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GRINDSTONE CREEK WATER CLARITY - SOURCES AND EFFECTS

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SOURCES AND EFFECTS

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MANAGEMENT PERSPECTIVE

The Grindstone Creek delta has been identified in the Hamilton Harbour RAP as an important area in the Harbour for fish habitat. Efforts to promote fish habitat have concentrated on increasing submergent aquatic plant abundance in the delta and have been given high priority in the RAP exercise. Aquatic plant abundance is presently limited by poor water clarity in the delta.

A spatial survey of water clarity in Grindstone Creek has identified that the sources of high turbidity in the delta are predominately the resuspension of silt in the ponds just upstream from the delta and to a lesser extent high chlorophyll concentrations. Water clarity was poorest during May and June despite an eight-week drought during that time period. The source of the high turbidity during the drought is postulated to be the spawning activity of carp. Upstream Secchi disc depths were consistently greater than 1 m whereas the downstream ponds had a seasonal mean Secchi depth of only 28 cm. The poor water clarity is predicted to limit aquatic plants to only 4 ha and improvements in silt or chlorophyll concentrations could increase plant distribution to 25 ha.

PERSPECTIVE-GESTION

On a désigné, dans le Plan de mesures correctives du port de Hamilton, le delta du ruisseau Grindstone comme étant une zone du port importante pour l'habitat du poisson. Les efforts pour favoriser l'habitat du poisson, qui sont hautement prioritaires dans le Plan, portent principalement sur l'augmentation de la quantité de plantes aquatiques partiellement submergées dans le delta. L'abondance des plantes aquatiques est actuellement limitée par la faible transparence de l'eau dans le delta.

Des mesures de la transparence de l'eau le long du ruisseau Grindstone ont révélé que les principaux facteurs responsables de la turbidité élevée de l'eau dans le delta sont la remise en suspension du limon dans les étangs situés juste en amont du delta et, dans une moindre mesure, les concentrations élevées de chlorophylle. Les plus faibles transparences de l'eau ont été enregistrées en mai et en juin, malgré une sécheresse de huit semaines qui a sévi durant cette période. On suppose que la turbidité élevée durant la sécheresse est due au frai des carpes. En amont, les transparences au disque de Secchi étaient, de manière constante, supérieures à 1 m, tandis que la moyenne saisonnière de la transparence des étangs situés en aval n'était que de 28 cm. On prévoit que la faible transparence de l'eau limitera la distribution des plantes aquatiques à seulement 4 ha et qu'une diminution des concentrations de limon ou de chlorophylle pourrait porter la distribution des plantes à 25 ha.

ABSTRACT

A spatial survey of water clarity in Grindstone Creek has identified that the sources of high turbidity in the delta are predominately the resuspension of silt in the ponds just upstream from the delta and to a lesser extent high chlorophyll concentrations. Water clarity was poorest during May and June despite an eight-week drought during that time period. Upstream Secchi disc depths were consistently greater than 1 m whereas the downstream ponds had a seasonal mean Secchi depth of only 28 cm. The poor water clarity is predicted to limit aquatic plants to only 4 ha and improvements in silt or chlorophyll concentrations could increase plant distribution to 25 ha.

RÉSUMÉ

Des mesures de la transparence de l'eau le long du ruisseau Grindstone ont révélé que les principaux facteurs responsables de la turbidité élevée dans le delta sont la remise en suspension du limon dans les étangs situés juste en amont du delta et, dans une moindre mesure, les concentrations élevées de chlorophylle. Les plus faibles transparences de l'eau ont été enregistrées en mai et en juin, malgré une sécheresse de huit semaines qui a sévi durant cette période. En amont, les transparences au disque de Secchi étaient, de manière constante, supérieures à 1 m, tandis que la moyenne saisonnière de la transparence des étangs situés en aval n'était que de 28 cm. On prévoit que la faible transparence de l'eau limitera la distribution des plantes aquatiques à seulement 4 ha et qu'une diminution des concentrations de limon ou de chlorophylle pourrait porter la distribution des plantes à 25 ha.

INTRODUCTION

The Grindstone Creek delta is one of the more turbid areas in Hamilton Harbour. The high water turbidity restricts aquatic plant growth and hence impairs the use of the shallow delta as fish habitat in Hamilton Harbour. The 1988 report on Hamilton Harbour water clarity (Painter and McCabe, 1988) estimated that a small improvement in water clarity at the mouth of the delta could dramatically increase the distribution of submergent vegetation from an estimated 4 ha to almost 45 ha.

From April to November 1988, Grindstone Creek was sampled at selected locations to determine the sources responsible for the high turbidity. Two possible sources of turbidity are the phosphorus loading from the Waterdown Sewage Treatment Plant (STP) resulting in algal growth, and watershed erosion from agriculture or urban construction resulting in high seston concentrations.

METHODS

Water samples were collected weekly at eight locations, 29 times between April 12 and November 25, 1988. Additional data collected during 1988 by the Ministry of the Environment at Hidden Valley supplemented our data. Parameters measured during the study include Secchi disc transparency, seston, mineral and chlorophyll. Figures 1 and 2 illustrate the area of study and the sampling locations as well as the Waterdown STP and relevant landmarks. The sampling locations were chosen to elucidate the factors responsible for the spatial variability in water clarity.

At each sampling location, Secchi disc transparency and vertical extinction coefficients were measured. The vertical extinction coefficients were determined with a Biospherical Instrument Profiling Quantum Scalar Irradiance system with quantum response in the range of 400 to 700 nm. The downwelling irradiance was measured at 10 cm intervals.

Composite water samples for Chlorophyll a analyses were collected through a depth equal to twice the Secchi disc transparency to approximate the depth of the euphotic zone. Aliquots (0.2-1.0L) were filtered through GF/F glass-fibre filters (Whatman Co.), frozen, and analyzed later using the methods employed by the Water Quality Branch, Environment Canada (see Environment Canada, 1979). The calculated chlorophyll concentration uncorrected for phaeophytin was used to assess the relative contribution of algae to the Secchi disc transparency because it takes into account that living as well as dead or decaying algal cells contribute to the water clarity. Seston and mineral concentrations were measured by filtering known volumes of water through Whatman GF/C filter papers. The mineral content was determined by muffling the total seston at 550°C for two hours.

RESULTS

An eight-week drought was experienced during the 1988 sampling period from mid-May to mid-July. Consequently, erosion of soil from the watershed during this period would be virtually non-existent and indeed, all the minor tributaries of the Creek were observed to be dry during this period. The occurrence of the drought was unfortunate in that the contribution of erosion would be underestimated using the 1988 observations. But the drought also provided an excellent opportunity to observe the water clarity in the absence of erosion from the watershed.

Hidden Valley experienced low seston concentrations and good water clarity throughout the sampling period (Figures 3 & 4). The peaks occurring in the April, May and October seston concentrations coincided with significant precipitation events. Seston, mineral and chlorophyll concentrations were low, averaging 7.6 mg/L, 5.1 mg/L and 11 μg/L, respectively (Figures 7, 8, and 11). The seston was approximately 61% mineral and fluctuations in both were closely related (Figure 3).

The good water clarity persisted as far downstream as Hendrie Valley, which is located just above the slow moving portion of the stream. Seston, mineral, percent mineral and chlorophyll were similar to Hidden Valley suggesting that no new inputs or processes have occurred between the two locations to affect water clarity. Chlorophyll concentrations were low at the two upstream stations because phytoplankton populations do not tend to develop in riffle streams which is the condition of the Creek at and above these two locations.

Immediately downstream of Hendrie Valley, the channel has widened and deepened, the creek banks are protected by extensive cattail stands and water velocity has reduced considerably. At Station 9, the station downstream from the cattail marshes, water clarity was poorer than the upstream sites. Seston was low from April to mid-May, peaked in late May and June, and declined gradually thereafter (Figure 5). The May to June peak in seston concentrations occurred during the drought, suggesting that watershed erosion was not the source of turbidity. Secchi disc transparency followed the oscillations of seston and mineral concentrations, and to some extent, chlorophyll. Chlorophyll concentrations were higher at Station 9 compared to Hidden Valley and Hendrie Valley (Figure 6). Mineral concentrations averaged 25 mg/L, five times that found upstream (Figure 8). Throughout the season at Station 9, the seston was predominantly mineral (76%), suggesting that the majority of the seston was silt (Figure 10).

For all parameters measured, a consistent spatial pattern is recognizable (Figures 7 to 12). Both Hidden Valley and Hendrie Valley had low concentrations of seston, mineral and chlorophyll. Secchi disc transparency at these stations was slightly greater than 1.0 m. At Station 9 an observable decline in water clarity is apparent, with Secchi disc transparency practically half the upstream reading. An even more pronounced decline in water clarity is seen at Station 8, the dock, and Station 7. Secchi disc transparencies at these stations were approximately 25% of that found at Hendrie Valley. The water clarity began to recover at Stations 6 and 5, with average Secchi disc transparencies of 53 and 70 cm, respectively (Figure 9).

Seston, mineral and chlorophyll concentrations followed the same pattern as Secchi disc transparency with respect to water clarity. From Station 9 to Sunfish Pond seston and mineral double and chlorophyll increases five-fold. As you move out into the delta, water clarity improves as seston, mineral and chlorophyll decrease. The percent mineral composition of the seston in the delta also decreases (Figure 10), suggesting that silt is settling out of the water column in this area.

Both chlorophyll and mineral contribute to the Secchi disc transparency, however which of the two is most influential remains unclear. To determine the relative importance of chlorophyll and mineral, the following equation, derived from Bannister (1974) can be used:

$$\% \text{ chlorophyll contribution} = \frac{k_c*[chl]}{k_c*[chl] + k_m*[min]}$$

where: k_c = phytoplankton extinction coefficient
k_m = mineral extinction coefficient
[chl] = chlorophyll concentration (µg/L)
[min] = mineral concentration (mg/L)

A regression analysis of Secchi disc transparency, chlorophyll, and mineral provided a statistically significant relationship (r^2=0.86). The regression coefficients from the equation were used to determine the relative contribution of mineral and chlorophyll (Figures 13 and 14). Mineral is the dominating factor responsible for decreased water clarity in the Creek. The chlorophyll contribution is lowest at Station 9 which was where the first increases in seston were observed. As the turbid water moves down the Creek into Sunfish Pond, chlorophyll concentration increases and the contribution to water turbidity also increases. Within the delta, sedimentation occurs and the mineral concentration decreases two-thirds. The chlorophyll concentration also decreases but only by one-half. The combined effect of the two reductions of different magnitudes decreases the contribution of mineral and increases the contribution of chlorophyll to water turbidity.

Evidently, siltation of the Delta, Elbow, and Sunfish Pond is extremely important, for it is this cache of suspended solids and its subsequent resuspension that is so drastically affecting water clarity. Resuspension of the accumulated sediment is occurring in the Creek just downstream of Hendrie Valley and continues through Sunfish Pond. More than likely the cause of resuspension is the carp utilizing the creek in these silted areas. Both feeding and spawning activities of carp could contribute significantly to resuspension. Clearly the seston is not originating on a daily basis along the creek upstream of Hendrie Valley, nor at the Waterdown STP. The May and June peak seston concentrations at Station 9 occurred during the peak spawning period for carp.

The Grindstone Creek delta has been identified as an important area for possible fish habitat (COA, 1988). Painter and McCabe (1988) illustrated the relationship between submergent vegetation response to changes in Secchi disc transparency at the mouth of the delta (Figure 15). The summer average Secchi disc transparency of 28 cm at the outflow of Sunfish Pond would limit aquatic plants to 4 ha according to the depth of colonization/light relationship reported by Chambers and Kalff (1985). A small increase in Secchi disc transparency will dramatically increase aquatic plant habitat. For instance, a 5 cm increase in Secchi disc transparency will increase the area available for plant cover to approximately 25 ha. The analysis suggests a maximum achievable area of 45 ha available for colonization at a 45 cm Secchi disc transparency at the outflow from Sunfish Pond.

In order for Secchi disc transparency to increase to the point where aquatic plant cover is significant, a reduction in either chlorophyll or mineral is necessary. As mentioned earlier, mineral was determined to be the dominant factor influencing water clarity. Assuming that chlorophyll concentrations will not decrease due to the nutrient loading supplied by the Waterdown STP, the regression equation can be used to predict the mineral concentration necessary to achieve the desired water clarity. An increase in aquatic plant colonization to 25 ha requires a reduction in the mineral concentration of 5 mg/L from the present concentration of 37 mg/L. To achieve 45 ha of habitat the mineral concentration would have to be reduced by half. Hence, a small change in mineral concentration could significantly affect aquatic plant cover but for complete vegetation coverage in the delta a major reduction in silt concentrations would be required.

One could also assume that reducing resuspension of sediments will not be successful and that the only way of improving water clarity in the delta is through chlorophyll reductions via STP phosphorus loading reductions. Water clarity is insensitive to chlorophyll changes in the Elbow and Sunfish Pond due to the high mineral concentrations in the water column. In the delta, a reduction of chlorophyll concentrations to 25 μg/L from the present 50 μg/L would improve water clarity by approximately 5 cm. As mentioned earlier, this 5 cm improvement could result in 25 ha of vegetation. Reductions in chlorophyll concentrations below 25 μg/L in the delta are unlikely given the natural inputs of nutrients from the watershed and the fact that the western portion of Hamilton Harbour had a mean chlorophyll concentration of 25 μg/L in 1988 and 1989. Therefore, reasonable reductions in either mineral or chlorophyll could expand aquatic vegetation in the delta from 4 to 25 ha, but to achieve further increases in habitat, reductions in both mineral and chlorophyll will be necessary.

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COA. 1988. Goals, problems and options, a discussion document. Hamilton Harbour Remedial Action Plan.

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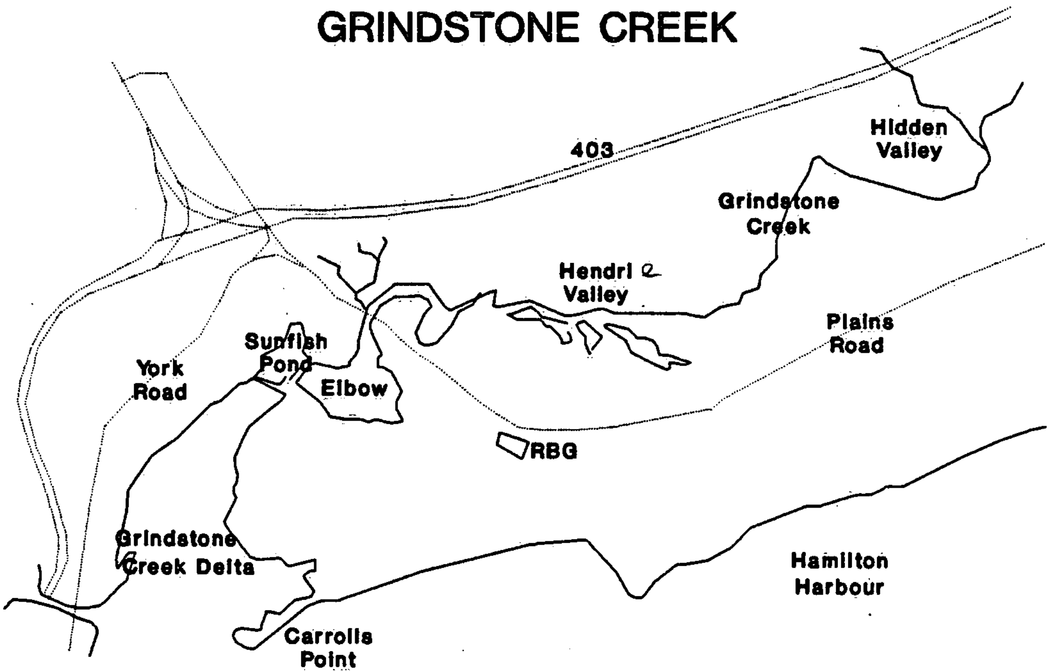
Figure 1. Grindstone Creek Watershed Relevant Landmarks
Figure 2. Grindstone Creek Station Locations

GRINDSTONE CREEK



Grindstone Creek Station Locations

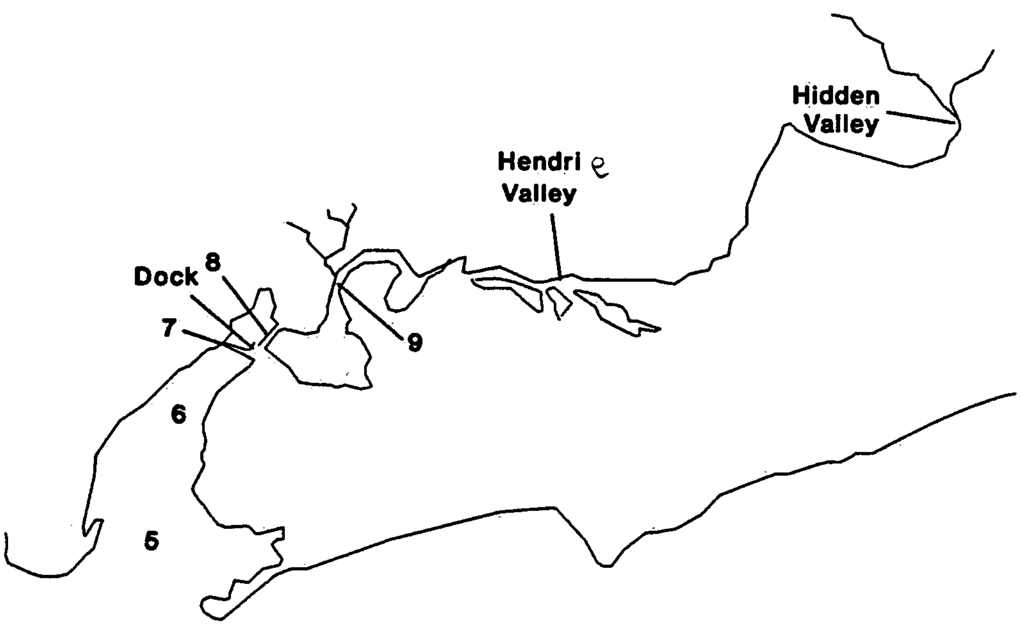
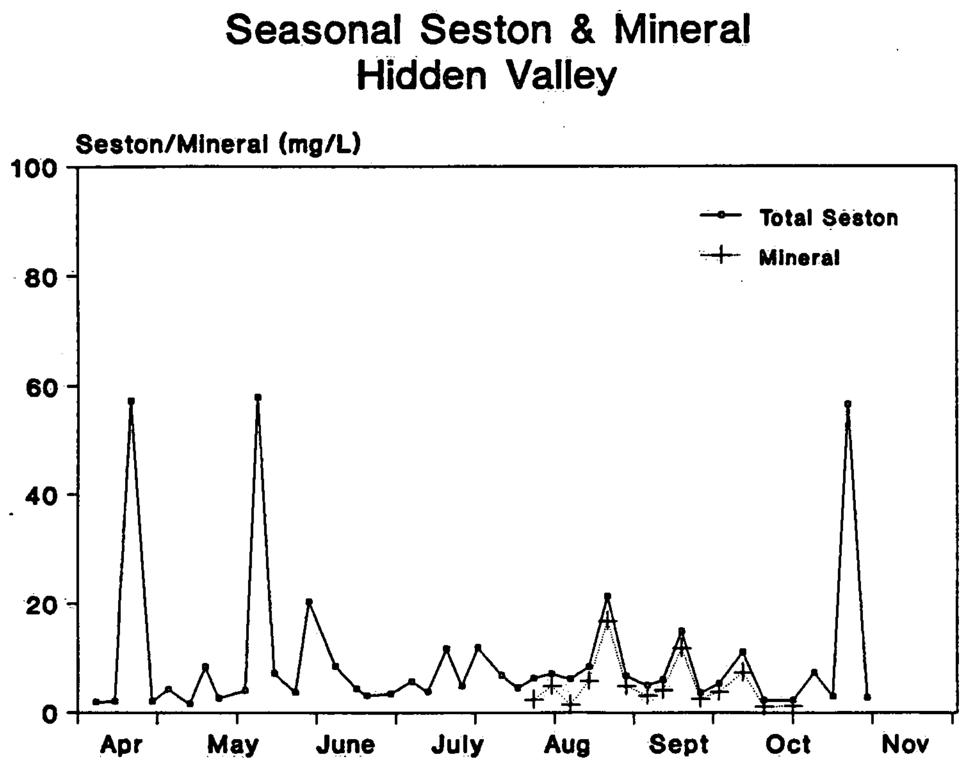


Figure 3. Hidden Valley Seasonal Seston and Mineral
Figure 4. Hidden Valley Seasonal Secchi and Chlorophyll


Seasonal Seston & Mineral
Hidden Valley
Seston/Mineral (mg/L)
100
80
60
40
20
0
Total Seston
Mineral
Apr
May
June
July
Aug
Sept
Oct
Nov

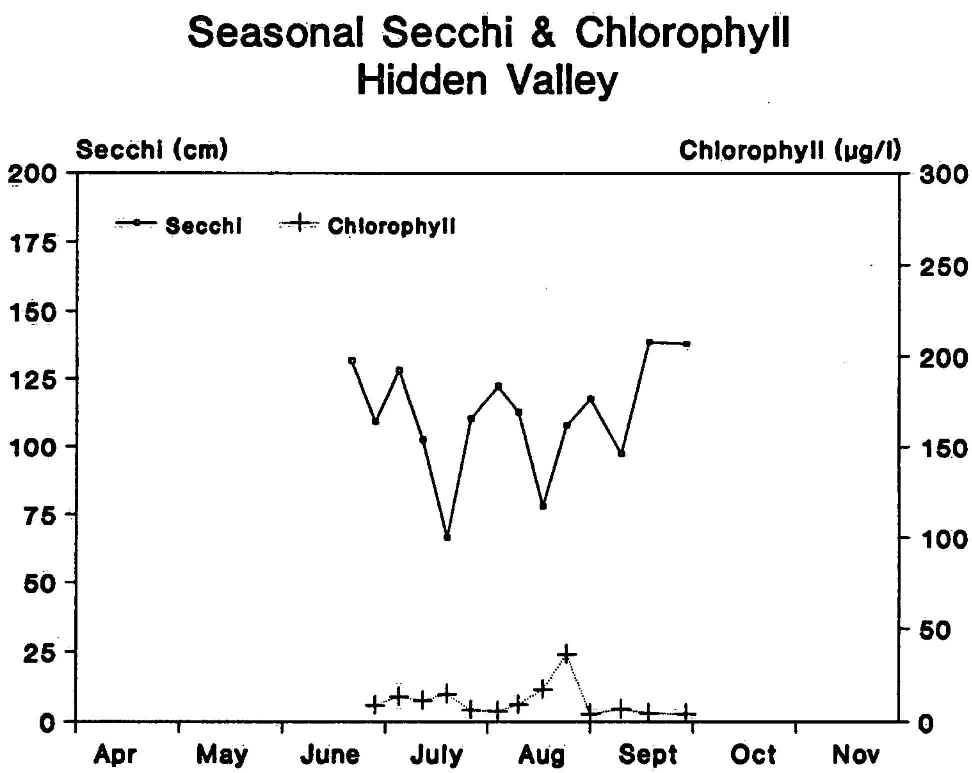
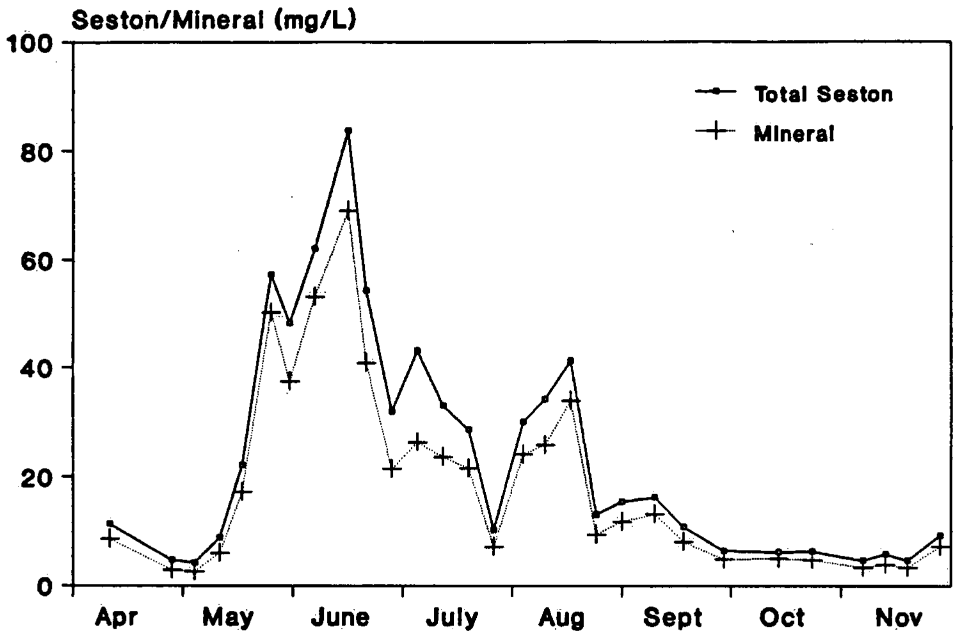

Seasonal Secchi & Chlorophyll
Hidden Valley
Secchi (cm)
Chlorophyll (µg/l)
200
175
150
125
100
75
50
25
0
300
250
200
150
100
50
0
Secchi
Chlorophyll
Apr
May
June
July
Aug
Sept
Oct
Nov

Figure 5. Station 9 Seasonal Seston and Mineral
Figure 6. Station 9 Seasonal Secchi and Chlorophyll

Seasonal Seston & Mineral
Station 9



Seasonal Secchi & Chlorophyll
Station 9

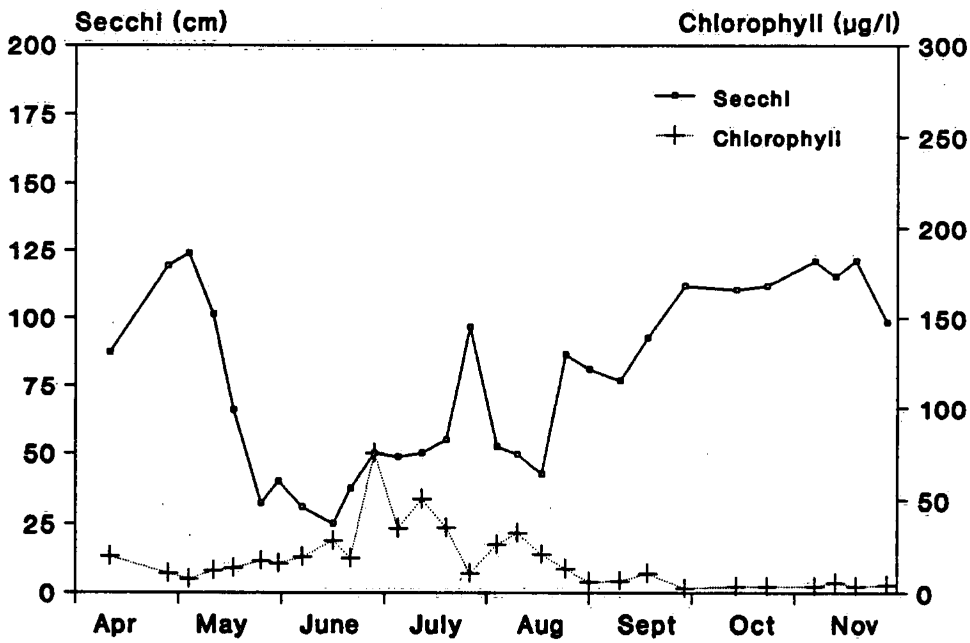
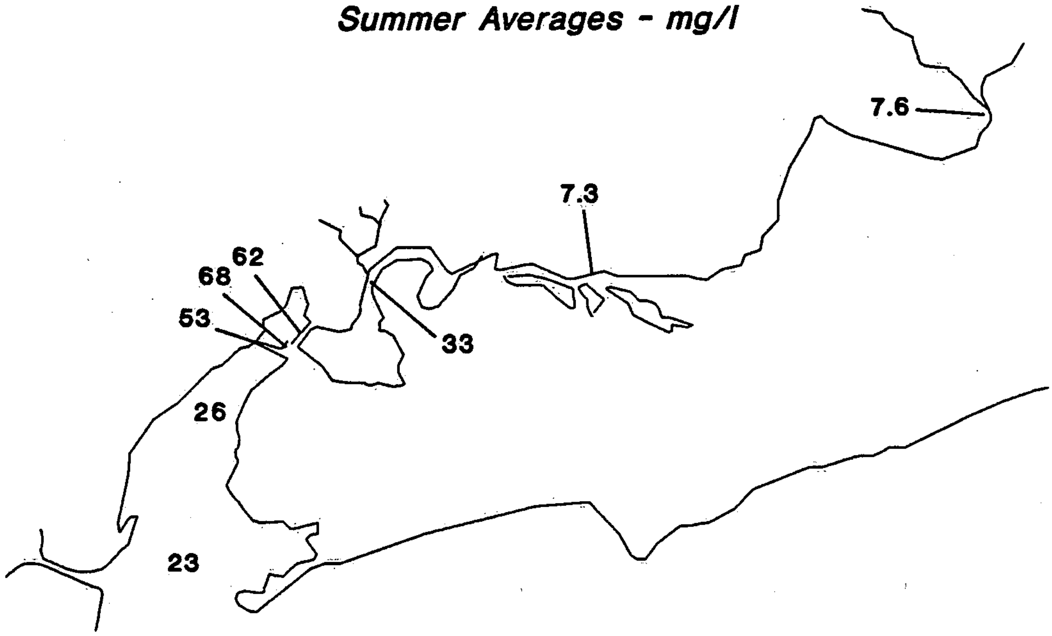


Figure 7. Spatial Map of Grindstone Creek Total Seston
Figure 8. Spatial Map of Grindstone Creek Mineral

Grindstone Creek Total Seston

Summer Averages - mg/l



Grindstone Creek Mineral Concentration

Summer Average - mg/l

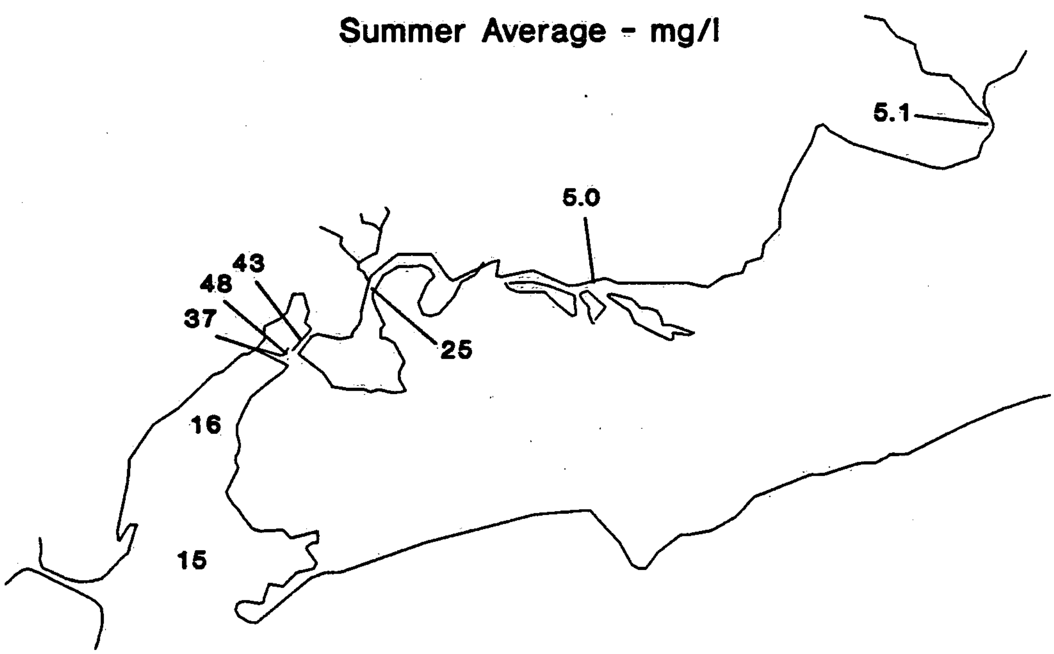
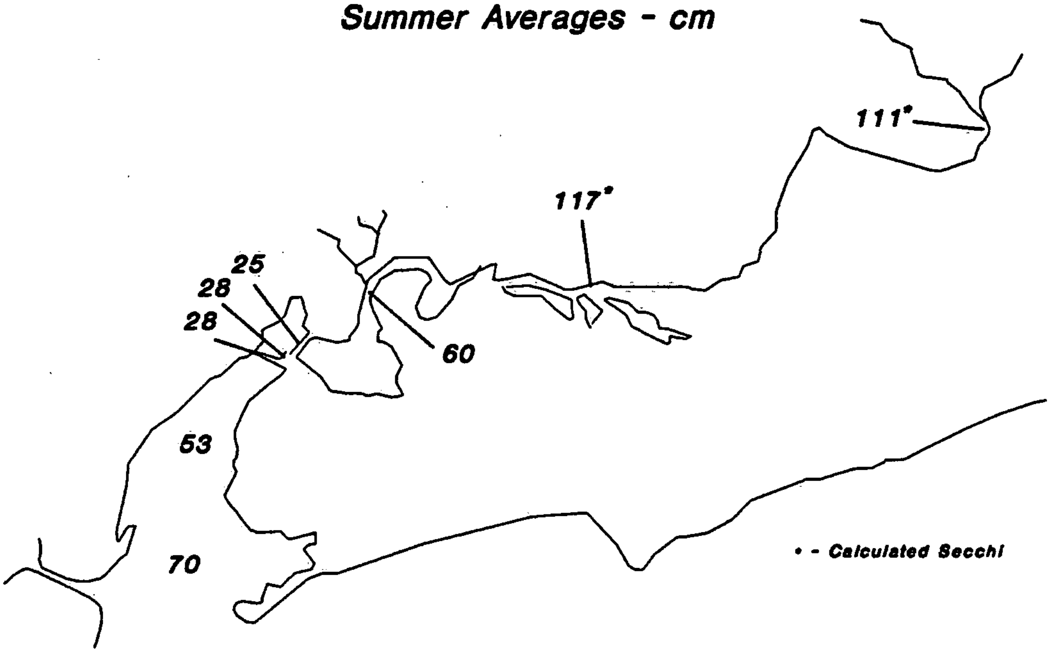


Figure 9. Spatial Map of Grindstone Creek Secchi Disc Transparency
Figure 10. Spatial Map of Grindstone Creek Percent Mineral

Grindstone Creek Secchi Disc Transparency

Summer Averages - cm



Grindstone Creek Percent Mineral

Summer Averages - %

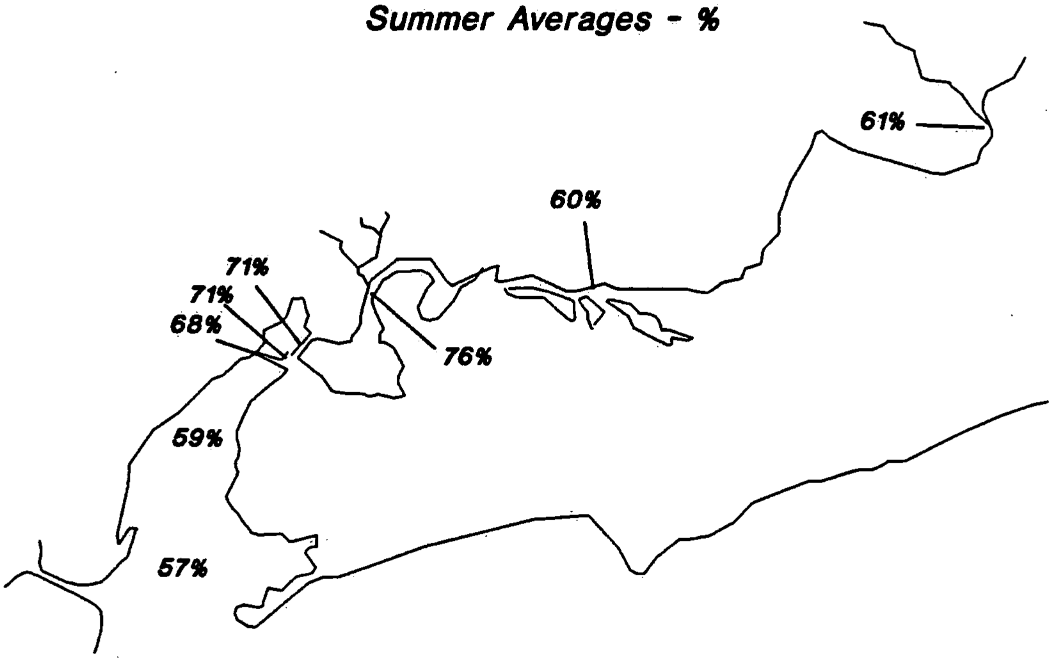
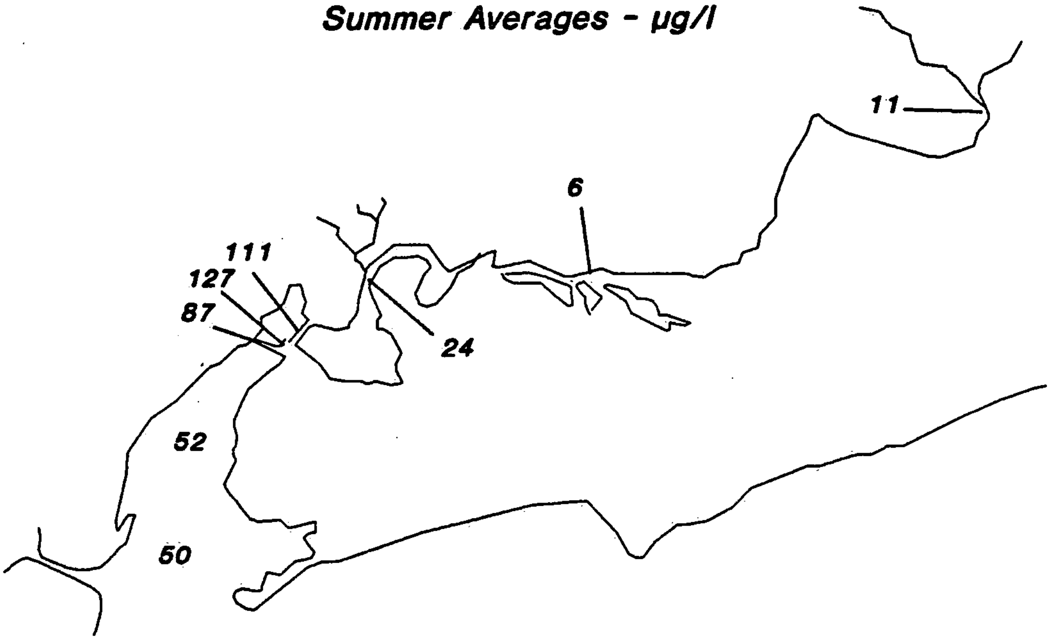


Figure 11. Spatial Map of Grindstone Creek Uncorrected Chlorophyll
Figure 12. Spatial Map of Grindstone Creek Corrected Chlorophyll

Grindstone Creek Uncorrected Chlorophyll

Summer Averages - µg/l



Grindstone Creek Corrected Chlorophyll

Summer Averages - µg/l

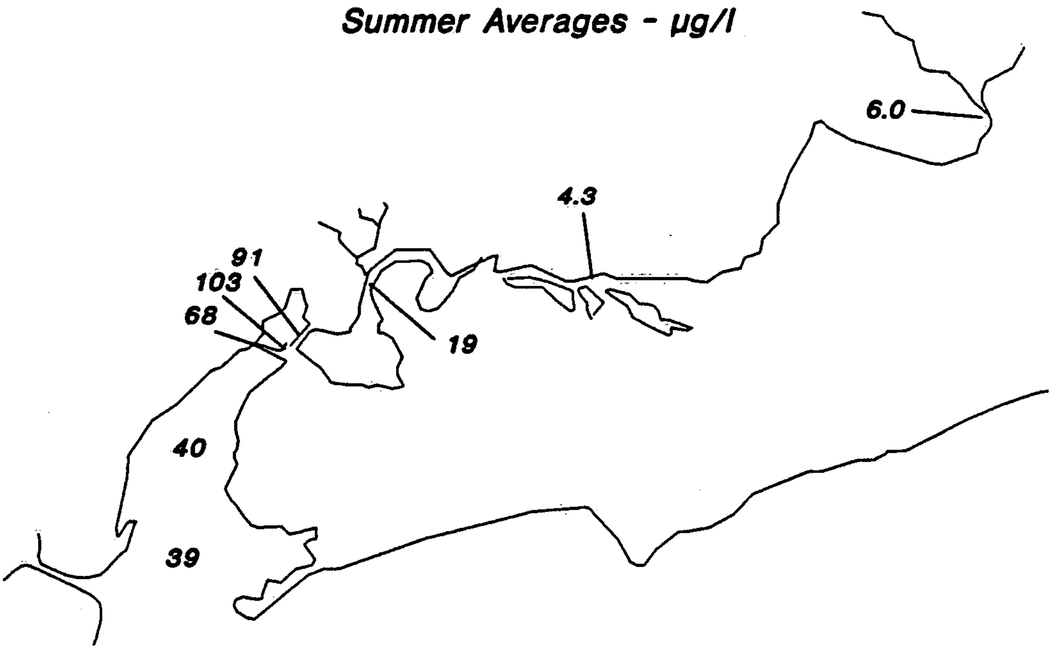
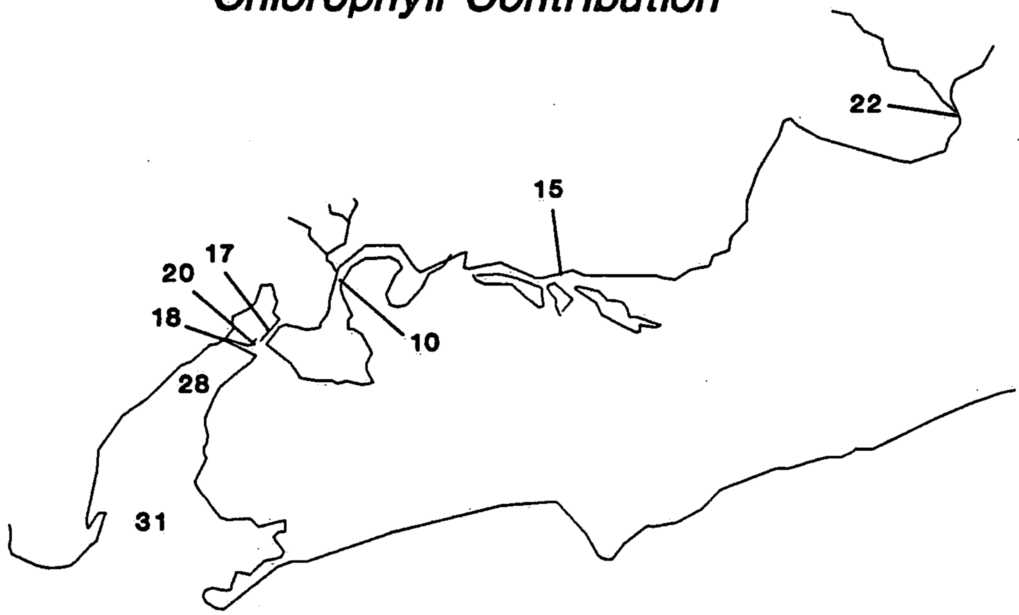


Figure 13. Grindstone Creek Chlorophyll Contribution
Figure 14. Grindstone Creek Mineral Contribution

Grindstone Creek Summer Chlorophyll Contribution



Grindstone Creek Summer Mineral Contribution

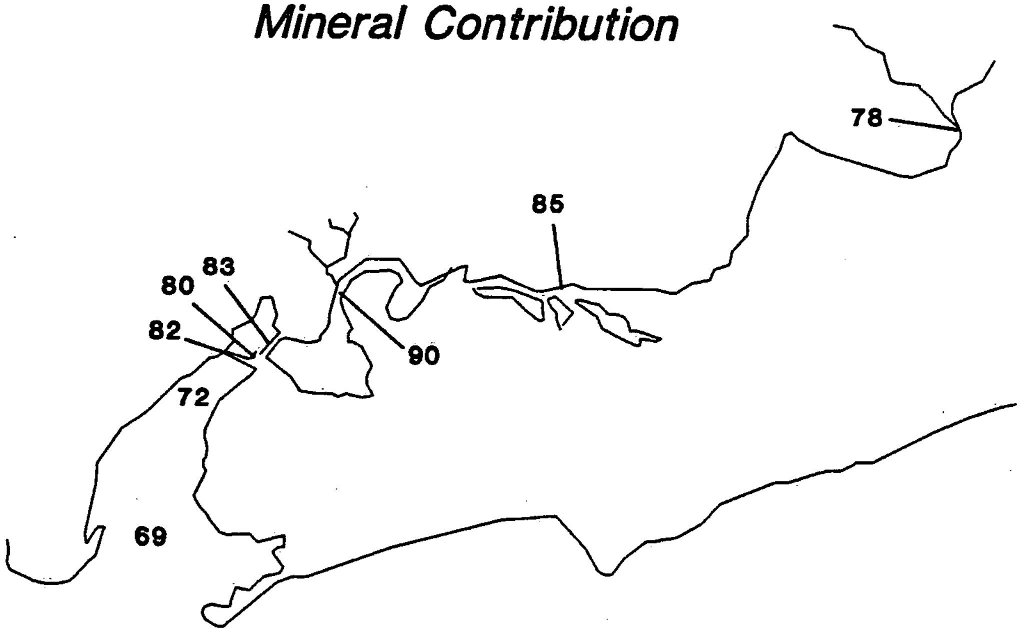
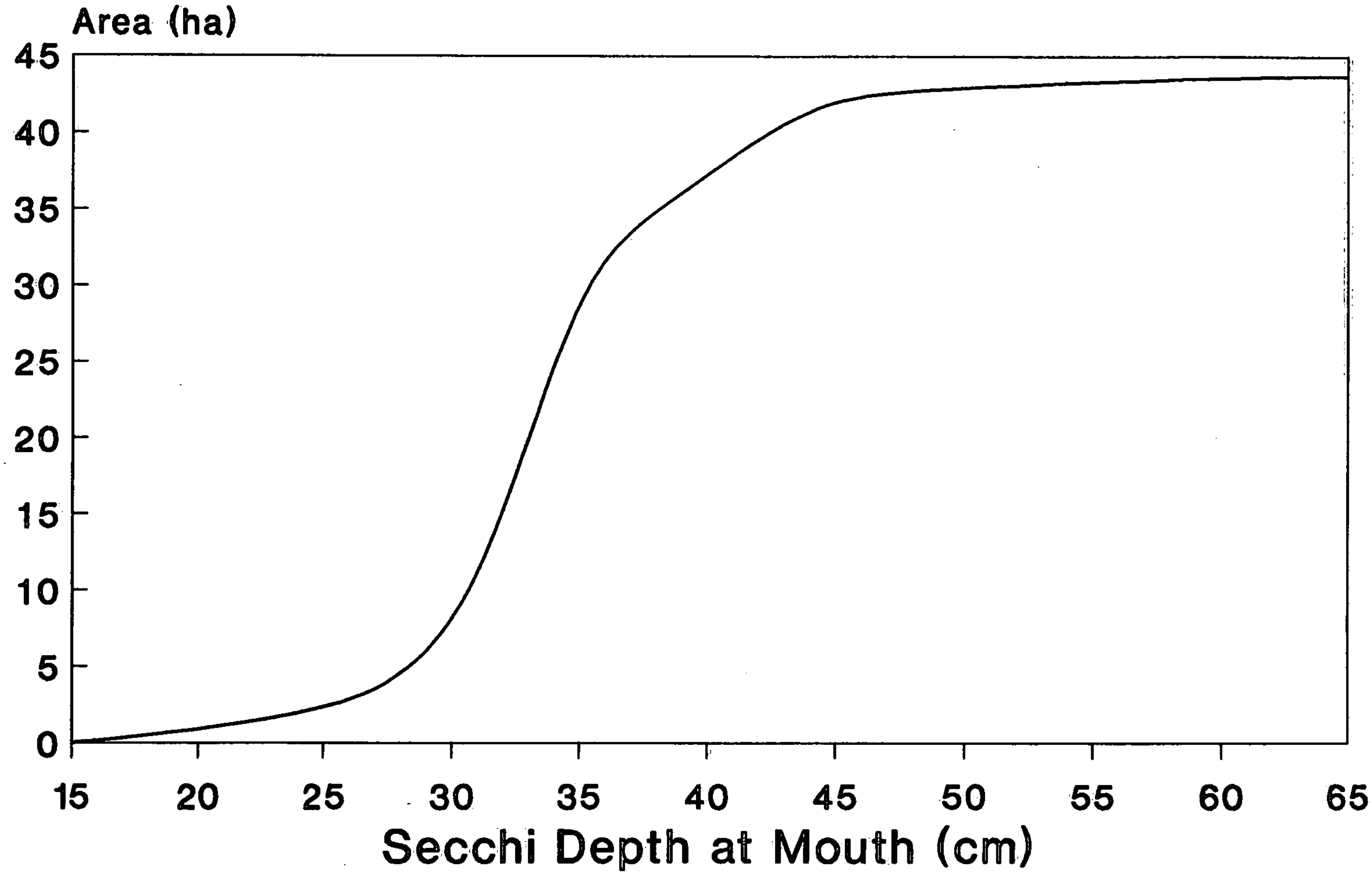


Figure 15. Predicted Aquatic Plant Response to Changes in Water Secchi Depth

Grindstone Creek Aquatic Plant Response to Water Secchi Depth



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