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CHAPTER 8 OCEANOGRAPHY AND COOLING WATER SUPPLY

8.1. PARAMETERS STUDIED

Oceanography data are relevant to safety in so far as they bear upon:

a) the possibility of flooding from the sea,

b) the security of the cooling water (CW) supply in as much as it is affected by extreme low water levels and blockage by sand, oil slicks, debris or marine flora and fauna,

c) the design of certain safety-related systems since these are sized to give adequate cooling at a maximum sea temperature.

Derivation of liquid effluent discharge limits, (radio active limits, chemical limits, etc) are considered in ***Chapter 14***.

Parameters which have been studied are as follows:

- tide heights (including storm surge)
- tsunami risk
- wave height, period, direction, set-up and run-up
- close-in and off-shore surface and sub-surface currents
- correlation of wind and current water temperature
- chemical composition of sea-water sand in suspension
- grain size
- movement of beach and sea-bed
- marine fouling
- effects of elevated water temperature on marine organisms.

Only those data of relevance to safety are reported on here.

8.2. FLOODING FROM THE SEA

Wave data analysed by Rossouw, ***Reference 94***, was extrapolated to determine extreme values and the best fit line is given in ***Figure F-8.1.***

Return periods for extreme high water levels resulting from the combined effects of tide (including sea level rise), surge, wave run-up and wave set-up are given in ***Table T-8.1***, Summary of Extreme Values, together with an indication of confidence limits. The basic oceanographic data are given in ***Reference 3*** to ***Reference 84***, ie, covering the period January 1969 to December 1996. ***Table T-8.1*** gives a comparison of Watermeyer, Prestedge, Retief WPR (1997) figures with Watermeyer Halcrow and Partners (WHP, 1980) figures.

Data on the likely incidence and size of tsunamis are given in ***Reference 87*** and ***Reference 95***. A tsunami run-up of +4.0 m could, however, be envisaged (according to Wijnberg (1988), following a magnitude 7.8 seismic upheaval at the South Sandwich Islands. This tsunami would have a period of 45 minutes. In determining extreme water levels for licencing ***Reference 98*** combines the maximum credible tsunami run-up with the highest astronomical tidal level (HAT) to obtain a maximum flood level of +5.2 m MSL.

In ***Reference 98*** extreme high water levels were obtained by combining probable maximum sea level rise by the year 2030 of 0.6 m from ***Reference 97***, see ***Figure F-8.5***, with tide plus surge data from ***Reference 96***, and wave run-up and wave set-up data from ***Reference 94***. This yielded the conclusion that a terrace level at +8.0 m MSL, as constructed, is acceptable and that no wave wall is necessary.

8.3. AVAILABILITY OF COOLING WATER

Conditions which might jeopardise the security of the essential services cooling water supply are as follows:

a) exposure of intakes at extreme low water,

b) damage to intake structure by waves or other means,

c) silting up of basin entrance,

d) blockage of intakes by sand, oil slicks, flotsam or marine life.

8.3.1 Exposure of Cooling Water Intakes

The difference between mean sea level and extreme low water is less than the difference between mean sea level and the extreme high water levels discussed above because of the large influence of wave set-up on the latter.

From ***Reference 98*** the minimum still water level due to extreme low tide, combined with extreme negative storm surge is given as -2.17 MSL.

Short period (less than five minutes) oscillations within the basin, viz, short and long period waves may be superimposed upon this. Normal wave action (referred to here as short period waves) will be minimal in order to be consistent with the assumption of zero wave set-up used to obtain the above extreme low water level of -2.17 m MSL.

Studies of possible resonance of the basin volume to long period waves shared a strong correlation between seiche and larger offshore wave conditions. Larger waves cause increased set-up near the coast which would raise water levels in the basin. Thus the assumption of a lowered water level of 1 m due to seiche in the ISSR report is considered to be very conservative, but due to a lack of further information, is again applied. The minimum 1 in 10^6 year water level for low tide, plus negative surge and seiche, at the 68 % confidence level, and ignoring possible sea level rise, is found to be - 3.17 m MSL.

The maximum run-down due to the tsunami described in Section 8.2 is expected to be -4 m below SWL. If this occurs at lowest astronomical tide (LAT) of -0.81 m MSL the extreme low water level could be -4.81 m MSL.

The SEC Pumphouse is designed to accommodate a minimum short period water level of -2.50 m MSL under normal operating conditions. If the water level drops below this level there will be a reduction in pumping efficiency due to increased head difference across the pumps, and reduced area of flow through the screens. If the sea level drops below -3.5 m MSL no water will reach the pumps.

If in the improbable event of extreme low water levels being so severe that the emergency cooling water demand of about 5 m^3/s cannot be obtained from the sea the necessary cooling will be provided by the application of the procedure described in ***Section 8.3.5***.

8.3.2 Storm Damage

The basin arms are designed on "Zero Percent Damage" criteria (as defined in ***Reference 89***) for the maximum possible wave heights which can exist in the depth of water found at the basin entrance. Damage to the south breakwaters due to wave action during the period up to 1996 has been assessed at 3.8%, which is less than the "zero percent damage" definition of 5% (***Reference 98***). Ongoing monitoring should continue and if damage repair is carried out in the event that damage should exceed 5%, the risk to the structural integrity of the breakwaters will not be increased. The importance of regular monitoring and maintenance is therefore stressed. Damage might be caused if a vessel collided with the breakwaters. However, it is considered that damage to the arms would not jeopardise the availability of water within the harbour. Warning lights have been erected on the harbour arms. Damage to the intake structure in the relatively still water within the harbour is not considered to constitute a safety problem.

8.3.3 Sedimentation

8.3.3.1 General Accretion/Erosion

Regular surveys have indicated that no long term erosion or accretion of the beach or seabed in the vicinity of the cooling water intake basin has occurred, except for the need to carry out minor erosion damage repair on the south side of the basin. The programme of ongoing surveys will continue.

8.3.3.2 Silting up of Basin Entrance

Since commissioning the cooling water system in 1982, regular surveys of the basin have been carried out and the rate of sedimentation in the basin monitored. The infill rate on average has been about 132 000 m^3/a (***Reference 98***) and four main dredging contracts have been carried out to date to remove accumulated sediment from the settling basin.

Based on experience of the operation of the cooling water intake basin it is considered that the possibility of sediment blocking the entrance and preventing the inflow of cooling water is highly improbable.

An excessive accumulation of sediment in the basin would increase the risk of suspended sediments entering the cooling water pumphouse and cooling water system. This would impact on normal power station operation and maintenance but would not threaten the supply of emergency cooling water. A study was undertaken (***Reference 93***) into the long term strategy for maintenance dredging. It was concluded that Koeberg should in the short term acquire limited in-house sand pumping capability. This recommendation is presently being implemented and will improve the ability to manage the basin sedimentation. This would be evaluated with a view to possibly implementing a fixed sand pumping installation in the longer term.

8.3.4 Blockage of Cooling Water Intakes

The front wall of the pumphouse is such that water is drawn below a level of -3.7 m MSL, nevertheless suitable coarse and fine screens prevent a complete blockage of the cooling water intakes by flotsam, fuel oil, marine flora or fauna.

Chlorine used to keep the cooling water system free of marine growth is produced by means of electrolysis. The sodium hypochlorite produced decomposes slowly to release chlorine. Marine growth at the pumphouse intakes has been a maintenance problem owing to deficiencies in the chlorination system. The chlorination system operation requires attention to ensure the control of marine growth and the minimisation of risks to cooling water inflow.

The intakes of the SEC Pumphouse were designed to minimise the possible ingestion of sand. The cooling water intake basin is dredged to a depth of -7.5 m MSL for a distance of 75 m in front of the pumphouse, ie, deeper than the remainder of the basin which is dredged to -6.0 m MSL. The level of the bottom of the opening to the intake is -5.2 m MSL. The floor of the pumphouse slopes towards the sea in the vicinity of the intakes to further minimise the possibility of sand saltating along the floor towards the pump intakes. In practice, however, accumulation of sediment immediately in front of the pump house has occurred. To ensure that this sand is removed frequently enough to permit normal operation of the intake, as designed above, Eskom intends procuring appropriate in-house sand pumping equipment shortly to address this issue. In the event of ingestion of sand the pumps can cope with concentrations of suspended sand up to 50 parts per million which is considered an extreme limit considering the intake flow velocity of about 0.14 m/s.

An oil spill contingency plan is at an advanced stage of preparation. As part of this work, an oil boom has been procured for deployment in front of the pumphouses in the event of an oil spill entering the basin. This provides an additional safety measure to keep oil away from the intakes. There is an upper limit to conditions under which the oil boom is effective in restraining a floating oil slick. The depth of the intake of the SEC pumphouse is below -3.75 m MSL, which also has the purpose of excluding oil floating at the water surface.

A study into the possible effect of liquefaction of the revetted slope adjacent to the pumphouses, with respect to blocking the pumphouse intakes, led to the conclusion (***Reference 98***) that such a possibility was too unlikely to require further consideration.

Alternative cooling arrangements (see ***Section 8.3.5***) will ensure core cooling in the unlikely event that the system provided to clear the coarse and fine screens is overwhelmed, or if the intakes are blocked by sediment.

8.3.5 Alternative Heat Sink

Studies by Electricité de France (EdF) have led to a procedure titled "Total Loss of Heat Sink" (Procedure HI) in which the total loss of the RRI system (Component Cooling System) and SEC System (Seawater Cooling System) are addressed.

Koeberg Nuclear Power Station has developed its own procedures based on this EDF procedure and these address a general case of loss of heat sink and a particular case of loss of heat sink due to oil pollution.

These two procedures are respectively:

1. KWB - I. RRI 7/SEC - Loss of RRI and/or SEC
2. KWB - I. Oil - Ingress of oil into sea water intake

These procedures consider the loss of heat sink at all reactor states as well as addressing the cooling of the spent fuel storage pools.

As these procedures have proved acceptable it is concluded that there is no need now or in the future for an alternative heat sink at Koeberg Nuclear Power Station and although provisions for connecting an alternative water supply into the RRI (Component Cooling System) have been provided they will not be utilised.

8.4. SEA TEMPERATURES

The results given below are based on an analysis of sea water temperatures recorded at the cooling water intake (1 January 1987 to 31 December 1994) and a review of the results of the mathematical model on which the ISSR report was based.

The intake temperatures for various return periods obtained from the recorded temperatures are given in ***Table T-8.1*** and ***Figures F-8.3*** and ***8.4***.

The recorded average daily intake temperatures have been found to be less than the predicted average daily temperatures given in the ISSR report.

The percentage exceedance of average daily temperature, see ***Figure F-8.2***, as well as the intake temperatures for various return periods obtained from the recorded temperatures are given in ***Reference 98***.

The original predicted intake temperatures were found to be conservative when compared to the results of the analysis of recorded data. The recorded data (95% confidence limit) gives the 1:100 year temperature as 19.03 °C when compared with 28.10 °C given previously.

A considerably lower 1 in 1 year (95% confidence level) extreme value of 16.38 °C is obtained from the records compared with the previous "maximum annual intake temperature" of 22.0.°C. When extrapolated the present analysis gives the 1:10 year intake temperature as 18.09 °C and the 1:100 year intake temperature as 19.03 ° C.

The ISSR report states that a shut down of the reactor will be necessary if the intake temperature exceeds 23 °C. The recorded data gives the return period of a temperature exceeding 23 °C as 1:170 000 years.

TABLE T-8-1
SUMMARY OF EXTREME VALUES

Component	Units	WHP 1980		WPR 1997	
		Best fit	Upper confidence limit	Best fit	Upper confidence limit
Return period 1 in 1 year					
Significant wave height	m	7.10		6.68	6.75
Wave set-up	m	1,04		0.95	1.03
Wave run-up	m	0.51		0.46	0.50
High tide plus positive surge	m MSL	1.32		1.40	1.41
High tide plus surge, set-up and run-up	m MSL	2.87		2.81	2.94
Low tide plus negative surge	m MSL	-0.91		-1.02	-1.02
Intake water temperature			22.00	16.19	16.38
Return period 1 in 10 years					
Significant wave height	m	8.50	11.00	8.36	9.01
Wave set-up	m	1.22	1.61	1.22	1.33
Wave run-up	m	0.54	0.60	0.05	0.58
High tide plus positive surge	m MSL	1.42	1.54	1.70	1.76
High tide plus surge, set-up and run-up	m MSL	3.18	3.75	2.97	3.67
Low tide plus negative surge	m MSL	-0.97	-1.05	-1.32	-1.32
Intake water temperature			25.10	18.09	18.09
Return period 1 in 100 years					
Significant wave height	m	10.00	14.70	10.03	11.25
Wave set-up	m	1.46	2.16	1.50	1.70
Wave run-up	m	0.59	0.70	0.62	0.65
High tide plus positive surge	m MSL	1,49	1.72	1.80	1.92
High tide plus surge,set- up and run-up	m MSL	3.54	4.58	3.92	4.27
Low tide plus negative surge	m MSL	-1.01	-1.71	-1.48	-1.49
Intake water temperature			28.10	18.77	19.03
Return period 1 in 1 000 000 years					
Significant wave height	m	14.60	27.80	16.60	20.10
Wave set-up	m	2.13	4.16	2.50	3.10
Wave run-up	m	0.70	1.13	0.75	0.85
High tide plus positive surge	m MSL	1.64	2.30	2.70	3.02
High tide plus surge, set-up and run-up	m MSL	4.47	7.59	5.95	6.97
Sea level rise to 2030	m			0.40	0.60
High tide plus surge, set-up and run-up	m MSL			6.35	7.57
Low tide plus negative surge	m MSL	-1.09	-1.53	-2.12	-2.17
Seiche amplitude	m	-1.00	-1.00	-1.00	-1.00
Low tide plus negative surge and seiche	m MSL	-2.09	-2.53	-3.12	-3.17
Tsunami run-up		2.25		4.00	
HAT				1.20	
Tsunami run-up plus HAT				5.20	
Tsunami run-down				-4.00	
LAT				-0.81	
Tsunami run-down plus LAT				-4.81	
Intake water temperature				24.05	24 .95

Confidence limits used for waves and water levels 68%

Confidence limits used for temperatures and water levels 95%

FIGURE F-8-1
EXTRAPOLATION OF SIGNIFICANT WAVE HEIGHT BASED ON KOEBERG WAVE DATA RECORDS

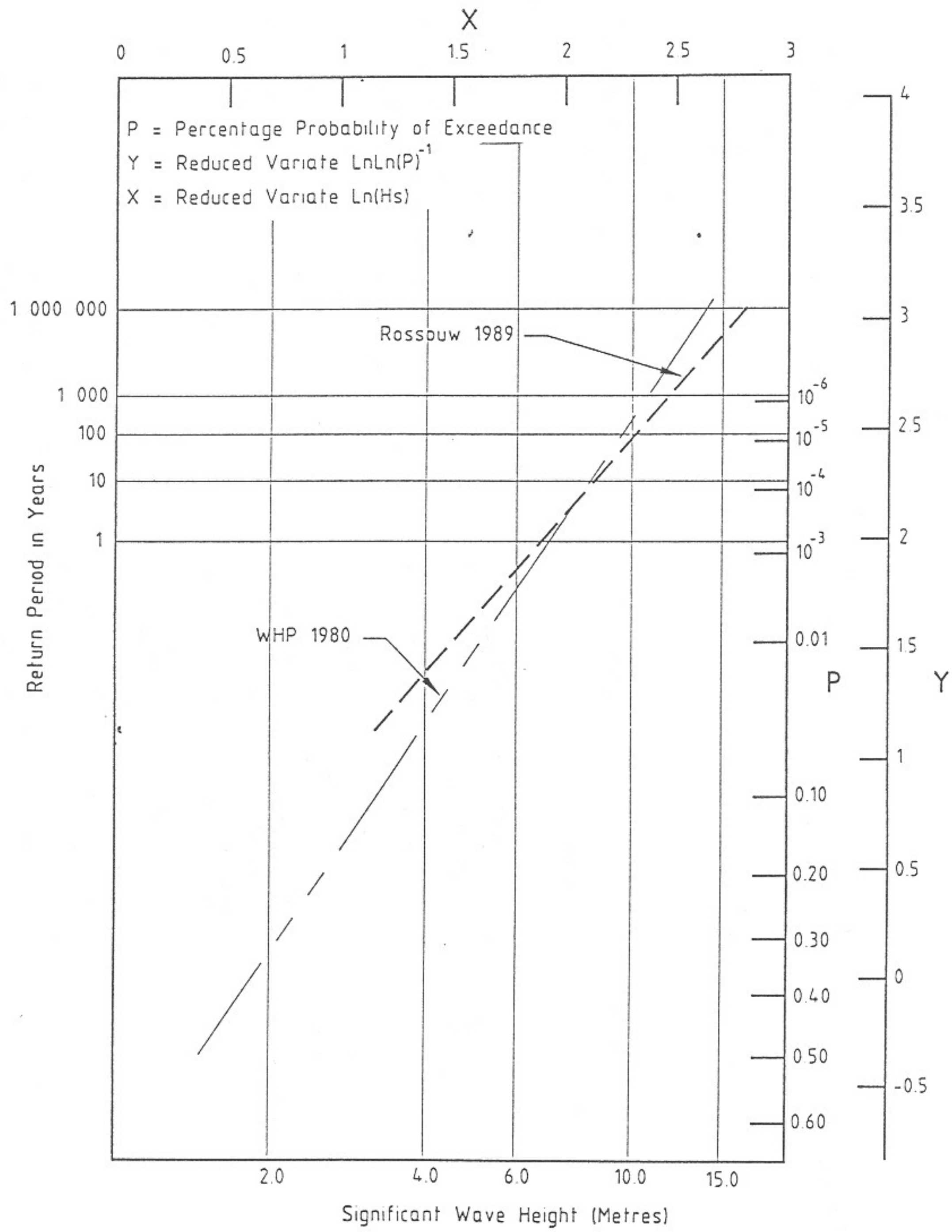


FIGURE F-8-2
EXCEEDENCE OF DAILY AVERAGE INTAKE TEMPERATURES MEASURED DATA

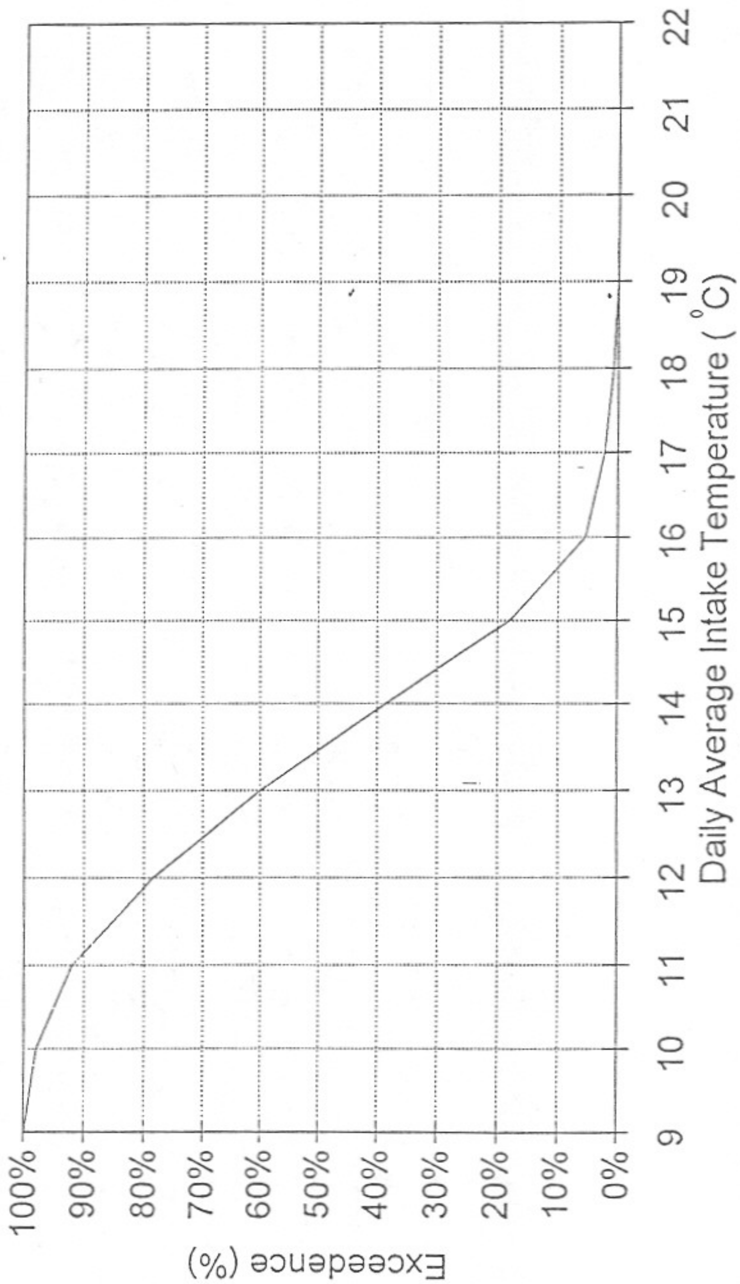


FIGURE F-8-3
REGRESSION FIT OF EVENT DATA

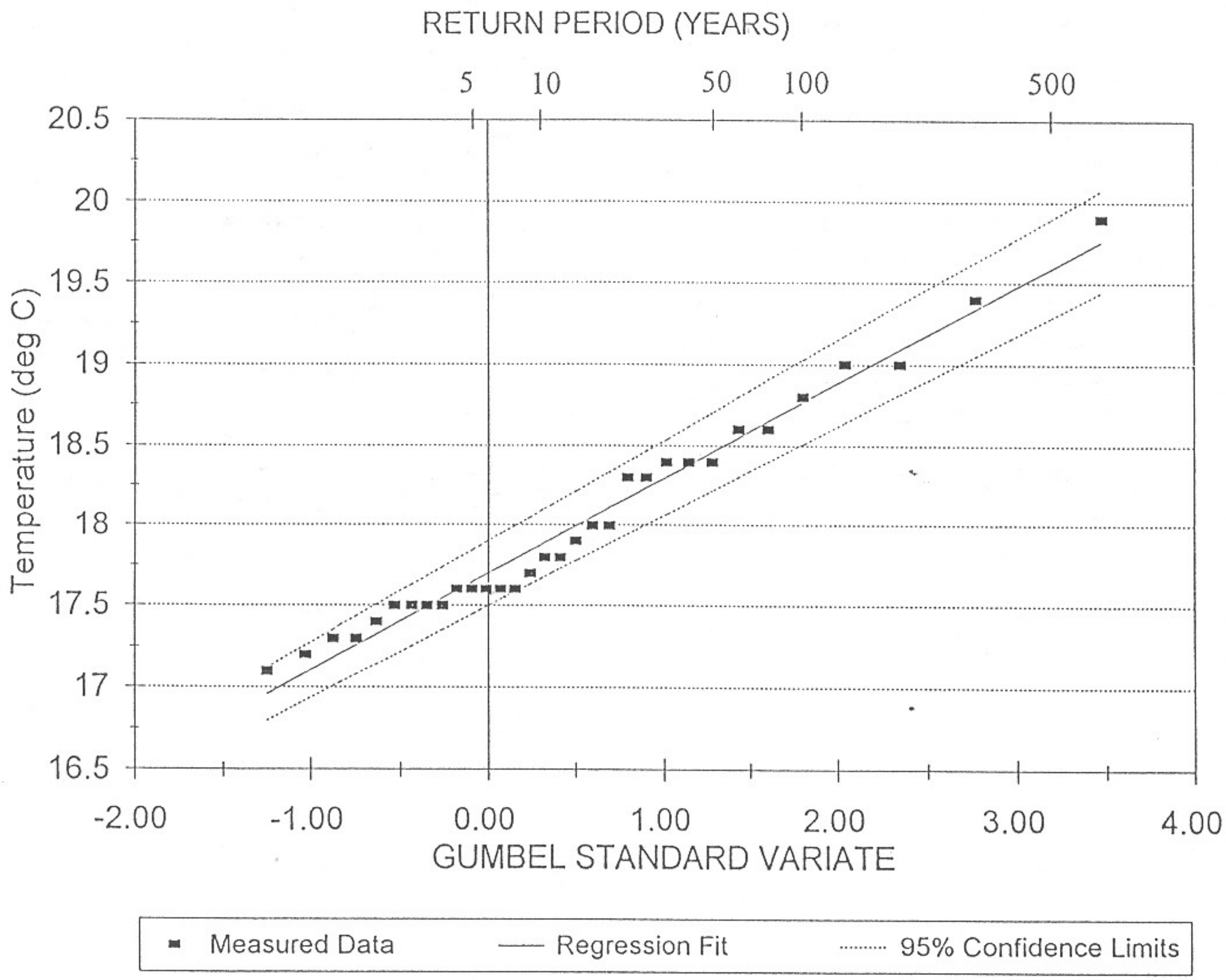


FIGURE F-8-4
EXTREME VALUES FOR INTAKE TEMPERATURE

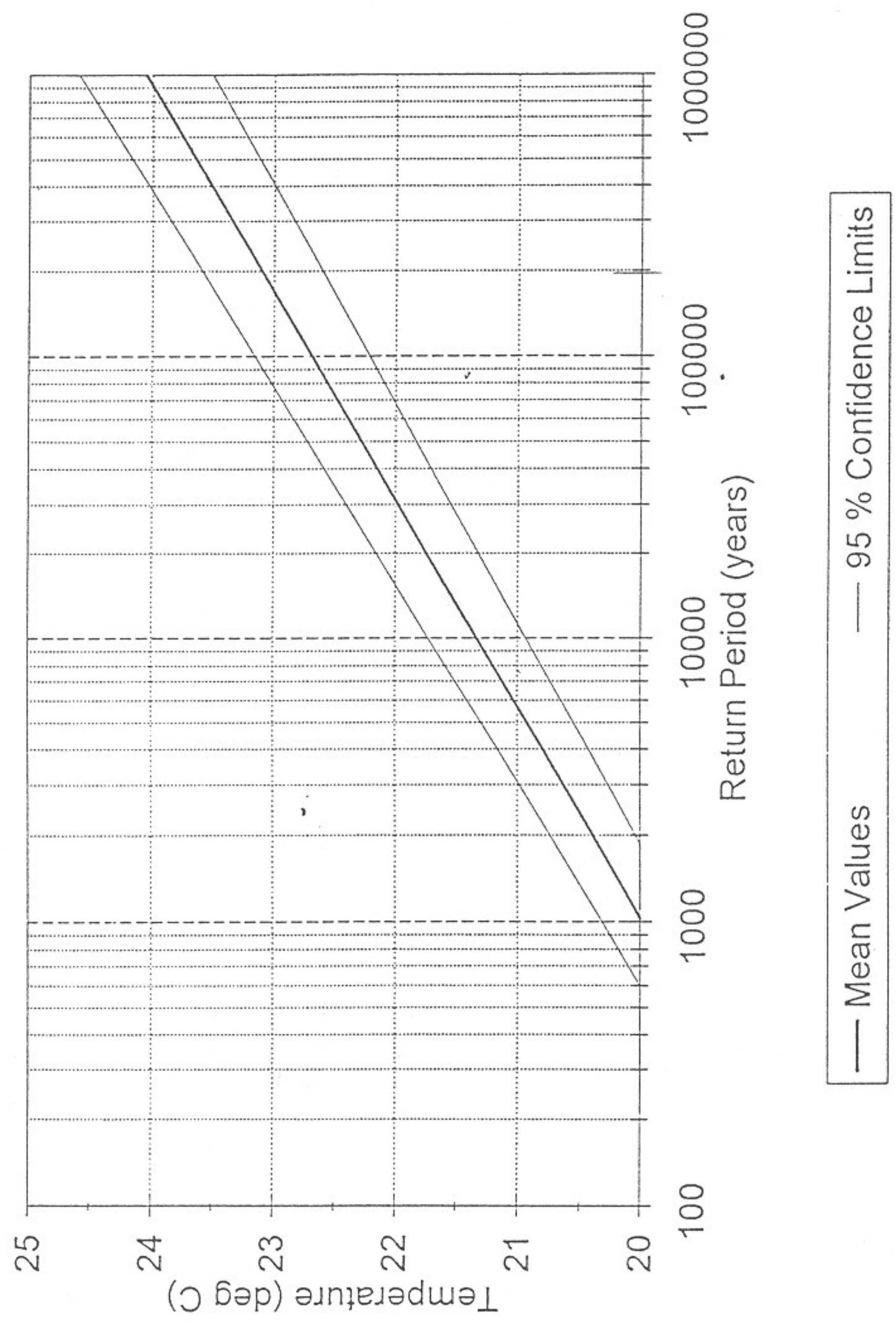
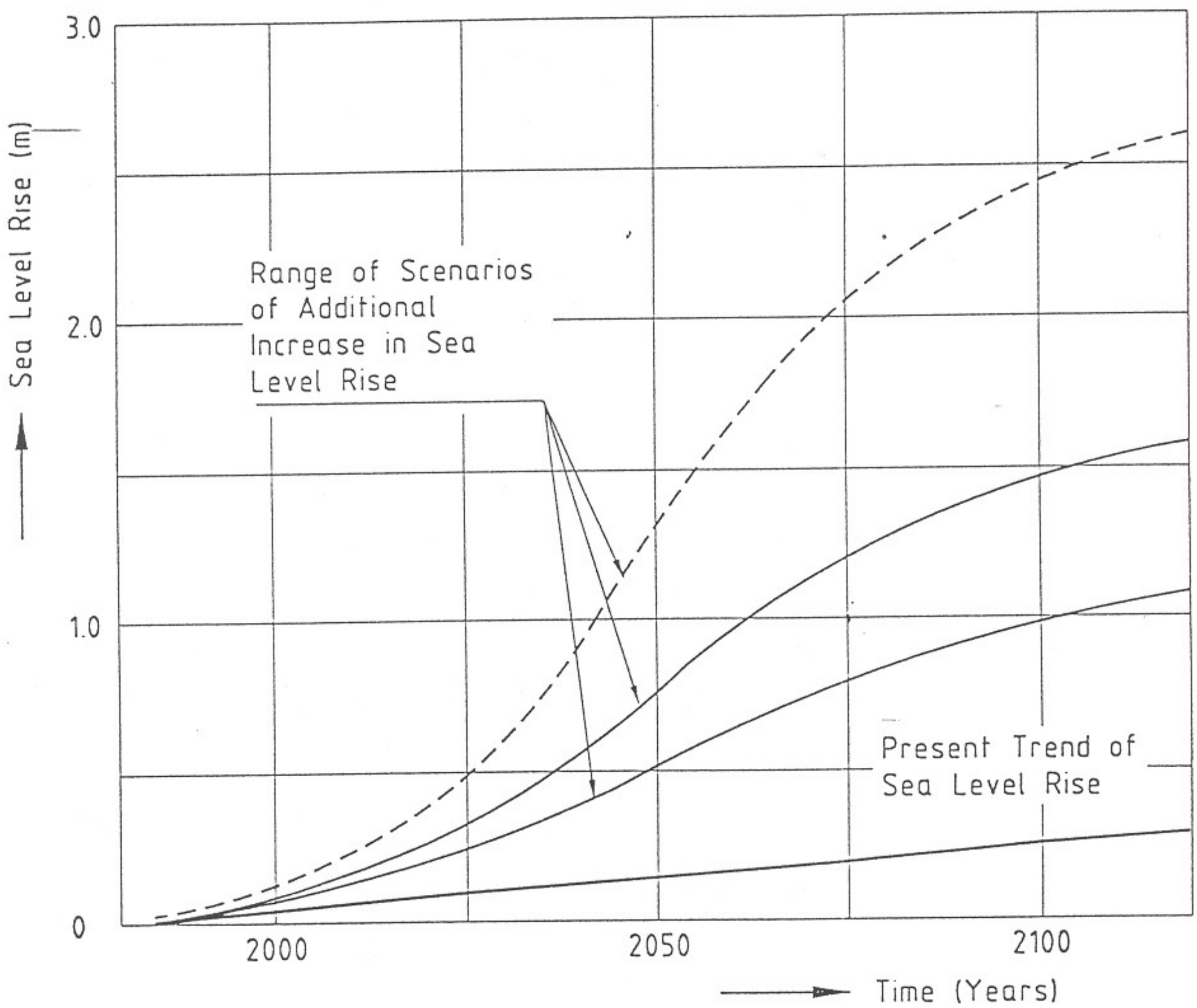


FIGURE F-8-5
SUGGESTED FUTURE INCREASES IN SEA LEVEL
(AFTER PRINS et al 1986)



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