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Technical Memorandum

Tracking Chlorophyll-*a* and Light Attenuation in Tampa Bay: Application to 2002 Data

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Water quality targets have been adopted by the TBNEP Management and Policy Committees for the four mainstem segments of Tampa Bay. The Tampa Bay Estuary Program has developed a tracking process to determine if water quality targets are being achieved (Janicki et al., 2000). The process to track the status of chlorophyll-*a* concentration and light attenuation involves two steps. The first step utilizes a decision framework to evaluate differences in mean annual ambient conditions from the established targets. The second step incorporates the results of the decision framework into a decision matrix leading to possible outcomes dependent upon the magnitude and duration of the events in excess of the target (Janicki et al., 2000). The objective of this technical memorandum is to compare the annual mean ambient chlorophyll-*a* concentration and light attenuation for 2002 to the segment-specific targets using the tracking process.

The tracking process is used not only to determine if there are differences between ambient conditions and targets, but also to determine the size of the differences and how long the conditions exist. The first step of the tracking process is presented in Figure 1. When mean ambient chlorophyll-*a* concentrations are less than the target, there is no cause for concern, as represented by Outcome 0 in Figure 1. When mean ambient chlorophyll-*a* concentrations are greater than target values, however, the size of the difference and the duration of the difference are considered. Small differences for short time periods result in Outcome 1, while large differences for short time periods and small differences for long time periods result in Outcome 2. In the most severe condition, when large differences exist for long periods, the framework results in Outcome 3.

The second step of the tracking process involves combining the outputs from the decision frameworks for chlorophyll-*a* concentration and light attenuation in a decision matrix to provide direction for management responses when targets are exceeded. The decision framework shown in Figure 1 for chlorophyll-*a* concentration is the same as that for light attenuation.

The decision matrix incorporating the outcomes for chlorophyll-*a* concentration and light attenuation is shown in Table 1. When outcomes for both chlorophyll-*a* concentration and light attenuation are good, as represented by Outcome 0 for both, a condition exists in which targets are being met, and so no management response is required. This condition is signified by the green cell in Table 1.

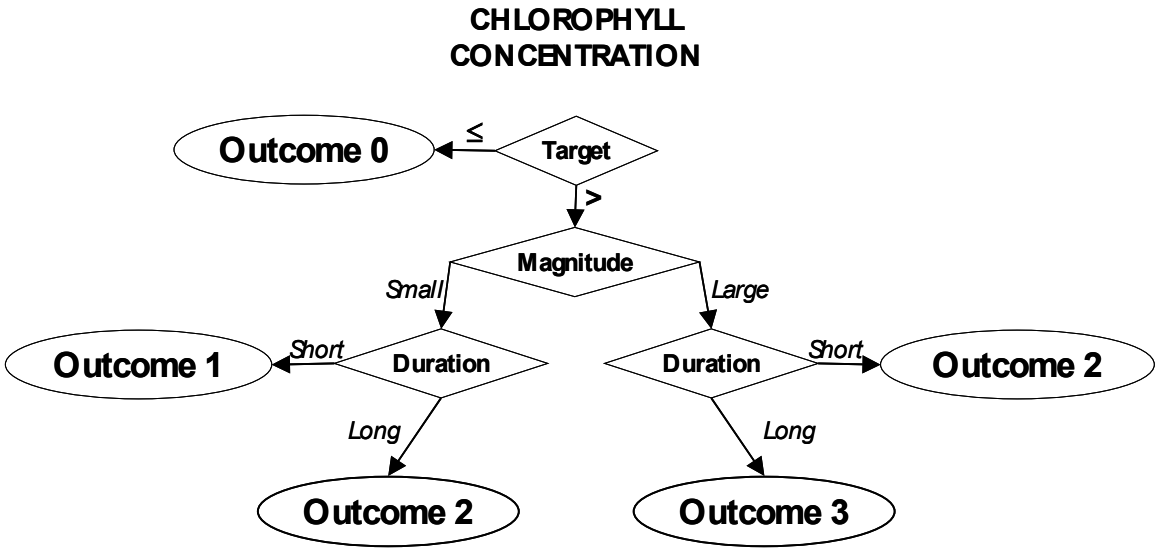

Figure 1. Monitoring and assessment decision framework for chlorophyll-*a* (from Janicki et al., 2000).

When conditions are intermediate, as signified by the yellow cells in Table 1, differences from the targets exist for either or both chlorophyll-*a* concentration and light attenuation. These conditions may result in some type of management response.

When conditions are problematic, such that the outcomes for the parameters fall within the red cells of Table 1, stronger management responses may be warranted. The types of management actions resulting from the decision matrix are classified by color into three categories, shown following Table 1.

Table 1. Decision matrix identifying appropriate categories of management actions in response to various outcomes of the monitoring and assessment of chlorophyll-*a* and light attenuation data.

CHLOROPHYLL ▼	LIGHT ATTENUATION			
	Outcome 0	Outcome 1	Outcome 2	Outcome 3
Outcome 0	GREEN	YELLOW	YELLOW	YELLOW
Outcome 1	YELLOW	YELLOW	YELLOW	RED
Outcome 2	YELLOW	YELLOW	RED	RED
Outcome 3	YELLOW	RED	RED	RED

- **GREEN** "Stay the course"; partners continue with planned projects to implement the CCMP. Data summary and reporting via the Baywide Environmental Monitoring Report and annual assessment and progress reports.

- **YELLOW** TAC and Management Board on caution alert; review monitoring data and loading estimates; attempt to identify causes of target exceedences; TAC report to Management Board on findings and recommended responses if needed.

- **RED** TAC, Management and Policy Boards on alert; review and report by TAC to Management Board on recommended types of responses. Management and Policy Boards take appropriate actions to get the program back on track.

In preparing the 2002 chlorophyll-*a* and light data for evaluation, one data point was noted as questionable and subjected to further examination. In Hillsborough Bay, a very high chlorophyll-*a* value, 261.9 µg/L, was measured near the mouth of the Alafia River at EPCHC Station 8 in September 2002. Mr. Richard Boler of the EPCHC was asked to check this value, and replied that the measurement appeared correct.

To examine the accuracy of this one datum, we compared this high value with other data collected in and around Hillsborough Bay. Examination of chlorophyll-*a* data from all other stations sampled in September 2002 showed the next highest concentration to be 44.0 µg/L, on the western side of Hillsborough Bay at EPCHC Station 44. During August 2002, in the month preceding the very high value, chlorophyll-*a* concentration at Station 8 near the mouth of the Alafia River was 20.6 µg/L, while the October 2002 observation was 15.7 µg/L. Additionally, examination of the data from the most downstream Alafia River EPCHC site, Station 74, showed observed chlorophyll-*a* values of 9.0 in August 2002 and 13.5 in September 2002.

In contrast, monitoring performed by the City of Tampa Bay Study Group showed several locations in Hillsborough Bay with relatively high chlorophyll concentrations in August and September 2002, resulting from dinoflagellate blooms (R. Johansson, pers. comm.). The high value is retained for the decision matrix evaluations provided below.

Inclusion of this high chlorophyll-*a* value from one station in Hillsborough Bay during one month of the year in the estimate of mean annual chlorophyll-*a* concentration for all of Hillsborough Bay increased the mean annual estimate by 2.5 µg/L, from 11.2 µg/L to 13.7 µg/L. Both of these values are below the threshold for small magnitude differences in Hillsborough Bay. As described in Janicki et al. (2000), the threshold in Hillsborough Bay for a small magnitude difference is 14.1 µg/L, greater than the 13.7 µg/L value.

The time series of annual chlorophyll-*a* concentrations and light attenuation for 1974-2002 in Old Tampa Bay, Hillsborough Bay, Middle Tampa Bay, and Lower Tampa Bay are shown in Figures 2 through 9. The mean ambient chlorophyll-*a* concentration and light attenuation for 2002 for each segment are shown in Table 2, along with the segment-specific targets.

Table 2. Mean ambient chlorophyll-*a* concentrations and light attenuation for 2002.

Bay Segment	Chlorophyll-*a* (µg/L)		Light Attenuation (m^{-1})	
	2002	Target	2002	Target
Old Tampa Bay	**7.8**	**8.5**	**0.93**	**0.83**
Hillsborough Bay	**13.7**	**13.2**	**1.18**	**1.58**
Middle Tampa Bay	**6.6**	**7.4**	**0.74**	**0.83**
Lower Tampa Bay	**3.8**	**4.6**	**0.61**	**0.63**

Applying the decision frameworks for chlorophyll-*a* concentration and light attenuation as shown in Figure 1, the outcomes for the 2002 data were:

Bay Segment	Chlorophyll-a Concentration	Light Attenuation
Old Tampa Bay	**0**	**2**
Hillsborough Bay	**0**	**0**
Middle Tampa Bay	**0**	**0**
Lower Tampa Bay	**0**	**0**

Placing these outcomes in the decision matrix shown in Table 1 leads to the following results:

Old Tampa Bay: **Yellow**
Hillsborough Bay: **Green**
Middle Tampa Bay: **Green**
Lower Tampa Bay: **Green**

The "Yellow" result for Old Tampa Bay follows from the short duration (2001-2002) of high magnitude differences between the observed light attenuation values and the target value, as shown in Figure 6. Figure 8 shows that in Middle Tampa Bay, the 2002 mean annual light attenuation was below the target, in contrast to the large magnitude long duration differences in light attenuation found prior to 2001.

To place the 2002 decision matrix results in perspective with results from previous years, the decision matrix results for 1975-2002 are shown below in Table 3. The "Yellow" matrix results for Old Tampa Bay follows from the outcome of the light attenuation decision framework.

Table 3. Decision matrix results.

Year	Old Tampa Bay	Hillsborough Bay	Middle Tampa Bay	Lower Tampa Bay
1975	Red	Red	Red	Green
1976	Red	Red	Red	Yellow
1977	Red	Red	Red	Red
1978	Red	Red	Red	Yellow
1979	Red	Red	Red	Red
1980	Red	Red	Red	Red
1981	Red	Red	Red	Red
1982	Red	Red	Red	Red
1983	Red	Yellow	Red	Red
1984	Red	Green	Red	Yellow
1985	Red	Red	Red	Yellow
1986	Red	Yellow	Red	Green
1987	Red	Yellow	Red	Green
1988	Yellow	Green	Yellow	Green
1989	Red	Yellow	Red	Yellow
1990	Red	Green	Red	Yellow
1991	Green	Yellow	Yellow	Yellow
1992	Yellow	Green	Yellow	Yellow
1993	Yellow	Green	Yellow	Yellow
1994	Yellow	Yellow	Red	Red
1995	Red	Yellow	Red	Yellow
1996	Yellow	Green	Yellow	Green
1997	Yellow	Green	Red	Yellow
1998	Red	Red	Red	Red
1999	Yellow	Green	Yellow	Yellow
2000	Green	Green	Yellow	Yellow
2001	Yellow	Green	Yellow	Yellow
2002	Yellow	Green	Green	Green

In conclusion, 2002 is the first year of the period of record in which three of the four mainstem bay segments were classified in the "Green" category. Only the light attenuation in Old Tampa Bay resulted in this segment falling into the "Yellow" category, as chlorophyll in Old Tampa Bay was less than the target. Water quality constituents other than chlorophyll may be adversely affecting the light field in this segment. We recommend evaluation of other constituents as potentially important in affecting light attenuation in Old Tampa Bay, and in Tampa Bay in general. The 2002 data also provided an anomalous data value for consideration, although inclusion of the data value did not affect the matrix results. We recommend that an objective approach be developed for dealing with potential outliers in the future.

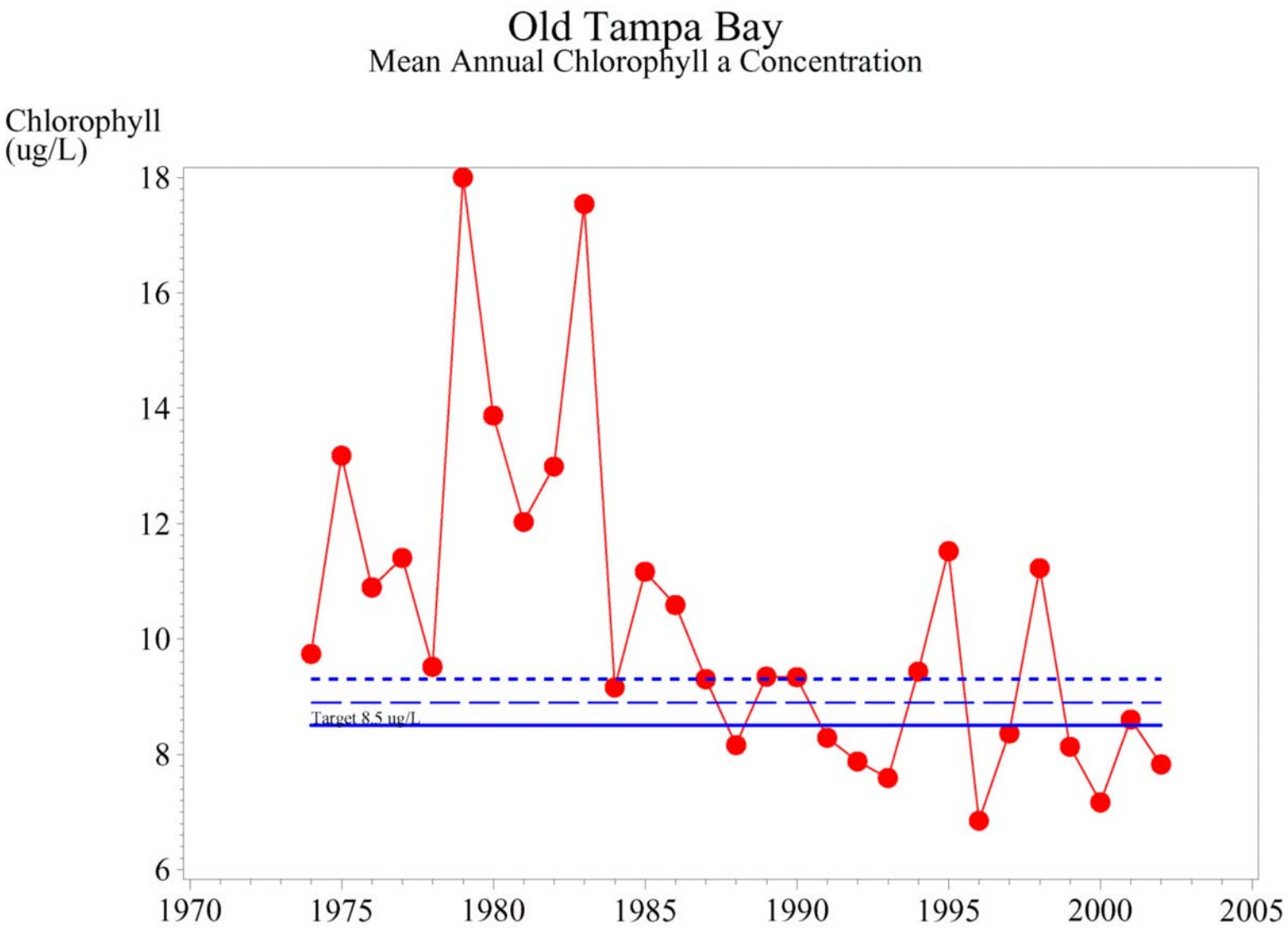

Figure 2. Old Tampa Bay mean annual chlorophyll-*a* concentrations, with target (solid line), small magnitude difference threshold (long dashed line), and large magnitude difference threshold (short dashed line).

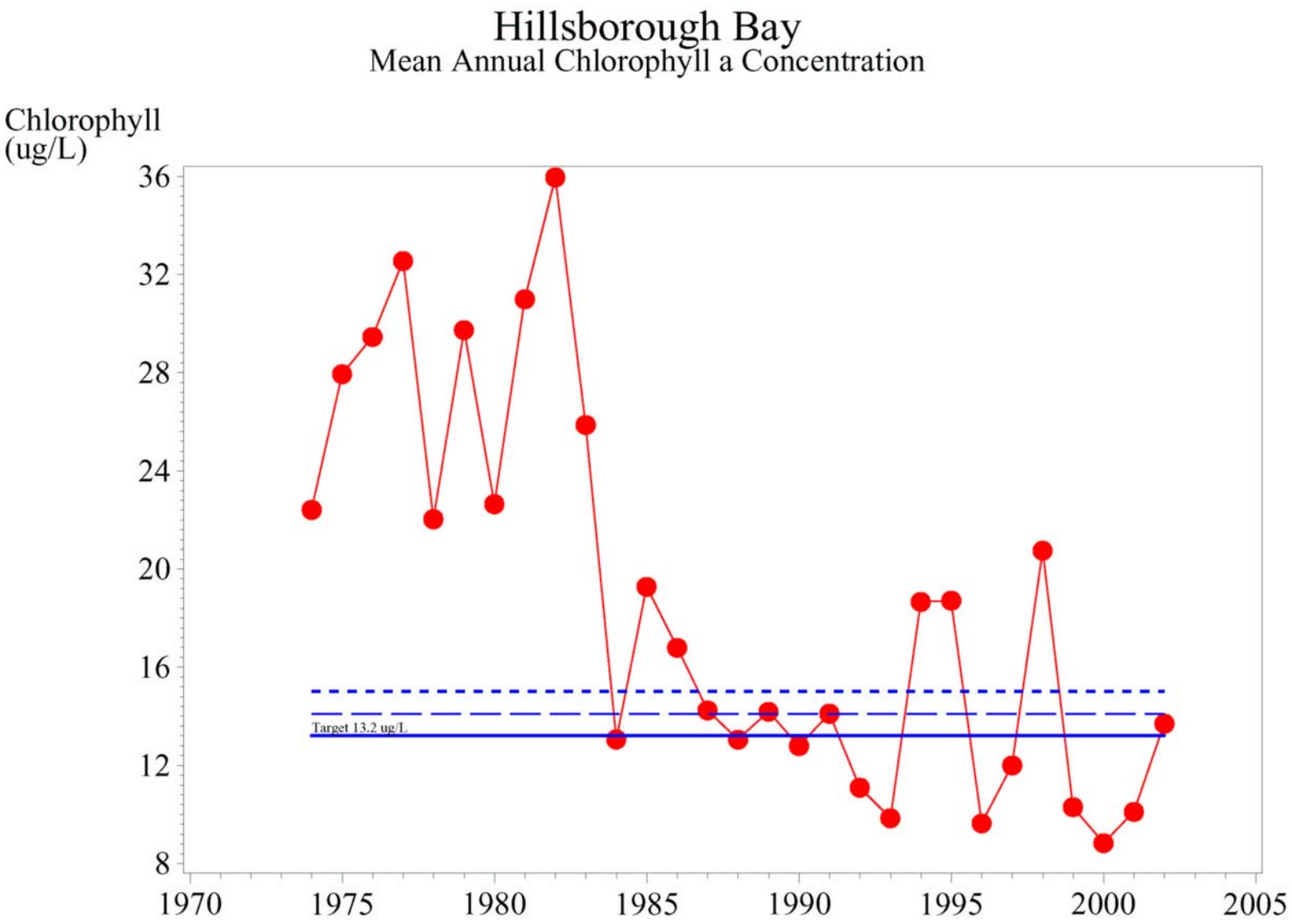

Figure 3. Hillsborough Bay mean annual chlorophyll-*a* concentrations, with target (solid line), small magnitude difference threshold (long dashed line), and large magnitude difference threshold (short dashed line). Data from EPCHC Station 8 for September 2002 are included.

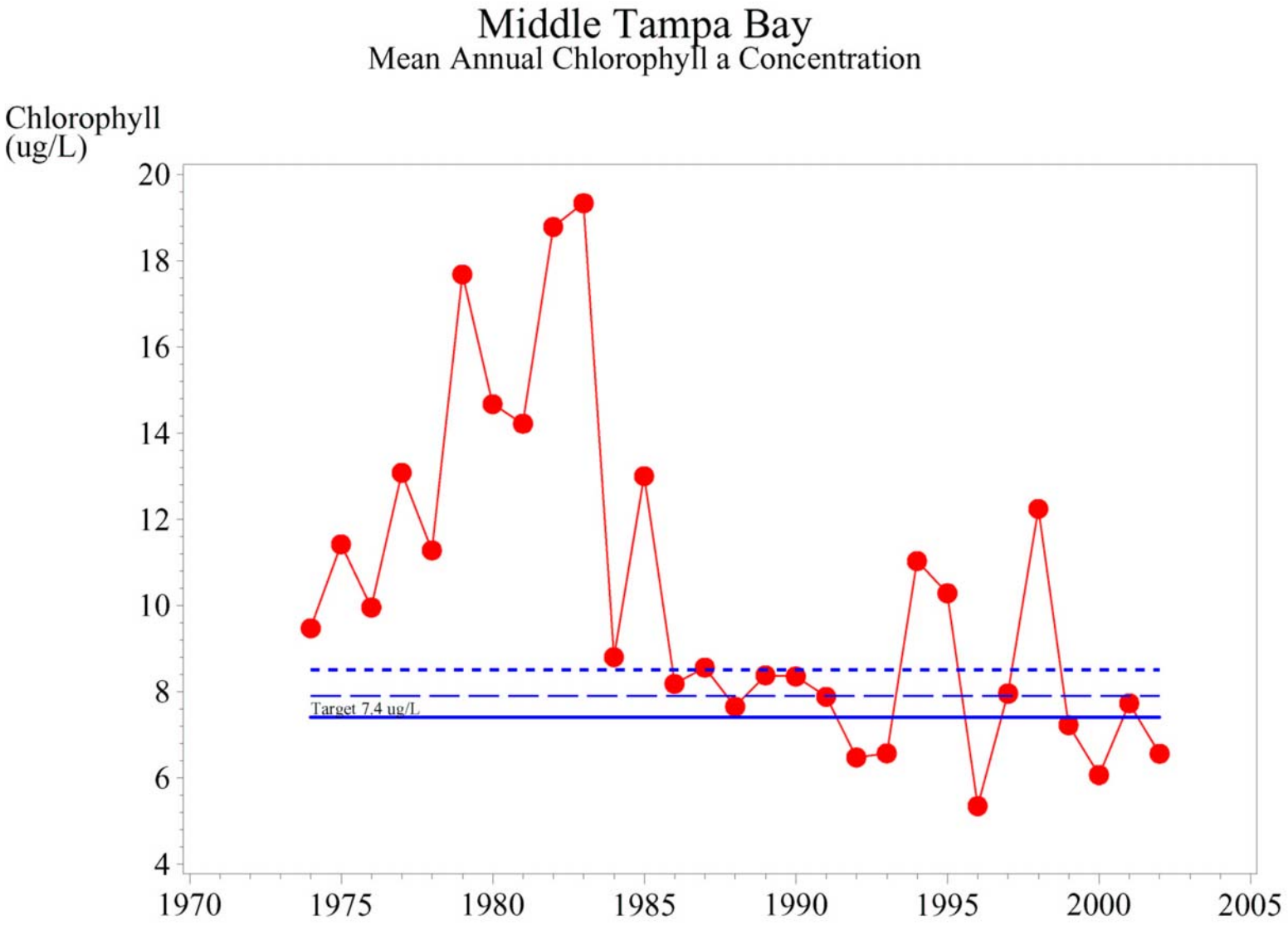

Figure 4. Middle Tampa Bay mean annual chlorophyll-*a* concentrations, with target (solid line), small magnitude difference threshold (long dashed line), and large magnitude difference threshold (short dashed line).

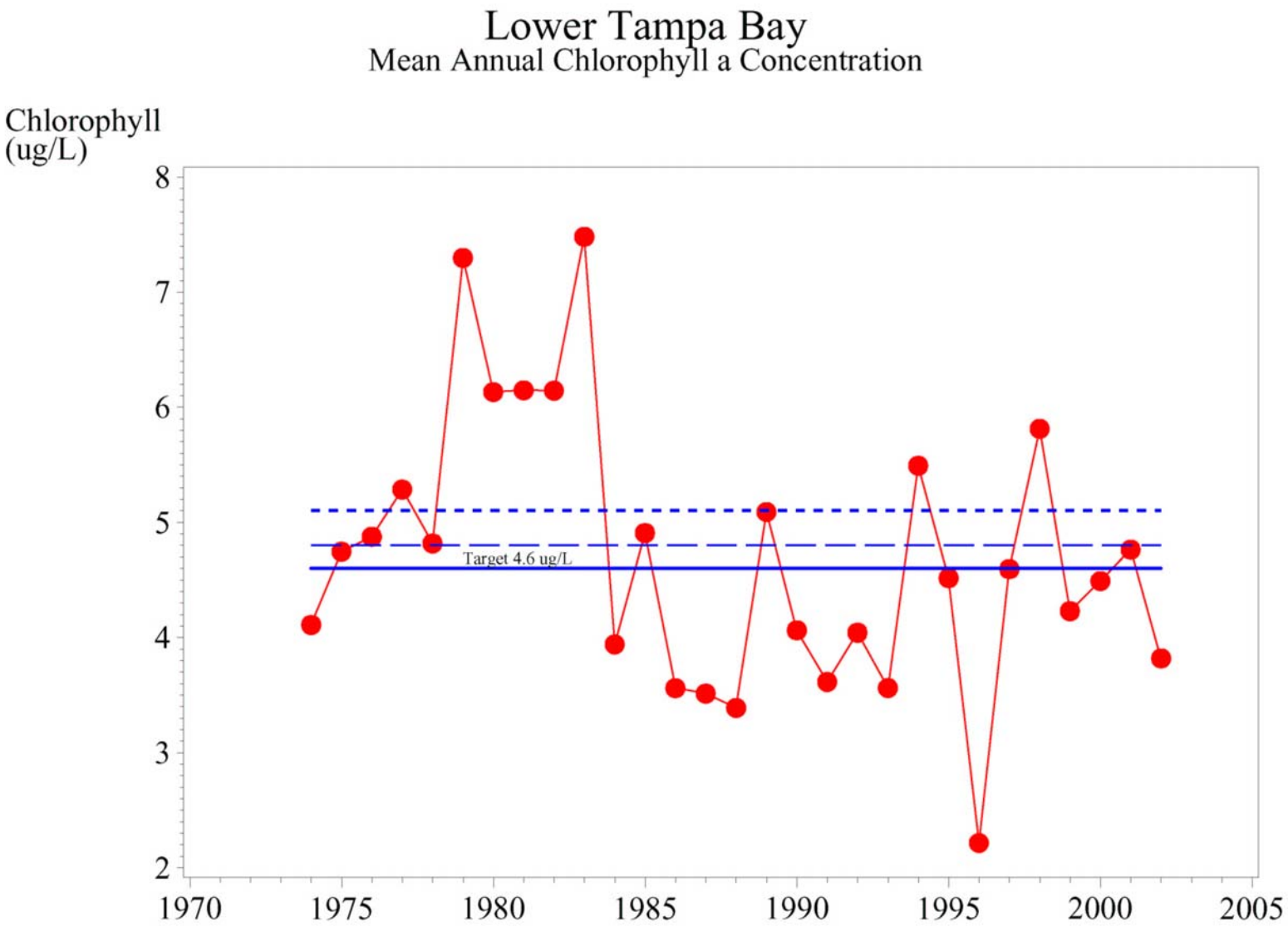

Figure 5. Lower Tampa Bay mean annual chlorophyll-*a* concentrations, with target (solid line), small magnitude difference threshold (long dashed line), and large magnitude difference threshold (short dashed line).

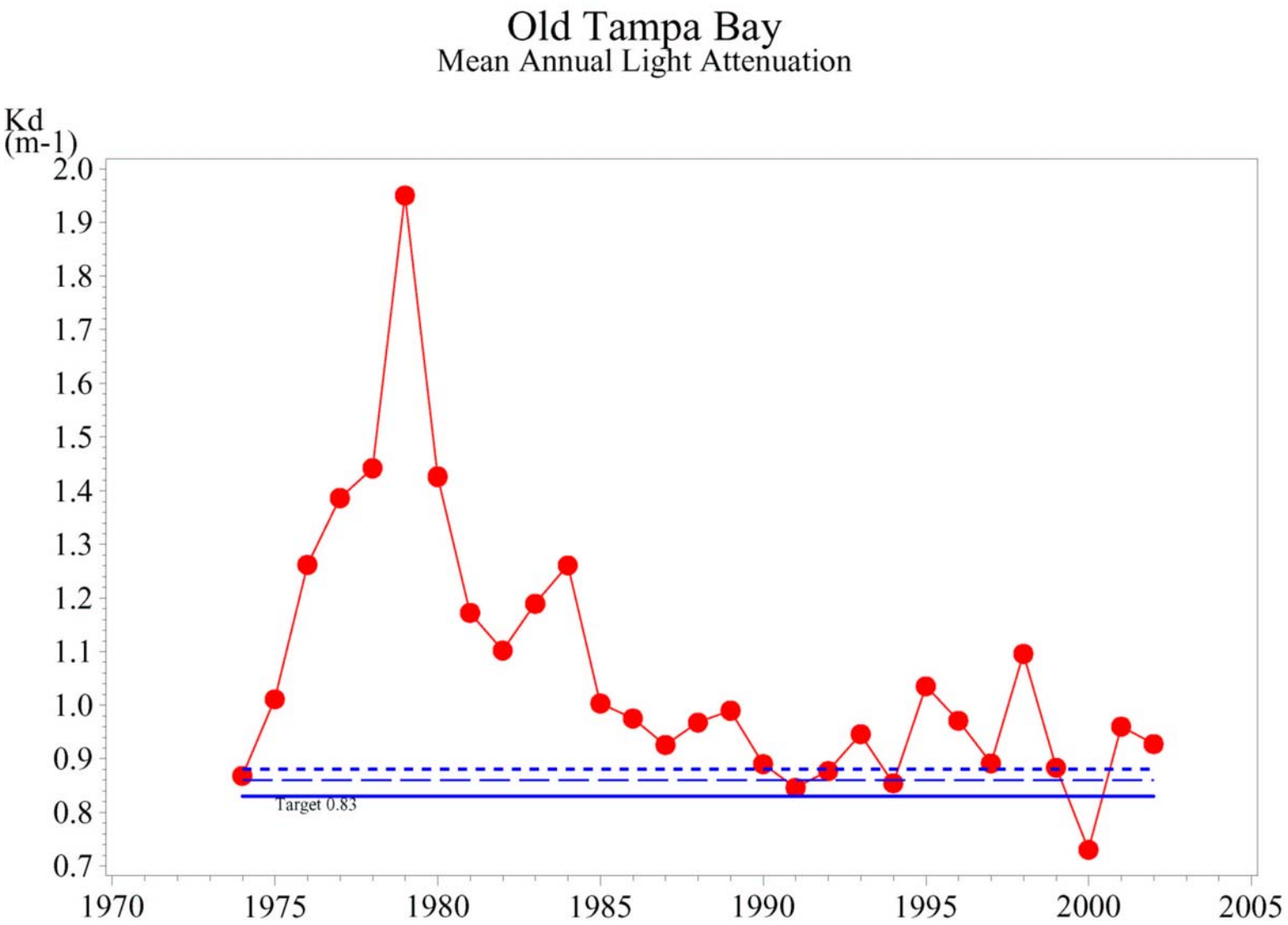

Figure 6. Old Tampa Bay mean annual light attenuation, with target (solid line), small magnitude difference threshold (long dashed line), and large magnitude difference threshold (short dashed line).

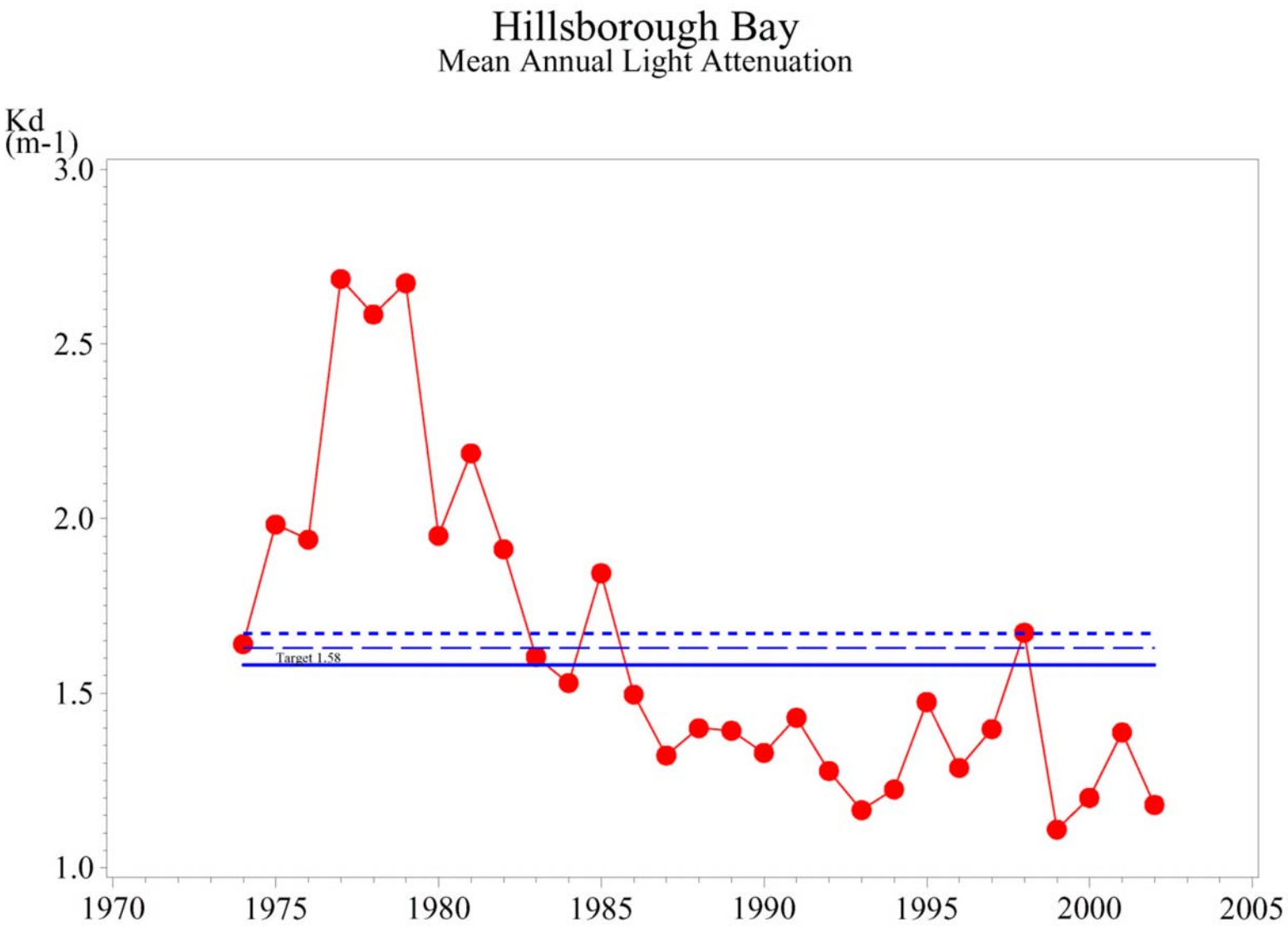

Figure 7. Hillsborough Bay mean annual light attenuation, with target (solid line), small magnitude difference threshold (long dashed line), and large magnitude difference threshold (short dashed line).

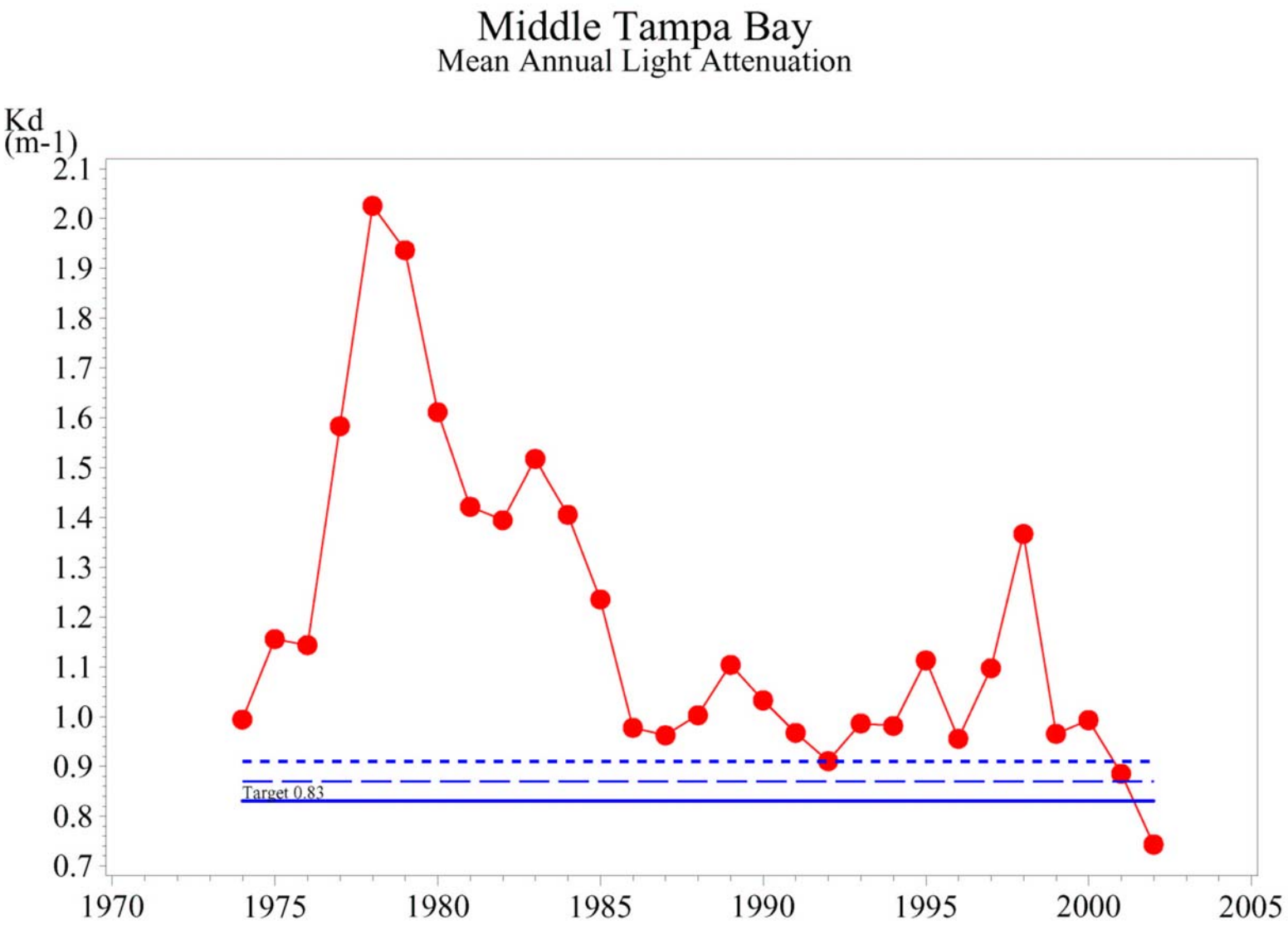

Figure 8. Middle Tampa Bay mean annual light attenuation, with target (solid line), small magnitude difference threshold (long dashed line), and large magnitude difference threshold (short dashed line).

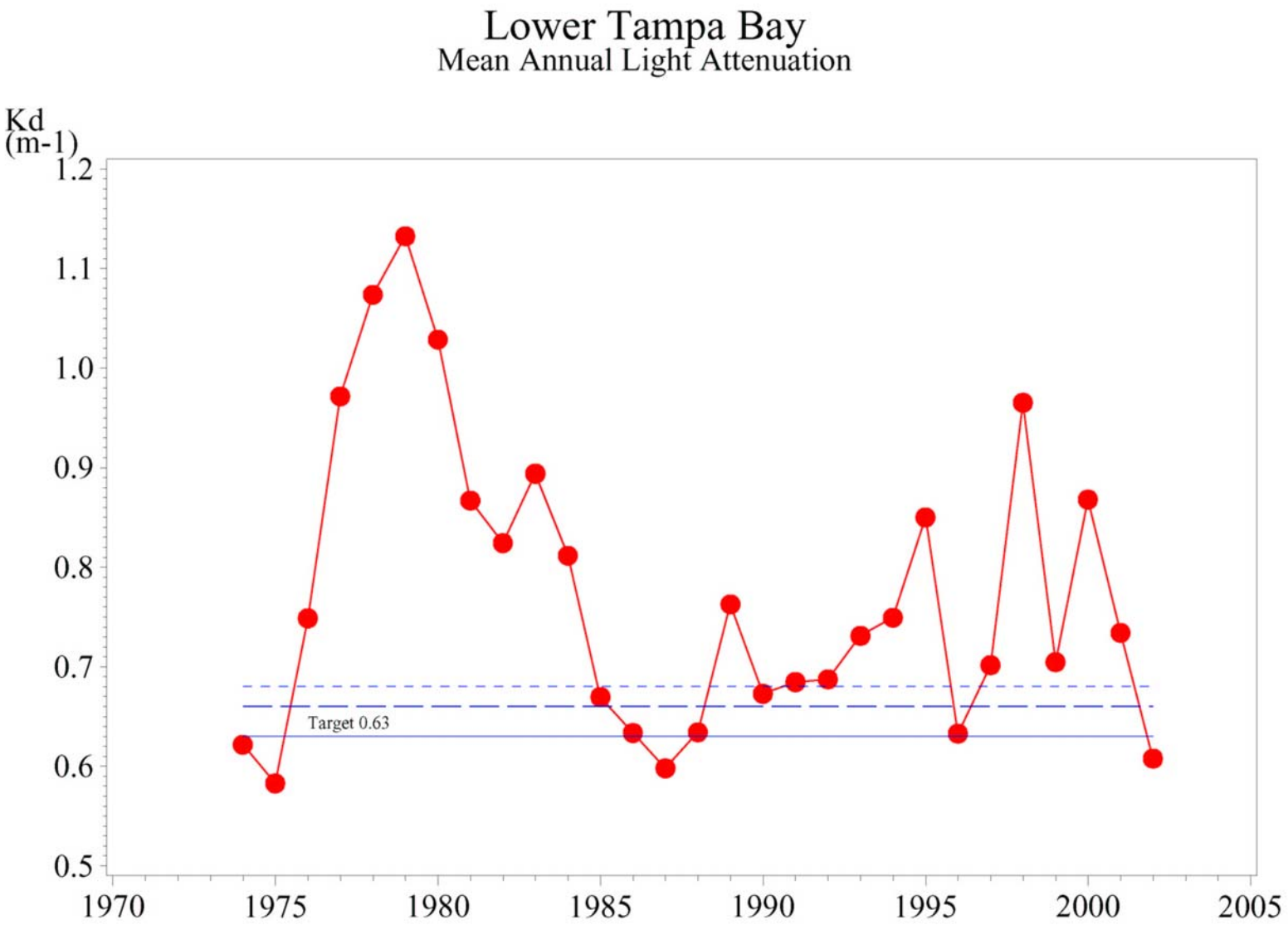

Figure 9. Lower Tampa Bay mean annual light attenuation, with target (solid line), small magnitude difference threshold (long dashed line), and large magnitude difference threshold (short dashed line).

References

Janicki, A.J., D. Wade, and J.R. Pribble. 2000. Establishing a process for tracking chlorophyll-*a* concentrations and light attenuation in Tampa Bay. Prepared for: Tampa Bay Estuary Program. Prepared by: Janicki Environmental, Inc.