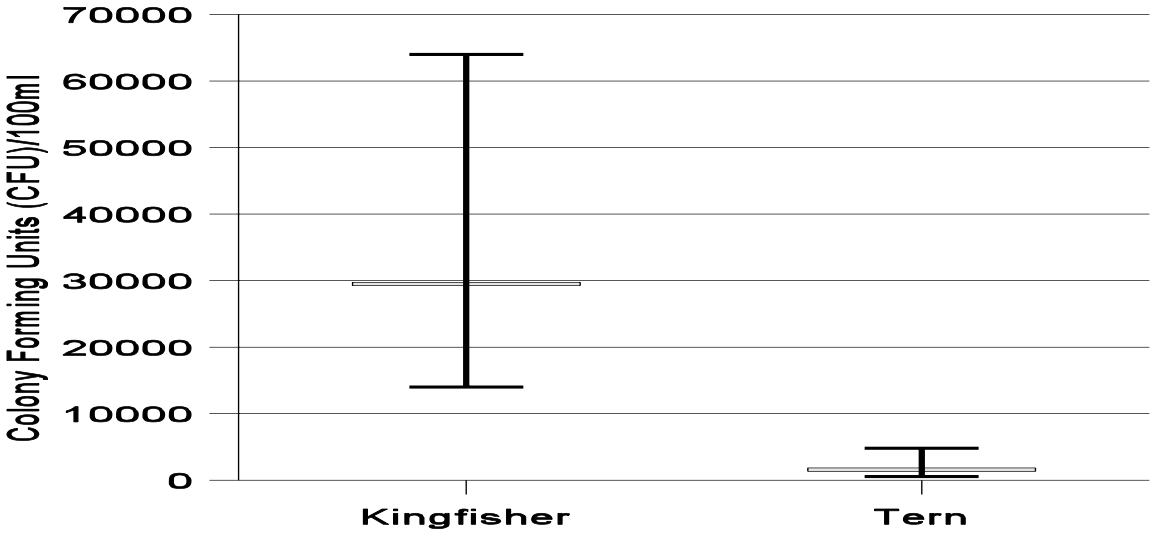


FIGURE 3
Total Coliform Statistics

Total coliform levels at Kingfisher Canal and Tern Waterway. The vertical bar represents the 3-month mean (horizontal bar) +\- one standard deviation at each station.



The Broward County Natural Resource Protection Code (DNRP, 1994) defines marine waters as those having a specific conductance of greater than 5,000 umhos/cm. Specific conductance readings at the Kingfisher Canal and the Tern Waterway were predominately in excess of this value. Therefore, marine water quality standards are applicable.

Temperature, pH and turbidity readings never exceeded standards.

Mean nitrite+nitrate levels were 19% higher in the Kingfisher Canal than the Tern Waterway while total nitrogen levels were about 18% higher at the comparison site. The nitrite+nitrate difference was determined to be

statistically significant on a two-tailed Students t-test ($t_{\alpha=0.05}$=2.92, t=3.28). Although the total nitrogen standard of 1.5 mg/l-N was violated on March 26, 1997 at the comparison site, average total nitrogen readings were within standards and no statistically significant difference in total nitrogen mean values was found between sites ($t_{\alpha=0.05}$=2.92, t=1.39).

The dissolved oxygen standard was violated once at each site during the study. Average dissolved oxygen readings were approximately 25% higher in the comparison canal. Again, the observed difference was not statistically significant ($t_{\alpha=0.05}$=2.92, t=0.80).

Total phosphorus readings exceeded the 0.05 mg/l standard at both sites on every occasion. Total phosphorous readings at the comparison canal were about 35% higher than on the Kingfisher Canal. The observed difference, however, was not statistically significant ($t_{\alpha=0.05}$=2.92, t=1.0).

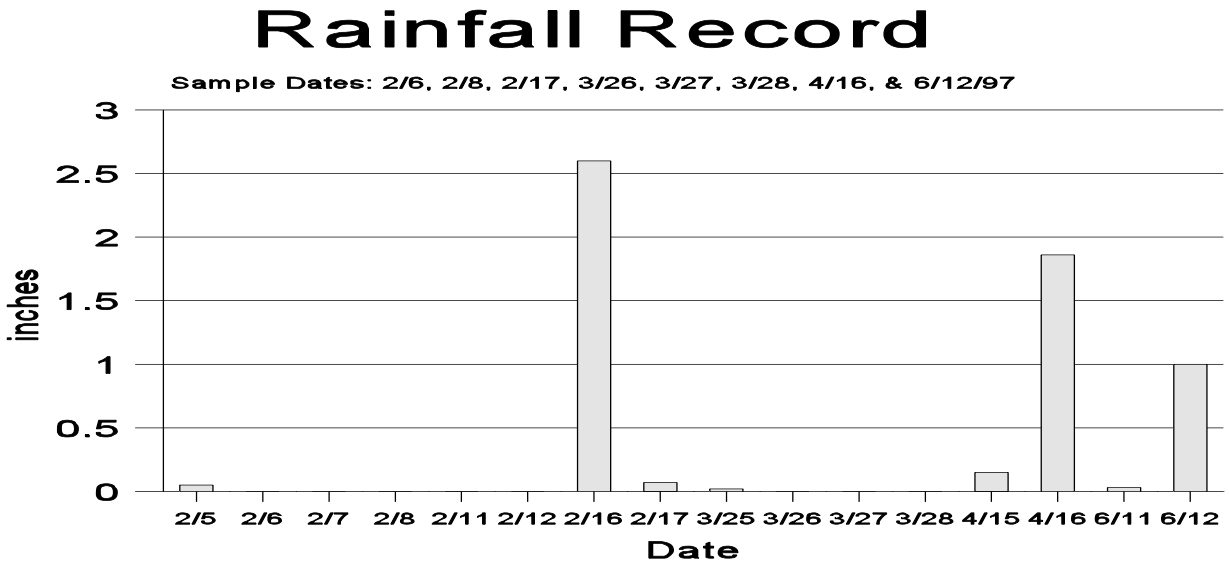
The total coliform standard was violated on every occasion at the Kingfisher Canal site but only once at the comparison site. Average total coliform readings at the Kingfisher Canal were nearly 18 times higher than the comparison canal. This difference was determined to be statistically significant ($t_{\alpha=0.05}$=2.92, t=12.1).

The fecal coliform standard was also violated on every occasion at the Kingfisher Canal site and on 2 of 3 occasions at the comparison site. Average fecal coliform readings were four times higher on the Kingfisher Canal than the comparison canal. This difference was also found to be statistically significant ($t_{\alpha=0.05}$=2.92, t=3.19).

B. Rainfall Data

Figure 4 presents rainfall amounts recorded on sampling dates as well as the preceding days. Two of the three surface water sampling events may have been impacted by rain events. Two and six-tenths (2.60) of an inch of rainfall was recorded at the System 2A water treatment plant in Pompano Beach on February 16, 1997, the day preceding one of the sampling events while 0.07" fell on the day of the February 17, 1997 sampling. On the April 16, 1997 sampling, 1.86" of rain fell. One inch of rain also fell during the sampling of the outfalls on June 12, 1997.

FIGURE 4



C. Outfall Test Results

On February 6, 1997, a sample was collected from the 24" outfall pipe for nutrient analyses. Additional samples were collected on February 8, 1997 for nutrients, oil & grease, petroleum hydrocarbons and volatile organic compound analyses. The following results were obtained:

TABLE 3
24" Outfall Pipe Test Results

	Sample Date	Result	Standard
Ammonia, Total	02/06/97	6.50 mg/l	None
Ammonia, Total	02/08/97	6.95 mg/l	None
Nitrite+nitrate	02/06/97	0.042 mg/l	Not >10 mg/l
Nitrite+nitrate	02/08/97	0.312 mg/l	Not >10 mg/l
Tot. Kjeldahl Nitrogen	02/06/97	119 mg/l	No standard
Tot. Kjeldahl Nitrogen	02/08/97	129 mg/l	No standard
Total Nitrogen	02/06/97	119 mg/l	Not >1.5 mg/l
Total Nitrogen	02/08/97	129.3 mg/l	Not >1.5 mg/l
Total Phosphorus	02/06/97	6.68 mg/l	Not >0.05 mg/l
Total Phosphorus	02/08/97	11.3 mg/l	Not >0.05 mg/l
1,2,4-trimethylbenzene	02/08/97	0.070 ug/l	No standard
Benzene	02/08/97	0.050 ug/l	71 ug/l
Bromodichloromethane	02/08/97	0.130 ug/l	10 ug/l
Chloroform	02/08/97	0.480 ug/l	Not >470 ug/l, annual avg.
Cis-1,2-dichloroethene	02/08/97	0.030 ug/l	No standard
Ethyl benzene	02/08/97	0.050 ug/l	No standard
Meta+para xylene	02/08/97	0.050 ug/l	No standard
Methyltertbutyl ether	02/08/97	0.570 ug/l	No standard
N-propyl benzene	02/08/97	0.040 ug/l	No standard
Naphthalene	02/08/97	0.240 ug/l	No standard
Para-isopropyl toluene	02/08/97	0.210 ug/l	No standard
Toluene	02/08/97	0.070 ug/l	No standard
Trans-1,2-dichloroethene	02/08/97	0.030 ug/l	No standard
Oil & grease	02/08/97	1,070 mg/l	Not >1.0 mg/l
Tot. pet. hydrocarbons	02/08/97	169 mg/l	No standard

On March 26, 1997, flow from the 24" pipe was tested for conductivity and salinity over a three hour period. The

results were as follows:

TABLE 4
Conductivity and Salinity Readings from 24" Pipe

Time	Conductivity, us	Salinity, ppt
2:10 pm	4,710	2.6
3:00 pm	4,800	2.7
3:50 pm	4,880	2.7

On June 12, 1997, samples were collected from both Kingfisher Canal outfall pipes and a catch basin located in the shopping center at the NE corner of Federal Highway and 10th Street. This catch basin drains into the 24" pipe into the Kingfisher Canal. The samples were analyzed for total and fecal coliform and conductivity. The results of these tests are presented in Table 5.

TABLE 5
Outfall Testing, June 12, 1997

	72" Outfall Pipe	24" Outfall Pipe	Catch Basin
Conductivity, us	3370	2780	570
Total Coliform, CFU/100ml	2000	>67,000	>53,000
Fecal Coliform, CFU/100ml	110	>2,500	1,700

As can be seen from the table, the smaller pipe carries much greater levels of bacteria than the larger pipe. In addition, the bacteria levels are elevated in the shopping center catch basin up-gradient from the outfall.

D. Sediment Results

On March 26 and 28, 1997, sediment samples from the Kingfisher Canal and the comparison canal were collected and tested for total petroleum hydrocarbons (TRPH) and polynuclear aromatic hydrocarbons (PAHs). The results of these tests were as follows:

	TRPH	**PAHs, Total**
Kingfisher Canal	230 mg/kg	26.2 mg/kg
Tern Waterway	14.9 mg/kg	3.08 mg/kg

E. Microscopic Examination

A sample of the dark, amorphous matter, the suspected fecal matter reported floating in the canal, was collected for microscopic examination. The examination established that rather than fecal matter, it was primarily herbaceous material, mixed with a green filamentous algae.

IV. DISCUSSION

In this study samples of canal water and sediments, stormwater pipe discharge, and floating matter were collected for laboratory analyses. With the exception of bacteria and nitrite+nitrate, there was no significant difference in water quality between the Kingfisher Canal and the Tern Waterway. The 24" stormwater outfall carried water with a much higher pollutant concentration than the 72" outfall. Sediments in the Kingfisher Canal contained much greater concentrations of petroleum contaminants than the Tern Waterway. While the floating matter seen in the canal was not fecal in nature, it may contribute to water quality problems by depressing dissolved oxygen levels and clog cooling water intakes of vessels navigating the waterway.

A. Water Column Results

With the exception of nitrite+nitrate and bacteria, no statistically significant difference in water quality was observed between the Kingfisher Canal and the Tern Waterway.

High levels of bacteria and reduced forms of nitrogen (ammonia and TKN) were found to be discharged from the 24" outfall pipe. The elevated nitrite+nitrate levels in the Kingfisher Canal may originate from this pipe as reduced forms of nitrogen are converted to nitrite and nitrate in the surface water environment. Furthermore, the combination of bacteria and reduced nitrogen suggests contamination of the outfall discharge with fecal material. These observations suggest two possibilities: (1) stormwater runoff carrying animal waste and (2) sewage in the outfall resulting from cross-connection between the storm and sanitary sewer system.

Beyond the observation of elevated bacteria levels in the Kingfisher Canal as compared to the Tern Waterway, the bacteria levels in the Tern Waterway itself are unexpectedly high. Neither live-aboard vessels nor septic tanks were observed in the area. Rainfall occurred during two of the three sampling events and undoubtedly contributed to the elevated bacteria levels recorded on those dates. Elevated surface water bacteria levels are commonly seen throughout the county following significant rainfall as fecal material from assorted wild and domestic animals is washed off the land.

B. Outfall Results

Of the two outfall pipes studied, the 24" pipe carried a much greater pollutant load than the 72" pipe. The results from the VOC test of the 24" outfall pipe indicate the presence of light weight organic compounds characteristic of petroleum products (gasoline). The presence of chloroform and bromodichloromethane, characteristic of treated drinking water, indicate that the discharge has a potable water component as well. The presence of cis- and trans-dichloroethylene suggest that the flow also has a groundwater component since these compounds are usually only seen in groundwater as the decomposition products of chlorinated solvents.

The flow from the 24" pipe was highly elevated in nutrients, particularly phosphorus and the reduced forms of nitrogen. Moreover, the levels in the discharge were remarkably similar over time as evidenced by the results of the February 6 and 8, 1997 samples. The observation of flow from this pipe in the absence of rainfall during the four days preceding the collection of these samples indicates the flow has sources other than just stormwater. Possible sources of flow include groundwater seepage, sprinkler runoff, return of tidal waters that entered the system at high tide, and cross connection between storm and sanitary sewers.

The levels of oil and grease detected in the 24" outfall pipe also exceed what might be expected from stormwater runoff. Indeed, petroleum hydrocarbons, which would be expected to be the major component of the oil and grease in stormwater runoff, were only about 16% of the total oil and grease, indicating that the outfall is carrying an oil & grease component that has animal and/or vegetable sources.

The uniform and relatively high conductivity and salinity readings seen during the 2 hour monitoring of the outfall suggest that groundwater, probably mixed with saline surface water, is a significant component of the discharge. The observation of flow from the outfall during dry weather further points to contributions other than stormwater runoff make up the flow from this pipe.

The results of the outfall tests on June 12, 1997 show that the 24" pipe carries higher levels of bacteria than the larger 72" pipe. Moreover, the elevated bacteria levels are evident in the pipe all the way back to the catch basin

located on the shopping center up gradient from this pipe. This smaller pipe appears to be a source of the bacteria elevations seen in the Kingfisher Canal.

C. Sediment Results

As mentioned earlier, sediments preserve the effects of water quality impacts. Total petroleum hydrocarbons were 15 times higher in sediment from the Kingfisher Canal as compared to sediment from the comparison canal. Similarly, polynuclear aromatic hydrocarbons, common components of waste oils and hydrocarbon combustion, are 8.5 times higher in the Kingfisher Canal sediment, clearly indicating impacts from highway and parking lot runoff.

D. Microscopic Examination

To the unaided eye, the dark, amorphous floating matter reported in the Kingfisher Canal, resembles fecal matter. The microscopic examination, however, indicated that it was composed of algal matter. The phenomenon of this floating algal matter is seen county-wide on occasion. Changes in weather, especially rainfall, result in the production of gases in algae growing at the bottom of many waterways. These gases cause the algae to break loose from the bottom and appear as “pop-ups” on the surface. The growth of algae is encouraged by high concentrations of nitrogen and phosphorus in the water. These algal clumps may contribute to water quality problems by serving a media for bacteria growth and by consuming oxygen as they decompose. They may also clog cooling water intakes of vessels navigating the waterway.

V. CONCLUSIONS

The water quality in the Kingfisher Canal, with respect to bacteria, is poor as compared to the nearby Tern Waterway and violates DNRP water quality standards. The bacteria levels in the Tern Waterway, however, is also unexpectedly high. The 24" stormwater outfall pipe at the western end of the Kingfisher Canal was found to be enriched in bacteria, nutrients, and oil & grease. The chemical composition of water flowing from this pipe indicates that during dry weather conditions, flow from the pipe is made up of groundwater, potable water and surface water that entered the pipe during high tide. The flow from this pipe also carried pollutants typical of runoff from roads and parking lots. The flow from the pipe also appears to be carrying sanitary waste. The results, however, are inconclusive as to the source of the waste. The pollutants carried by this pipe appear to have contributed to water quality degradation in the Kingfisher Canal.

Possible explanations for the presence of animal, vegetable and petroleum oil and grease in the outfall even during periods of dry weather include car washing and/or grease trap cleaning or overflow, and sanitary waste.

While the discharge is also enriched in nutrients, the absence of significant nutrient elevations in the surface waters indicates the waterway has the capacity to assimilate or dilute this nutrient load.

The sediments of the Kingfisher Canal also have been adversely impacted by petroleum products washed off roadways and parking lots through the stormwater management system.

Reports of floating fecal matter are more likely due to the presence of algae mats on the canal bottom that are occasionally disrupted by atmospheric conditions. These mats may serve a media for the regeneration of bacteria, cause dissolved oxygen levels to be depressed and foul cooling water intakes of vessels navigating the canal.

VI. RECOMMENDATIONS

Given the water quality problems revealed by this study, a comprehensive review of the facilities and land use in the drainage area is warranted.

The City of Deerfield Beach Public Works Department, believed to be the owners of the 24" outfall pipe, should examine the entire length of the pipe to insure there are no cross-connections between it and the sanitary sewer system.

The owners of the 72" and 24" outfalls to the Kingfisher Canal, FDOT and City of Deerfield Beach respectively, should install appropriate pollutant retardant mechanisms on the outfalls to reduce adverse impacts on surface water quality.

The parties responsible for siltation of the waterway should remove excess buildup of sediments from the waterway.

VII. LITERATURE CITED

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VIII. APPENDIX

Data Table 1: General Water Quality Parameters

Site	Date	Time	Lab ID	Cond	pH	Temp	Turb	NH_4	Org N	TKN	TP	NO_2+NO_3	TN	DO	O-PO_4	T. Coliform	F. Coliform
Units				us	unit	deg. C	NTU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	CFU/100ml	CFU/100ml
24" pipe	970206	1158	60562					6.50		119	6.68	0.0415	119.0				
24" pipe	970208	1605	60580					6.95		129	11.3	0.312	129.3				
Kingfisher Canal	970217	1435	60641	4490	7.4	24.6	4.0	0.186	0.434	0.620	0.064	0.227	0.847	6.2	0.061	5600	72000
Tern Waterway	970217	1500	60642	4980	7.8	25.1	4.0	0.176	0.459	0.635	0.012	0.194	0.829	7.1	0.087	3200	>5500
Kingfisher Canal	970326	1550	60931	5220	7.4	27.2	6.8	0.286	0.724	1.010	0.149	0.161	1.171	2.6	0.060	3800	>21000
Tern Waterway	970326	1540	60932	15100	7.6	28.4	12	2.186	1.254	1.440	0.253	0.114	1.554	5.7	0.045	490	>730
24" pipe	970326	1550	60940	4880													
24" pipe	970326	1410	60938	4710													
24" pipe	970327	1500	60939	4800													
Kingfisher Canal	970416	1235	61085	5490	7.1	25.2	3.3	0.254		0.852	0.170	0.203	1.055	4.4	0.143	6500	17000
Tern Waterway	970416	1255	61086	7290	7.1	24.4	2.6	0.240		0.990	0.135	0.189	1.179	3.3	0.084	1200	1100
24" pipe	970612	0950	61551	2780												>67000	>2500
Catch basin	970612	1010	61559	570												>53000	1700
72" pipe	970612	0955	61552	3370												2000	110

Data Table 2: Organic Contaminants

Site	Date	Time	Lab ID	T VOCs	TRPH	Oil & Grease	% Solids	Tot. PAHs
24" pipe	970206	1156	60563		50.9 mg/l			
24" pipe	970208	1514	60581	2.02 ug/l				
24" pipe	970208	1603	60579		169 mg/l	1070 mg/l		
Kingfisher Sediment	970326	1550	60972				66.1	26.25 ug/l
Kingfisher Sediment	970326	1550	60933		230 mg/kg		66.1	
Tern Waterway Sediment	970328	1600	60973				70.6	3.083 ug/l
Tern Waterway Sediment	970328	1600	60956		14.9 mg/kg		70.6	

1. TITLE AND SUBTITLE *AN INVESTIGATION OF WATER QUALITY COMPLAINTS IN THE KINGFISHER CANAL, DEERFIELD BEACH, FLORIDA*	2. REPORT DATE *JANUARY 1998*
3. CONTRIBUTORS *RUSSELL RAND, CRAIG S. WILBUR, REGINALD PAGE, NANCY HOLSING, BEVON JOHNSON, MARIA FERNANDEZ, NANCY GASSMAN AND GEORGE F. RILEY*	4. PERFORMING ORGANIZATION REPORT NO. *TECHNICAL REPORT SERIES TR:98-02*
5. RESPONSIBLE DEPARTMENT AND DIVISION *BROWARD COUNTY DEPARTMENT OF NATURAL RESOURCE PROTECTION* *218 SW 1ST AVENUE* *FORT LAUDERDALE, FL 33301*	6. STRATEGIC ASSESSMENT PROGRAM ELEMENT NO. 7. CONTRACT/GRANT NO.
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10. SUPPLEMENTARY NOTES	

11. ABSTRACT

THIS REPORT DESCRIBES A STUDY OF SEDIMENT AND WATER QUALITY IN A SHALLOW MARINE WATERWAY IN NORTHEASTERN BROWARD COUNTY, FLORIDA. THE PURPOSE OF THE REPORT IS TO SUMMARIZE THE FINDINGS OF THE STUDY WHICH WAS INITIATED TO INVESTIGATE THE SOURCE OF WATER QUALITY PROBLEMS REPORTED BY RESIDENTS LIVING ON THE WATERWAY. THE RESIDENTS WERE CONCERNED THAT THE STORMWATER OUTFALLS WERE CONTRIBUTING TO THE POLLUTION OF THE WATERWAY.

THE STUDY INCLUDED TESTING OF SURFACE WATERS, SEDIMENTS AND THE STORMWATER OUTFALLS IN THE STUDY AREA FOR BACTERIA, NUTRIENTS, PETROLEUM HYDROCARBONS AND POLYNUCLEAR AROMATIC HYDROCARBONS. A NEARBY WATERWAY, WHICH WAS SIMILAR TO THE STUDY WATERWAY WITH THE EXCEPTION OF THE STORMWATER OUTFALLS, WAS ALSO SUBJECTED TO THE SAME SAMPLING PROTOCOL FOR COMPARISON PURPOSES.

RECOMMENDATIONS FOR IMPROVING WATER QUALITY IN THE WATERWAY ARE INCLUDED.

12. KEY WORDS

SEDIMENTS
SURFACE WATER
BACTERIA
FECAL COLIFORM
PETROLEUM HYDROCARBONS
POLYNUCLEAR AROMATIC HYDROCARBONS
STORMWATER OUTFALLS
NUTRIENTS

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