

*Flying Geology And
History Tour
Port Aransas to
Matagorda Island, Texas
November, 2004*

*Richard L. Watson, Ph.D.
Consulting Geologist
361-749-4152*

Flight Plan and Site Description

KRAS---We will depart from Mustang Beach airport KRAS (previously 2R8). We will taxi down the runway together and line up in flying sequence. The lead plane will take off and each succeeding plane will take off when the lead plane lifts off of the runway. We will fly to the beach and make a left turn to the NE up the coast. When flying a shoreline all planes will keep the shoreline to their left and treat it like the centerline of a highway. The lead plane will climb to 1000 ft. Each succeeding plane will climb to an altitude 100 feet above the one in front of it. If there are enough planes that altitude exceeds 2000 ft., the following planes will each fly 100 ft. lower until a minimum of 1000 is reached. Try to keep the plane ahead easily in sight, but if the wheels are easy to see, you are probably getting too close. If we have any 172 class planes we will fly at an indicated airspeed of 90 knots or 103 mph. If there are only faster planes in the flight, we will fly at an indicated airspeed of 115 knots or 132 mph. On extended legs, the lead plane will relay the GPS ground speed in knots. We will communicate on 122.85. The lead plane will call Corpus Approach before departure to advise them of the flight, but will not be able to listen. We will make all route turns to the left and leave all route waypoints to the left. That is, on the turn, they will be on the pilot side of the plane. If you lose sight of the plane ahead, it would be best to turn out to the RIGHT and climb above all planes. You can then move to the end of the line, if you are SURE of the location of all traffic. Safety is much more important than the sightseeing. We have only four route turns, other than following a coastline, so this should not be too difficult. It is very important to maintain visual contact with the plane ahead and to maintain spacing.

ARANSAS PASS JETTIES—Almost immediately after departing Mustang Beach airport and turning left along the beach (and out over the water) we will cross Aransas Pass with its mile long jetties. This is the entrance to the Corpus Christi Channel and the Gulf Intracoastal Waterway. The Port of Corpus Christi is the 5th largest port in the U.S. based on tonnage. It handles mostly grain, cotton and petroleum products. The Gulf Intracoastal Waterway goes from Brownsville, Texas to Apalachicola, Florida with minimum depths of 12 feet. It carries a huge amount barge traffic. A ton of cargo can be carried 50 miles on a gallon of gas in a truck and 500 miles on a gallon of fuel in a barge. There is a gap of 140 miles where boats have to

go offshore between Appalachicola, Florida and Tarpon Springs, Florida. Other than that 140 miles offshore in the Gulf, boats can travel from Brownsville to New Jersey without ever having to go offshore.



Aransas Light

ARANSAS LIGHT (27 51.85, 97 3.33) is located on the island just across from the inland waterway about a mile past the jetties. It was built in 1857 and served as an important light house until about 1930. The natural pass used to be adjacent to the lighthouse, but the channel was moved and stabilized in its present position

early in the last century. The valuable fresnel lens built in France was taken out and buried to protect it from the Yankees during the civil war. That lens was replaced with a second lens after the war. It is now located in the new Port Aransas Museum. In 1971, Charles Butt, the owner of HEB grocery stores bought the property and restored it. He found a replacement antique lens and obtained permission to light it and the light once again is operating, though it is no longer necessary for navigation.



The island that we are flying along north of Aransas Pass is called San Jose Island. The entire island is owned by the Bass family and is a private ranch. We will soon be flying by the ranch headquarters and private airfield XS67. It has private FAA instrument approaches. The owners have a small Bell helicopter used for ranching and local flights, a Cessna 182 and a Falcon Jet. They also have a fleet of boats, including a car ferry, small boats, barges and sport fishing boats that they keep either in their harbor on the island or in their private harbor at Rockport. There are loads of deer and other game on

the island as well as cattle. Try to figure why there are so many mowed circles on the ground.

WASHOVER (28 4.84, 96 53.75) – The large washover fan which looks like a river delta coming from the sea is on the left. As sea level rises, barrier islands rise with it and migrate landward if there is sufficient sand supply. This is one of the largest presently active washover fans on the Texas coast. Water and sand enter at its mouth at Cedar Bayou and are deposited through the distributary channels into the bay, extending the island in the landward direction. Be sure to look on the landward side of Matagorda Island which is the next island after we pass Cedar Bayou, a natural inlet separating San Jose Island from Matagorda Island. Matagorda Island has several washover fans that are probably several thousand years old. Note that they are not as well defined as this fan. They been sinking due to sediment compaction as well as becoming flooded by rising sea level. Sand dunes have closed their source at the beach a long time ago.



San Jose Washover Fan

CEDAR BAYOU (28 3.77, 96 51.20) Cedar Bayou is a natural, unjettied pass. It closes from time to time by the huge amount of sand carried along the coast to the south in the surf zone. That sand transport is called littoral



Cedar Bayou, 1996

drift. It can amount from a couple of hundred thousand yards per year along the Texas coast to as much as 750,000 cubic yards per year. That is as much as 250 dump trucks per day. With wider deeper channels in the man made passes along with reduced river outflow due to upstream use of water, many natural passes close

or become smaller as they are no longer able to flush out the huge amount of

sand crossing their mouths in the surf zone. Cedar Bayou closed naturally, but was dredged open in 1995 to improve fish migration and fishing. It has been intermittently closed for the past three years.

The ranch houses and the airport on Matagorda Island are now owned by the Nature Conservancy. It used to be the Toddy Wynne Ranch. No, we are not allowed to land there, boat visitors are the only ones welcome. Matagorda Island and the adjacent marshes on the other side of the Gulf Intracoastal Waterway are the wintering grounds for Whooping Cranes and include the Aransas Wildlife Refuge. The northern 2/3 of Matagorda Island was leased to the U.S. Government during WWII for a bombing range and Army Air Base. It was leased for one dollar, but after it was no longer needed in the late 60s or early 70s, the government refused to return it and now the entire island is state and federal park or Nature Conservancy. If you look carefully, you may still be able to see the outlines of some huge round bulls eyes used for bombing practice. You can see the runways of the abandoned Airforce base near the north end of Matagorda Island. No, we can't land there either, though we are welcome by boat.

FORT ESPERANZA (Fort Hope) (28 29.74, 96 25.65) Fort Esperanza was built at the north end of Matagorda Island to protect Pass Cavallo from entry



Fort Esperanza earthworks 1863

by Union Forces.

The GPS coordinates are for a line of earthworks that extend from the Gulf beach to the bay shoreline. The actual fort was located at the north end of the island and has eroded into Pass Cavallo. The earthworks were built to

prevent Union forces from walking up the island from the south to attack the back of the fort.

“Fort Esperanza rose from the sand in December, 1861, halfway up the frontage of the pass. Confederate Col. R.R. Garland had chosen the site after determining that old Fort Washington on the extreme southeast corner of the island was too exposed. Fort Esperanza’s location put the Confederates out of range of the guns on larger Federal vessels in the Gulf, but allowed them to command the channel with eight 24 pound and one 28 pound gun. Control of the channel, however, proved possible more in theory than reality. On Oct. 25, 1862, with Galveston already in the hands of the North, three heavily armed Union warships appeared off Pass Cavallo and bombarded the Rebel fortification, convincing the commander of the Indianola Artillery Guards that retreat would be prudent. Federal troops took over the fort. Union Capt. William B. Renshaw’s navy continued up the pass unmolested and captured Indianola, pillaging stores and residences along the way. After a brief occupation, Renshaw withdrew his forces, shelled Port Lavaca on the way back to the Gulf, and then steamed away.... After the Union debacle in the battle of Sabine Pass in September 1863, the federal invasion plans for Texas shifted south. The Rio Grande valley was invaded in early November. Corpus Christi and Aransas Pass fell in the middle of the month. Union troops advanced up St. Joseph's Island. Their crossing to Matagorda Island was unsuccessfully challenged, and a battle took place on November 23 at Cedar Bayou, which separates the two islands. After Union forces under Gen. T. E. G. Ransom reached Fort Esperanza on November 27 and dug in, a two-day battle followed. On the night of November 29 the Confederates, outnumbered and outflanked, evacuated the fort after spiking the guns, firing their stores, and blowing up their magazines. The fort was occupied and repaired by the Union forces, who used it as their base of operations for further campaigns in the area.”



Matagorda Light

(<http://www.tpwd.state.texas.us/news/magazine/matagord.htm>)

MATAGORDA LIGHT (28 20.27, 96 25.44) Matagorda Light is located along the dirt road just a short distance north of the Confederate earthworks. The 55 foot iron tower was lined with bricks and finished in 1852 with a

reflecting lens which was upgraded to a revolving fresnel lens in 1859. The Confederates removed and buried the lens and tried to blow up the tower before the attack of Union forces. They did little damage to the tower. The lighthouse was moved nearer to the pass and raised to 91 feet by 1873. In



1882, the old oil lamps were replaced with “modern” kerosene lamps. From the 1840s to the mid 1880s, Indianola was one of the most important ports in Texas and this light guided the ships to the port and its entrance at Pass Cavallo.

The lighthouse had been de-activated by the Coast Guard in 1995, but it was renovated in 1999 and a modern low power solar lamp now lights the Matagorda Light once again. It can be seen for about 10 miles.

PASS CAVALLO (CAVALLO 28 20.56, 96 21.83) Pass Cavallo is a large, deep natural pass. It has been used for centuries for ocean going vessels to navigate into Lavaca Bay, starting with Robert Cavelier, Sieur de La Salle. La Salle was born in France in 1643. He was educated by Jesuits and planned to become a priest. However, he set out for the wilds of Canada. His early explorations were so successful, including building Fort Frontenac on Lake Ontario that King Louis XIV appointed him governor and granted him a title of nobility. After learning survival skills and canoeing down the Mississippi River all the way to the Gulf of Mexico, he claimed the entire

Mississippi basin for France in 1682! He built Fort St. Louis on the Illinois River in 1683.

La Salle formulated another ambitious project — to build forts along the mouth of the Mississippi and to invade and conquer Spanish provinces in Mexico. To accomplish this he would need an army of 200 Frenchmen, 15,000 Indians and privateers. La Salle's opponents doubted the feasibility of his plan, but Louis XIV saw it as an opportunity to strike out against Spain, with whom France was at war. La Salle was given men, ships and money.



Belle (model)

The mission was a series of failures.

La Salle and the naval commander did not get along. La Salle had a strong personality, demanding the most of himself, but also of others. Often he pushed people to their limits, and became upset when they would not see a situation his way. Not a good leader, he was never on friendly terms with most of his men.

After a stop in the West Indies, one ship was captured by pirates. Sickness took its toll. Maps were difficult to follow. Because of this, La Salle missed the mouth of the Mississippi River and landed at Matagorda Bay in Texas, nearly 500 miles away. While attempting to negotiate the narrow passageways of the inlets, a second ship, the *Aimable*, was lost. Valuable cargo of food, medicine, supplies and trade goods for the Indians was lost. A third ship, the *Belle*, became stranded on a sandbar during a storm. Several men drowned as they tried to raft away from the vessel.

La Salle made several attempts to correct his navigational error, but was never able to lead his group to the Mississippi. He established Fort St. Louis in present-day Victoria County, Texas. He then attempted to lead a



Cannons at Fort St. Louis

party overland, but was killed by his own men near present-day Navasota, Texas. Although he was praised by his close friends Tonty and Frontenac, detractors such as Henri Joutel, one of the few survivors of La Salle's last expedition, felt his arrogance contributed to his death. A man of great vision, La Salle lacked leadership ability. The building of a French empire in the New World would be left to other men.



LaSalle

(<http://www.thc.state.tx.us/lasalle/laslife.html>).



Matagorda Ship Channel

Fort St. Louis was destroyed by Karankawa Indians in 1688 and the settlers were either killed or captured.

The Amiable was lost in Pass Cavallo and the Belle was lost in Matagorda Bay near Pierce Field where we will turn back. Texas found the Belle and

constructed watertight coffer dams around it, pumped the water out and recovered the entire remains of the wreck, including guns, and countless artifacts from the late 1600s. Those items are in various Texas museums.

After the Matagorda Ship Channel was built with long jetties into the Gulf in 1962, it captured much of the natural tidal flow in and out of Lavaca Bay. As a result, there was much less flow through Pass Cavallo and though it stays well open, it is not nearly as large and deep as it used to be and is not safely navigable by large vessels anymore.

MATAGORDA SHIP CHANNEL (28 25.42, 96 29.46) Note the huge accumulation of sand against the northeast jetty by the littoral drift moving to the south. Likewise there has been considerable erosion south of the southwest jetty since it is now starved by the amount of sand that is trapped against the updrift jetty plus what is lost by tidal flow into the bay and jetted offshore out of reach by ebb tides. This is a deep draft channel for ships which primarily serves the aluminum plant and Formosa Plastics further up the bay. It also serves for deep water access to the gulf for oil field service vessels based at Port O'Connor and for shrimp boats and yachts from Port O'Connor, Port Lavaca, and Palacios. Of course, it is also another open Gulf access point from the Gulf Intracoastal Waterway. We will now fly a short distance past the ship channel to Pierce Field which is now a private airport on Matagorda Peninsula.

PIERCE FIELD (28 27.33, 96 18.00)

The only way to get there is by boat from Port O'Connor or by airplane. Visitors are not welcome to land without prior approval. I think that there may be more building lots available, but I am not sure. Years ago, we used to anchor our sailboat in the bay and walk across the runways to the beach. This was an airforce base in the past. Betsy and I took a ride on a WWII 45 cubic inch Harley that we found rusting in the sand. We had to find a 2x6 to use for handlebars. We found that the bike went faster with loud rmmm, rmmmm sounds.

There was the old wooden officer's club complete with bar, but it had been taken over by cattle. None of the original buildings remain.

We will fly around Pierce field and fly back the BAY SHORELINE of Matagorda Bay and then turn right to fly past Port O'Connor to Indianola. Make sure that you fly over the bay with the barrier peninsula to your left. We don't want to come face to face with the planes following us.

INDIANOLA (28 30.726, 96 29.286) There is nothing but a few vacation houses and a cemetery where once stood one of the greatest ports in Texas.

From what she was, she's the biggest ghost of them all, but not to the eye. At the terminus of Texas 316 south of Port Lavaca, all is clean tranquillity - a deception. Sea and desert have defeated many towns. The sea is more ruthless - implacable until every tree is scoured away, until all is virgin sand where the footprints of men apparently never trod. The prints of 6,000 and more did tread here, when concrete and stout-timbered structures lined what was considered the finest harbor on the Gulf of Mexico. Piers thrust into the bay for half a mile, funneling rich cargoes to and from great ships. In the 1840's German colonists landed, led by Prince Carl of Solms-Braunfels. In the 1850's an army depot supplied the frontier forts of all Texas. Here two shiploads of Arabian camels landed, beginning the imaginative experiment of Jefferson Davis. Warehouses stored ice, winter-cut on the Great Lakes, shipped south at great expense and effort, and prized during the Texas summers.

The bustling, prosperous town survived shelling, capture and recapture during the War of the Northern Aggression, yellow fever epidemics, and one of the most violent storms of the era in 1866. But all were only prelude to Sept. 17, 1875. The sea that had created and nourished Indianola rose in monstrous salty, gray hummocks, lashed by shrieking winds - HURRICANE! Nine hundred perished, and three fourths of the city lay in matchbox shambles. "Quelle tragedie", as the French say. Disaster on an unimagined scale.



Betsy & Richard at Matagorda circa 1977

But Indianola was too prosperous, too vital, to quit because of one freak tragedy. So they decided to wait for another. Larger warehouses were raised; new piers of heavier pilings sprouted. Eleven years passed before a brutal fact was driven home: the earlier black September was no freak. An even more savage storm sounded the city's death knell.

Indianola was literally gone. After this second catastrophe, even wreckage was scarce. The few citizens who somehow survived did not return. The county seat, in name, was moved to Port Lavaca for there was really nothing left to move.

Today the tide laps at a few stones of the courthouse foundation. Inches above the smooth sand, outlines of a few shattered concrete cisterns remain. Some fishermen's homes have come of late, and the state has erected an historical marker.

One thing more, appropriately: a solitary rose granite statue of Rene Robert Cavalier, Sieur de la Salle. The French explorer was first to leave a boot print on the sands of Indianola more than 300 years ago. Today his stone likeness surveys the same featureless, unmarked sands.

(<http://www.lone-star.net/mall/txtrails/indiana.htm>)

We will now fly direct to El Copano one of the first ports in Texas. It is located on the northwest side of Copano Bay at the mouth of Mission Bay. Copano Bay is full of long narrow oyster reefs and one of the biggest goes well into the bay from the point just east of the mouth of Mission Bay. It makes a perfect natural breakwater for ships. It was difficult to get ships this far inland in Copano Bay because of the many shoals and oyster reefs. The ships entered at Aransas Pass (near the lighthouse) went north the length of Aransas Bay and then entered Copano Bay. Even though it was very difficult to get the ships that far inland, it was much easier than transporting a ship load of goods overland.

COPANO, TEXAS. The long-abandoned port, and later town, of Copano was at what is now called Copano Point on the northwestern shore of Copano Bay, thirty miles north of Corpus Christi in southeastern Refugio County. The town site is practically inaccessible by land, but can be reached by boat from Bayside, the nearest town, five miles to the south. Copano was named for the Copane Indians who frequented the area and during the Spanish and Mexican eras was known as El Cópamo. The town is believed to have served as a port and rendezvous for pirates and smugglers and may have been in use as a port as early as 1722. Copano was used as a port of entry by Spanish governor Bernardo de Gálvez^{qv} during the 1780s, but from the time of Spanish and Mexican Texas^{qv} through revolutionary times, there was little more at Copano than a customhouse or warehouse and a fresh-water tank. Nevertheless, the port played an important role during the colonial and revolutionary periods. In 1834 Gen. Juan N. Almonte,^{qv} on an inspection tour for Mexican president Antonio López de Santa Anna,^{qv} reported Copano to have the deepest port in Texas.

Between 1828 and 1835 groups of colonists passed through the port on their journeys from Europe to settlement in Texas. Groups of Irish^{qv} arrived during 1833 and 1834. One large group of Irish colonists was struck by cholera during the voyage from New York, and many arrived in Texas only to be buried on the Copano beach. The port of Copano became strategically important to both the Mexican and Texas armies during the Texas Revolution.^{qv} On September 20, 1835, Mexican general Martín Perfecto de Cos^{qv} and his army landed at Copano on their way to Goliad and Bexar. The next month Gen. Sam Houston^{qv} issued orders that Copano be fortified. The Texans held the site and used it as a port of entry for supplies and provisions until March 1836, when the port fell to the

Mexicans under Gen. José de Urrea.^{qv} When Maj. William P. Miller^{qv} and his Nashville Company of volunteers anchored at Copano in late March 1836, they were captured by the Mexicans. The port was used by the Mexicans to receive reinforcements and to evacuate their wounded and prisoners. After they withdrew from the area in May 1836, the Texans once again gained control of the port. The famous "Horse Marines"^{qv} incident occurred on the beach at Copano on June 3 and June 17, 1836, when Maj. Isaac W. Burton's^{qv} Mounted Rangers captured Mexican vessels, men, and supplies.

Settlement of Copano began around 1840 under the direction of James Power.^{qv} Associated with Power in the townsite project were Robert J. Walker, Duncan S. Walker, and Robert H. Hughes. The first home built at Copano was constructed by Joseph E. Plummer, Jr., around 1840. The Plummer cemetery is a mile north of the Copano townsite. By 1852 a dozen homes had been built in Copano, all of shell concrete made from materials found on the beach. A small school and two stores were constructed in the town. One store housed the post office, which operated between 1851 and 1867. Three wharves stretched into the town's harbor, described by a visitor as being "by far the safest harbor on the entire [Texas] coast." Cotton, hides, and tallow were principal products shipped through the port. Copano thrived during the Civil War.^{qv} Most Southern ports were blockaded, but because Copano was located on an inlet, ships could be loaded there unobserved by Union forces and then slip out to sea. However, in response to blockade running, a Union gunboat fleet anchored at Copano in 1864, and the town's inhabitants fled and remained away until the Yankees left a few days later. Various efforts to connect the town by railway to Goliad and San Antonio failed, and the inhabitants traveled to Refugio and the interior on an old military road that went north fourteen miles to the Refugio Mission, and later over a longer, more traveled highway that paralleled the bluff above Mission Bay, crossed Melon Creek, and then turned westward to Refugio. Throughout Copano's existence, an adequate fresh-water supply was difficult to maintain. The water problem, combined with the absence of a railroad and efficient interior transportation route, led to the demise of the town. Most residents moved to nearby Refugio, and by the 1880s Copano was abandoned.

BIBLIOGRAPHY: Hobart Huson, *El Copano: Ancient Port of Bexar and La Bahia* (Refugio, Texas: Refugio *Timely Remarks*, 1935). Hobart Huson, *Refugio: A Comprehensive History of Refugio County from Aboriginal Times to 1953* (2 vols., Woodsboro, Texas: Rooke Foundation, 1953, 1955).

June Melby Benowitz

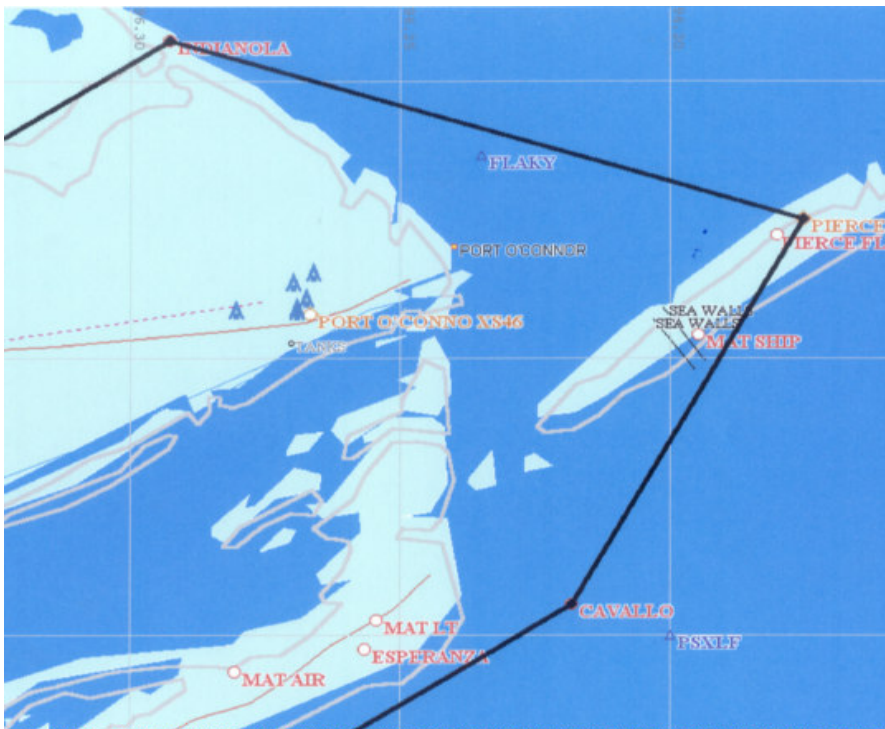
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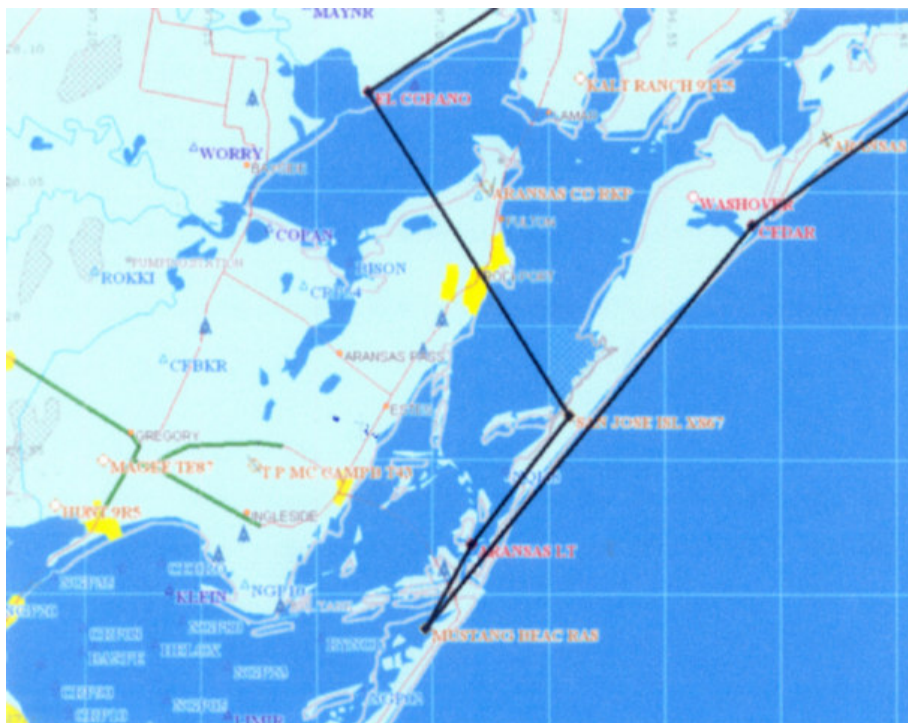
"COPANO, TX." The Handbook of Texas Online.
<<http://www.tsha.utexas.edu/handbook/online/articles/view/CC/hvc74.html>> [Accessed Mon Oct 4 18:05:00 US/Central 2004].

SAN JOSE AIRPORT (XS67 27 56.67, 96 59.10) We will now fly direct to the San Jose Airport (XS67) and then to KRAS and enter downwind for landing. It would be best if the leading airplanes speed up and the trailing planes slow down or divert so that we don't all arrive at the same time.

See y'all on the ground.

Thanks to Guthrie Ford for correcting a few of the dates in this document.
Richard





PILOT: Richard L. Watson

FLITESOFT™ FLIGHT LOG

10/4/2004

AIRCRAFT: Cessna 182 Skylane N3107R

Page 1

Ident	Waypoint	Type	Location	Freq	Latitude	Longitude	Elev	MVar	+Fuel
RAS	MUSTANG BEAC	Apt	MUSTANG BEAC, TX	122.90	27.48.71	097.05.33	5'	-5	74
CEDAR	CEDAR	User		-	28.03.77	096.51.20	0'	-5	0
CAVALL	CAVALLO	User		-	28.20.56	096.21.83	0'	-5	0
72TA	PIERCE FLD	Apt	PIERCE, TX	-	28.27.52	096.17.52	5'	-5	0
INDIANO	INDIANOLA	User		-	28.30.73	096.29.27	0'	-5	0
EL COPA	EL COPANO	User		-	28.08.74	097.07.79	0'	-5	0
XS67	SAN JOSE ISL	Apt	SAN JOSE ISL, TX	122.90	27.56.67	096.59.10	10'	-5	0
ARANSA	ARANSAS LT	User		-	27.51.85	097.03.32	0'	-5	0
RAS	MUSTANG BEAC	Apt	MUSTANG BEAC, TX	122.90	27.48.71	097.05.33	5'	-5	0

Ident	Crs	Hdg	Dist	TDist	Time	TTime	Burn	TBurn	Altitude	Power	TAS	GS	WDir/Spd
RAS	035	035	20	20	00:11	00:11	4	4	1500'	65	110	110	000/0
CEDAR	052	052	31	50	00:17	00:27	4	8	1500'	65	110	110	000/0
CAVALL	024	024	8	58	00:04	00:32	1	9	1500'	65	110	110	000/0
72TA	282	282	11	69	00:06	00:38	1	10	2500'	65	113	112	000/0
INDIANO	232	232	40	110	00:21	00:59	5	15	2500'	65	113	113	000/0
EL COPA	143	143	14	124	00:07	01:06	2	16	3500'	65	122	116	000/0
XS67	213	213	8	130	00:03	01:09	1	17	2500'	65	122	122	000/0
ARANSA	204	204	4	134	00:02	01:11	0	17	2500'	65	122	122	000/0
RAS													

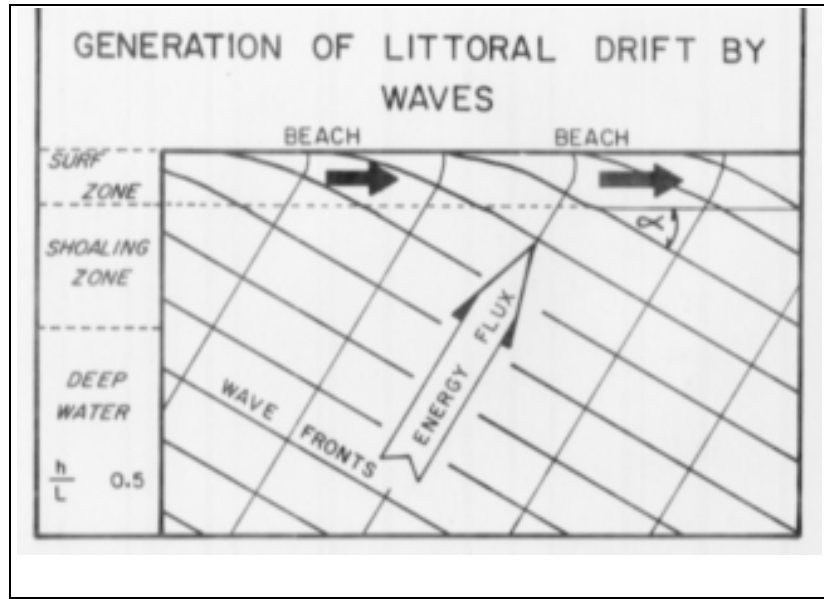
*** SUMMARY ***

Total Dist (nm):	134	Rem Dist (nm):	483	Block Speed (kts):	113
Total Fuel (ga):	17	Rem Fuel (ga):	57	Mileage (nm/ga):	7.91
Flight Time:	01:11	Rem Cruise Time:	04:01	Burn Rate (ga/hr):	14.2
Overall Time:	01:11	Dept Time (CDT):	07:55 pm	Arrival (CDT):	09:06 pm

COASTAL PROCESSES

The wind in the nearshore Gulf of Mexico generates waves which move toward the shore in the direction the wind is blowing. As the waves approach shallow water, they become steeper and eventually break, forming surf. Once the waves have broken, they become a

moving mass of water approaching the shoreline at a slight angle. This generates a current moving parallel with the shoreline within the surf. Whenever a wave breaks, it suspends sand from the bottom into the water. This sand is then carried a short distance along the shoreline until it settles out, only to be re-suspended and carried along by the next breaking wave. This



process creates a virtual conveyor belt of sand along the shoreline in the surf zone. It has been called a river of sand and frequently amounts to hundreds of thousands of cubic yards of sand.. This diagram shows sand movement in the opposite direction that occurs along this coast. Here the wind and waves come primarily from the right, making the sand movement go to the left. Winds from the southeast and east dominate and produce average wave directions from the east through the south. These waves approach the shore at an angle and result in a net movement of beach material from northeast to southwest.

The amount of sediment transported along the shoreline as littoral drift at any location is dependent on the size of the breaking waves, and the angle they meet the shore. If there is sand present on the beach, it will be transported in a downdrift direction. In order for there to be equilibrium and not have a net loss of sand and beach erosion due to the littoral drift sand transport system, it is critical that each section of beach have the same amount of sand supplied to it from the updrift direction as is removed in the downdrift direction. If less is supplied than is removed, then beach erosion will occur. If more is supplied than removed, then beach growth, or accretion, will occur. This causes a large fillet of sand to build up on the updrift side of a jetty or groin. Sand is being brought in from the updrift side, but none can get past the jetty. At the same time, the downdrift side of the jetty or groin usually has a highly eroded beach. Sand is still leaving on the littoral drift conveyor belt, but no sand is coming from the updrift side. It is trapped by the jetty.

Inlets also produce beach erosion by starving the downdrift beaches of sand. Sand flows in through the inlet and is deposited in the bay. The beaches, downdrift of the inlet, are starved by the amount of sand that flows in through the inlet.

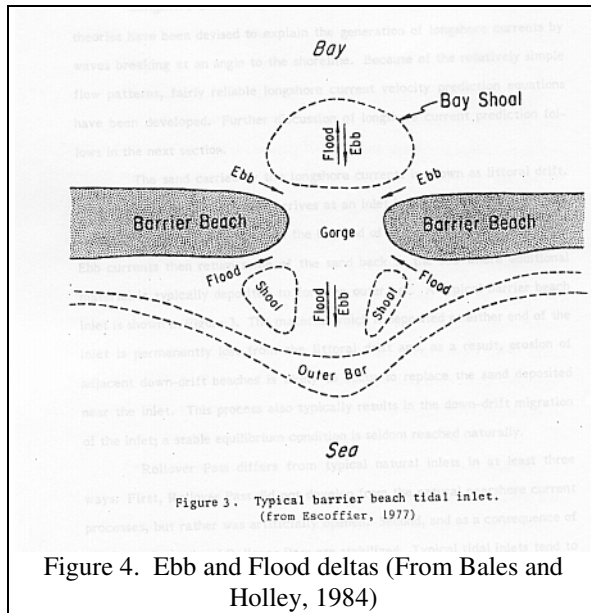


Figure 4. Ebb and Flood deltas (From Bales and Holley, 1984)

In addition to washing sand into the bays and forming a flood tidal delta in the bay, the ebb jet washes material offshore and forms an ebb tidal delta as well (Fig. 4). The sand in the ebb and flood tidal deltas is no longer available for transport down the beaches.

Tropical storms and hurricanes cause both permanent and temporary loss of beach sand. During a storm, the upper beach and dunes are eroded and much of that sand is carried offshore into a nearshore bar system. With the return of calm waves after the storm, that material is carried back up onto the beach over a period of many months and sometimes

years. Once the sand is deposited on the beach by waves, the wind will blow it inland to the first vegetation and a dune ridge will form. This is important, because the sand in that dune ridge will be carried Gulfward to the bar system in the next large storm. This cycle repeats with every storm. In some cases, if there is no dune ridge and the barrier island or peninsula is very low, a considerable amount of sand is carried inland and deposited as flats on the bay side of the barrier.

If there is no dune ridge storing sand between storms, and sand is carried inland, or further offshore out of reach of the gentle waves which can carry it back onshore, there is permanent beach erosion. When storms attack a clay shore, all of the clay is carried permanently away in suspension. It is not deposited just offshore in the bar system to be carried back onshore with the return of gentle waves.