CERP Guidance Memorandum

South Florida Water Management District – Jacksonville District, U.S. Army Corps Of Engineers

CGM NUMBER-REVISION: 016.00

EFFECTIVE DATE: 05/27/2004

CATEGORY: General

SUBJECT: Sea Level Rise Considerations for Formulation and Evaluation of CERP Projects

DESCRIPTION: Future sea level rise should be a formulation and performance consideration for all CERP components and features. Sea level rise refers to the rise in sea level along coastlines and in estuaries and the apparent rise in ocean surface when compared to a stable landmark. The linear trend at a coastal location is primarily a combination of the global sea level rise and any local vertical land movement. Possible causes of sea level rise include global warming, subsidence, erosion and geomorphological actions. This guidance only addresses issues potentially arising from global sea level rise and its possible impact on the performance of the CERP components and operations.

The most widely forecasted effects of future sea level rise are inundation, erosion, increased flooding, and saltwater intrusion. Flooding would increase because storm surges would have higher bases to build upon (Kana et al. 1984; Leatherman 1984) and because rainwater would drain more slowly (Titus et al. 1987). The salinity of estuaries and aquifers would increase, threatening water supplies and aquatic life (e.g. Hull and Titus 1986; Williams 1989). Landward displacement of the salt- and freshwater interface may be large. It would be reasonable to expect that current problems of saltwater intrusion into groundwater supplies will be increased with only relatively small rises in sea level.

For CERP projects, this CGM provides updated technical information to supplement that contained in the Corps' Planning Guidance Notebook (ER-1105-2-100). ER-1105-2-100 required that a National Research Council (NRC) report on sea level change (Responding to Changes in Sea Level; Engineering Implications, 1987) be used for technical guidance until data that are more definitive become available. Since 1987 additional studies have been conducted and in 1995 USEPA (the lead Federal agency for guiding coastal states on planning for sea level rise) published the report "The

Probability of Sea Level Rise", James G. Titus and Vijay Narayanan. 1995. Washington, D.C.: U.S. Environmental Protection Agency, 186 pp. (EPA 230-R95-008).

Research by the EPA recommends a probability-based projection for eustatic (change in volume of ocean basins) sea level change that can be adjusted to local tide-gauge trends to estimate future sea level at particular locations. The procedure is explained in this CGM. For its publication, the EPA has consulted with a large group of leading experts in the fields of climate variability, oceanography and glaciology to estimate the most probable sea level rise that will likely occur in the future. The scientists that contributed to the EPA estimates were generally experts from the National Academy of Sciences and the Intergovernmental Panel on Climate Change. The report was published in 1995 (Appendix 1). The EPA report provides recent and more definitive guidance, in term of appropriate probability analysis, for sea level rise projections.

Sea Level Rise Considerations in the C&SF Project Restudy

During the Restudy, the sensitivity of the C&SF Project to sea level rise was evaluated with a modeling scenario for the future without plan condition, utilizing a 15 cm (0.5 ft) rise in sea level by 2050. The sea level rise scenario changed the boundary conditions of the South Florida Water Management Model in the Lower East Coast. The South Florida Water Management Model assumptions for the scenario were as follows: specific coastal canals were maintained at higher stages, flood control releases were delayed to allow a higher maintenance level but the water level at which maximum releases were made was not altered, and trigger levels for water supply cutbacks were also raised by 15 cm.

Analysis of this scenario showed that sea level rise had the most impact on the coastal canals and communities with loss of flood protection and saltwater intrusion being the primary impacts. Lower East Coast water supply cutbacks were anticipated to increase significantly as well as regional water deliveries to Lower East Coast service areas. The analysis also showed that coastal ecosystems and estuaries were adversely affected and would require additional deliveries of freshwater to maintain desirable salinity patterns and healthy ecosystems. Performance measures for the interior of south Florida did not appear to be influenced by the sea level rise. This was due to the higher water elevations in the interior regions compared to those found along the coast. This study, titled "Estimated Impacts of Sea Level Rise on Florida's Lower East Coast", was conducted by the SFWMD's Hydrologic Systems Modeling Division (Appendix 2).

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"Formulation of alternative solutions that are more robust and resilient would be one of the desired outcomes of risk sensitivity analysis." Hanchey, Schilling, and Stakhiv (1987) *in Water Resources Planning Under Climate Uncertainty*

GUIDANCE: CERP components should seek to optimize project benefits considering that sea level rise will occur. Although CERP is not responsible for updating existing non-CERP projects, new CERP components and operations should not be adversely affected by sea level rise impacts created by structural or operational changes at existing coastal project features. The U.S. Army Corps of Engineers normally requires their projects to be designed for a fifty (50) year project life (ER 1105-2-100, page F-21). At the present time, the year 2000 is the existing condition and year 2050 would be the future with project condition. As CERP projects are implemented over time, the base and future conditions will change. The same procedure outlined in this guidance applies such that project delivery teams (PDTs) would have to make a linear interpolation calculation to obtain the normalized values for years other than those provided in Table 2.

A sensitivity analysis should be conducted, as a minimum, to determine what effect (if any) changes in sea level would have on a project's selected alternative plan. PDTs in coastal areas should give consideration to sea level rise in their final array of alternatives, particularly if the PDT believes sea level rise may be a substantial or significant factor affecting plan performance. Whatever the course of action by the PDT, the analysis should be based, as a minimum, on the procedure explained in this CGM.

Estimating Future Sea Level Rise

Historic rates of sea level rise at various locations in the United States with geographic significance to the study area are shown in Table 1. Normalized sea level projections for 2025, 2050 and 2100, compared with 1990 levels, are shown in Table 2. The normalized projection estimates represent the projected acceleration in sea level compared with historic trends due to the greenhouse contribution.

Table 1- Historic rate of sea level rise at some NOAA stations in Florida.

Atlantic Coast			Gulf Coast		
NOAA station name	Rate of sea level rise (mm/yr)	Stan-dard error	NOAA station name	Rate of sea level rise (mm/yr)	Stan-dard error
Fernandina Beach	2.04	0.12	Key West	2.27	0.09
Mayport	2.43	0.18	Naples	2.08	0.43
Miami Beach	2.39	0.22	Ft. Meyers	2.29	0.45
-----	-----	-----	St. Petersburg	2.40	0.18
-----	-----	-----	Cedar Key	1.87	0.11
Source: Sea Level Variations for the United States1854-1999, National Oceanic and Atmospheric Administration Technical Report NOS CO-OPS 36, National Ocean Service, Silver Spring, MD, Chris Zervas, 2001. Additional stations may be found at http://co-ops.nos.noaa.gov/publications/techrpt36doc.pdf .					

Table 2- Normalized sea level projections for 2025, 2050 and 2100, compared with 1990 levels

Cumulative probability (percent)	Exceedence frequency (percent)	2025 (cm)	**2050 (cm)**	2075 (cm)	2100 (cm)
10	90	-1	-1	0	1
20	80	1	3	6	10
30	70	3	6	10	16
40	60	4	8	14	20
50	50	5	10	17	25
60	40	6	13	21	30
70	30	8	15	24	36
80	20	9	18	29	44
90	10	12	23	37	55
95	5	14	27	43	66
99	1	19	35	57	92
Mean		5	**11**	18	27
Standard deviation		6	10	15	23
NOTE: The normalized estimates represent the projected acceleration in sea level compared with historic trends due to the greenhouse contribution.					

To estimate sea level rise at a particular location, the historic sea level rise is added to the projected rise that would occur if current trends were to continue. For example, the historic rate of sea level rise at Miami Beach is 2.39 mm per year (Table 1). Under current trends, sea level will rise 14 cm between 1990 and 2050 (2.39 mm/yr x 60 yr x 1/10 cm/mm). Adding this 14 cm to the normalized values in Table 2, the mean estimate for 2050 is 25 cm (14 cm computed using Table 1 + 11 cm from Table 2), with a one percent chance of a 49 cm rise (14 cm computed using Table 1 + 35 cm from Table 2), and a 50 percent chance that sea level will rise at least 24 cm (14 cm computed using Table 1 + 10 cm from Table 2) or **0.8 ft** which reflects an expected future sea level trend of 0.013 ft/year during the 1990 to 2050 period**.**

Since the historic sea level trends in Table 1 include the local vertical land motion, the PDTs are advised that there is no need to adjust the estimated sea level rise to include historic vertical land motion unless there is strong evidence that the historical rate in vertical land motion has increased or decreased. No recent reports have been published, to our knowledge, indicating that the historic rate of vertical land motion in Florida is increasing or decreasing. The PDTs are not precluded from formulating for other sources of sea level rise such as erosion and geomorphological actions.

Table 3 shows the probability distribution for Miami Beach for years 2025, 2050, and 2100. PDTs should compute and use the probability distribution for their particular area to conduct their sensitivity analyses to determine what effect (if any) changes in sea level would have on plan evaluation and selection.

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Table 3- Probability distribution of sea level rise for Miami Beach for years 2025, **2050**, 2075, and 2100.

Percent chance exceed-ence	2025		**2050**		2075		2100	
	cm	ft	cm	ft	cm	ft	cm	ft
90	7	0.2	13	0.4	20	0.7	27	0.9
80	9	0.3	17	0.6	26	0.9	36	1.2
70	11	0.4	20	0.7	30	1.0	42	1.4
60	12	0.4	22	0.7	34	1.1	46	1.5
50	13	0.4	24	0.8	37	1.2	51	1.7
40	14	0.5	27	0.9	41	1.4	56	1.8
30	16	0.5	29	1.0	44	1.5	62	2.0
20	17	0.6	32	1.1	49	1.6	70	2.3
10	20	0.7	37	1.2	57	1.9	81	2.7
5	22	0.7	41	1.4	63	2.1	92	3.0
1	27	0.9	**49**	**1.6**	77	2.5	118	3.9
Mean	13	0.4	**25**	**0.8**	38	1.3	53	1.7

Most-Probable Scenario[1]

PDTs should conduct sensitivity analyses that are appropriate for the most-probable rate (formerly referred as to "low level") in sea level rise. Although limited by time and funding constraints, PDTs, at a minimum, should consider and address in their design operational flexibility to minimize the possible effects that would be caused by the most probable scenario of sea-level rise. From the procedure outlined above, the most-probable scenario is obtained by computing the **mean** value of projected sea-level rise.

[1] ER 1105-2-100 directs the Corps of Engineers to consider the "most-probable" and "worst-case" sea level rise scenarios. The CERP program is requesting an exception to the "worst-case" scenario in the Programmatic Regulations Guidance Memorandum for instructions for formulation and evaluation of alternatives developed for Project Implementation Reports.

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System-wide Sea Level Rise

For the south Florida system, the stations with the longer sea-level records are Key West (87+ years) and Miami Beach (51+ years). When applying the above-mentioned procedure, the projected sea-level rise for 2050 is 0.81 ft for Key West and 0.83 ft for Miami Beach, or in essence, a **0.8 ft rise** for the region. Therefore, a value of 0.8 ft should be used when considering the most-probable sea level rise for system-wide analyses. In fact, Table 3 above can reasonably be used as the sea level rise probability distribution for system-wide and project considerations. RECOVER's system-wide analyses of projects using computer models, should use this value.

Considerations

As discussed previously, the following operational changes are expected at existing coastal structures during the projected most-probable sea level rise scenario performed for the Restudy (0.5 ft): (1) coastal canals would have to be maintained higher, (2) trigger levels for water supply cutbacks would have to be raised, and (3) fresh-water deliveries to estuaries and coastal ecosystems to manage saltwater intrusion would have to be increased. One of the primary objectives of the CERP is to reduce fresh-water discharges to tide in order to make more freshwater available for the natural system.

As the above apply to their projects and in view of the projected conditions, the PDTs, at a minimum, should:

1. consider design tailwater conditions (water surface elevations immediately downstream) at coastal structures and possible higher interior stages
2. consider the most-probable sea level rise scenario in the performance of their project as a consideration in choosing the selected alternative plan
3. consider which designs and operations are most appropriate for the most-probable sea level rise scenario
4. when applicable, address whether the alternatives selected for restoration of more natural patterns of water delivery to the estuaries would achieve project objectives (such as improved/better salinity gradients).

For system-wide evaluations, RECOVER, at a minimum, should:

1. Conduct sensitivity analyses on the 2050 future without plan condition and the 2050 future with plan condition, using the most-probable (0.8 ft) sea level rise projection; the results of these analyses will be provided to the project teams
2. Consider which system-wide operational measures are most appropriate for the most-probable sea level rise scenario
3. Consider operational measures that mitigate the projected effects on flood protection and water supply as sea level rises
4. Address the question of whether the flood protection and water supply system will be adequate or need to be modified in the future because of sea level rise
5. When applicable, address whether the alternatives selected for restoration of more natural patterns of water delivery to the estuaries would achieve project objectives (such as improved/better salinity gradients).

APPLICATION: Effective the date of this memorandum, PDTs will utilize this guidance when preparing Project Management Plans. The PDTs will also utilize this guidance when conducting plan formulation and evaluation during the PIR phase of a CERP project as follows: (1) at a minimum, the selected alternative plan should be evaluated with consideration of sea level rise; (2) the PDTs should decide if sea level rise considerations should be given to the final array of alternatives being considered, particularly when the PDT believes that sea level rise may be a major factor that could substantially or significantly affect plan selection and costs.

This CGM does not apply, however, to PDTs who have gone already through the alternative selection process. Those PDTs were required to use ER-1105-2-100. This CGM will be revised as more current information becomes available.

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