GEOLOGICAL REVIEW OF DOCUMENTS PERTAINING TO THE REOPENING OF PACKERY CHANNEL, NORTH PADRE ISLAND, TEXAS

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Introduction

This summary report was prepared at the request of the General Land Office as part of a review of documents pertaining to the proposed reopening of Packery Channel on North Padre Island, Texas. The principal purpose of the review was to determine if geological issues were adequately addressed in the environmental assessment report prepared by Shiner, Moseley and Associates, Inc. (1987), hereinafter referred to as SMA (1987).

The analysis of potential environmental impacts of the proposed channel by SMA (1987) relies heavily on hydrodynamic, bathymetric, and sedimentological data collected at the Mustang Island Fish Pass (Watson and Behrens, 1976; Behrens and others, 1977). When it was dredged in 1972, the Fish Pass was approximately 8 ft deep and 60 ft wide at the bottom of the channel. During the first few years of operation, it had an equilibrium cross-sectional area of about 1,000 ft^2 (Watson and Behrens, 1976, p. 36). As currently designed, reopened Packery Channel would have a bottom width of 140 ft, a depth of 10 ft, and 3:1 sloping sides that would provide an effective cross-sectional area of about 1,700 ft^2 (SMA, 1987, p. II.3), or nearly twice the cross-sectional area of the Fish Pass.

Five of the most significant geological and hydrological issues involving a dredged channel across North Padre Island are: (1) general water circulation, (2) storm flooding, (3) shoaling of the dredged channel, (4) shoreline erosion, and (5) potential effects on the stability of Aransas Pass. Because of the complex nature of coastal processes in the area, most of these issues are partly interrelated, but they are listed separately for purposes of discussion.

General Water Circulation

Broadly generalized statements repeated throughout the SMA assessment (1987, p. II.18; III.4; V.21) suggest that finger canals of the Padre Isles development would periodically be flushed and water quality improved if Packery Channel were reopened, but no evidence is presented to support these conclusions. The entire finger canal network at Padre Isles has few interconnections, and this limited water-exchange pattern prevents currents from establishing a fully integrated loop that would allow equal circulation and mixing in all cells. The number of dead-end channels, sharp bends, and great distances from the planned connection with Lake Padre make thorough flushing of the canal system improbable. The most likely scenario involves selective tidal action and flushing in only some of the canals because most of the tidal flow would follow the least resistant path depending on such factors as hydraulic gradient between the Gulf and Laguna Madre, wind direction, and wind strength.

Greatest potential for canal flushing would occur during Gulf storms when water flowing through the seagate into Lake Padre would substantially increase water levels, current velocities, and wave action in the canals. However, current velocities and waves significantly higher than existing ones would not be desirable if bulkheads lining the canals were not designed to withstand lateral loads and shear stresses attendant with high-energy processes (SMA, 1987, p. III.15).

Proposed plans also call for periodically closing the seagate at high tide to hold water in Lake Padre and opening the gate at low tide to assist in water exchange between Lake Padre and the finger canals of Padre Isles. If these conditions cause water to rapidly exit Lake Padre as described (SMA, 1987, p. II.10), then the outflow from Lake Padre could create a hazard to navigation near the intersection of Lake Padre and Packery Channel.

Storm Flooding

Preliminary modeling by SMA (1987, p. V.7) suggests that maximum flood elevations impinging on North Padre Island and the adjacent mainland by major hurricanes would not significantly increase if Packery Channel were to be reopened. This prediction appears to be reasonable because the dunes on Mustang and North Padre Islands are already breached at Packery Channel, Newport Pass, and Corpus Christi Pass, which serve as washovers during large storms. Despite this favorable impact analysis, it appears that at least four other important flood-related issues have not been adequately addressed, namely the potential for increased backbarrier flooding by storms of moderate size, the timing of major Gulf flooding events, a possible backwater effect created by the development, and possible impact on Park Road (PR) 53.

Storm hydrographs - The sand flats of Packery Channel prevent storm waters from flowing across North Padre Island and directly into Laguna Madre until water levels reach an elevation of about 4 ft above mean sea level (SMA, 1987, p. V.5, V.6). However, if Packery Channel is opened as proposed, then the flood protection provided by the land elevation would be lost and surges of less than 4 ft would be able to enter Laguna Madre and Corpus Christi Bay directly. Current plans provide for an open seagate during storm approach to allow safe passage for boats entering the Harbor of Refuge. This configuration would also allow storm forerunners to increase water elevations in Packery Channel, Lake Padre, and possibly Padre Isles development long before storm landfall.

If Packery Channel is reopened, important consequences of the lost barrier protection would be increased water elevations and inundation of areas that are currently emergent during storms of moderate size. For example, minor backbarrier and bay flooding associated with Hurricane Gilbert

(1988) probably would have been greater if Packery Channel had been open, allowing water to flow into the bay, while the storm was in the Gulf of Mexico.

The SMA report (1987, p. V.5, V.7) repeatedly refers to the PR 53 bridge over Packery Channel as a "throttle" that would act as a choke to prevent additional floodwaters from reaching Laguna Madre. This analysis is somewhat misleading because the cross-sectional area of the channel at the bridge is not constant. The channel width is limited by the bridge abutments; however, the water surface is a free surface and more importantly the channel bottom is a movable bed composed of fine sand. Sand flooring the channel is easily eroded at high velocities that occur during storm flooding, and the scoured channel depths, which partly compensate for the fixed width, provide a larger cross-sectional area. Thus flow rates and therefore total water volume delivered to the back island and bay-margin environments can be increased during major storms. The most recent example of cross-sectional area adjustment occurred during Hurricane Allen (1980), when the channel at the PR 53 bridge eroded to a depth of 20 ft (SMA, 1987, p. II.8, V.5). Flow depths of this magnitude provide a cross-sectional area of about 4,000 ft^2 (SMA, 1987, p. V.5), which is approximately twice as large as the proposed reopened channel.

A related concern is the potential for accelerated flooding associated with an unrestricted channel into Laguna Madre. If Packery Channel is opened, flood waters would reach a given elevation more rapidly because the forerunners would not be blocked by the barrier island. This means that low-lying areas near the channel, such as those below 4 ft elevation, would flood sooner than they do now. Perhaps of greatest concern are the approaches to the JFK Causeway that could be flooded early in the storm cycle, thus substantially decreasing the amount of time available for emergency evacuation of Mustang and North Padre Islands.

Possible retention of floodwaters by development - Proposed plans show that elevations surrounding Packery Channel would be raised above present grade by constructing bulkheads and a perimeter protection structure with 13-ft elevations on the south side of the channel and disposing dredged material on the north side of the channel. Post-construction elevations would increase away from the channel, ranging from 5 ft at the channel bulkhead to 13 ft at the perimeter protection structure (SMA, p. V.6). Such dramatic increases in elevations at the project site could have an adverse effect on flooding by ponding backbarrier and lagoon water and retarding the flow returning to the Gulf of Mexico. The broad sand flats at Packery Channel currently act as a large drain for seaward return of storm floodwaters or as an outlet for water driven to the southeastern margin of Corpus Christi Bay by strong northers in the winter or by hurricanes making landfall to the northeast. Increasing surface elevations at the project site could create a local backwater condition, thereby increasing the time required for floodwaters to subside and placing additional pressure on the carrying capacities of Newport Pass and Corpus Christi Pass.

Possible impact on Park Road 53 - Channel bulkheads tied to the bridge abutment would protect the south side of PR 53; however, it appears that the north side would not receive equal protection. A low, discontinuous breakwater allowing open exchange of water between the channel and wetlands adjacent to PR 53 (SMA, 1987, p. II.4, II.15) would also focus the path of high-velocity storm waters flowing across the road north of the bridge, possibly causing severe damage such as occurred during Hurricane Allen.

Shoaling of Packery Channel

Artificial channels opened to control salinities or to allow migration of aquatic species can function adequately even if they are partly blocked by shoals; however, a channel that is opened explicitly for boat traffic would need to be kept free of large shoals in order to provide continuous safe navigation. The SMA (1987) report does not ignore anticipated needs for periodic dredging to maintain an unrestricted channel, but it does not provide any quantitative data concerning the expected frequency of dredging, sediment volumes, or costs associated with maintenance dredging. Design plans depict a long channel with several bends that extends landward into a shallow body of water (Laguna Madre). Such a design would be somewhat inefficient because of a low hydraulic gradient and considerable friction around bends and the long channel perimeter.

Average wave characteristics and offshore slope along Mustang and North Padre Islands combine to produce an upper shoreface about 2,000 ft wide where three migratory breaker bars are maintained by the interaction of waves and longshore currents. Although much of the littoral drift is transported by traction and suspension in this zone of breaking waves, substantial volumes of sand are stored and transported across the middle and lower shoreface, which extends seaward of the surf zone to depths of at least 30 ft and distances of more than a mile offshore. During major storms the surf zone widens, wave heights increase, longshore currents accelerate, and sediment transport significantly increases along the shoreface. In the western Gulf of Mexico, counterclockwise circulation of hurricane winds drives strong longshore currents to the southwest. These same currents flowing offshore of the Texas coastal barriers entrain enormous volumes of sand that are deposited at channel entrances or other locations where flow conditions abruptly change and velocities decelerate. Aerial photographs show that much of the sand that eventually caused the closing of Mustang Island Fish Pass was transported and redeposited by Hurricane Allen (1980).

Monthly calculations extending over a period of several years demonstrate that gross sediment transport along the Gulf shoreline of Mustang and North Padre Islands ranges between 725,000 and 925,000 yd^3/yr (Behrens and others, 1977, p. 24; Watson and Behrens, 1976, p. 51). Those same estimates consistently demonstrate that the net southwesterly sediment transport is between 66,000 and 80,000 yd^3/yr (Behrens and others, 1977, p. 24; Watson and Behrens, 1976, p. 51). Because the gross longshore transport is more than 10 times the net transport, it is expected that substantial volumes of sand would be carried into the dredged channel and deposited by flood-oriented currents.

The SMA (1987, p. II.10, II.22) analysis uses a net longshore transport value of 70,000 yd^3/yr to estimate the volume of sediment that would be involved in annual maintenance, most of which is attributed to the sand bypass system. This value for longshore transport may be appropriate for calculating minimum transfer volumes but, because of the sandy shoreface and physical processes previously described, it is inappropriate to assume that most of the sand transported in the littoral system would be trapped at the jetties and available for sand bypassing. Sand transported in water depths greater than 10 ft will pass around the jetties unimpeded, and some would be carried into the channel during most tidal cycles. It appears that using net littoral drift instead of gross littoral drift could greatly underestimate average dredging requirements if Packery Channel were to be reopened.

Goldston Engineering (1985) estimated that maintaining a substantially open Fish Pass at Mustang Island State Park would require dredging approximately 45,000 yd^3/yr every 1-2 years at an expected cost of $100,000-$125,000/yr. These estimates are significant because theoretically the Fish Pass should be a more efficient channel because of its location near deep water and its relatively steep hydraulic gradient. Maintenance costs at Packery Channel would involve two separate activities, (1) sand bypassing at the jetties and (2) dredging the channel. Furthermore, average annual costs of maintenance at Packery Channel would probably be greater than those at the Fish Pass because of longer jetties, a larger cross sectional area, and less efficient design at Packery Channel.

Shoreline Erosion

Stability of adjacent Gulf beaches and channel banks is also a critical issue with regard to the environmental impact and efficient operation of the proposed inlet.

Channel banks - It appears that unprotected (unbulkheaded) channel banks would erode along the segment between the PR 53 bridge and the Gulf Intracoastal Waterway (GIWW) (SMA, 1987,

p. V.13) because of increased current velocities during daily tidal cycles and storms as well as superimposed bow waves from increased boat traffic. If channel banks remain unprotected, these processes would probably contribute to maintenance dredging requirements because sand eroded from channel banks and spoil mounds would be deposited in the channel.

Gulf shoreline - As indicated in the SMA (1987, p. V.11) report, historical data show that Gulf shoreline segments near the proposed project are slightly erosional and that shoreline retreat locally increased seaward of the North Padre Island seawall after this structure was built (Morton, 1988). Reopening Packery Channel could also increase erosion of beaches southwest of the project if the littoral drift system and sediment budget were permanently altered in such a way that sand supply would be reduced. A greater deficit in the sediment budget could occur if large volumes of sand are trapped by the jetties or if any Gulf sand deposited in the channel is not returned to the beach.

Whether or not sand impounded by the jetties would influence downdrift beach erosion appears to be adequately addressed by the proposed sand bypass system. As designed (SMA, 1987, p. II.7), a jet pump and pipeline would be used to transfer sand across the channel so that accretion at the jetties would be minimized and no net loss in beach sand would occur. The volume of sand permanently trapped on both sides of the jetties as a result of wave refraction and reversing littoral currents would probably extend about 2,000 ft away from the channel on the south side and therefore would not appreciably benefit the beach in front of the seawall, despite statements to the contrary (SMA, 1987, p. II.7, II.10). Nourishment of the North Padre Island beach using about 250,000 yd^3 of sand dredged from the sand flats during initial channel construction (SMA, 1987, p. III.5, V.12) would partly compensate for the loss of sand permanently trapped by the jetties. If, however, more sand is trapped by the south jetty than indicated in the assessment, then this material would represent a net loss to beaches on Padre Island farther southwest. Some method would need to be devised to restore that sand to the littoral drift system beyond the wave shadow zone created by the jetties.

Clearly the seawall segment would experience additional beach erosion if not periodically nourished because it is located on the net downdrift side of the jetties and it is already eroding. Moreover, a reopened Packery Channel is expected to act like a typical unbarred artificial inlet. Beaches near unbarred inlets along the Texas coast accrete on the updrift side and erode on the downdrift side except for the local shoreline curvature immediately adjacent to the downdrift jetty (Morton, 1977).

Potential Effects on Aransas Pass

The natural tidal inlet at Packery Channel closed shortly after Aransas Pass was deepened and widened to accommodate Corpus Christi Ship Channel. Packery Channel became more inefficient and shoaled primarily because the enlarged Ship Channel captured the tidal prism that normally flowed into and out of Corpus Christi Bay through Packery Channel (Collier and Hedgpeth, 1950; Price, 1952). Conversely, a reopened Packery Channel could decrease discharge and therefore increase shoaling in Aransas Pass and the adjacent Ship Channel if sufficient tidal prism now flowing through Aransas Pass were diverted through Packery Channel.

Records kept by the Corps of Engineers show that annual maintenance dredging requirements at Aransas Pass did not increase during the 10-yr period when Mustang Island Fish Pass was open (J. Moseley, personal communication, 1988). However, this is insufficient evidence to prove conclusively that the effects of Packery Channel also will be negligible because the Fish Pass was specifically designed to avoid any interference with Aransas Pass (Behrens and others, 1977, p. 18). Furthermore, the Fish Pass began shoaling shortly after it was opened, and the average volume of water it carried diminished throughout its brief history.

Current plans for Packery Channel call for a larger, much more efficient channel that will be kept open by periodic dredging and therefore will handle more tidal flow than did the Fish Pass. The critical element that needs to be addressed is the long-term balance in water volume between ebb and flood cycles. Seasonal and short-term meteorological or astronomical conditions can favor either dominant flood discharge into the bays (strong onshore winds, Gulf storm surges, spring tidal phase) or dominant ebb discharge into the Gulf (strong offshore winds, riverine floods, neap tidal phase). Natural inlets of the Texas coast are largely ebb dominated because rivers emptying into the bays contribute a surplus of water to the hydrologic system in addition to that exchanged during a normal tidal cycle.

Long-term net outflow (ebb dominance) at Packery Channel would decrease discharge through Aransas Pass and probably cause an increase in shoaling because of attendant lower velocities in the Ship Channel. Conversely, long-term net inflow (flood dominance) at Packery Channel, similar to that experienced at the Fish Pass, would have the opposite effect and therefore would increase discharge through Aransas Pass.

Qualitative Comparison of Scenarios

Uncertainty about the long-term behavior of a reopened channel and its influence on surrounding environs requires identifying reasonable but opposite scenarios and comparing their positive or negative characteristics. Such an analysis focuses on extreme conditions so that perhaps a balance among competing factors, or a compromise, can be achieved. The following general observations are offered for clarification of competing uses and expected impacts of the proposed project.

• Attempts to improve water quality in finger canals of Padre Isles by increasing circulation carry a risk of increased flooding and strong currents during storms. Conversely, minimizing the tidal exchange between Lake Padre and Padre Isles canals would also minimize the flushing action and potential for improving degraded conditions.

• Improving the efficiency of Packery Channel to minimize shoaling and possible ponding of floodwaters also increases its ability to transport storm waters into Lake Padre and Laguna Madre.

• Seagate operation during hurricanes would control boat access to the Harbor of Refuge as well as control flood elevations in Lake Padre and adjacent Padre Isles canals. Early closure would provide maximum flood protection to the development while denying safe entry to boats. On the other hand, maintaining an open gate during storm approach would leave the development vulnerable to increased flooding.

• Erecting a perimeter protection structure and raising surface elevations on adjacent property for commercial development would probably cause ponding of floodwaters in proportion to the increase in elevation above natural grade.

• Effective interception of littoral drift by the jetties would minimize channel shoaling, but it would also greatly increase demands on the sand bypass system. Conversely, if large volumes of sediment were transported alongshore seaward of the jetties, then high rates of channel shoaling would result.

• Long-term net inflow (flood dominance) at Packery Channel would cause additional net outflow through the Ship Channel at Aransas Pass, but it would also contribute to significant shoaling of Packery Channel.

RECOMMENDATIONS FOR ADDITIONAL DOCUMENTATION

The following list summarizes specific issues that need further discussion, clarification, or analysis to ensure that reopening Packery Channel would not create undesirable or unanticipated effects. These recommendations for further documentation are made considering the preceding review as well as the "Guidelines for Environmental Impact Statement" previously prepared by the General Land Office. Numbered items in the following list refer to those in the "Guidelines for Environmental Impact Statement."

- Expand the discussion of item 4 to include impacts of Packery Channel on circulation and salinity in Padre Isles finger canals, and provide data to substantiate the predicted improvement in water quality.
- Evaluate potential impacts of storm flooding on the Padre Isles finger canals, focusing especially on efforts to minimize destructive currents, waves, and water levels in the canal system.
- Simulate the impoundment and release of water from Lake Padre and evaluate the turbulence and velocities expected near the seagate where Lake Padre and Packery Channel would intersect.
- Using the design storm parameters (SMA, 1987, p. V.59), prepare synthetic storm surge hydrographs for several sites (such as Padre Isles finger canals, Flour Bluff segment of the JFK Causeway, intersection of Packery Channel and GIWW) comparing the predicted rise in water levels under present-day conditions with those expected if Packery Channel were reopened.
- Calculate the projected changes in hydraulic radius at Packery Channel considering the present width, elevation, and slope of the sand flat as compared to the proposed post-construction topography (channel, walkways, landfill, and perimeter protection structure). Then, using the design storm parameters, simulate flooding and runoff scenarios at Packery Channel and evaluate the potential for retarding reflux of storm waters by the project.
- Expand the discussion of item 6 to include effects of the segmented breakwater on storm flow impinging on the north side of PR 53.
- Clarify discussions of annual maintenance requirements by separately identifying predicted sediment volumes and costs for (1) operating the sand bypass system and (2) periodically dredging the channel. Justify the use of net drift for estimating maintenance requirements. Discuss the margin of error in the maintenance cost estimates considering the fact that net drift is less than 10 percent of gross drift.
- Expand discussions of item 5 to include contingency plans if long-term average volumes of sand trapped by the jetties and deposited in the channel exceed 70,000 yd^3/yr.
- Discuss the predicted long-term net balance between flood and ebb tidal dominance of reopened Packery Channel and its effect on the hydrodynamic and sediment dynamic behavior of Aransas Pass.

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