EXECUTIVE SUMMARY

BACKGROUND

The increasing awareness of the need to protect the quality of South Africa's water resources from degradation, has resulted in a growing awareness of the need to also control non-point pollution. Legislation controlling non-point pollution may affect the forestry industry and their management of catchment water resources.

This project was undertaken to analyse and synthesise inorganic streamwater quality data collected over 16 years in afforested montane catchment areas in South Africa. The aim of this analysis was to develop rule models or guidelines which the forestry industry could apply in a cost-effective way to monitor impacts of management activities on water quality. This entailed identifying the most important water quality variables, and also where and how to sample to obtain reliable data.

OBJECTIVES

The aims of the project as they were described in the original proposal are as follows:

(a) To investigate the importance of specific water quality variables as indicators of impacts of forestry management practices, by conducting an intensive analysis of stream water quality data currently in place on the Forestek database.

(b) To determine possible correlations between stream water quality variables which would indicate if some variables can be used as indicators for others. The Forestek database will be used in corroboration with internationally published data. The water quality variables include: suspended sediment, pH, conductivity, Na^+, K^+, Ca^{2+}, Mg^{2+}, NH_4^+, Cl^-, SO_4^{2-}, NO_3^-, PO_4^{3-}, HCO_3^-, TP (total phosphate), KN (Kjeldahl/total nitrogen), Si and F.

(c) To provide two rule-based models or sets of guidelines for the forestry industry, giving the most cost-effective methods for water quality monitoring for both short- and long-term goals. One model will be simple, using easily measurable variables, and the other more detailed, including all relevant variables. The rule models will be based on normal forestry management practices, for example clearfelling, site preparation and afforestation.

APPROACH

Water quality data from three different mountain catchment areas were analysed for changes that could be attributed to changes in forestry management practices. These consisted of three catchments under plantations in the south-western Cape, two indigenous forested catchments in north-eastern Transvaal, and one partly afforested catchment in the eastern Transvaal.

The management practices that were considered varied from riparian zone clearings to afforestation of a once indigenous forested catchment with commercial tree species. Of the Cape catchments, one was kept as a control. A second catchment underwent a riparian clearing, followed by the total clearfelling of the plantation (and catchment) and subsequent re-afforestation. Just more than half of the third catchment was under plantation, and this was clearfelled over a period and planted with a second-rotation crop. A few years later the whole of the latter catchment accidentally burnt down, and was planted-up again. Of the indigenous forested catchments in north-eastern Transvaal, one was bulldozed and burnt, and a plantation established, while the other was maintained as a control. The catchment in the eastern Transvaal underwent several riparian clearings. Before the final burning of the riparian zone, the plantation, which covered 25% of the catchment, was clearfelled.

Samples taken from both high- and low-flow conditions were included in the study. All water quality variables indicated under 'Objectives' were analysed. Statistical analyses applied on all variable concentrations included tests for normality of data, the Wilcoxon Rank Sums tests on concentration ratios, Kendal's Tau trend analyses which included test for seasonality and auto-correlation, and correlation analyses.

MAJOR RESULTS AND CONCLUSIONS

There were no consistent statistically significant changes in the concentrations of the variables in spates (high flow) as a result of the different forest management practices. Suspended sediment was the only variable that changed as a result of a number of different management practices. The most marked increases in sediment, upto five-fold, occurred after a fire burnt a plantation in the south-western Cape. Although the effects were short-lived, the extent of the increases indicated that spate sampling would be needed to monitor such extreme changes in vegetation cover.

Grab-sample concentrations of suspended sediment, NO_3^--N, PO_4^{3-}-P, K^+ and Ca^{2+} provided good indications of the effects of most forest management practices. Management practices which disturbed the upper soil layers caused sediment concentrations to increase in streamwater. The increased concentrations of NO_3^--N, PO_4^{3-}-P, K^+ and Ca^{2+} is attributed to water percolating through decaying litter, slash, roots and ash and the consequent leaching of these important plant nutrients. NO_3^--N and K^+ were also found to be indicators of long-term change, with concentration levels being elevated for a number of years following disturbance caused by changes in management practices. Intensive site preparation during the conversion of an indigenous forest to plantation caused the most lasting concentration increases of NO_3^--N and K^+ in streamwater.

There were no consistent significant correlations between variables, and none could be used to predict others.

The method of stream ordering was used to indicate a sampling hierarchy in greater catchment areas. A control or untreated catchment provided a highly effective way of separating actual changes in water quality in the treated area from changes caused by variation in climate. Monthly grab samples were found adequate for general monitoring while specific sampling of high-flow conditions will be needed to determine the effects of extreme management practices or events on catchment water quality.

MEETING OF OBJECTIVES

The objectives, as set out in the original proposal were generally met. Suspended sediment, NO_3^--N, PO_4^{3-}-P, K^+ and Ca^{2+} were found to be reliable indicator variables of the impacts of forestry management practices. Correlation analyses involving all the sampled variables in all the catchments showed that

(a) none of the variables were consistently highly correlated and

(b) they could not be used to predict each other.

The third objective was met in that general guidelines for water quality monitoring were compiled. No rule models were determined.

Part B of this report provides guidelines to forest managers for designing a water quality monitoring system for forested catchments, and can be used as a stand-alone section.

RECOMMENDATIONS FOR FURTHER RESEARCH

Sampling frequency determinations still need more attention. The *inconsistent* results for different variables found in this study points to the need for a more detailed analysis than was possible in this study.

The effects of different site-preparation techniques on streamwater quality have not been specifically researched. Information on these impacts could affect conclusions about the importance of specific variables, and refine the guidelines for monitoring.

Although this study did not include aquatic organisms, it would seem that they can be used complementary to inorganic indicators and are potentially more sensitive indicators of change in montane headwater streams. A combination of both types of monitoring (inorganic and biotic) might give a better indication of the effects of forest management practices on water quality.