Coastal Systems Research Group
Ecosystem Services Competence Area

Final Report

our future through science

Port of Richards Bay
Expansion Programme:
Implications of a Basic
Water Quality Survey

March 2013

Report Details

Prepared for:	Mr Peter Teurlings Senior Principal Environmental Specialist Environmental Management Department Infrastructure and Management Services BKS (Pty) Ltd Pretoria
Prepared by:	Coastal Systems Research Group Ecosystem Services Competence Area Natural Resources and the Environment CSIR
Authors:	Brent Newman Roy van Ballegooyen
Contact person:	Brent Newman PO Box 17001 Congella 4013 Durban South Africa Telephone: (031) 242 2377 Telefax: (031) 261 2509 Email: bnewman@csir.co.za
Date:	March 2013
For bibliographic purposes this report should be cited as:	CSIR (2013) Port of Richards Bay expansion programme: Implications of a basic water quality survey. CSIR Report CSIR/NRE/ECOS/ER/2013/0028/C.

Table of Contents

1. Introduction

Transnet SOC Ltd (hereafter referred to as Transnet) forecasts considerable growth in the volume of cargo imported and exported through the Port of Richards Bay over the next 30 years. This and some inefficiencies associated with the existing port layout led to Transnet identifying several expansion scenarios for the port, to accommodate the forecast growth. It is beyond the scope of this report to document the potential expansion scenarios save to state that the expansion will take place predominantly in the western part of the Bay. Each expansion scenario will require the (capital) dredging and disposal of significant volumes of sediment. A concern in any situation where sediment is dredged is the ecological impact of dredging induced increases in water column turbidity and suspended solids concentrations.

2. Purpose of this Report

To supplement existing turbidity and total suspended solids concentration data for Richards Bay, these parameters were measured in surface and bottom water samples collected at 15 stations spread across the proposed expansion footprint in February 2013. The findings are discussed in a companion report that focusses on turbidity and suspended solids in Richards Bay. At the same time that water samples were collected the Coastal Systems Research Group of the CSIR took the opportunity to measure some basic water quality indicators *in situ* at each station. The purpose of this report is to present the findings of this survey and to discuss the potential implications for the Port of Richards Bay expansion programme.

3. Study Area

Richards Bay is a semi-enclosed estuarine embayment situated on the subtropical northeast coast of South Africa, in the province of KwaZulu-Natal (entrance at 32°02′E, 28°48′S). The Port of Richards Bay is situated within the Bay (Figure 1). For the purposes of this study the Bay is divided into the following areas: Inner Basin 1, Inner Basin 2, Inner Basin 3 (these are collectively referred to as the Inner Basin complex), Richards Bay Coal Terminal Basin and Mudflats (Figure 1). The Inner Basin complex (Inner Basin 1, Inner Basin 2 and Inner Basin 3) and Richards Bay Coal Terminal Basin are of a deepwater nature, with a maintained water depth of about 22 meters. The water column over the Mudflats, in contrast, is shallow, with a depth of between about 1 - 2 meters. The Bhizolo Canal, which serves as a conduit for surface runoff, discharges into the western portion of the Mudflats.

Although its primary function is for the trade of bulk cargo the Port of Richards Bay is fairly unique in the context of South African ports since only about 40% of the land surface area has been developed. Large areas of relatively undisturbed natural habitat, including extensive intertidal sand and mudflats, and mangroves exist alongside traditional port infrastructure. These habitats have retained much of their natural functioning and the Bay plays an important role in the life cycles of numerous fish and invertebrates that show an estuarine dependence (Weerts 2002, Weerts and Cyrus 2002, Weerts *et al*. 2003). The Bhizolo Canal, lined by mangroves, offers particularly important habitat for crustaceans, especially juveniles of commercially important prawn species (Weerts *et al*. 2003). These habitats also support high abundances of fish (Weerts 2002). The Bay is ranked 26th amongst South African estuaries in terms of conservation importance (Turpie *et al*. 2002), underlying its ecological importance.

The presence of natural areas in the Bay lends aesthetic appeal and it also serves as an important recreational venue for the local community, being particularly popular for water related activities such as fishing, canoeing and sailing.

4. Materials and Methods

4.1. Sampling design

In situ measurements were made at 15 stations across the proposed expansion footprint on the 5th of February 2013 (Figure 2).

4.2. Fieldwork

A Yellow Springs Instrument 6600 multiparameter water quality sonde was used to profile temperature, salinity, pH, turbidity and dissolved oxygen and chlorophyll-*a* concentration through

Figure 1. Map of Richards Bay showing features and place names mentioned in the text.

Figure 2. Map of Richards Bay showing the positions were *in situ* water quality measurements were made and water samples were collected for turbidity and total suspended solids concentration analysis in the laboratory.

the water column at each station. Probes of the sonde were calibrated a few days prior to fieldwork with the exception of the chlorophyll-*a* probe, which was not calibrated. Chlorophyll-*a* concentrations were generated by default algorithms of the sonde's software. The sonde was programmed to log at three second intervals. The sonde's probes were held about 30 cm below the water surface for approximately one minute to equilibrate, held in place for an additional minute, and then slowly lowered through the water column. On contact with the bottom the sonde was raised about 30 cm and held in place for approximately three minutes. This was considered sufficient time for disturbed sediment to settle and disperse and still allow for a one minute period of logging of bottom water physical, chemical and biological characteristics representative of the undisturbed condition. Field staff also moved approximately one meter along the vessel from

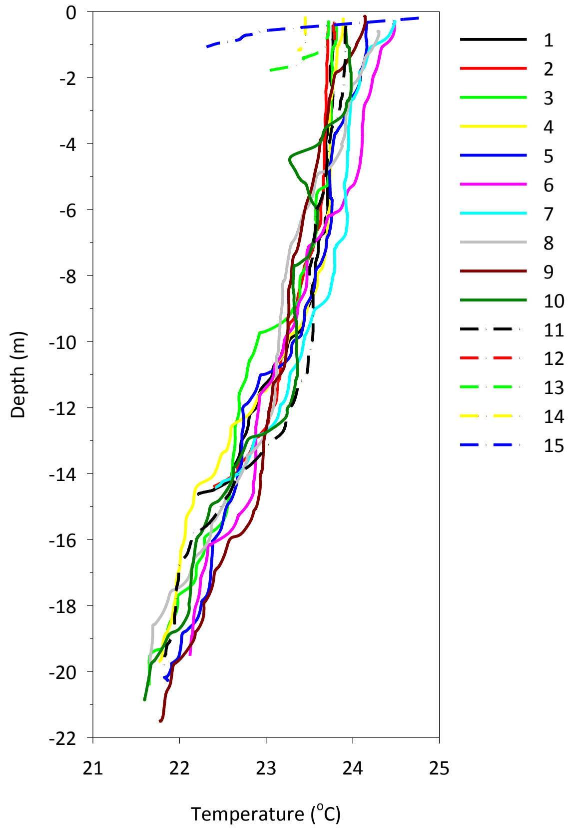

Figure 3. Temperature profiles for the water column in Richards Bay on the 5th of February 2013.

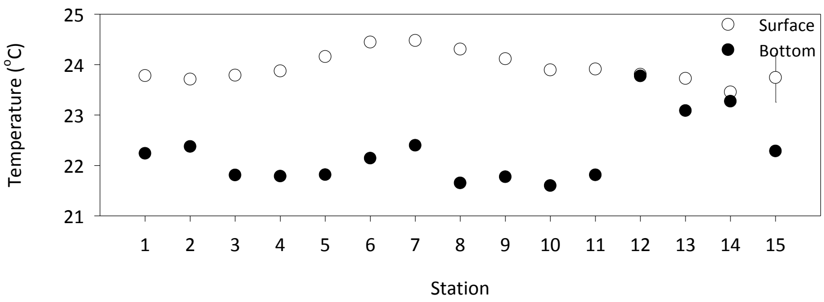

Figure 4. Comparison of the temperature of surface and bottom waters in Richards Bay on the 5th of February 2013.

which monitoring was performed in a further attempt to avoid the influence of disturbed sediment on the measurements. Holding the sonde in surface and bottom waters for an extended period provided an estimate of the short-term variability in water column physical, chemical and biological characteristics, and allows for the statistical comparison of data between stations if required.

4.3. Data analysis

The average (± standard deviation) of one minute periods of data logged *in situ* with the multiparameter water quality sonde are used to summarise the short-term variability of physical, chemical and biological parameter values and concentrations in surface and bottom waters. *In situ* profiles of physical, chemical and biological parameters are presented graphically and interpreted visually, that is, by examining for anomalies in profiles at the station specific level and for differences or similarities in profiles between stations.

5. Results and Discussion

Profiles of physical, chemical and biological parameters through the water column and their comparison between surface and bottom waters at each station are presented in Figures 3 - 14.

There is no point discussing water column temperature in any detail save to state that the water column was moderately thermally stratified and there was little difference in temperature

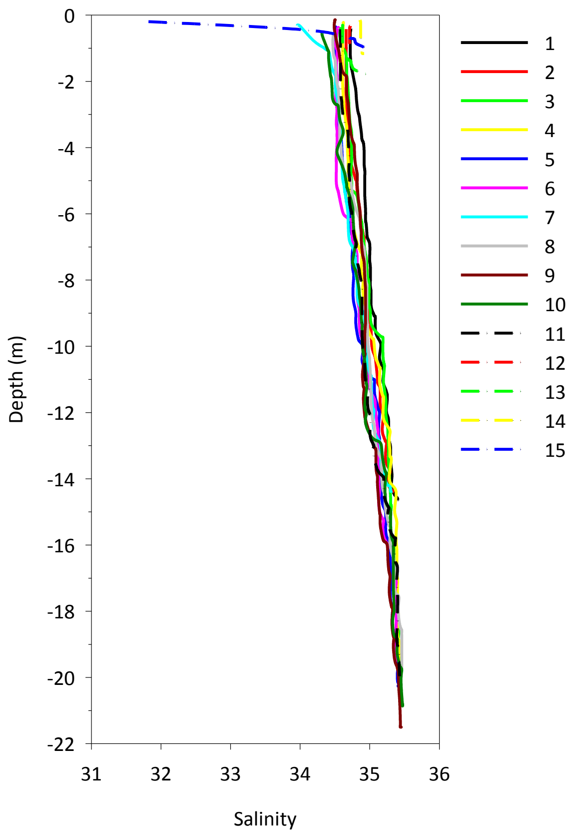

Figure 5. Salinity profiles for the water column in Richards Bay on the 5th of February 2013.

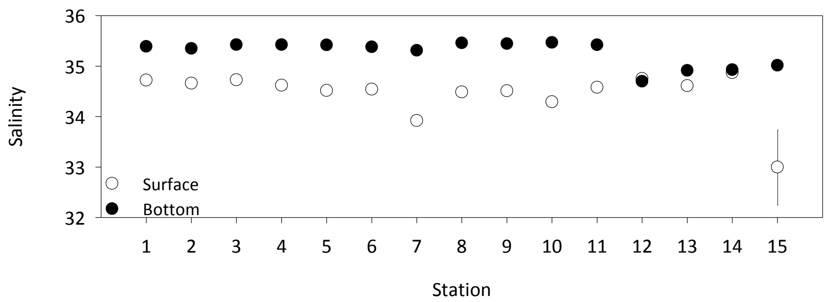

Figure 6. Comparison of the salinity of surface and bottom waters in Richards Bay on the 5th of February 2013.

between stations with the exception of station 15 on the Mudflats, where thermal stratification was relatively pronounced (Figures 3 and 4). The significance of thermal stratification is that it provides a measure of the degree of mixing of the water column and is useful for inferring the cause of anomalies for some water quality parameters (*e.g.* dissolved oxygen concentration).

Salinity increased progressively (albeit marginally) through the water column at each station, and varied little between stations (Figures 5 and 6) with two exceptions. At the majority of stations the salinity was essentially identical to that for seawater, reflecting the strong marine influence on the Bay's water column. The exceptions were station 7 in Inner Basin 3, where the surface water salinity was marginally depressed, and station 15 on the Mudflats, where the surface water salinity was considerably lower compared to other stations. The depressed salinity at station 7 probably reflects the inflow of freshwater via several stormwater outfalls that discharge surface runoff into the northern part of Inner Basin 3, while the depressed salinity at station 15 on the Mudflats undoubtedly reflects the influence of freshwater inflow from the Bhizolo Canal. The salinity of bottom water at all stations on the Mudflats other than station 15, and at station 12 in the shallow southern part of the Richards Bay Coal Terminal Basin was somewhat lower compared to bottom water at the deepwater stations, but this is simply attributable to the shallow nature of the water column and evidence that the water column was weakly mixed at the

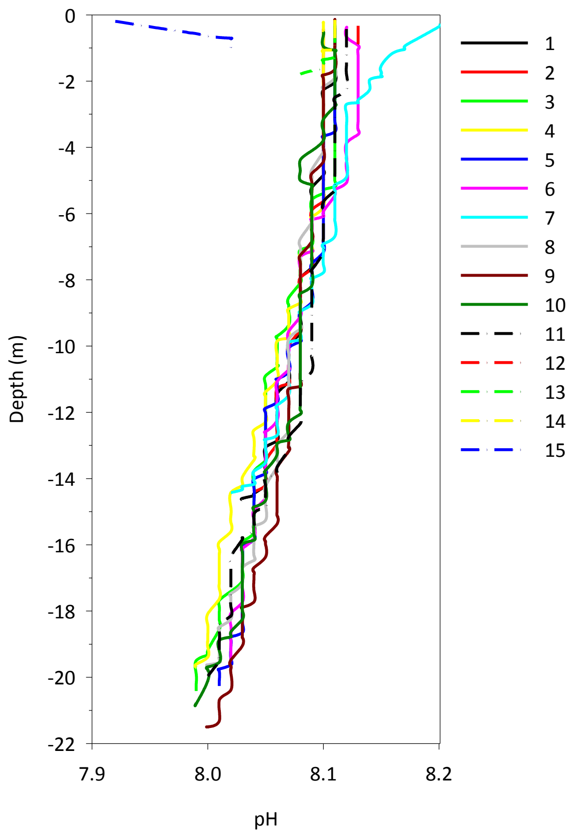

Figure 7. pH profiles for the water column in Richards Bay on the 5th of February 2013.

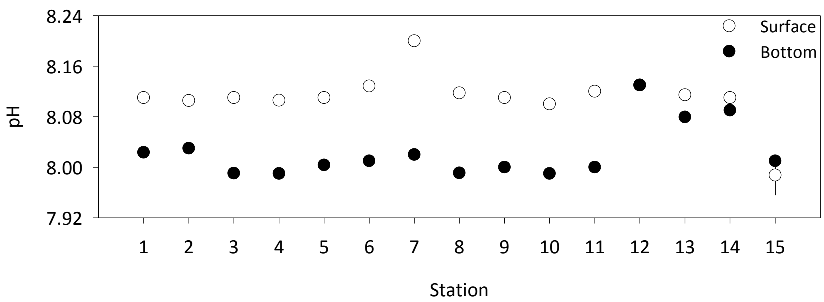

Figure 8. Comparison of the p of surface and bottom waters in Richards Bay on the 5th of February 2013.

time of monitoring (no difference between surface and bottom water would be expected if the water column was well-mixed).

The pH decreased progressively (albeit marginally) through the water column at each station, and varied little between stations (Figures 7 and 8). As was the case for salinity there were two exceptions, namely station 7 in Inner Basin 3 and station 15 on the Mudflats. At station 7 the pH in the upper 2 m of the water column was somewhat higher compared to other stations, undoubtedly reflecting the higher chlorophyll-*a* concentration (a surrogate measure of microalgal biomass) in the upper part of the water column at this station (see below). Through the photosynthetic process microalgae consume carbon dioxide and hence decrease the amount of carbonic acid in the water column, thereby increasing the pH. At station 15, the pH through the entire water column was somewhat lower compared to other stations, including stations on the Mudflats. Although freshwater naturally has a lower pH compared to seawater, based on the salinity the pH at station 15 is too low to only be a consequence of freshwater outflow from the Bhizolo Canal and almost certainly reflects a pollution impact. The Coastal Systems Research Group of the CSIR has previously measured abnormally low pH in the Bhizolo Canal. In fact, in a survey for the Long-Term Ecological Monitoring Programme for the Port of Richards Bay performed the day after the survey discussed in this report, the pH in the Bhizolo Canal was as low as 7.4.

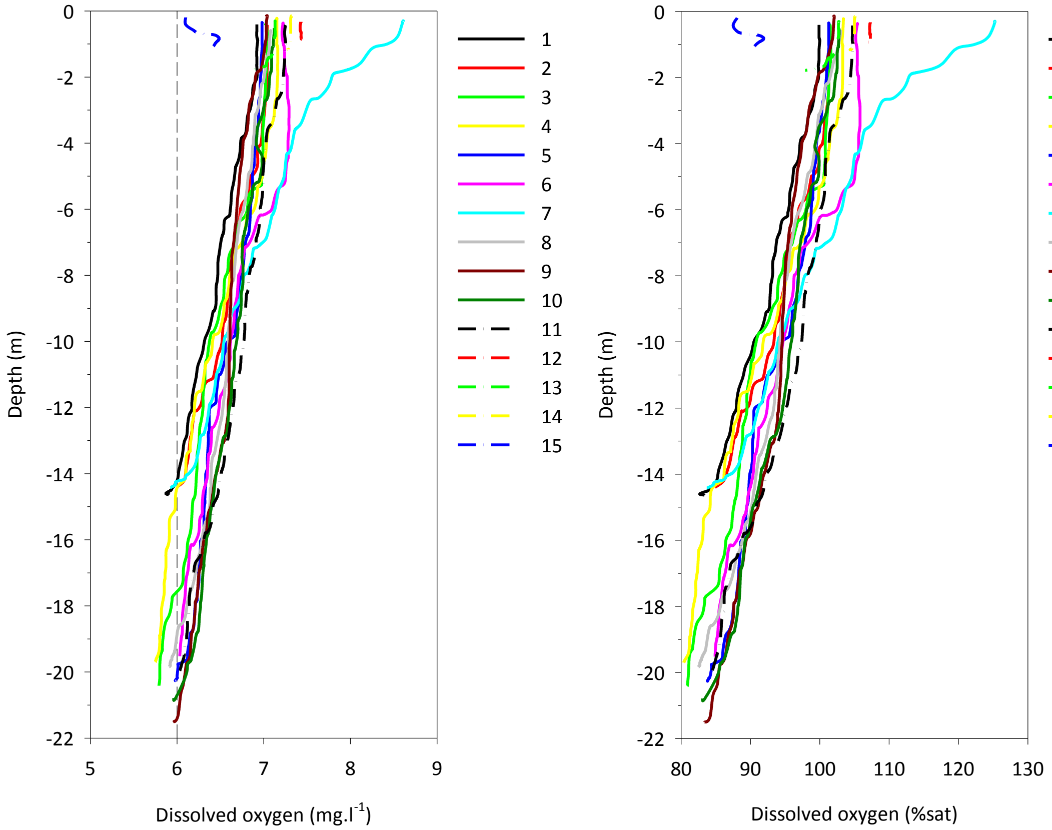

Figure 9. Dissolved oxygen concentration and saturation profiles for the water column in Richards Bay on the 5th of February 2013. The dashed line represents the South African Water Quality Guidelines for Coastal Marine Waters target dissolved oxygen concentration that must be met 95% of the time.

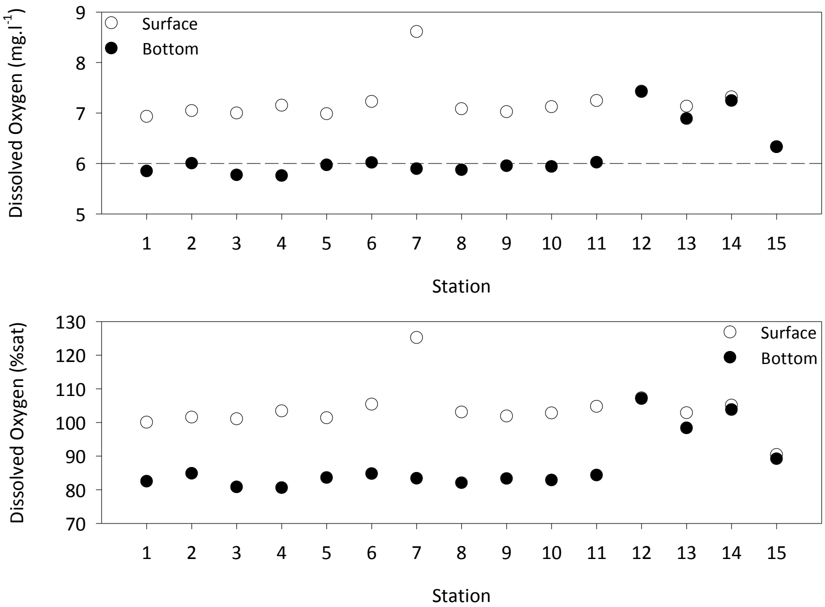

Figure 10. Comparison of the dissolved oxygen concentration and saturation of surface and bottom waters in Richards Bay on the 5th of February 2013. The dashed line represents the South African Water Quality Guidelines for Coastal Marine Waters target dissolved oxygen concentration that must be met 95% of the time.

The pH of bottom water at all stations on the Mudflats other than station 15, and at station 12 in the shallow southern part of the Richards Bay Coal Terminal Basin was somewhat higher compared to the deepwater stations, but again this was simply attributable to the shallow nature of the water column at these stations and evidence that the water column was not well-mixed at the time of monitoring.

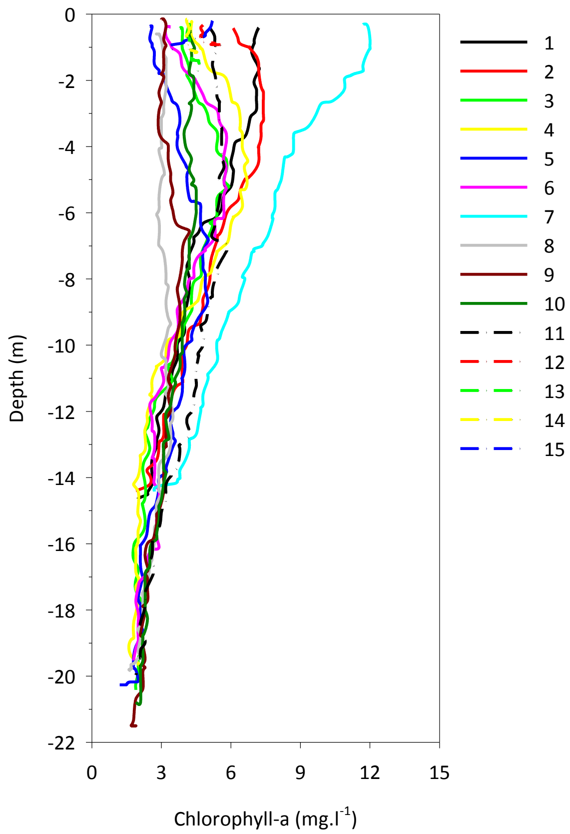

Figure 11. Chlorophyll-*a* profiles for the water column in Richards Bay on the 5th of February 2013.

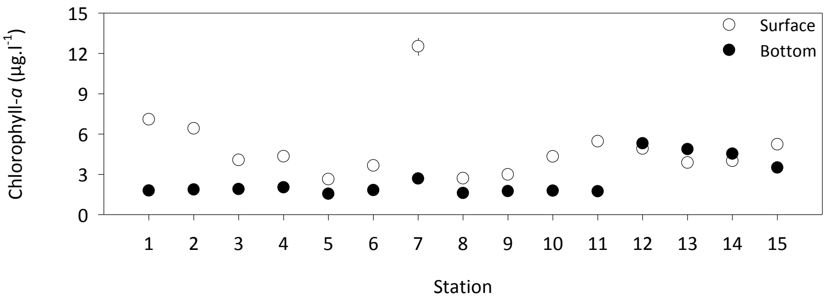

Figure 12. Comparison of the chlorophyll-*a* concentration in surface and bottom waters in Richards Bay on the 5th of February 2013.

Dissolved oxygen concentration and saturation decreased progressively (albeit marginally) through the water column at each station, and varied little between stations (Figures 9 and 10). Station 7 in Inner Basin 3 and station 15 on the Mudflats were again exceptions. At station 7, the dissolved oxygen concentration and saturation in the upper 3 - 4 m of the water column was somewhat higher compared to other stations, this undoubtedly attributable to the photosynthetic production of dissolved oxygen by the high microalgal biomass present in the upper part of the water column at this station (see below). The dissolved oxygen concentration and saturation in surface water at station 15 was lower compared to other stations, while the concentration and saturation in bottom water was also lower compared to other shallow water stations and again suggests a pollution impact. At station 12, in the shallow southern part of the Richards Bay Coal Terminal Basin, and at stations 13 and 14 on the Mudflats, the bottom water dissolved oxygen concentration was somewhat higher compared to the deepwater stations. This again reflects the shallow nature of the water column at these stations and evidence that the water column was not well-mixed at the time of monitoring.

Bottom water dissolved oxygen concentrations at numerous deeper water stations fell marginally below the South African Water Quality Guidelines for Coastal Marine Waters target of 6 mg.l^{-1} that

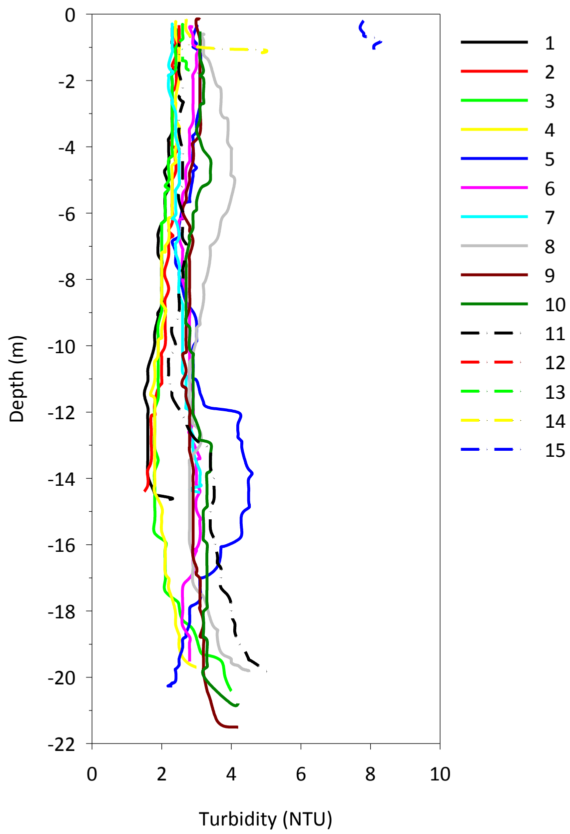

Figure 13. Turbidity profiles for the water column in Richards Bay on the 5th of February 2013.

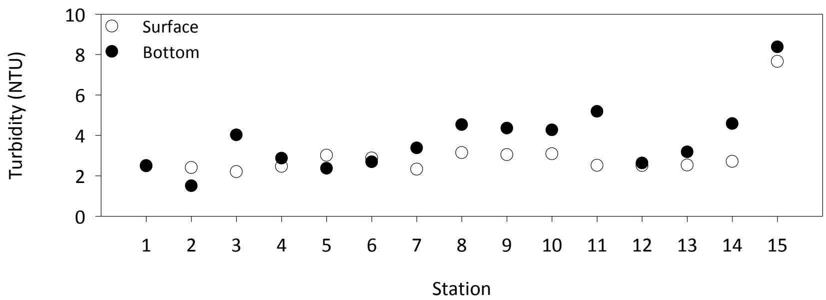

Figure 14. Comparison of the turbidity of surface and bottom waters in Richards Bay on the 5th of February 2013.

must be met 95% of the time, but exceeded the target of 5 mg.l^{-1} that must be met 99% of the time (Figures 9 and 10).

As mentioned previously, the chlorophyll-*a* concentration in the upper part of the water column at station 7 in Inner Basin 3 was somewhat higher compared to other stations (Figures 11 and 12). There was clearly a nutrient source fuelling the growth of microalgae at this station, possibly introduced by the previously mentioned inflow of freshwater from stormwater outfalls situated on the northern bank of this basin. Elevated chlorophyll-*a* concentrations were also evident in surface water at station 1 in Inner Basin 1 and station 2 situated nearby in Inner Basin 2 (Figures 11 and 12).

Turbidity at the time of monitoring was low and generally varied little through the water column at each station and between stations. The exception was station 15, where the turbidity and total suspended solids concentration in surface and bottom waters was somewhat higher compared to other stations. The higher turbidity at station 15 undoubtedly reflects the inflow of turbid water from the Bhizolo Canal.

6. Implications for Expansion Programme

The findings of the water quality monitoring are revealing in terms of the proposed expansion programme from several perspectives.

First, microalgal biomass (chlorophyll-*a* concentration) was highest in and near small 'dead-end' basins, namely Inner Basins 1 and 3. This is not the first time the Coastal Systems Research Group of the CSIR has recorded higher chlorophyll-*a* concentrations in these basins compared to other areas of the Bay (*e.g.* CSIR 2011). There was obviously a source of nutrients sustaining the elevated microalgal biomass in and near these basins and which was presumably derived from an anthropogenic source. However, of greater significance is that the exchange of water between these basins and the greater Richards Bay is restricted because of their 'dead-end' nature. This facilitates an increase in microalgal biomass, because the water retention time exceeds the generation time of the microalgae. Elevated microalgal biomass is a common feature of the water column in many South African ports, especially in areas of ports where water exchange is restricted and there is an anthropogenic source of nutrients. The implication for the proposed expansion programme is that if port development further restricts the exchange of water between 'dead-end' basins and the greater Richards Bay and anthropogenic nutrient inputs continue then there is strong possibility that eutrophic conditions may manifest. This will ultimately lead to the development of hypoxia and possibly even anoxia in bottom water and sediment, with a host of associated adverse ecological impacts. Careful consideration must, therefore, be given during the infrastructure design phase for achieving the maximum possible water exchange between 'dead-end' basins and the greater Richards Bay.

The second revealing feature is the low pH of the water column off the Bhizolo Canal. There was clearly an anthropogenic source of contamination to the Bhizolo Canal that was driving the low pH. As was the case for microalgal biomass this is not the first time the Coastal Systems research group of the CSIR has recorded low water column pH in and near the Bhizolo Canal (*e.g.* CSIR 2011). In fact, the concentrations of fluoride, some nutrients (especially ortho-phosphate), chlorophyll-*a* concentration, turbidity and total suspended solids are usually considerably higher in the Bhizolo Canal compared to the rest of the Bay (*e.g.* CSIR 2011). Careful consideration must, therefore, also be given during the infrastructure design phase as to the future discharge point of the Bhizolo Canal. Connecting this canal to a 'dead-end' basin will have adverse ecological implications unless the source/s of contaminants in the canal catchment are identified and controlled, although it is improbable that all sources will be identified and/or entirely controlled.

Third, consideration must be given during the infrastructure design phase as to where surface runoff (stormwater) from quay surfaces will be discharged. Discharging surface runoff into 'dead-end basins', where water exchange with the greater Richards Bay is poor, will increase the probability for water and sediment quality impairment. This is because surface runoff is an important vector for the introduction of materials accidentally spilled on quay surfaces into Richards Bay. Water and sediment quality impairment is not only important from an ecological perspective but also from a dredging perspective. As discussed in a companion report prepared by the CSIR (2013) that describes metal contamination of surface sediment in the proposed expansion footprint, there is very strong evidence that accidentally spilled metal ore fragments and metal flecks, and possibly also fragments and flecks introduced by surface runoff, are the cause of significant metal contamination of sediment in Inner Basins 1, 2 and 3. The magnitude of metal contamination in some parts of these basins is such that the Department of Environmental Affairs may prohibit the unconfined openwater disposal of dredged sediment. The financial implications of alternate (*e.g.* on-land) sediment disposal will be significant. This situation will continue unless the sources of and vectors for the entry of metals and other contaminants into Richards Bay are identified, reduced and controlled. As discussed above, one of the vectors is surface runoff. Ideally, surface runoff from quays should be diverted to detention ponds to facilitate the settlement of particulate material and the overflow then discharged to the Bay. The scientists that prepared this report are, however, aware that the construction of retention ponds may not be feasible, but it might be possible to construct particulate matter settlement systems within the stormwater reticulation system.

7. References

CSIR (2011) Long-Term Ecological Monitoring for the Port of Richards Bay: Surveys made in 2011. CSIR Report CSIR/NRE/ECOS/ER/2011/0123/C+.

Turpie JK, Adams JB, Joubert A, Harrison TD, Colloty BM, Maree RC, Whitfield AK, Wooldridge TH, Lamberth SJ, Taljaard S and Van Niekerk L (2002) Assessment of the conservation priority status of South African estuaries for use in management and water allocation. *Water SA* 28: 191-206.

Weerts SP (2002) *Habitat utilisation by juvenile fish in Mhlathuze Estuary and Richards Bay Harbour*. MSc thesis, University of Zululand, South Africa.

Weerts SP and Cyrus DP (2002) Occurrence of young and small-sized fishes in different habitats within a subtropical South African estuary and adjacent harbour. *Marine and Freshwater Research* 53: 447-456.

Weerts SP, Cilliers G and Cyrus DP (2003) Estuarine macrocrustacea of Richards Bay Harbour, South Africa, with particular reference to the penaeid prawns. *African Journal of Zoology* 38: 285-296.