5. ASSESSMENT OF OVERALL SITUATION

(i) The quantity of fine sediment released during the dredging operation and from erosion of the spoil dump in the period immediately afterwards, was substantial and significantly altered the sediment distribution pattern on the reef flat. With time, this fine material has been winnowed out and the distribution pattern is now returning to that expected under natural conditions.

(ii) Initially, it was reported that the fine material formed a thin layer on the reef flat but was soon taken into suspension and mixed with the coarser material normally present on the reef flat or removed from the reef top altogether. By the time of the first sampling in December 1987, there was no evidence of such a layer nor of anoxic conditions within fine material on the reef flat.

(iii) The beach rock, especially that on the southern side of the island, was covered initially by considerable amounts of silt and fine sand. Except for the lower seaward region of the western end of the beach rock immediately east of the spoil dump, the beach rock is now (Dec. 1991) almost completely clear of significant accumulations of fine sediment.

(iv) Areas of the surface of the spoil dump are relatively consolidated due mainly to compaction by the continuous traffic of heavy machinery over these areas, rather than by natural cementation. The areas not subjected to such traffic, especially the seaward margin of the dump, are being colonised by vegetation.

(v) The initial volume of the spoil dump in December 1987 has been estimated as 14860m^3 relative to August 1984 beach contours. This volume has been reduced by 1780m^3 (12%) during the three and a half year period to June 1991. It is estimated that about 10% of the material in the spoil dump is silt.

(vi) Silt is very unevenly distributed within the spoil dump, often being concentrated in lenses, and generally it is more prevalent in the northern part of the spoil dump near the jetty. This is also the region of strongest wave attack. The silt in the highly concentrated zones develops cohesion on drying. When exposed, this cohesion is sufficient to maintain a vertical erosion scarp up to 0.5m high. Erosion resisting deposits also exist on the reef flat between the boat harbour and the beach.

(vii) Silty material is being released into the reef-top waters when waves erode the seaward face of the spoil dump. As the size of the waves increases with both wind speed and tide level, silt plumes are more likely to occur when winds are strong and tides are high. They do not occur on most occasions when wind speeds are less than 15kn, average breaking wave heights less than 0.2 to 0.3m and high tide levels less than 2.5m. Prior to January 1991, the incidence of silt plumes was decreasing. However, there was a substantial increase in the number of plumes during that month following the renewed exposure of silt. Nevertheless in April 1991 the silt plumes were less extensive than they were two years earlier. The influence of rainfall upon the occurrence of silt plumes is not simple nor as significant as winds, waves and tide level.

(viii) Erosion of the northern end of the spoil dump near the jetty is primarily caused by waves coming from the northern side of the reef, whereas erosion of the southern end of the spoil dump is caused by waves coming from the southern side of the reef. More silt plumes are generated at station 2 near the jetty than at station 1 at the southern end of the spoil dump. This is because breaking waves during the period of observation were generally larger at station 2 than station 1 and there is more silt in the vicinity of the jetty than further south.

(ix) The two occasions when significant erosion of the spoil dump occurred, exposing silt deposits and causing increased silt plume occurrences, were both associated with swell, originating from distant cyclones (Aivu in April 1989 and Joy in January 1991) and coming over the northern reef edge on very high tides.

(x) During the process of erosion and reshaping of the seaward face of the spoil dump, the silt is carried away by currents and either deposited on the reef flat or removed from the reef platform. Sand and shingle are redistributed to form the new beach profile and new beach alignment. Rubble generally remains on the beach at the base of the erosion scarp until removed by human action, generally to protect the jetty or the helipad or to provide easy access to boats anchored on the reef flat.

(xi) The shoreline of the spoil dump is being realigned by the present dominant waves into a new "stable" equilibrium form. Waves from the north breaking at an angle to the shoreline are attempting to form a crenulate bay shape south from the southern end of the timber wall protecting the helipad. This process is causing considerable erosion in the vicinity of the jetty and is being modified by human activity involving the placement of rubble to reduce erosion. The southern portion of the spoil dump and its adjoining beach have been realigned to be parallel to the crests of waves coming over the reef edge to the south of the boat harbour. In both cases the realignments appear to be a response to negligible net alongshore sediment transport towards the spoil dump.

(xii) The initial direction of movement of the silt plume when erosion occurs at high tide is normally dependent upon the wind direction. As the tide commences to fall, the plume will move with the ebb tide along the moat towards the boat harbour and then seawards along the southern side of the southern harbour bund wall. Outflow into the ocean occurs either over the reef rim immediately south of the wreck or through a low point in the bund wall at the landward end of the wreck, and then out through the boat channel.

(xiii) Material in the silt plume is predominantly silt and has essentially the same size distribution as the silt found in the spoil dump. The extreme size range is 0.0015 to 0.095mm but most of the material (>90%) lies between 0.004 and 0.06mm with the median size being about 0.01mm. Silt deposited on the reef flat closer to the spoil dump is somewhat coarser (d_{50} _ 0.03mm) than that released in the plume. Negligible amounts of material finer than 0.008mm were found on the reef flat and this is consistent with the very long settling time for such particles which is of the order of 8h to fall through a depth of 2m. Such particles will be removed from the reef flat by tidal currents after being stirred up by wave action.

(xiv) The conditions under which fine material is released from the spoil dump by natural causes are different from those which created the extensive plumes and deposits during construction of the boat harbour. During that period, excavation, dredging and overflow of the settling pond would have occurred at various states of the tide including the flood tide. Moreover silt plumes were generated from various locations along the boat channel. Northerly winds dominated on most occasions and these would have assisted the flood tides to move silt plumes eastward across the reef flat and along the moat. Now, erosion of the spoil dump is mostly only possible under conditions when the plume moves seaward fairly soon after its generation.

(xv) The meteorological events which generate the waves which are eroding the spoil dump may extend over several days or more but the actual release of sediment onto the reef flat is in a series of separate pulses defined by the tidal rise and fall associated with each high

tide. Erosion will occur and a silt plume develop as the tide rises above a level of the order of 2.5m. With the dominant eastsoutheasterly to southeasterly winds the plume should be confined to the region near the spoil dump before the ebb tide moves it offshore, either through the boat harbour or across the reef flat just south of the harbour. Only on occasions of strong northerly winds and very high tides, are significant eastward movement of sediments and their depositon on the beach rock or reef flat further east likely to occur before the ebb tide begins to control the movement of the silt plume.

(xvi) Under natural conditions, the larger waves crossing the reef-flat will stir up existing sediments, putting them into suspension, and creating turbidity. Some of these naturally suspended sediments will be caught in reef-top sediment traps, even though no net accumulation of sediment is occurring on the reef flat. Hence, sediment traps may overestimate average accumulation rates. Furthermore, when the waves subside, the coarser suspended sediments will be deposited relatively rapidly during a comparatively short period. Consequently the actual rate of deposition during this period may be much greater than the average rate determined over a week or month or whatever the period between emptying the trap may be. Hence significant deposition may occur on the reef flat under natural conditions with no additional sediment being supplied to it. Moreover actual deposition rates during short periods of time may be much greater than average rates over longer periods. The ecological impact of this deposition could depend upon the amount of sediment suspended, the rate at which it settles and its timing relative to the life cycles of marine organisms.

(xvii) During the period of monitoring, recorded wind velocities did not exceed 35 kn and the highest predicted tide level was 3.25m. Stronger winds are known to have occurred in November 1988. The anemometer did not function properly then but 40kn winds are believed to have occurred. Earlier, cyclonic winds of 70 to 80 kn were recorded at Heron Island during cyclone "Simon" in February 1980. If this situation reoccurs, coinciding with a very high tide, waves of the order of 1.5m maximum height could reach the spoil dump and cause substantial erosion, involving reshaping of the beach and realignment of the shoreline. These changes could be accompanied by the release of substantial quantities of silt. However once released in this way, much of the silt is also likely to be removed from the reef platform by tidal and other currents, either during the cyclone or other occasions when waves stir up sediments on the reef flat.