Dickinson Bay and Dickinson Bayou are located between Houston and Galveston on the upper Texas coast (fig. 1). Dickinson Bay is a secondary bay on the western shoreline of Galveston Bay. Maximum fetch across the Dickinson Bay is approximately 3.2 km. A navigation channel providing access to Galveston Bay bisects Dickinson Bay in a northwest-southeast direction.

The Dickinson Bayou watershed encompasses approximately 171 km² in Galveston and Brazoria counties (Walsh Engineering, Inc., 1993) (fig. 1). The watershed varies from 1.8 km wide, north-south, at the upper or western end, to 12.2 km wide near its midpoint. From its headwaters near Alvin, Dickinson Bayou flows generally eastward for 36 km to its confluence with Dickinson Bay. The bayou receives runoff from five major tributaries on the north side of the bayou and seven on the south side. Flows in the upper reaches of each of these streams are intermittent (Walsh Engineering, Inc., 1993). The terrain is relatively flat over the watershed, and elevations vary from 15 m at the western end to sea level near the mouth of the bayou (Walsh Engineering, Inc., 1993). Local relief does not exceed 7.6 m.

Several major roads, railroads, and canals cross the watershed. Roads running generally north-south are Interstate Highway 45, State Highway 146, State Highway 3, State Highway 35, and FM 528. Highways running east-west include FM 517, FM 646, and State Highway 6. Three railroads cross the watershed, with two of the three crossing Dickinson Bayou. Irrigation canals crossing the watershed are the American Canal and the Gulf Coast Water Authority "Galveston Channel" (Walsh Engineering, Inc., 1993).

PHYSICAL SETTING

Climate

Climate in the Dickinson Bay and Dickinson Bayou watershed is humid and greatly influenced by the Gulf of Mexico. Mean annual precipitation averages approximately 122 cm, and monthly rainfall is generally evenly distributed throughout the year (Walsh Engineering, Inc., 1993). Although the watershed experiences occasional droughts, it is also affected by higher than normal precipitation levels. During Tropical Storm Claudette in 1979, for example, a record 107 cm of rain fell in less than 24 hours at one location near Alvin. Rainfall totals were well above totals associated with a 100-year frequency storm event, and widespread flooding damaged an estimated 1,757 structures (Walsh Engineering, Inc., 1993).

Two principal wind regimes dominate the area--persistent southeasterly winds from March through November, and short-lived but strong northerly winds from December through February (Fisher

et al., 1972). Long warm summers and short mild winters result in a growing season of about 330 days (Walsh Engineering, Inc., 1993). The mean annual temperature is approximately 21°C. During January, the normal daily maximum temperature is approximately 15°C, and the normal daily minimum is 9°C. Cold fronts, while causing an abrupt drop in air temperature, cumulatively lower the water temperature of the bay and bayou. During August, the normal daily maximum temperature reaches 32°C, while the normal daily minimum is approximately 26°C (Walsh Engineering, Inc., 1993).

Geology

Dickinson Bay and the Dickinson Bayou watershed owe their origin to large-scale sea-level fluctuations associated with the advance and retreat of continental ice sheets during and after the Wisconsinan glacial stage (approximately 18,000 to 120,000 years before present) (Paine and Morton, 1986). The growth of the ice sheets removed large volumes of water from the oceans, causing sea levels to fall. The melting of the ice sheets released the stored water and sea levels rose. Pleistocene fluvial and deltaic muddy and sandy sediments (Beaumont Formation) deposited in both marine and nonmarine environments surround the Dickinson Bay and Bayou area (Fisher et al., 1972; Paine and Morton, 1986). Pleistocene fluvial and deltaic deposits form clay bluffs along parts of the Dickinson Bay shoreline.

After deposition of the Beaumont Formation, sea level lowered during Wisconsinan glaciation, and entrenchment of coastal rivers and streams occurred in response to the lowering (Paine and Morton, 1986). Glacial retreat released stored water, causing sea level to rise. About 5,000 years ago, the rate of sea-level rise decreased. Estimates of rates of rise during the last 3,000 years range from 2.5 to 12.5 cm per century. During the Holocene, or the last 10,000 years, deposition of sediments partly filled stream valleys (Paine and Morton, 1986). Several processes, including erosion of valley walls and oyster-reef growth, contributed to estuarine sedimentation as the rate of sea-level rise diminished. Geologic formations that now crop out in the area are Beaumont Formation clays and sands (Barnes, 1992).

Geologic processes that are active in the Dickinson Bay and Bayou area are shoreline erosion and relative sea-level rise. Paine and Morton (1986) calculated shoreline erosion rates for the Galveston Bay area, including Dickinson Bay. Long-term erosion rates in Dickinson Bay range from 0.3 to 1.2 m/yr. Paine and Morton (1986) suggest that these rates are slightly lower than for many shorelines in the Galveston Bay system, "because the bay is shallow and has short wave fetch in all directions." Data are not available on erosion rates in the bayou.

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Relative sea-level rise, or a rise in sea level with respect to the surface of the land, has also impacted the area. Relative sea-level rise consists of two components, actual sea-level rise and subsidence. Subsidence may be caused by natural compaction of sediments or by withdrawal of underground fluids (White et al., 1993; Paine, 1993). Subsidence in the Galveston Bay area is caused primarily by groundwater withdrawal for industrial use. In the Dickinson Bay and Bayou area, from 0.6 to 1.2 m of subsidence occurred between 1906 and 1987 (Gabrysch and Coplin, 1990). Subsidence rates have recently declined as reliance on groundwater has decreased. Between 1978 and 1987, the area experienced only 0.08 to 0.15 m of subsidence (Gabrysch and Coplin, 1990).

Surficial sediments in deeper parts of Dickinson Bay are composed predominantly of sandy muds (White et al., 1985). Muddy sands occur along the bay margins. Powell et al. (1994) delineated approximately 193 acres of oyster reef and shelly mud in Dickinson Bay, primarily in the area where Dickinson Bay intersects Galveston Bay. Sediments in the bayou are predominately mud with occasional patches of sand.

Soils

Soils north of Dickinson Bay and in the Dickinson Bayou watershed are defined by the Soil Conservation Service as nearly level, somewhat poorly drained, nonsaline, loamy soils with a clayey subsoil (Crenwelge et al., 1988) (fig. 4). The major soil series associated with these areas are the Lake Charles-Bacliff, Bernard-Verland, and the Kemah-Edna-Leton. These soils are primarily prairie soils, with forested soils along the bayou and creeks. The major soils south of Dickinson Bay are deep, saline soils of the marshland that are somewhat or very poorly drained and have a loamy or clayey surface layer. Major soil series found in these areas are the Narta-Francitas and the Ijam. Hydric soils in the Dickinson Bay and Bayou area are Leton loam, Bacliff clay, Ijam, Harris clay, Veston loam, Narta loam, and Francitas clay.

Land Use and Population

Land use around Dickinson Bay and in the Dickinson Bayou watershed varies from open pasture and agriculture to high-density residential. Most of the area on the south side of Dickinson Bay is open pasture. The northern shoreline of Dickinson Bay is high-density residential, while large areas further inland are classified as open pasture and agriculture (Newell et al., 1992). Almost 65 percent of the Dickinson Bayou watershed is open pasture and agriculture. The rest of the watershed is residential (14%), wetlands (19%), water (1%), or forest (1%) (Newell et al., 1992). The areas of highest urban development are in the vicinity of the cities of Dickinson and

League City. The 1990 population in the watershed was 44,051 (Walsh Engineering, Inc., 1993).

Tides

Astronomical tides inundate bay and Gulf of Mexico shorelines either daily (diurnal tides) or twice daily (semidiurnal tides) during most of the year. Tides along the Gulf of Mexico are predominately diurnal because the magnitudes of the diurnal constituents are much greater than those of the semidiurnal constituents. Astronomical tides in the Galveston Bay system are microtidal (<1 m). Tidal amplitudes at the Eagle Point tide gauge near Dickinson Bay range from approximately 0.1 to 0.6 m, with a mean tide range of approximately 0.4 m. More significant in this area are wind-generated tides, which affect most bay environments (White et al., 1985).

Bathymetry

Dickinson Bay is a relatively shallow bay, with water depths generally less than one meter. The Dickinson Bay Channel, which is privately maintained, is 18.3 m wide and 1.8 m deep. The width of the channel in the lower nontidal area of Dickinson Bayou ranges from approximately 6 to 8 m, with an average depth of 0.5 m (Walsh Engineering, Inc., 1993). Depths in the upper tidal segment of Dickinson Bayou from Gum Bayou to near Cedar Creek range from 1 to 7.9 m.

Salinity

Average salinity in the upper 1.5 m of Dickinson Bay is 14.8 parts per thousand (ppt) (Ward and Armstrong, 1992). The average summer salinity during July, August, and September in the bay is 15.9 ppt. Surface salinities taken in Dickinson Bayou at Highway 146 from June 1992 to December 1993 range from near 0.0 ppt in April 1993 to 23 ppt in October 1992 (Fitzgerald, 1993-94). Salinities at the Highway 146 site averaged 6.9 ppt in 1993. Total precipitation for the area in 1992 and 1993 was above normal. Salinity data for the tidal segment of the bayou range from 0.0 to 26.0 ppt, with a mean of 7.5 ppt (Ward and Armstrong, 1992). The above-tidal segment ranges from 0.0 to 20.0 ppt, with a mean of 0.6 ppt (Ward and Armstrong, 1992).

Water and Sediment Quality

The TNRCC routinely samples both the tidal portion of Dickinson Bayou and the above-tidal area for water quality as part of the Stream Monitoring Network. The tidal portion extends from the confluence with Dickinson Bay, 2.1 km downstream of Highway 146, to a point 4.0 km downstream of FM 517 in Galveston County, a distance of 24.3 km. Water uses in both the tidal and above-

Figure 4. Soils of the Dickinson Bayou Watershed

Ar - Aris fine sandy loam

Be - Bernard clay loam

Bn - Bernard-Edna complex

Bu - Bernard-Urban land complex

Ed - Edna fine sandy loam

Es - Edna-Aris complex

Fo - Follet loam

Fr - Francitas clay

ImA - Ijam clay, 0-2% slopes

ImB - Ijam clay, 2-8% slopes

KeA - Kemah silt loam,
0-1% slopes

LaA - Lake Charles clay,
0-1% slopes

LaB - Lake Charles clay,
1-5% slopes

Le - Leton loam

Ls - Leton-Aris complex

Lx - Leton-Lake Charles complex

Ma - Mocarey loam

Mb - Mocarey-Algoa complex

Mc - Mocarey-Cieno complex

Md - Mocarey-Leton complex

Me - Morey silt loam

Mf - Morey-Leton complex

Na - Narta fine sandy loam

Pa - Sand Pits

Va - Vamont clay

Ve - Verland silty clay loam

Vx - Veston loam, slightly to
strongly saline complex

W - Water