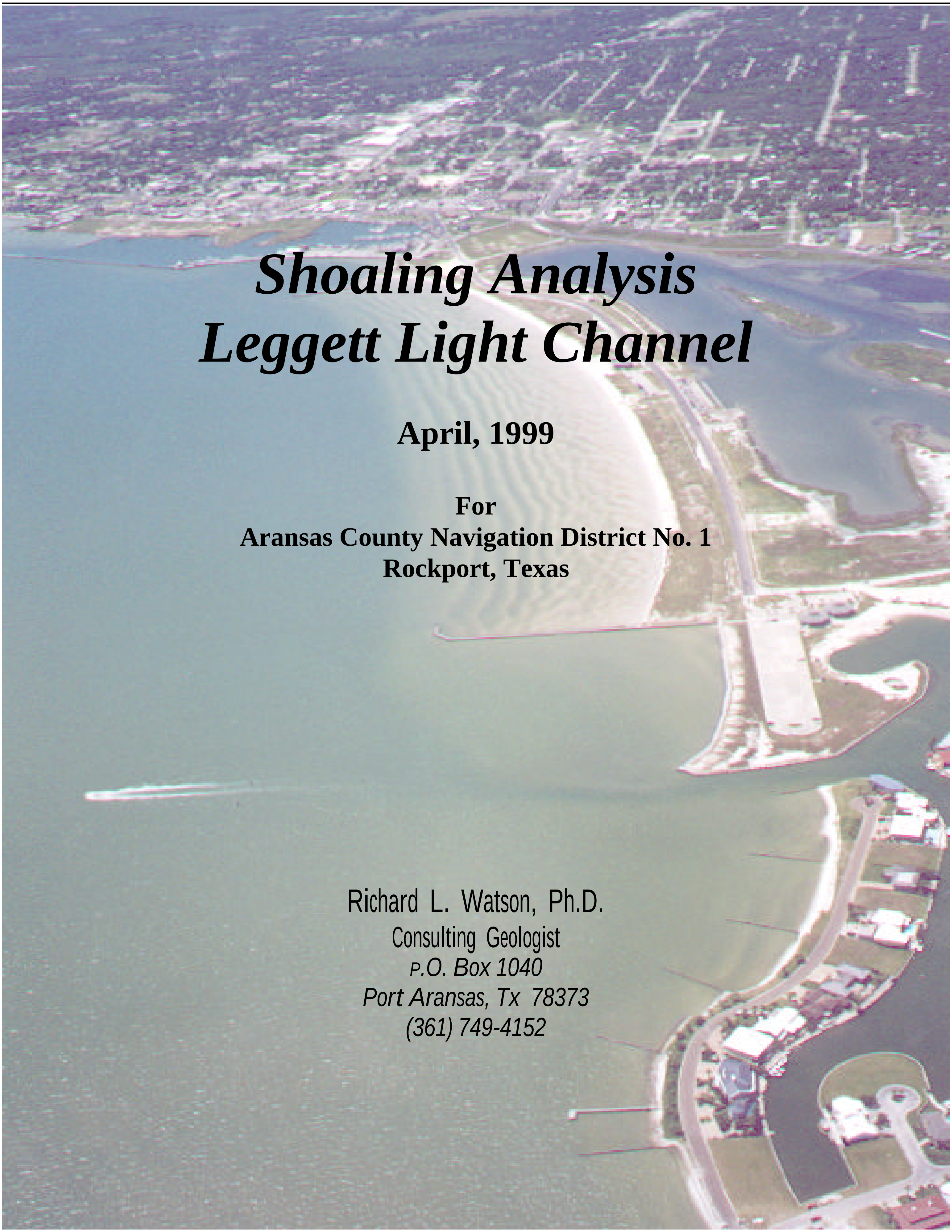

Shoaling Analysis Leggett Light Channel

April, 1999

For
Aransas County Navigation District No. 1
Rockport, Texas

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Executive Summary

Every five or six years 11,000-12,000 cubic yards of sand must be dredged from the Leggett Light Channel, in order for it to remain navigable. Most the sand accumulates in three problem areas: the west side from station 6+00 to station 10+15, the outer east side from station 2+00 to station 7+30, and the inner east side from 9+00 to 11+15.

The east side shoaling is due to wave action on the outer part of the large shoal east of the channel sweeping sand into the channel. The large shoal east of the channel is a virtually unlimited source of sand. The shoaling of the inner east side of the channel is due to a current generated by waves breaking along the beach, sweeping sand around the short jetty on the east side into the channel.

The shoaling on the west side of the channel is due to wave action, especially during south winds sweeping sand into the channel along the outer part of the shoal, and due to return currents caused by the presence of the east groin of Rockport Beach sweeping sand into the channel near the bulkhead.

Construction a 500 ft. long jetty on the west side of the channel and a 1000 ft. to 1200 ft. jetty on the east side of the channel would eliminate almost all of the sand transport into the Leggett Light Channel.

Construction of a 500 ft jetty on the west side of the channel along with a 400 ft. extension of the existing jetty would stop the shoaling of the inner part of the channel.

Over-dredging of the channel may reduce maintenance costs by extending the time period between dredging operations. This will reduce costs, primarily by reducing mobilization and dike building costs. Over-dredging of only the west side of the channel will probably have the greatest benefit. The sand source that is filling the west side of the channel is limited to the small shoal between the groin at the east end of Rockport Beach and the channel. This shoal is naturally becoming smaller due to sand loss into the channel which is subsequently pumped onto the beach. Over-dredging this side of the channel will have the double benefit of extending the time before shoaling of the west side of the channel becomes critical for navigation and speeding the reduction of the sand source area. Over-dredging along the east side of the channel will buy time between dredging operations, but since the net sediment transport is from east to west and the huge shoal east of the channel has a nearly endless sediment supply, over-dredging on the east side will not effectively reduce the source area.

Construction of any of the jetty alternatives on a single side of the channel would reduce the shoaling in that area. Likewise a combination such as constructing a 400 ft. extension of the east jetty in combination with over-dredging of the west side of the channel would also be effective. Over-dredging of just the west side of the channel will likely have the highest benefit for the cost.

Introduction

The entrance channel to Little Bay, the Leggett Light Channel, experiences shoaling on both sides of the channel requiring about 11,000-12,000 cubic yards of sand to be dredged from the channel every five or six years. The purpose of this study is to determine how sand is being transported into the channel and to investigate any possible solutions to the problem to reduce the long-term dredge maintenance cost. The problem has been analyzed using historical aerial photographs, 1998 aerial photographs, August 1998 and October 1993 channel profiles taken by J.L. Brundrett, Jr. Professional Surveyor, and on site observations.

Description of Shoaling Areas

There are three distinct shoaling areas with different processes causing shoaling in each area. A plot of the -6 ft. depth contour determined from the profiles in the 1998 Brundrett survey shows the location of the shoaling areas (Fig. 1). Note: there is major shoaling of

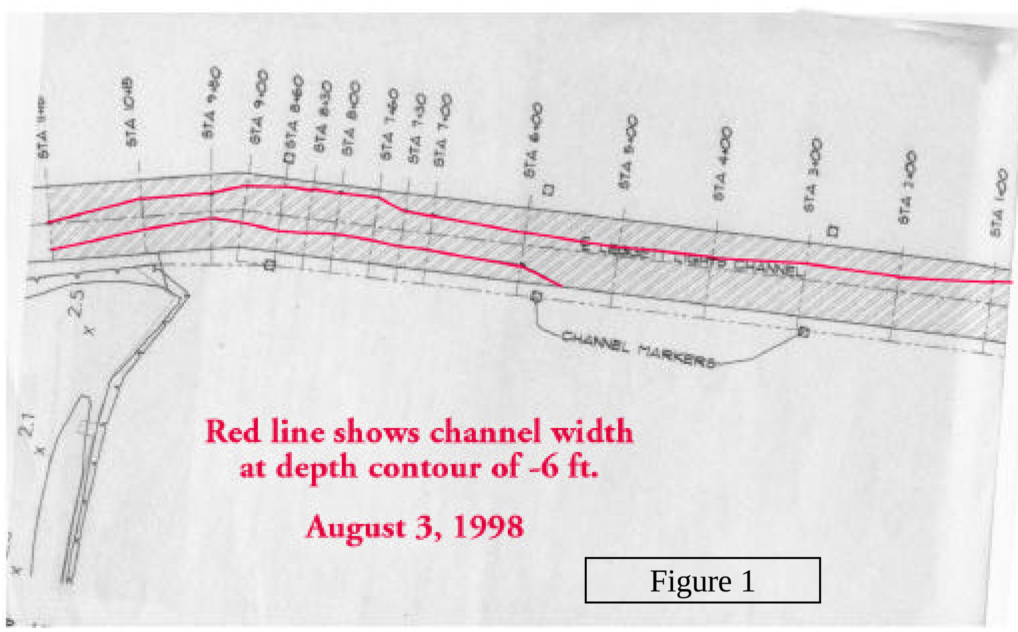


Figure 1

the outer part of the east side of the channel from station 2+00 through station 7+30. We will call this the outer east side. The second area of major shoaling is on the east side of the channel from station 9+00 to station 11+15. We will call this the inner east side. There is very little shoaling on the east side from station 7+30 to station 9+00. Finally, there is significant shoaling of the channel on the west side from station 6+00 to station 10+15. We will call this area the west side. Figure 2 is a plot of the -6ft. depth contour taken from the profiles measured in the 1992-1993 Brundrett survey. It shows a similar shoaling pattern to the 1998 survey.

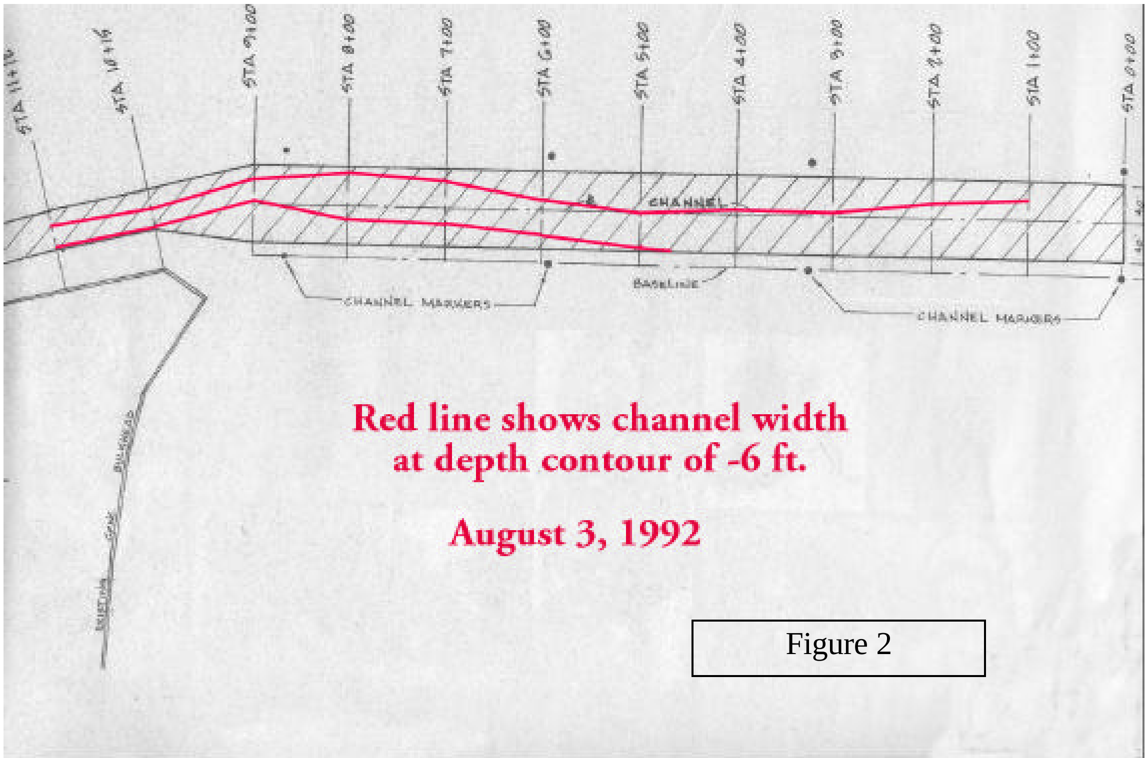


Figure 2

The cross sectional areas of shoaling shown on the 1998 Brundrett survey were measured on each side of the channel at each survey station and plotted in Table 1. In order to calculate the volume of shoaling, the distance between the midpoints of the stations was multiplied by the area of the shoaling at each station and entered in the table as a volume for that survey station. This was done for the total volume of shoaling for both sides of the channel as well as the east and west sides of the channel separately. The total shoaling for both sides of the channel is 11,367 cubic yards; the east side is 6981 cubic yards and the west side is 4386 cubic yards. The outer east side shoaling is 4189 cubic yards, the inner east side is 1818 cubic yards and the problem area on the west side is 3903 cubic

CHANNEL FILL VOLUMES AUGUST 1998 SURVEY
LEGGETT LIGHT CHANNEL

	BOTH SIDES				WEST SIDE				EAST SIDE			
STATION	UNITS	AREA SQFT	LENGTH FT	VOLUME CUYD	UNITS	AREA SQFT	LENGTH FT	VOLUME CUYD	UNITS	AREA SQFT	LENGTH FT	VOLUME CUYD
0+00	0.56	93	50	173	0.10	17	50	31	0.46	77	50	142
1+00	0.58	97	100	358	0.00	0	100	0	0.58	97	100	358
2+00	1.00	167	100	618	0.00	0	100	0	1.00	167	100	618
3+00	0.94	157	100	581	0.06	10	100	37	0.88	147	100	544
4+00	1.47	245	100	908	0.18	30	100	111	1.29	215	100	797
5+00	1.60	267	100	988	0.32	53	100	198	1.28	214	100	791
6+00	2.32	387	100	1433	1.00	167	100	618	1.32	220	100	815
7+00	2.24	374	65	899	1.10	183	65	442	1.14	190	65	458
7+30	2.00	334	30	371	1.10	183	30	204	0.90	150	30	167
7+60	1.72	287	35	372	1.22	203	35	264	0.50	83	35	108
8+00	1.73	289	35	374	1.26	210	35	272	0.47	78	35	102
8+30	1.80	300	30	334	1.16	193	30	215	0.64	107	30	119
8+60	1.82	304	35	394	1.15	192	35	249	0.67	112	35	145
9+00	2.19	365	45	609	1.38	230	45	384	0.81	135	45	225
9+50	2.50	417	57.5	888	1.46	244	57.5	519	1.04	173	57.5	369
10+15	2.59	432	82.5	1320	1.25	209	82.5	637	1.34	224	82.5	683
11+15	2.42	404	50	748	0.67	112	50	207	1.75	292	50	541
	TOTAL VOLUME CUYD			11367	WEST SIDE VOL CUYD			4386	EAST SIDE VOL CUYD			6981

Table 1

EAST SIDE 2+00 TO 7+30	4189	CUYD
EAST SIDE 9+00 TO 11+15	1818	CUYD
WEST SIDE 6+00 TO 10+15	3903	CUYD
TOTAL PROBLEM AREAS	9910	CUYD
TOTAL EAST SIDE	6981	CUYD
TOTAL WEST SIDE	4386	CUYD
TOTAL CHANNEL FILLING	11367	CUYD

yards. The total of the problem areas is 9810 cubic yards.

The channel fill rate at each station along the channel is presented graphically in Figure 3. This clearly shows the three different areas of concern. The red line shows the rate of shoaling is high on the outer east side from 200 ft. to 700 ft. from the channel mouth, drops low from 700 to 900 ft. on the middle east side, and rises sharply from 900 ft. to 1100 ft. on the inner east side. The blue line representing the west side of the channel shows the shoaling starts near 600 ft. from the channel entrance and stays high until over 1000 ft. from the channel entrance. The black line is a plot of a total of both sides of the channel. It shows the total shoaling, and thus the greatest navigation hazard exists, from 500 ft to 700 ft. and from 900 ft. to 1100 ft. The problem is reduced from 700 ft. to 900 feet due to the reduction in shoaling on the east side. The total shoaling is also not as serious between 500 ft and the entrance, because there is no shoaling on the west side in the outer channel.

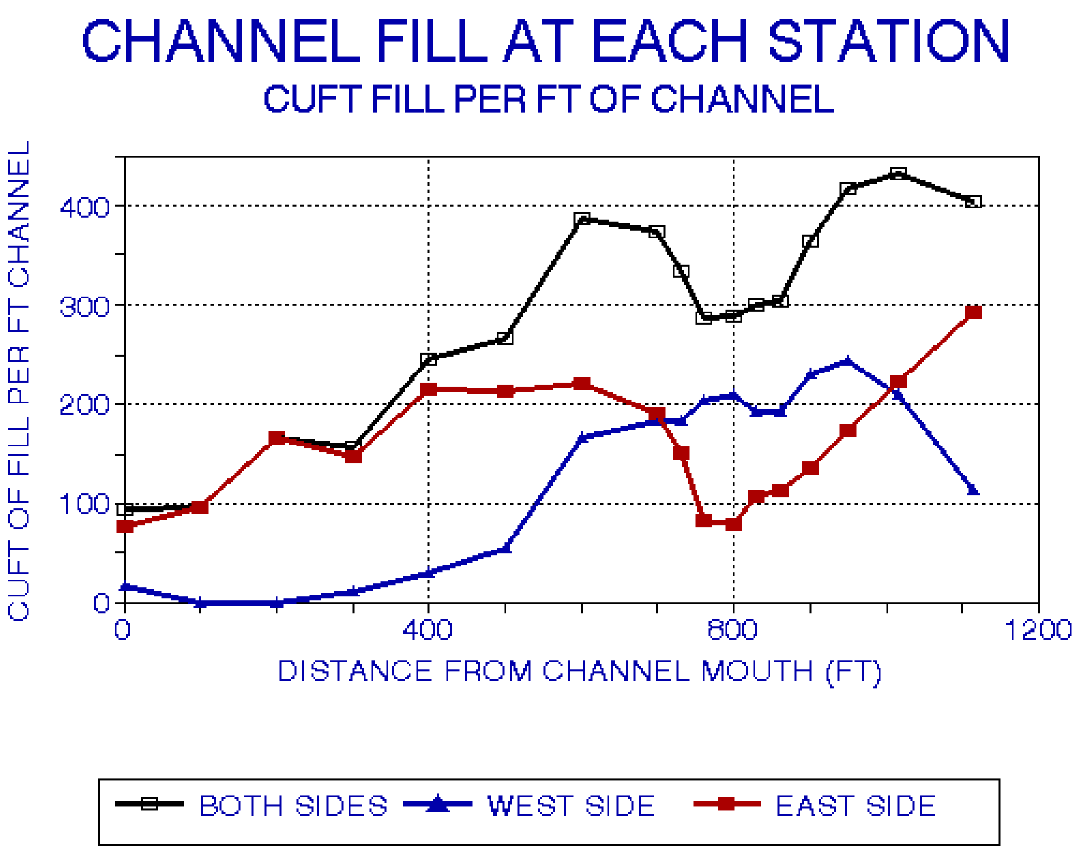


Figure 3

Aerial Photographs

Some enhanced aerial photographs will enable us to get a better understanding of the shoaling areas. A large shallow shoal exists on the east side of the Leggett Light Channel out to within 100 feet of the outer channel marker and covers the entire area to the east toward nine mile point. The shoal on the west side of the channel extends from the concrete bag groin at the east end of Rockport beach to the Leggett Light Channel (Photo 1). Note the shoal west of the channel has been truncated almost in a straight line from the end of the groin to the channel at the third channel marker from the entrance. There is no truncation of the shoal on the east side of the Leggett Light Channel. Photo 2 also clearly shows how the shoal is truncated on the west side of the channel. Note also how far the shoaling on the east side of the channel has progressed into the channel past the location of the channel markers.

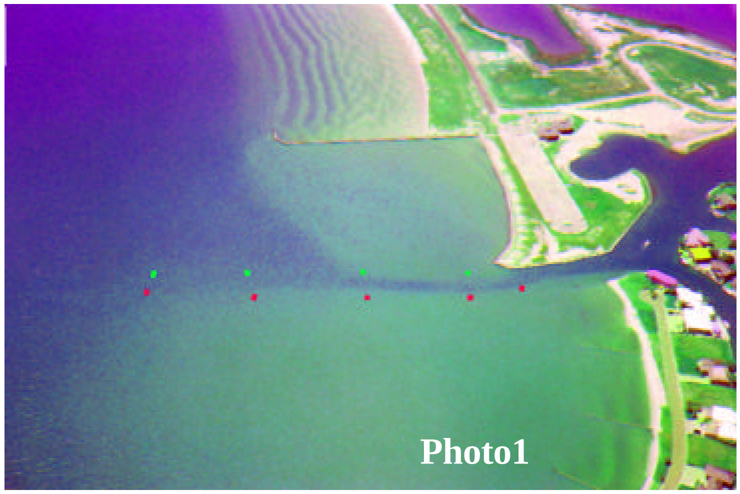


Photo1

Photo 2

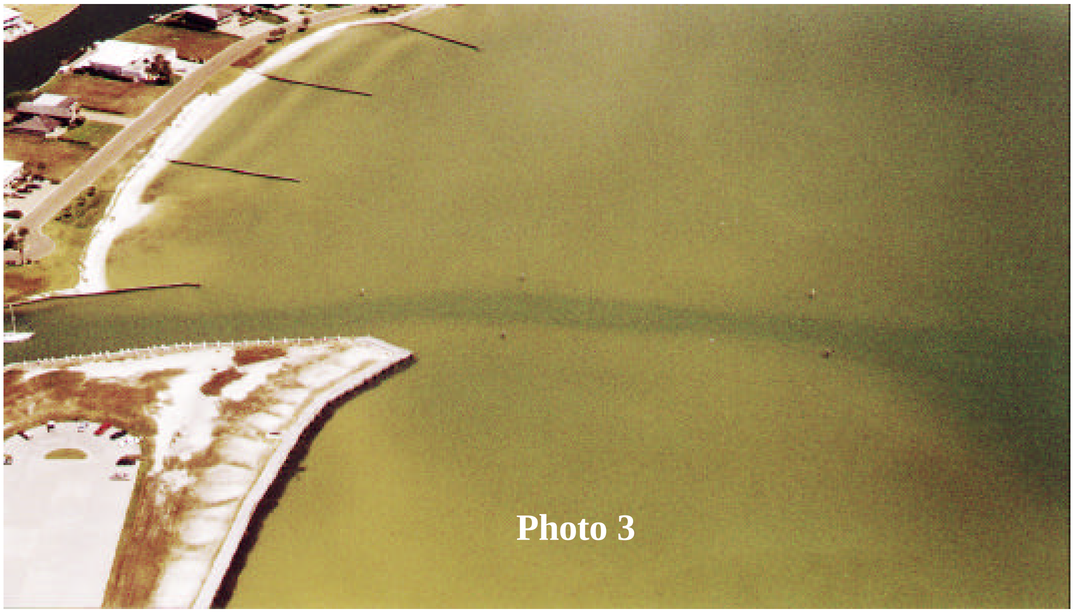


Photo three also shows how far the sand has moved into the channel relative to the channel markers. There is a narrow choke point just inside of the markers near station 6+00.

Processes Causing Shoaling

There are different processes causing the shoaling problem in each of the three problem areas. In 1985, Ercon Corporation studied the problems of beach erosion at Rockport Beach and made recommendations for beach restoration and stabilization (Ercon, June, 1985). The concrete bulkhead just west of the Leggett Light Channel at the east end of Rockport Beach was also failing. They found some of the sand was being lost offshore into the bay, some lost due to overwash into Little Bay during storms, and some lost into the Leggett Light Channel. They recommended constructing a groin on the west side of the channel extending the length of the channel and to a height of +6ft MLLW. Apparently, since that time, a low concrete bag groin was constructed at the east end of the concrete seawall and several hundred yards to the west of the Leggett Light Channel. This has served to protect the beach, but has not protected the channel from shoaling. In fact, its location may be increasing the rate of shoaling in the channel.

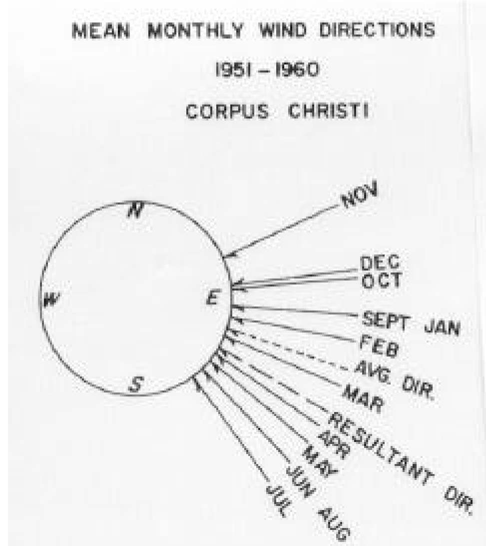
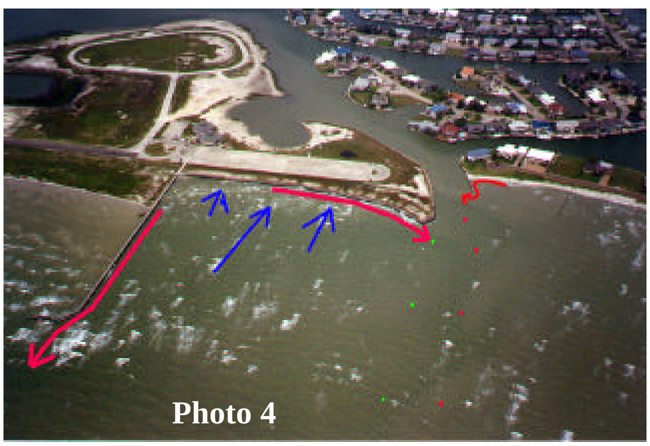


FIG. 5.—Mean monthly wind directions for Corpus Christi 1951–1960. Directions shown represent the average of the monthly vector resultants determined for 10 years of wind data collected at Corpus Christi. The RESULTANT DIR. shown is the vector resultant for the entire 10 year period. The AVG. DIR. is the average of all of the monthly vector resultant directions for the 10 year period. Note that the resultant direction and the average direction separate the winter regime of northers from the summer regime of strong southerlies if March is taken to be a transitional month.

Figure 4, from (Watson, 1971)

Most of the sediment movement on Rockport Beach and on the shoals adjacent to Leggett Light Channel is due to water motions from wind generated waves. The winds affecting this shoreline are predominantly from the east to the southeast (Fig.4). This means most of the wave generated sediment transport will be toward the west. This readily explains the sediment transport into the channel from the shoal east of the channel. However, there is also a large amount of sediment being transported into the channel on the west side. There are many days when the wind is from the south or nearly from the south. This south wind, in conjunction with the position of the groin at the east end of the beach, has aided in the shoaling process on the west side of the channel. Photo 4 shows how this is happening. On April 9th, when this photo was taken, the wind was from 160 to 176 degrees at 17 to 23 knots. Once the waves break, they are actually transporting water in the directions shown by the blue arrows. If water is moving onshore in the area constrained by the seawall and the groin, it must return to the bay. There is a return flow seaward along the groin shown by the red arrow and also a return flow along the seawall into the channel. This is the reason for the large amount of shoaling on the west side of the channel near the seawall. This is probably also occurring during southeast winds. The outer part of the west side shoal between the Leggett Light Channel and the groin on the east part of the beach has been truncated by erosion. Most of this material has probably been carried into the channel over the years. The net sediment transport along this shoreline is to the west. No sediment can pass from the east side of the channel to the west side, so the shoal between the channel and the groin on the east end of the beach is slowly being eroded and deposited into the channel. If the groin had been built along the west side of the channel, where it could also serve as a jetty for the channel, there would have been no deposition of sand on the west side of the channel. In the present configuration, the shoal between the east beach groin and the channel will continue to erode into the west side of the channel.



Note: even with the wind nearly out of the south, there is also a return flow along the east seawall and around the east jetty into the channel. This is the major source of the shoaling on the inner east side. The outer part of the big shoal east of the channel has not been truncated by erosion into the channel, because it is continually re-supplied with sand moving along it from the huge shoal to the east.

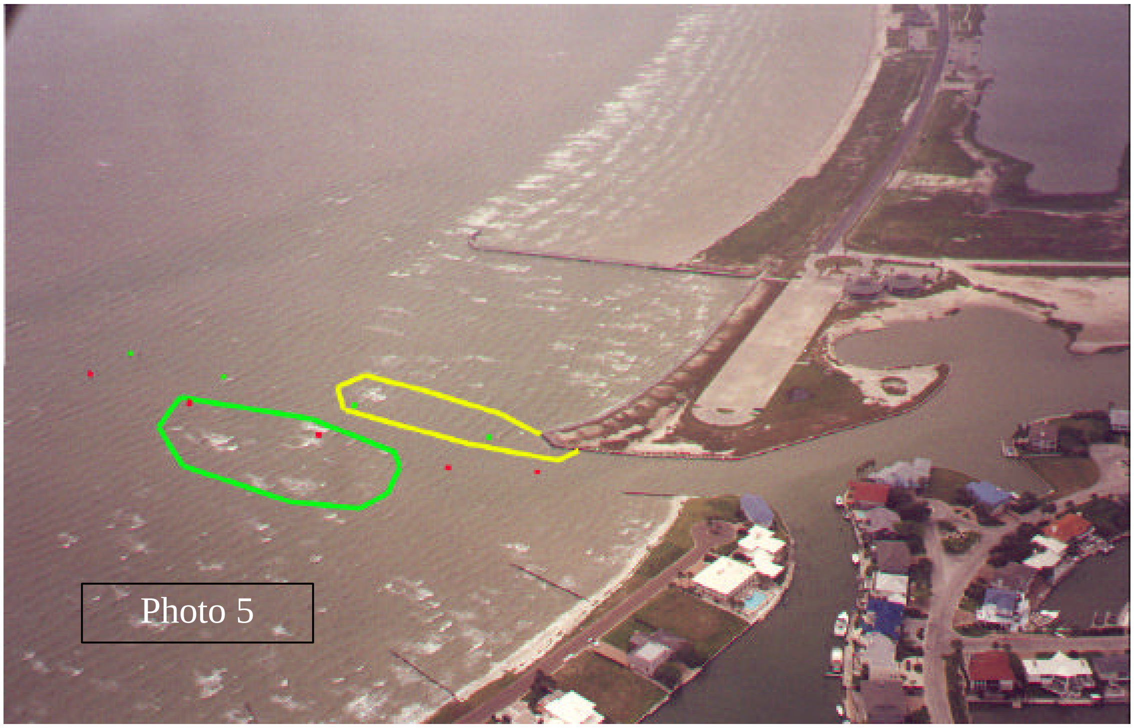


Photo 5 shows the shoals breaking under the influence of waves generated by south winds of 17 to 23 knots on April 9, 1999. The west side shoaling area is circled in yellow. The waves breaking on the outer part of this shoal will transport sand directly into the channel. The inner part of the yellow area is transporting sand into the channel with the aid of the return currents moving to the east along the seawall. The green circled area is the outer east side shoaling area. The surf breaking on the shoal adjacent to the channel has a net movement toward the channel and will continue to fill the channel. Note that there is no surf breaking in the inner east side near the inner two red channel markers. This is the area where little sand is entering the east side of the channel. Most of the wave energy has been expended further out in the green circled area. Surf again reappears near the beach in very shallow water. Under the normal southeast wind, these waves are approaching the beach on the east side of the channel with a component directed toward the west. These breaking waves create a current in the surf along the beach which moves to the west, around the small jetty on the east side of the channel and provide the sand which is shoaling the inner east side of the channel (see Photo 4).

Alternatives for Maintenance Reduction of Leggett Light Channel

Jetties

The best method to reduce dredge maintenance of the Leggett Light Channel is to build long jetties on both sides of the channel extending from the existing bulkhead and jetty to deep water. This requires a jetty about 500 ft. long on the west side and about 1000-1200 ft. long on the east side of the channel. It is unfortunate that the groin built at the east side of Rockport Beach was not built as a jetty on the west side of the channel. It would have served for maintenance reduction of the channel as well as simultaneous beach erosion protection and would have eliminated nearly all maintenance dredging on the west side of the channel. A short 400 ft. jetty extending the existing jetty on the east side of the channel would reduce a lot of the maintenance dredging needed on the inside of the east side of the channel. Any jetties to reduce maintenance dredging should be structures which are impermeable to the movement of sand. Each of these jetty alternatives will be helpful by itself, even if jetties are not built on both sides of the channel.

Over-dredging

Over-dredging the problem reaches of the channel should extend the time period between dredge maintenance operations. This will reduce mobilization costs, but will result in the same or a larger total amount of sand to be dredged. Bayward of 5+00 shoaling is occurring only on the east side, and between 7+30 and 9+00 shoaling is mostly on the west side. The channel sections experiencing the worst shoaling are from stations 5+00 to 7+30 and from 9+00 to 11+15. These are the channel sections that are being filled from both the west side and the east side simultaneously. Over-dredging these two reaches of the channel, either by increasing the depth or by dredging back behind the channel markers, will buy time before the dredging will have to be repeated.

Another alternative is to take all of the excess dredging from one side of the channel. If this alternative is chosen, it may be advantageous to take all of the excess dredge material from the west side of the channel from station 5+00 to the seawall. Due to the net transport of sand in the area from east to west across the shoals, there is a nearly endless supply of sand to fill the channel on the east side. On the other hand, the sand available to fill the channel on the west side comes only from the small shoal between the channel and the groin at the east end of Rockport Beach. The truncated outer end of this shoal between the outer end of the groin and the channel shows this shoal is being reduced in size as sand is eroded into the channel and then pumped onto the beach. As a result, this source area is becoming smaller. If all of the excess dredge maintenance is done on the west side of the channel, the sand source between the channel and the groin will be reduced faster and will eventually result in less maintenance dredging needed on the west side of the channel. Excess dredging only on the west side of the channel would also be less confusing to boaters who would realize that the channel is shifting to the west between dredging operations.

Selected Alternatives

Below are several alternatives for the reduction of maintenance dredging of the Leggett Light Channel. They are listed in order with the most effective alternatives first.

1. Build two long jetties, a 500 ft. jetty on the west side and a 1000 to 1200 ft. jetty on the east side. This would nearly completely eliminate shoaling.

2. Build two short jetties. A 500 ft jetty on the west side and a 400 foot extension of the existing jetty on the east side. This would limit shoaling to only the outer east side.

3. Over-dredge the west side of the channel and build a 400 ft. jetty extension on the east side of the channel. This will greatly reduce shoaling on the inner east side of the channel and speed removal of the shoal which is supplying sand to the west side of the channel.

4. Over-dredge the west side of the channel. This will extend the time between dredging operations and speed removal of the shoal on the west side which is the source of shoaling of the west side of the channel.

5. Over-dredge both sides of the channel in the problem areas. This will allow the channel to keep its design configuration for the greatest time between dredging operations, but there will be no long term benefit in removing sand from the east side of the channel as there is an endless source of sand to the east.

Alternative 4, over-dredging the west side of the channel is probably the most effective alternative that does not include jetties. This alternative will extend the time period between dredge mobilizations and remove the sand source which is filling the west side of the channel faster than is occurring naturally.

Conclusions

Every five or six years 11,000-12,000 cubic yards of sand must be dredged from the Leggett Light Channel, in order for it to remain navigable. Most the sand accumulates in three problem areas: the west side from station 6+00 to station 10+15, the outer east side from station 2+00 to station 7+30, and the inner east side from 9+00 to 11+15.

The east side shoaling is due to wave action on the outer part of the large shoal east of the channel sweeping sand into the channel. The large shoal east of the channel is a virtually unlimited source of sand. The shoaling of the inner east side of the channel is due to a current generated by waves breaking along the beach, sweeping sand around the short jetty on the east side into the channel.

The shoaling on the west side of the channel is due to wave action, especially during south winds sweeping sand into the channel along the outer part of the shoal, and due to return currents caused by the presence of the east groin of Rockport Beach sweeping sand into the channel near the bulkhead.

Construction a 500 ft. long jetty on the west side of the channel and a 1000 ft. to 1200 ft. jetty on the east side of the channel would eliminate almost all of the sand transport into the Leggett Light Channel.

Construction of a 500 ft jetty on the west side of the channel along with a 400 ft. extension of the existing jetty would stop the shoaling of the inner part of the channel.

Over-dredging of the channel may reduce maintenance costs by extending the time period between dredging operations. This will reduce costs, primarily by reducing mobilization and dike building costs. Over-dredging of only the west side of the channel will probably have the greatest benefit. The sand source that is filling the west side of the channel is limited to the small shoal between the groin at the east end of Rockport Beach and the channel. This shoal is naturally becoming smaller due to sand loss into the channel which is subsequently pumped onto the beach. Over-dredging this side of the channel will have the double benefit of extending the time before shoaling of the west side of the channel becomes critical for navigation and speeding the reduction of the sand source area. Over-dredging along the east side of the channel will buy time between dredging operations, but since the net sediment transport is from east to west and the huge shoal east of the channel has a nearly endless sediment supply, over-dredging on the east side will not effectively reduce the source area.

Construction of any of the jetty alternatives on a single side of the channel would reduce the shoaling in that area. Likewise a combination such as constructing a 400 ft. extension of the east jetty in combination with over-dredging of the west side of the channel would also be effective. Over-dredging of just the west side of the channel will likely have the highest benefit for the cost.

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