6.0 SUNSET ACRES CASE STUDY

As part of the Monroe County Residential Canal Inventory and Assessment, MACTEC E&C conducted a case study of a canal system that had recently undergone modifications, including being permanently opened (connected) to Florida Bay. This canal system is located in the subdivision of Sunset Acres on Key Largo, Monroe County, Florida (**Figure 6-1**).

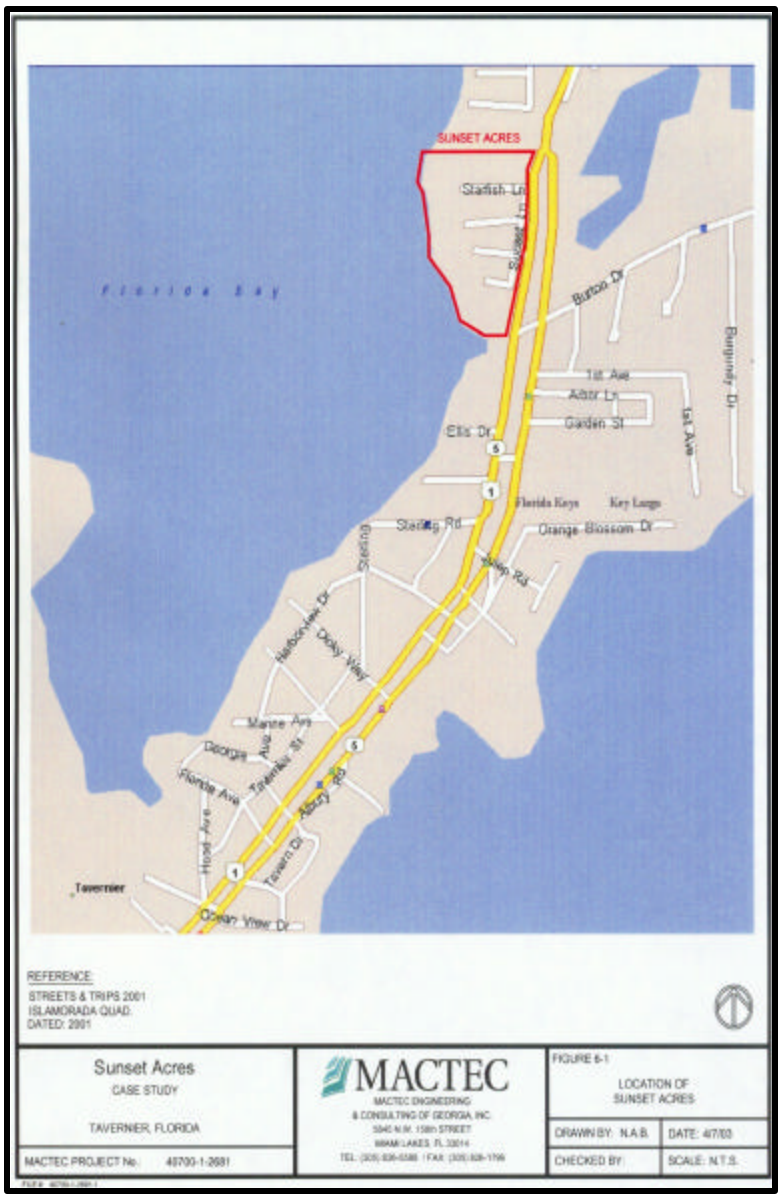

Figure 6-1 Sunset Acres on Key Largo, Monroe County, Florida

The purpose of the case study was to evaluate the water quality in the canal after modifications were completed. Modifications included installation of an aeration system, backfilling and opening a connection to Florida Bay. Historic water quality data, collected for approximately a decade, were compiled for comparison to water quality data collected subsequent to each of the modifications. The water quality data were compared to state water quality parameters, where applicable, and to ambient water quality data for Florida Bay. Additionally, water quality data were collected by MACTEC E&C on a quarterly basis for one year (2002-2003) to provide additional data for evaluation of post-modifications changes. Canal bottom sediment samples were also collected to measure sediment grain size and loading of accumulated organic matter to the canal system.

This section provides a brief summary of the study. The entire Case Study Report is included in **Appendix C** as well as in electronic form in the attached CD. The analytical data collected from this canal system has been incorporated into the GIS database.

6.1 SITE HISTORY

In 1970, a permit was issued to the developer of what was to become Sunset Acres by the Internal Improvement Trust Fund and authorized by the Florida Department of Pollution Control, predecessor to the present Florida Department of Environmental Protection (DEP). The permit authorized the developer to dredge the following:

- Three channels (canals) 100 ft long x 50 ft wide x 5 ft deep (30 x 15 x 1.5 m)
- One perimeter channel (connecting canal) 50 ft long x 30 ft wide x 5 ft deep (15 x 10 x 1.5 m)
- One access channel in Florida Bay of 150 ft long x 50 ft wide x 5 ft deep (45 x 15 x 1.5 m) (Note - This channel would act as a corridor through the shallow nearshore Florida Bay waters adjacent to the proposed development. Without this channel, boat traffic would inevitably cut lanes through the existing shallow waters and seagrass beds. This channel would direct boat traffic along a specific corridor to deeper water offshore.)

Residential lots would line the canals, and the access channel would provide boats access to Florida Bay.

Figure 6-2: Showing the residential canal of Sunset Acres

Before Sunset Acres was developed, however, ownership of the property changed hands and the permit was subsequently revised to be a landlocked canal system dredged from uplands with no bay access. It allowed the canals to be dredged and the access channel in Florida Bay to be dredged, but the permit did not allow the canals to be connected to the access channel. The canals were separated from the access channel in Florida Bay by a breakwater.

In 1973, the canal system was dredged as a landlocked system, per the existing permit. However, the dimensions of the canals, in particular the depth, were apparently increased (based on subsequent measurements and correspondence). The finished canal system consisted of:

- Three channels between 350 and 500 ft long x 50 ft wide x 15 to 20 feet deep (105 – 150 x 15 x 5 – 6 m)
- One perimeter channel 595 ft long x 30 ft wide x 15 to 20 ft deep (180 x 9 x 5 – 6 m)

The access channel, although still permitted, was not dredged.

In 1979 a permit application was submitted to allow removal of an earthen plug in order to connect the landlocked canal system to Florida Bay. The permit application was denied.

In 1980, the consultants for Sunset Acres began exploring options for modifications of the existing canal to address water quality concerns, and enhance the probability of eventual approval of a connection to Florida Bay. In the late 1980s, the community began collecting water quality data in preparation for installing an aeration device to improve the dissolved oxygen (DO) levels in the canal through oxygenation. Basically, in an aeration system, a stream of small air bubbles rises through the water column from perforated pipes laid along the canal bottom. This adds oxygen to, and provides some vertical mixing (by displacement) in the water column. An aeration system was installed in May 1989.

In 1997, after many proposals, negotiations, studies and revisions to proposals, the DEP and USACE issued a permit to backfill the canals to a depth of 6 feet, and unplug the breakwater to allow a permanent connection to Florida Bay. The permit required the use of clean limerock fill free of organic debris. In August 1998, the permitted work was completed. Monroe County issued a permit requiring the community to monitor the canal and adjacent waters in Florida Bay for one year.

Figure 6-3: Photograph showing breakwater and opening to Florida Bay

Subsequent to the completion of the one-year monitoring, additional water quality data were collected by MACTEC E&C on an approximately quarterly basis for one year (2002-2003) to provide additional data for evaluation of post-modifications water quality. Canal bottom sediment samples were also collected to evaluate if accumulated debris was providing a continued organic load to the canal system.

6.2 WATER QUALITY DATA SUMMARY AND CONCLUSIONS

In this section, water quality data, collected before and after the permitted modifications were made to the canal environment, are compared. The Case Study Report included in **Appendix C** contains all of the water quality data including a summary of the collection dates, the entity for whom the data were collected, the document from which the data were obtained as well as the parameters that were collected.

The following evaluation is divided into two sections. The first section will provide a comparison of water quality data collected before and after installation of the aeration system. This discussion will be followed by an evaluation of the water quality data collected before and after the mouth at Sunset Acres was permanently unplugged to allow access to Florida Bay.

6.2.1 Comparison of Water Quality Parameters Before and After Aeration System Installation

In May 1989, an aeration system was installed in the canal system of Sunset Acres at the request of, and through funds provided by, the homeowners in the community. A copy of the specifications and layout (drawing) are provided in Case Study Report. Aeration in canals treats one immediate symptom of high BOD which is low DO in the water column. Aeration does not treat the source of the problem, excess organic material and inorganic nutrient loading into the canal environment (water column and bottom).

To evaluate the effectiveness of the aeration system DO levels collected from nine sampling events were evaluated - three sets of samples collected prior to the system being installed and six sets of samples collected after installation. DO was utilized as it was the only parameter that was consistently collected over the entire period. Please refer to the Case Study report for the sample locations, dates, and measured values.

The pre-aeration system sample results indicate that stratification was occurring in the Sunset Acres canal. For example, as shown in **Table 6-1,** the DO concentration in the surface samples obtained from the canal ranged from 3.0 to 4.0 milligrams per liter (mg/L), whereas the concentrations of the mid-depth samples ranged from 1.1 to 3.4 mg/L. The mid-depth samples were between 0.1 and 1.9 mg/L and lower than the surface samples at each sample location. The decrease in the DO concentration was more pronounced in the bottom sample, where DO concentrations ranged from 0.2 to 0.4 mg/L, a decrease of between 2.8 and 3.6 mg/L. During the same sampling event, the DO concentration of the Florida Bay samples were 5.8 mg/L at both the surface and the bottom.

TABLE 6-1: PRE-AERATION SYSTEM DO CONCENTRATIONS (MG/L)

SAMPLE LOCATION	SURFACE SAMPLE	MID-DEPTH SAMPLE	BOTTOM SAMPLE	DIFFERENCE BETWEEN SURFACE AND MID-DEPTH DO CONCENTRATIONS	DIFFERENCE BETWEEN SURFACE AND BOTTOM DO CONCENTRATIONS
Station 1	3.0	1.3	0.4	1.7	2.6
Station 2	3.5	3.4	0.4	0.1	
Station 3	3.0	1.1	0.2	1.9	2.8
Station 4	4.0	3.0	0.4	1.0	3.6
Station 5	4.0	3.5	0.3	0.5	3.7
Florida Bay	5.8	Not collected	5.8	-	0

Following installation of the aeration system, stratification still was evident, but less pronounced. As shown in **Table 6-2**, the DO in the surface samples from the canal ranged from 5.4 to 5.8 mg/L. The mid-depth samples were similar to the surface, ranging from 5.1 to 5.8 mg/L. These all would be considered relatively high DO values for nearshore Florida Keys waters, and certainly capable of supporting marine life. The difference between the surface and mid-depth samples, ranging between 0 and 0.3 mg/L, indicated little stratification between these depths. The DO concentrations for the bottom samples ranged from 3.4 to 4.4 mg/L, a decrease of between 1.0 and 2.4 mg/L, which is relatively small compared to the differences in the pre-aeration samples. During the same sampling event, the DO concentration of the control sample in Florida Bay was 8.0 mg/L at both the surface and the bottom.

TABLE 6-2: POST-AERATION SYSTEM DO CONCENTRATIONS (MG/L)

SAMPLE LOCATION	SURFACE SAMPLE	MID-DEPTH SAMPLE	BOTTOM SAMPLE	DIFFERENCE BETWEEN SURFACE AND MID-DEPTH DO CONCENTRATIONS	DIFFERENCE BETWEEN SURFACE AND BOTTOM DO CONCENTRATIONS
Station 1	5.5	5.4	3.8	0.1	1.7
Station 2	5.7	5.4	4.4	0.3	1.3
Station 3	5.4	5.1	4.4	0.3	1.0
Station 4	5.8	5.5	3.4	0.3	2.4
Station 5	5.8	5.8	3.8	0	2.0
Florida Bay	8.0	Not collected	8.0	-	0

A few trends in the DO concentrations were evident from the data:

- Florida Bay concentrations do not exhibit stratification – i.e., the lines are flat. This is true for the bay samples both before and after the aeration system was installed. Open waters of Florida Bay receive significant vertical mixing from wind that is not seen in enclosed narrow canals.

- Florida Bay concentrations are higher than the canal concentrations both before and after the aeration system was installed.

- The concentrations in both the canal and Florida Bay increased following installation of the aeration system; however, the increase in the middle and bottom sample of the canal is of greater magnitude (approximately 4.0 mg/L and 3.5 mg/L, respectively) than the overall increase in the before and after aeration system installation of the bay samples (approximately 2.0 mg/L). This indicates the increase in the mid-depth and bottom canal samples are not just reflective of an apparent overall increase in DO, but of an improvement after the aeration system was installed.

- The canal concentrations still exhibit stratification after the aeration system was installed, but the difference between the surface and bottom sample is less after the aeration system was installed (approximately 1.5 mg/L) than before the installation (approximately 3.0 mg/L).

- As sampling continued through 1989, the DO concentrations remained above pre-aeration levels. Although the DO concentrations continued to exhibit stratification in the bottom sample, concentrations below the State criteria of 4.0 mg/L were less frequent. The occurrence of DO concentrations below the regulatory criteria were recorded in the samples collected at the dead end of Canals #1 and 3, and in the perimeter canal locations that are not adjacent to the flushing channels. The low DO concentrations (i.e., below 4.0 mg/L) always occurred in the bottom sample.

6.2.2 Comparison of Water Quality Parameters Before/After Modifications to Open Canal to Florida Bay

In 1997, Monroe County, FDEP and USACE granted Sunset Acres a permit to permanently remove a portion of the breakwater to allow access from the Sunset Acres canal to Florida Bay. Pertinent conditions of the permit included:

- Backfill existing residential canal system to an average depth of no greater than 6 feet below mean low water.
- Plug existing culverts.
- Construct and maintain a plug isolating the canal system from Florida Bay for the duration of the backfilling operations.
- Submit a bathymetric survey at completion of backfilling operation.
- Following approval of the backfilling operation, remove the plug and open the canal system to Florida Bay.
- Work to be completed before January 2000.

In addition, Monroe County required Sunset Acres to implement a water quality monitoring plan containing the following provisions:

- Parameters to be collected included: time of day, water depth, temperature, DO, electric conductivity, pH, turbidity and salinity.
- Data to be collected beginning on the day the plug is removed.
- Data to be collected from five locations in Sunset Acres, one location in Florida Bay and five locations in Hammer Point Subdivision (for comparison).
- Data to be collected from two depths at each location: one foot below the surface and one foot from the bottom.

The first sampling event occurred on August 4, 1998. Sampling continued monthly until August 18, 1999. Four additional sampling events were performed by MACTEC E&C between April 2002 and April 2003 as part of the Monroe County Residential Canal Assessment and Inventory.

The issuance of the permit was the culmination of almost 20 years of negotiations by the Sunset Acres homeowners to obtain access to Florida Bay. Throughout this time, water quality data were intermittently collected by various entities. The only parameter consistently collected throughout this period was DO; therefore DO has been utilized to evaluate the changes over time. A summary of the data collected, dates of collection, and the entity for whom data were collected is provided in the Case Study Report in **Appendix C**.

As noted in the previous discussion, the water quality parameters in the canal system exhibited stratification. A comparison of surface vs. bottom DO concentrations before and after the canal was backfilled in August of 1998 is provided in **Charts 1** and **2**, respectively.

Chart 1 compares the surface and bottom DO concentrations before the canal was backfilled. As illustrated in this chart, the DO concentrations for the bottom sample, while mimicking the surface sample, show wide variabilities in the concentrations, sometimes as much as 3 or more mg/L lower than the surface sample. However, in **Chart 2**, which compares the surface and bottom concentrations after the canal was backfilled, the variations are generally 1.0 mg/L or less. This indicates that there is more mixing since the canal was backfilled, although there is still some stratification. This appears to indicate that the main contributor to DO is mixing with the atmosphere.

A comparison of DO concentrations in the canal and adjacent bay before and after the 1998 modifications is provided in **Charts 3** and **4**, respectively. **Chart 3** illustrates the natural vertical mixing of the water column in adjacent bay waters (e.g. similar surface and bottom DO concentrations), as opposed to a highly-stratified water column in the narrow canal (e.g. lower bottom DO concentrations). **Chart 3** also illustrates the impact of storm and weather events on the coastal ecology, the canal and bay data are distinct and different, with the exception of one event in August 1995. Very hot tropical summer weather can drive DO of the natural system to levels approaching the canal DO. After modifications, there are fewer differences between canal and adjacent bay waters (**Chart 4),** indicating greater circulation through the canal system**.** The DO concentrations improved overall in the canals with increased water movement.

The DO concentrations were then compared over the 20-year span in which the data were collected. On **Chart 5A,** the DO concentrations in the surface samples of the canal and of the adjacent bay are plotted with a trendline. The apparent trend is a decrease in the DO concentrations in both the bay and the canal over time. The overall drop in DO for both the adjacent bay and canal is an indication of the chronic eutrophication of nearshore waters in the Florida Keys. The consistently lower DO in the canals is indicative of the higher BOD of the restricted system. In an attempt to evaluate whether this trend was long-term, on **Chart 5B** only the sampling data collected prior to the 1998 modifications were plotted. Here the trend indicates the DO concentration of the bay surface samples increased slightly, while that of the canal decreased. This suggests that the downward trend in the DO concentration of the surface sample in the bay occurred after the 1998 modifications. Even if this data set is small, the eutrophication of the adjacent bay water appears as a consistent trend since 1998. The cause of the decline can not be correlated to the Sunset Acres canal system directly and may be related to an overall Florida Bay water quality decline.

On **Chart 6A** the DO concentrations of the bottom samples of these water bodies are plotted. The trendlines through these data show two different patterns. Overall, the bottom waters experience greater intra-annual variability and lower extremes (near anoxia). While the DO concentrations in the adjacent bay waters appear to be decreasing (eutrophication), the canal DO concentrations slightly increased (improved circulation). Again, the DO concentrations were replotted using only the data collected prior to the 1998 modifications (**Chart 6B)**. This chart shows very little difference in bottom DO concentrations for both bay and canal waters prior to 1998.

6.2.3 Sediment Quality after Modifications to Open Canal to Florida Bay

As part of the Canal Inventory and Assessment work scope, sediment cores were collected from the canal bottom at several sampling locations (refer to the Case Study Report). The results showed that these sediments contained an organic content ranging from 2.8% to 6.1% of the dry weight, which is considered a relatively high organic content typically seen in sediments collected from canal bottoms from a wetland system. These values are one to two orders of magnitude higher than offshore sediment samples. The high organic matter suggests loading of nutrients/particulate organic material (POM) from the adjacent land and accumulation on the canal floor. Grain size of the sediments was not retained by 0.125 mm sieve, indicating very fine mud-clays. Sediments are likely resuspended and disturbed by wind or boats in the canal, thus remain unstratified, flocculent and likely support a robust anoxic microbial community. The small grain size supports a higher surface area for microbes and trapping POM. The nature of the sediments make them likely contributors to BOD loading in this canal system and contribute to the water quality degradation in this canal system.

6.2.4 Water Quality Conclusions

While there is sufficient data to make some overall conclusions about the Sunset Acres canal, the picture is not complete. The only data set of sufficient duration is that of DO, which by itself can be used as a good indicator of water quality and is a critical component in maintaining a healthy ecosystem and supporting marine life. When DO levels fall below 4.0 mg/L, certain marine species experience distress, and levels below 1.0 mg/L are fatal to some species. Therefore, low DO levels, even if it only occurs sporadically, can have detrimental effects on the marine environment (DPC, 1973).

The DO data for Sunset Acres indicate that DO concentrations in the canal when the data were first collected were frequently below the State regulatory criteria of 4.0 mg/L (**Chart 3**). While DO showed some improvement after an aeration system was installed (i.e., higher DO concentrations in both surface and bottom samples, and less variability between surface and bottom concentrations) stratification and DO concentrations below the regulatory criteria still occurred (as shown on **Chart 1)**. The DO concentrations after the 1998 backfilling modifications exhibited some stratification, but the incidences were sporadic and minimal, indicating that the water column is in better equilibrium and more closely resembles open water conditions (**Chart 2**). After modifications, there are fewer differences between canal and adjacent bay waters (**Chart 4),** indicating greater circulation through the canal system**.** The DO concentrations improved overall in the canals with increased water movement.

The overall drop in DO for both the adjacent bay and canal is an indication of the chronic eutrophication of nearshore waters in the Florida Keys. The consistently lower DO in the canals as opposed to adjacent bay is indicative of the higher BOD of the restricted system. The 1984 and 2002 sediment sampling studies found the substrate consisted of fine silts and clays high in organic content (DEP, 2001). As was noted above, DO concentrations showed some improvement after an aeration system was installed. However, stratification and DO concentrations below the regulatory criteria still occurred, which may be due to the inability of the aeration system to overcome the accumulation of organics. Additionally, the aeration system operation was not continued after opening the canal system to Florida Bay. Unfortunately, storm events or human activities can facilitate the catastrophic transport of pollutants and accumulated organic matter to adjacent nearshore marine communities. (Sealy, 2001). The export of organic material from canals is documented as a source of chronic nutrification to Outstanding Florida Waters of the Keys (Lapointe and Clark, 1992; Lapointe et al, 1994). An understanding of how much organics/nutrients are being input to the Sunset Acres canal system and their fate would be helpful in evaluating the DO trends noted.

In summary, the remedial measures that were implemented in the Sunset Acres canal, aeration and backfilling, did improve the water quality. However, additional water quality improvements may still be desirable. The bottom sediments contain an organic source that is an on-going biological oxygen demand on the canal system. Additionally, other land-based inputs are still occurring that need to be addressed. An initiative like the Florida Yards and Neighborhood's program can identify key actions in the majority of the homes that are contributing to the loading in this canal and assist in the implementation of best management practices for each homeowner.

An evaluation of how this canal system fits into the Residential Canal Inventory and Assessment Classification and Recommended Treatment Technologies is discussed in the following section.

6.3 SUNSET ACRES CANAL CLASSIFICATION

Sunset Acres canal system is labeled as Tavernier 101 in the GIS database. It is a medium sized canal consisting of 0.206 acres with a maximum length of 1,056 feet (322 meters). The area to length ratio is 2.78. The canal system has an outfall into Florida Bay that has medium energy with an orientation of 225 degrees. The canal construction in a combination of filled wetlands and nearshore hard bottom extending out from the original rocky, fringing mangrove shoreline. The level of development is high, over 70% of the lots are built out. Based upon this classification a Fair Water Quality Designation was predicted. **Table 6-3** presents some of the key canal physical attributes. The actual water quality was determined to be Poor based on the available information, much of which was collected when the canal mouth was plugged. Water quality designations in the classification system of this project were based on open canals with at least one mouth facilitating circulation with adjacent nearshore waters. It is clear from the water quality and sediment analysis that there has been a long-term accumulation of organic matter/nutrients in the canal system. The recommended treatment technologies for this canal were: Stormwater Management, Best Management Practices, Circulation Devices and Nutrient Removal.

TABLE 6-3 PHYSICAL ATTRIBUTES OF SUNSET ACRES CANAL (TAVERNIER 101)

RESIDENTIAL NAME	WATER QUALITY	ACRES	LENGTH (FT)	A/L RATIO	NO. OF MOUTHS	CONVOLUTIONS	CANAL OUTFALL/ ENERGY
Tavernier 101	Fair	0.206	1,056	2.78	1	3	Florida Bay Medium Energy
Classification: Level I C. Medium Size, II B Medium Energy, IIIA Dredge Construction, IV High Development							

Sunset Acres does fit the classification model. One of the recommended treatment technologies was applied (aeration – which is a less effective circulation system), and it did show some water quality improvement. It must noted that æration systems may show short-term immediate changes (weeks), but will not improve the water quality in the long-term (years) unless the loading source of nutrients/organic matter is addressed. The water quality continues to be influenced by ongoing BOD loading from sediments, stormwater runoff and other human influences. Best management practices would assist in reducing pollutant loading from non-sewage sources.

Chart 1: Canal Surface vs Bottom DO Concentrations Before 1998 Modifications
Sunset Acres Case Study
Monroe County Residential Canal Inventory & Assessment
MACTEC Project No. 40700-1-2681

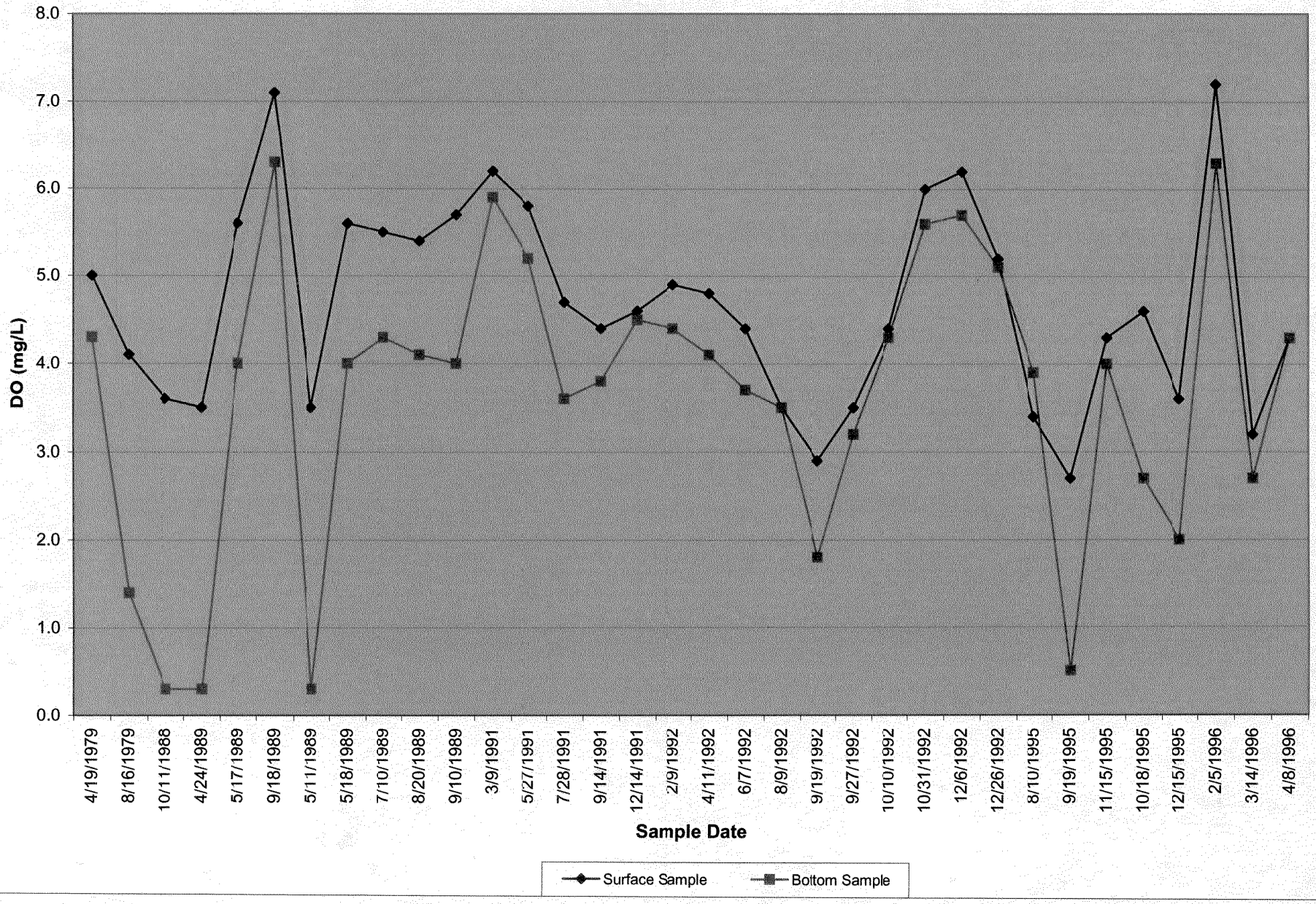

Chart 2: Canal Surface vs. Bottom DO Concentrations After 1998 Modifications
Sunset Acres Case Study
Monroe County Residential Canal Inventory & Assessment
MACTEC Project No. 40700-1-2681

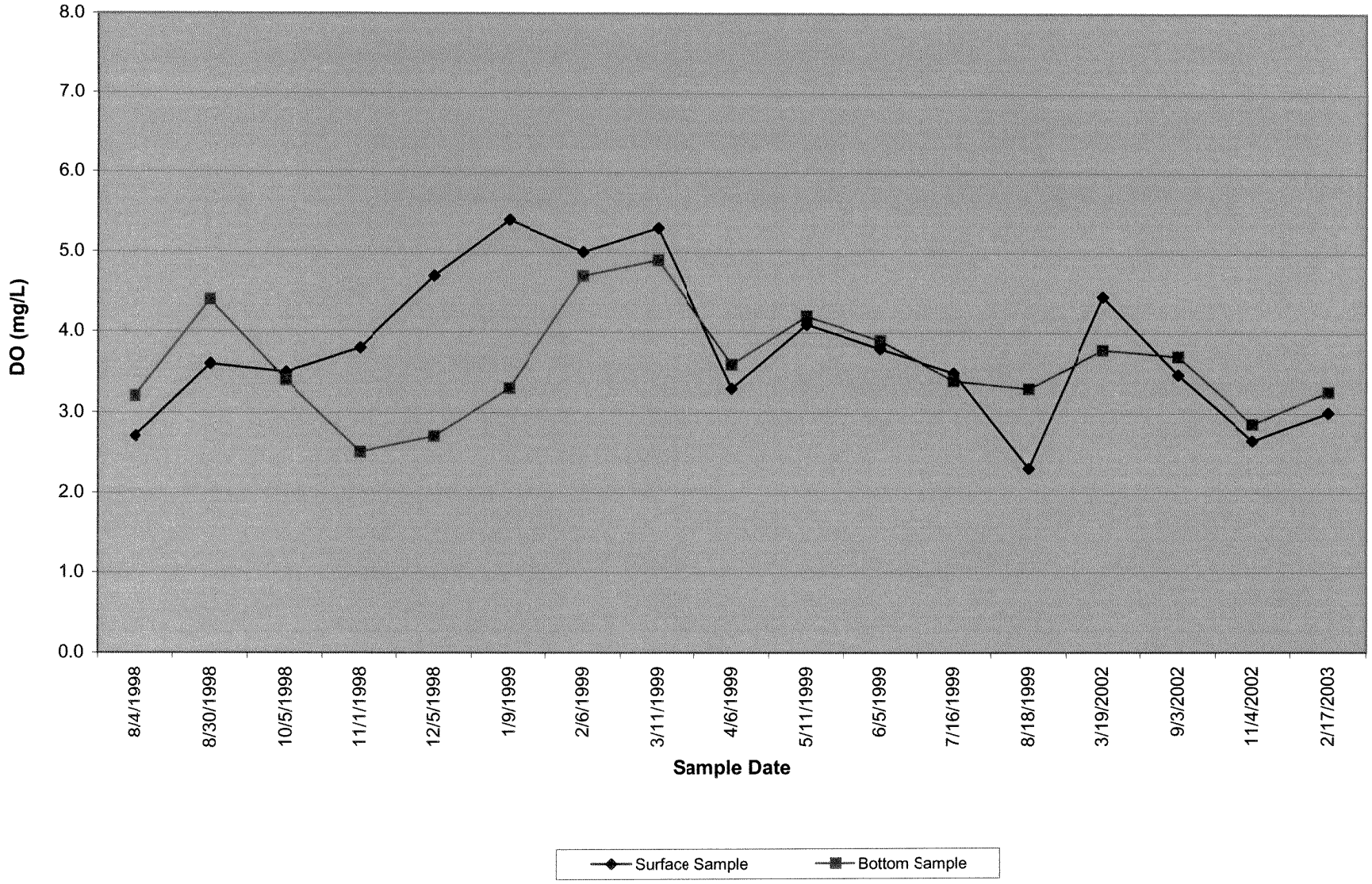

Chart 3: DO Concentrations Before 1998 Modifications
Sunset Acres Case Study
Monroe County Residential Canal Inventory & Assessment
MACTEC Project No. 40700-1-2681

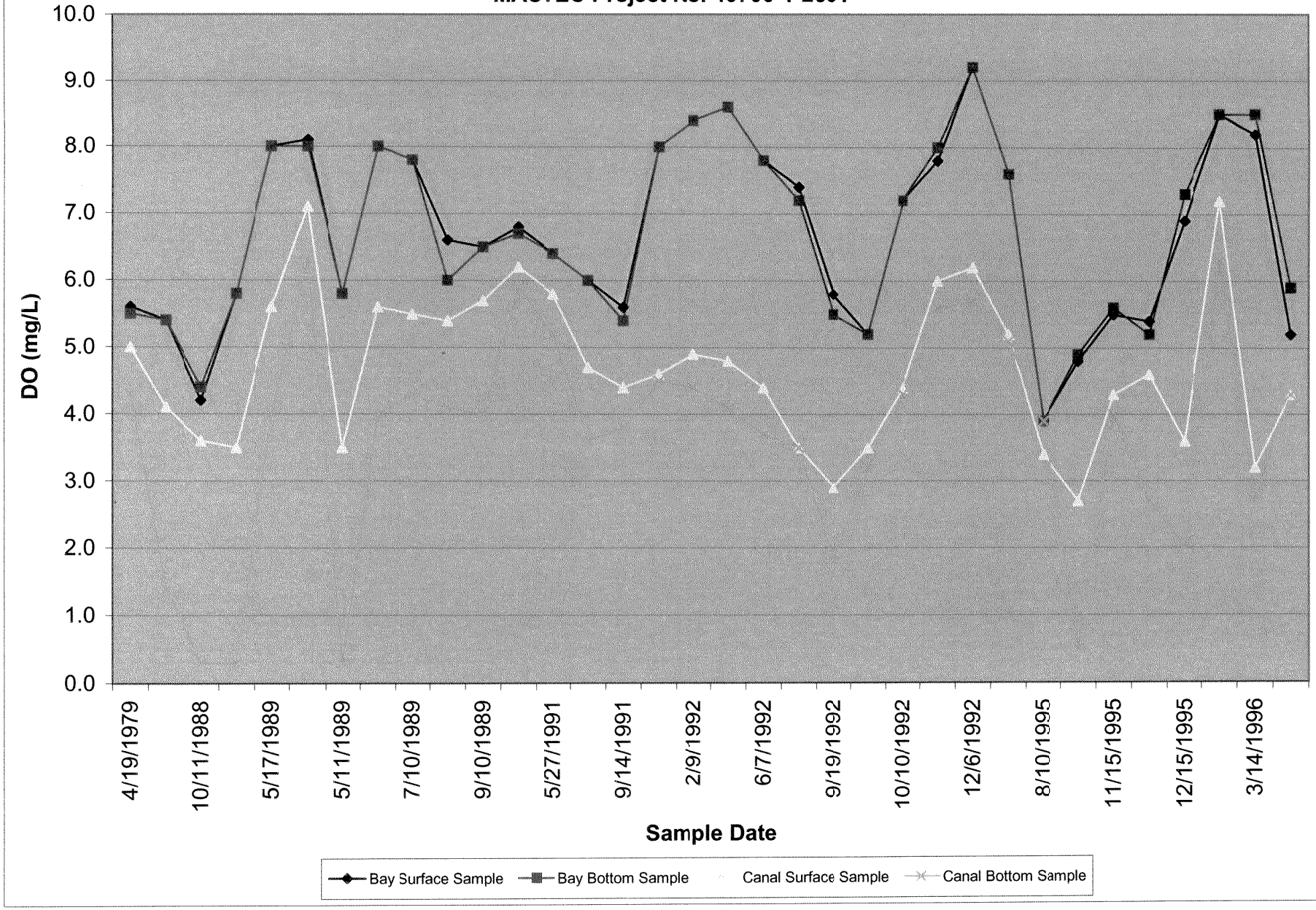

Chart 4: DO Concentration After 1998 Modifications
Sunset Acres Case Study
Monroe County Residential Canal Inventory & Assessment
MACTEC Project No. 40700-1-2681

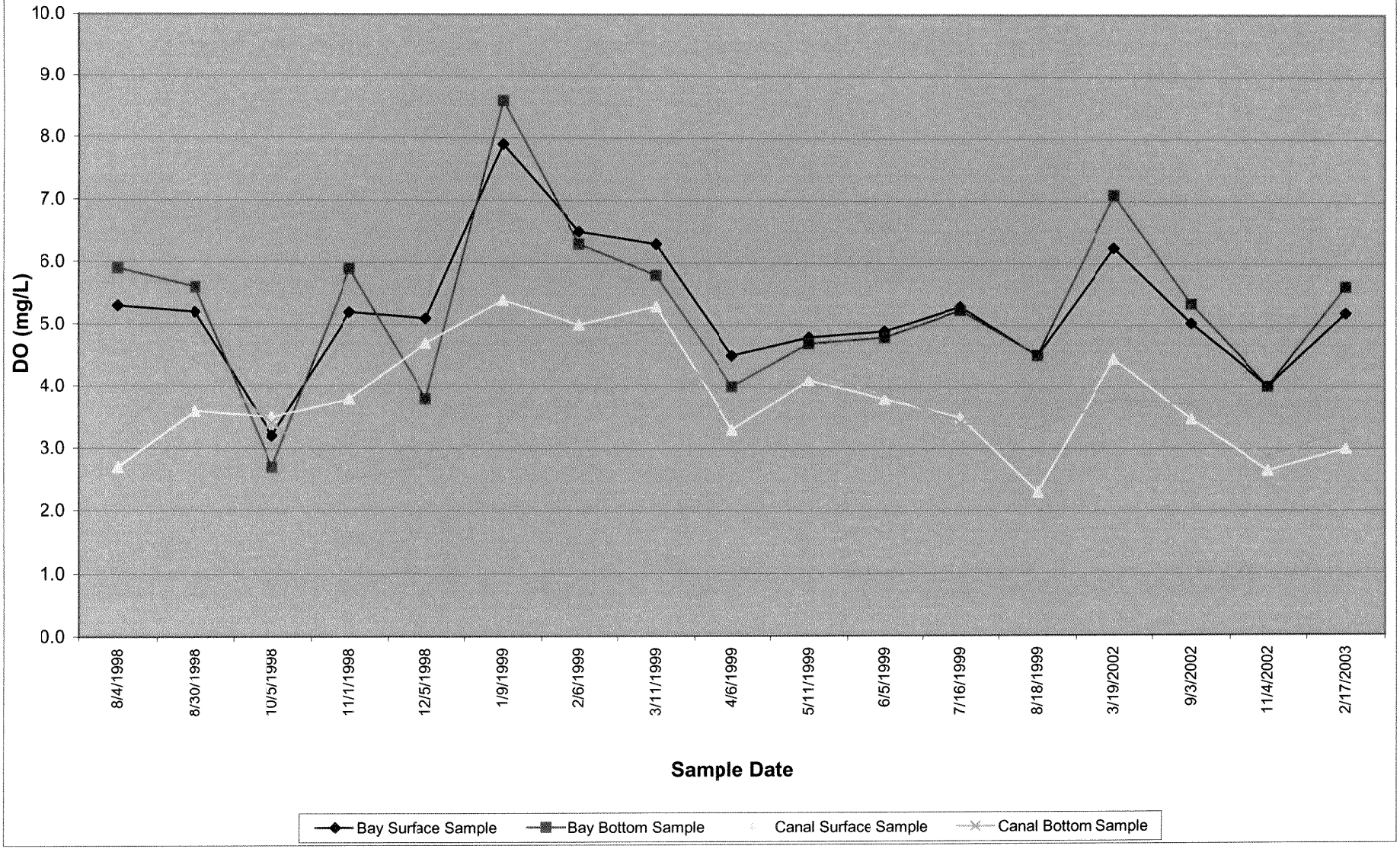

Chart 5A: Surface Sample DO in Canal vs Bay 1979 - 2003
Sunset Acres Case Study
Monroe County Residential Canal Inventory & Assessment
MACTEC Project No. 40700-1-2681

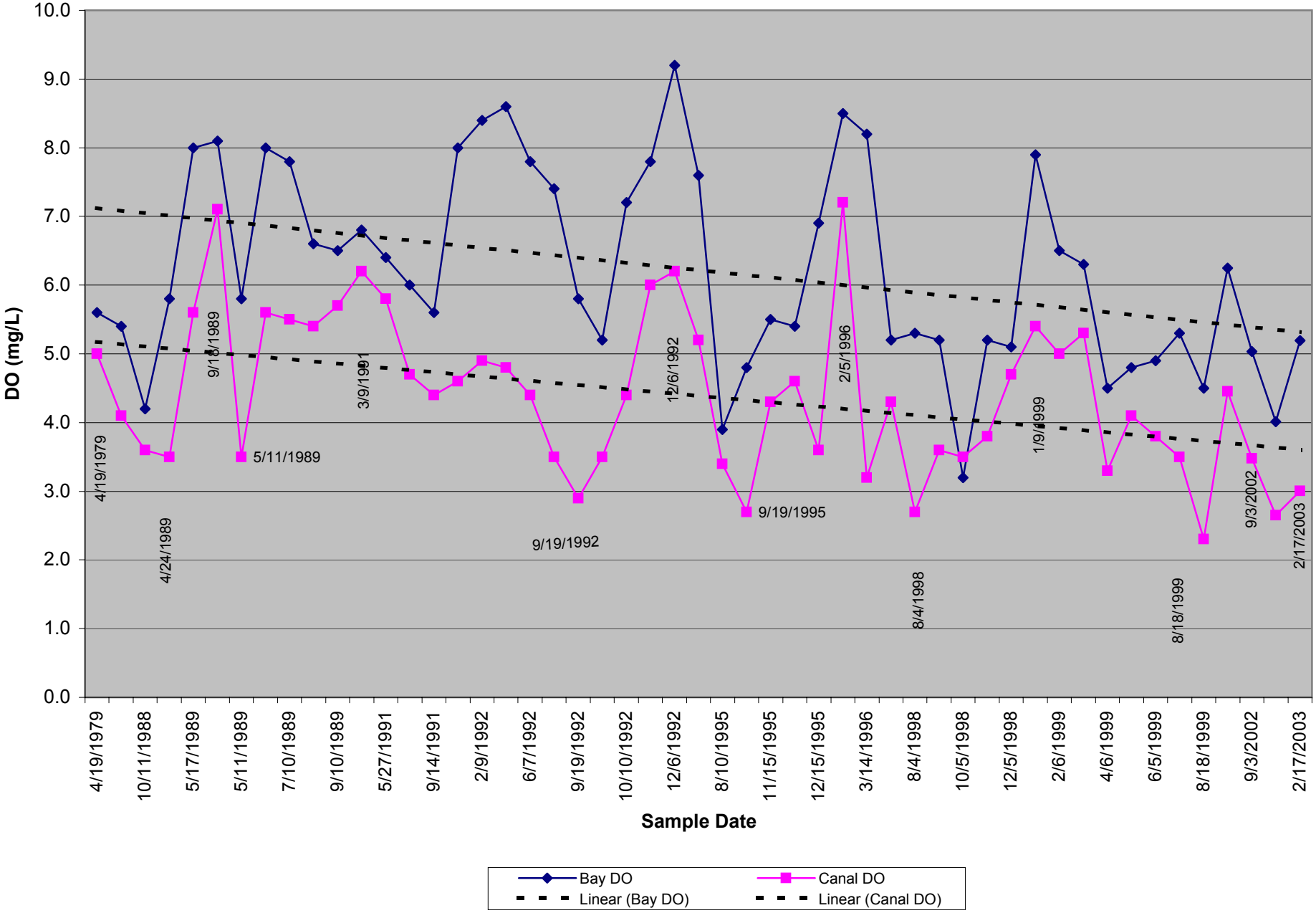

Chart 5B: Surface DO in Canal vs Bay Prior to 1998 Modifications
Sunset Acres Case Study
Monroe County Residential Canal Inventory & Assessment
MACTEC Project No. 40700-1-2681

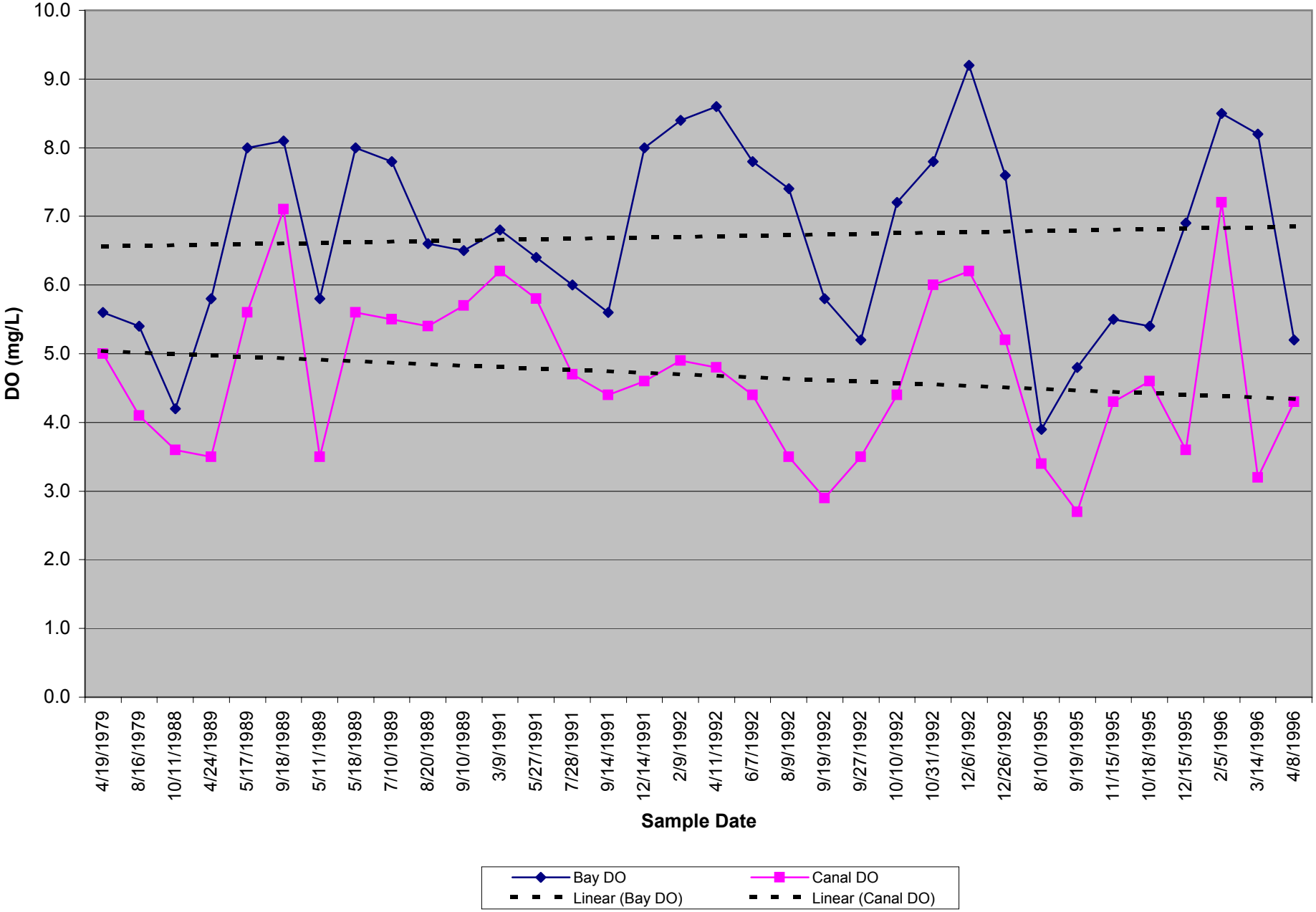

Chart 6A: Bottom Sample DO in Canal vs Bay 1979 - 2003
Sunset Acres Case Study
Monroe County Residential Canal Inventory & Assessment
MACTEC Project No. 40700-1-2681

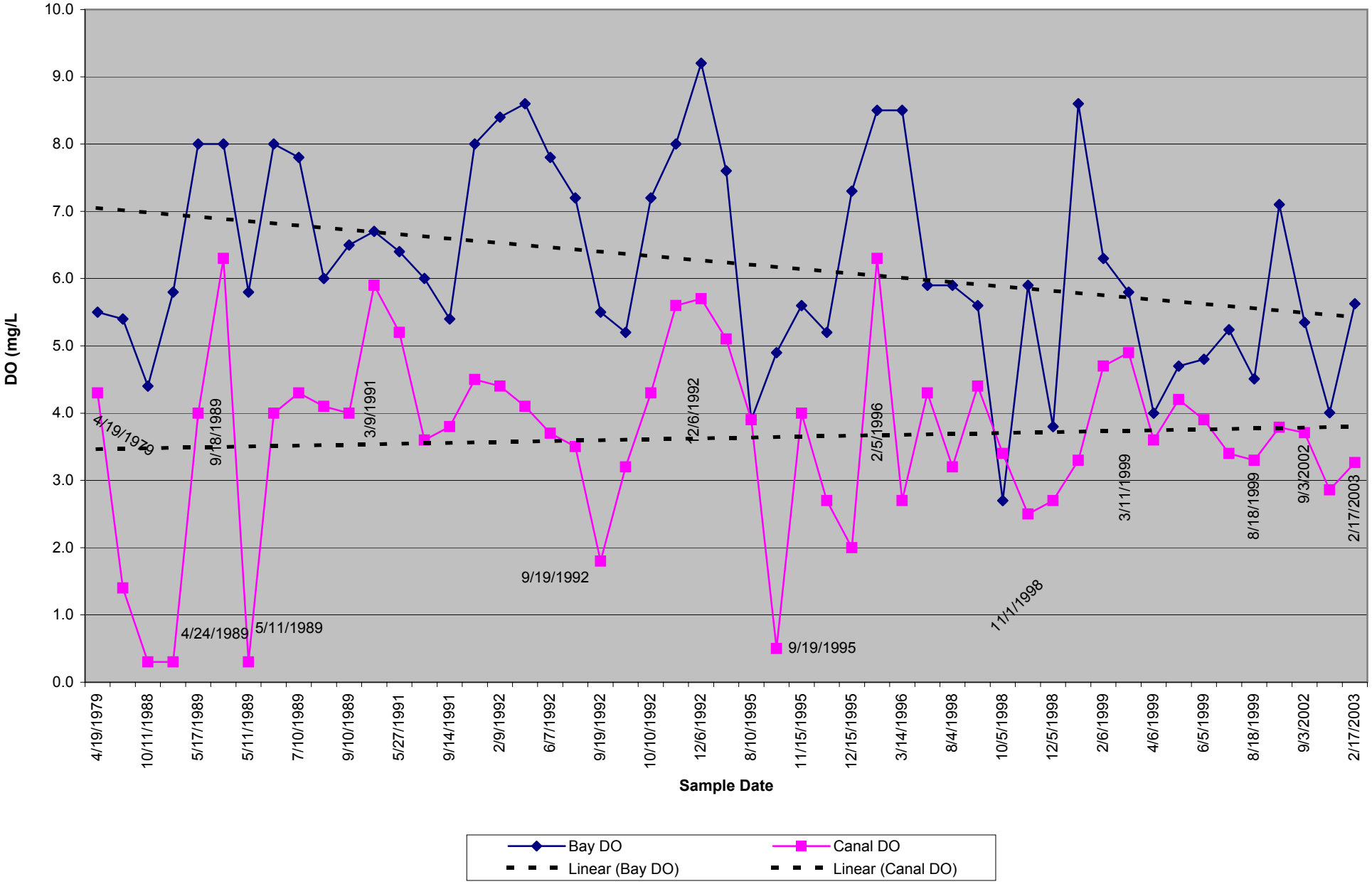
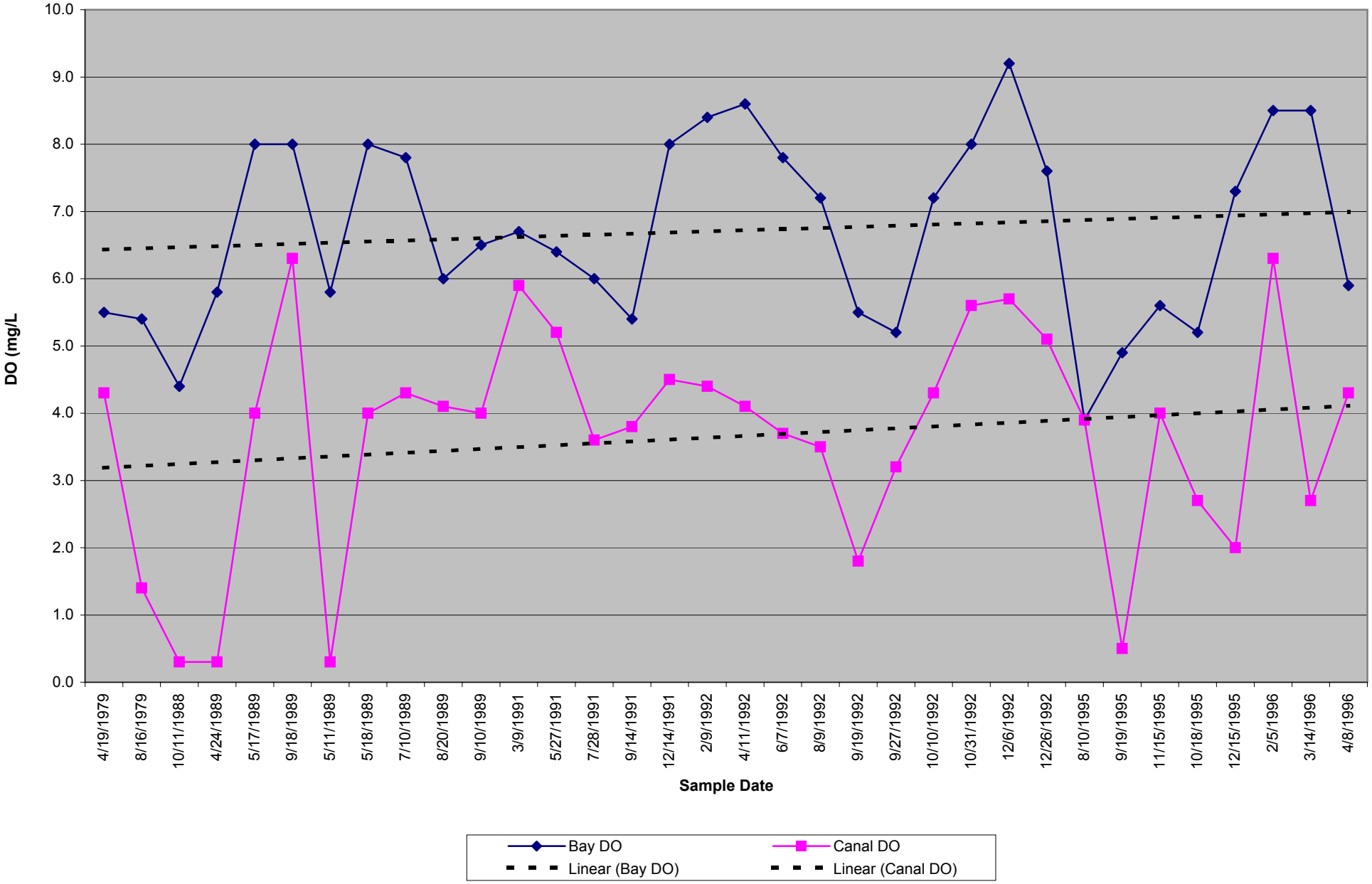
Chart 6B: Bottom DO in Canal vs Bay Prior to Modifications
Sunset Acres Case Study
Monroe County Residential Canal Inventory & Assessment
MACTEC Project No. 40700-1-2681