**Briefing Paper on Houston Area Bayous II:**
**Houston Ship Channel and Upper Galveston Bay plus**
**Addicks and Barker Reservoirs; Buffalo, Greens and White Oak Bayous**

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## Description of the Watershed

This subwatershed includes portions of Harris, Fort Bend, and Waller counties. The Addicks-Barker flood control reservoirs are located on the western edge of this area. Moving east, the subwatershed includes White Oak Bayou, Buffalo Bayou, and Greens Bayou which all ultimately flow into the San Jacinto River in the section that is now the Houston Ship Channel and then into Upper Galveston Bay. The bayous in this subwatershed grouping are some of the most heavily urbanized in the Lower Galveston Bay watershed. The area includes portions of the cities of Houston, Katy, Spring, Jersey Village, and Humble with more than 1.4 million people residing within its bounds. Given the dense residential and commercial development, flooding and nonpoint source water pollution are key issues.

## Land Use and Habitat in the Watershed

This watershed area is highly developed and consists primarily of residential and commercial development. Rice farming was a dominant agricultural activity in the western portions of the area near the Katy Prairie, located in northwestern Harris County and northeastern Waller County, until the latter decades of the last century. The tall grass prairie, originally 500,000 acres in western Harris and adjoining counties, now consists of approximately 200,000 fragmented acres due to development pressure. Snow geese are a dominant species on the Katy Prairie, but were originally drawn to the area by the habitat provided by rice fields.

Addicks and Barker Reservoirs were constructed in the late 1940s by the U.S. Army Corps of Engineers (COE) to provide flood control on Buffalo Bayou for the City of Houston. The area in and around the reservoirs has agricultural land use, residential and commercial development, as well as recreational land.

Prior to intense urban development, the bayous in this watershed area provided ribbons of riparian hardwood forest. White Oak Bayou stretches from the center of Houston northwest past Jersey Village. Its watershed is heavily urbanized with growth continuing north and west. This area has frequent flooding problems. Land subsidence near Jersey Village caused by groundwater withdrawal exacerbates flooding in that part of the watershed.

Buffalo Bayou, the bayou on which the City of Houston was founded by the Allen Brothers in 1836, is heavily urbanized. Some of Houston's oldest buildings can be found near its banks. Portions of the Bayou have been enlarged and straightened, and heavily modified. Some stretches of the Bayou are lined with riparian hardwoods and meander through a number of

Houston's Parks (including Eleanor Tinsley, Sam Houston, and Memorial Parks). Other stretches of the Bayou are the subject of a large economic revitalization project. Buffalo Bayou becomes the Houston Ship Channel at the turning basin where the surrounding land use then changes to petrochemical industry. The Houston Ship Channel meets the San Jacinto River with waters then flowing past more industry and the San Jacinto Monument before they discharge into Upper Galveston Bay.

Greens Bayou stretches from Humble and northeast Houston south to its confluence with the Houston Ship Channel. Its watershed includes a mix of undeveloped forested wetlands, dense urban residential and commercial development, and industrial land uses. It is the location of the first wetland mitigation bank in Harris County; the 1,400 acre mitigation bank is operated by the Harris County Flood Control District.

**Water Quality Issues**

Water quality in this watershed area is impacted by the existence of dense urban land use and petrochemical industry. The water quality of some segments is highly degraded with the nature of the contamination relating directly to the surrounding urban or industrial land use. As seen in Table 1, a number of water bodies in this area are listed on the State of Texas 303(d) list of impaired waters and are deemed unsuitable for fish consumption due to elevated levels of fecal coliform bacteria in the water or industrial chemicals in sediments or in fish and crab tissue. Finfish and blue crabs should not be harvested from many of the industrialized waterways nor should contact recreation (swimming) be exercised in the urban portions.

| | PCBs in Catfish, Spotted Seatrout, and Blue Crab | PCBs in Finfish | Dioxin in Catfish and Blue Crabs | Chlordane, Dieldrin, Heptachlor Epoxide in Finfish | Depressed Dissolved Oxygen | Fecal Coliform Bacteria |
|---|---|---|---|---|---|---|
| Garners Bayou | | | | | | ▲ |
| Greens Bayou Above Tidal | | | | | ▲ | ▲ |
| Little White Oak Bayou | | | | | ▲ | ▲ |
| White Oak Bayou Above Tidal | | | | | | ▲ |
| Buffalo Bayou Above Tidal | | | | | | ▲ |
| Buffalo Bayou Tidal | | | | | | ▲ |
| Houston Ship Channel/Buffalo Bayou Tidal | | | | ▲ ▲ | | |
| San Jacinto River Tidal | | ▲ | ▲ | | | |
| Houston Ship Channel / San Jacinto River Tidal | ▲ | ▲ | ▲ | | | |
| Cedar Bayou | | | ▲ | | ▲ | |
| Houston Ship Channel Tidal | | ▲ | ▲ | ▲ | | |
| Tabbs Bay Black Duck Bay Scott Bay San Jacinto Bay Burnett Bay | ▲ | | ▲ | | | |
| Upper Galveston Bay | ▲ | | ▲ | | | |

▲ = Total Maximum Daily Load (TMDL) study underway
▲ = TMDL to be scheduled; high rank
▲ = Additional data to be collected before a TMDL is conducted

Table 1. Summary of water bodies in the area on the Draft 2004 State of Texas 303(d) list of impaired waters. Table created by the Galveston Bay Status and Trends Project, Houston Advanced Research Center. Data source: Texas Commission on Environmental Quality.

Once on the 303(d) list, the waterbody becomes the subject of a Total Maximum Daily Load (TMDL) study. The TMDL process uses stakeholder input, existing data, and additional field studies to determine the amount (or load) of a pollutant that the body of water can receive and still support its beneficial use (e.g. seafood supply, aquatic life, public water supply). The load is then allocated among all the potential sources of pollution within the watershed. Measures to reduce pollutant loads are developed as necessary. Once the goal of restoring the waterbody to historic use conditions is met, the stream segment is removed from the 303(d) list.

According to the nutrient indicator (based on nitrogen, phosphorus, and phytoplankton concentrations) in Tables 1 and 2 below, the number of surface water samples exceeding nutrient screening limits set by the Texas Commission on Environmental Quality (TCEQ) appears to have improved somewhat over the last years for the San Jacinto River. However, nutrient loadings still appear to be elevated in Buffalo Bayou, the Houston Ship Channel and Upper Galveston Bay. Note that White Oak and Greens Bayous are not listed; the Galveston Bay Indicators Project looked at tidally influenced waters only.

| Rating | Percent of samples exceeding TCEQ screening levels |
|---|---|
| Very Good | 0-5% |
| Good | 6-15% |
| Moderate | 16-30% |
| Poor | >30% |

Table 2. Indicator rating system developed for the nutrients in surface waters indicator. Table created by the Galveston Bay Indicators Project, Houston Advanced Research Center. Data source: Texas Commission on Environmental Quality.

| Subbay or Tributary | 1970s | 1980s | 1990s | 2000s |
|---|---|---|---|---|
| San Jacinto River | | | | |
| Buffalo Bayou | | | | |
| Houston Ship Channel | | | | |
| Upper & Lower Galveston Bay | | | | |

Table 3. Indicator describing the state of nutrients (ammonia, nitrate-nitrite, total phosphorus) and chlorophyll-a concentrations in surface waters as a average proportion of TCEQ screening levels by decade from the 1970s through 2000s. Table created by the Galveston Bay Indicators Project, Houston Advanced Research Center. Data source: Texas Commission on Environmental Quality and the National Coastal Assessment, Texas Parks and Wildlife Department.

As seen in Table 1, a number of stream segments are listed on Texas 303(d) List for high concentrations of fecal coliform bacteria, an indicator of possible human pathogens in the water. Water bodies in this area included on the 303(d) List for this reason do not meet the designated use of contact recreation (i.e. recreational activities in which the user comes into direct contact with the water). The Galveston Bay Indicators Project found that concentrations of fecal coliform bacteria in surface waters exceeded TCEQ screening levels to a moderate degree in the San

Jacinto River south of the Lake Houston Dam and to a high degree in Buffalo Bayou and the Houston Ship Channel. This will not impact contact recreation in the Houston Ship Channel, since it is not used for swimming, canoeing, kayaking, etc. However, the San Jacinto River is used recreationally for these activities.

| Rating | Proportion of Samples Above Screening Level |
|---|---|
| Very Good | 0% samples above the screening level |
| Good | 1-9% samples above the screening level |
| Moderate | 10-25% samples above the screening level |
| Poor | >25% samples above the screening level |

Table 4. Indicator rating system developed for the fecal coliform bacteria in surface waters indicator. Table created by the Galveston Bay Indicators Project, Houston Advanced Research Center.

| Tributary or Subbay | 1970s | 1980s | 1990s | 2000s |
|---|---|---|---|---|
| San Jacinto River | | | | |
| Buffalo Bayou | | | | |
| Houston Ship Channel | | | | |
| Upper & Lower Galveston Bay | | | | |

Table 5. Indicator describing the state of fecal coliform bacteria in surface waters as a proportion of the TCEQ screening level. Refer to Table 4 for a description of the color system. Table created by the Galveston Bay Indicators Project, Houston Advanced Research Center. Data source: Texas Commission on Environmental Quality.

As evidenced by the number of stream segments on the Texas 303(d) list in Table 1, this area appears heavily impacted by industrial sources. Analyses by the Galveston Bay Indicators Project in 2004 compared concentrations of organic compounds in sediments to probable effect levels (PELs) established by the TCEQ (TCEQ, 2004). A PEL is defined as the concentration of a contaminant above which adverse biological effects are expected to occur. Major subbays and tributaries of the bay were rated based on the percentage of sediment samples exceeding PELs in a given decade (see Table 6). Areas shown in the tables below as yellow or red have an increased risk of adverse biological effects due to elevated levels of sediment contamination.

| Rating | Percent of Samples Exceeding the PEL |
|---|---|
| Very Good | 0% |
| Good | 1-9% |
| Moderate | 10-25% |
| Poor | >25% |

Table 6. Indicator rating system developed for toxic contaminants in sediments. Table created by the Galveston Bay Indicators Project, Houston Advanced Research Center.

As seen in tables 7 and 8 below, the majority of sediment quality problems occur in the Houston Ship Channel with the greatest problem being associated with industrial organics. Oddly, there

were insufficient data for polychlorinated biphenyls (PCBs) in the Houston Ship Channel. PCBs are legacy pollutants used as a fire retardant; their manufacture, sale, and use were banned in the United States nearly thirty years ago. PCBs have been detected at high levels in some fish and are a partial cause of the seafood consumption advisories in place for the Houston Ship Channel and Upper Galveston Bay (see Figure 1 below).

**Industrial Organics**

| Tributary or Subbay | 1970s | 1980s | 1990s | 2000s |
|---|---|---|---|---|
| Houston Ship Channel | | | | |
| Upper & Lower Galveston Bay | ns | | | |

Table 7. Indicator describing the state of industrial organics in sediment as a proportion of Marine Probable Effects Levels (PELs) published by the TCEQ. ns = Insufficient sample size (< 10 samples). Table created by the Galveston Bay Indicators Project, Houston Advanced Research Center. Data source: Texas Commission on Environmental Quality.

| Houston Ship Channel Detail | 2000s |
|---|---|
| Acenaphthene | |
| Acenaphthylene | |
| Anthracene | |
| Benzo(a)anthracene | |
| Benzo(a)pyrene | |
| Chrysene | |
| 1,2,4,6 Dibenzanthracene | |
| Fluoranthene | |
| Fluorene | |
| Naphthalene | |
| PCBs | ns |
| Phenanthrene | |
| Pyrene | |

Table 8. Detail of industrial organics in sediments of the Houston Ship Channel.
ns = Insufficient sample size (< 10 samples). Table created by the Galveston Bay Indicators Project, Houston Advanced Research Center. Data source: Texas Commission on Environmental Quality.

While a number of industrial organics are found in high concentrations in the Houston Ship Channel, the story for metals in sediment is a bit more variable. As one can see in Table 10, the concentrations of several metals have declined significantly over the last three decades. For example, cadmium, lead and silver rarely exceed their PELs. Out of nine metals assessed by the Galveston Bay Indicators Project, mercury and zinc had the highest concentrations in sediments sampled from this area in years since 1999. The summary indicator shown in Table 9 emphasizes the local nature of metal contamination of sediment. The problem is currently limited to the Upper Houston Ship Channel.

## Metals

| Tributary or Subbay | 1970s | 1980s | 1990s | 2000s |
|---|---|---|---|---|
| Houston Ship Channel | | | | |
| Upper & Lower Galveston Bay | | | | |

Table 9. Indicator describing the state of heavy metals in sediment as a proportion of Marine Probable Effects Levels (PELs) published by the TCEQ (TCEQ, 2004). Refer to Table 4 above for a description of the color system. Table created by the Galveston Bay Indicators Project, Houston Advanced Research Center. Data source: Texas Commission on Environmental Quality

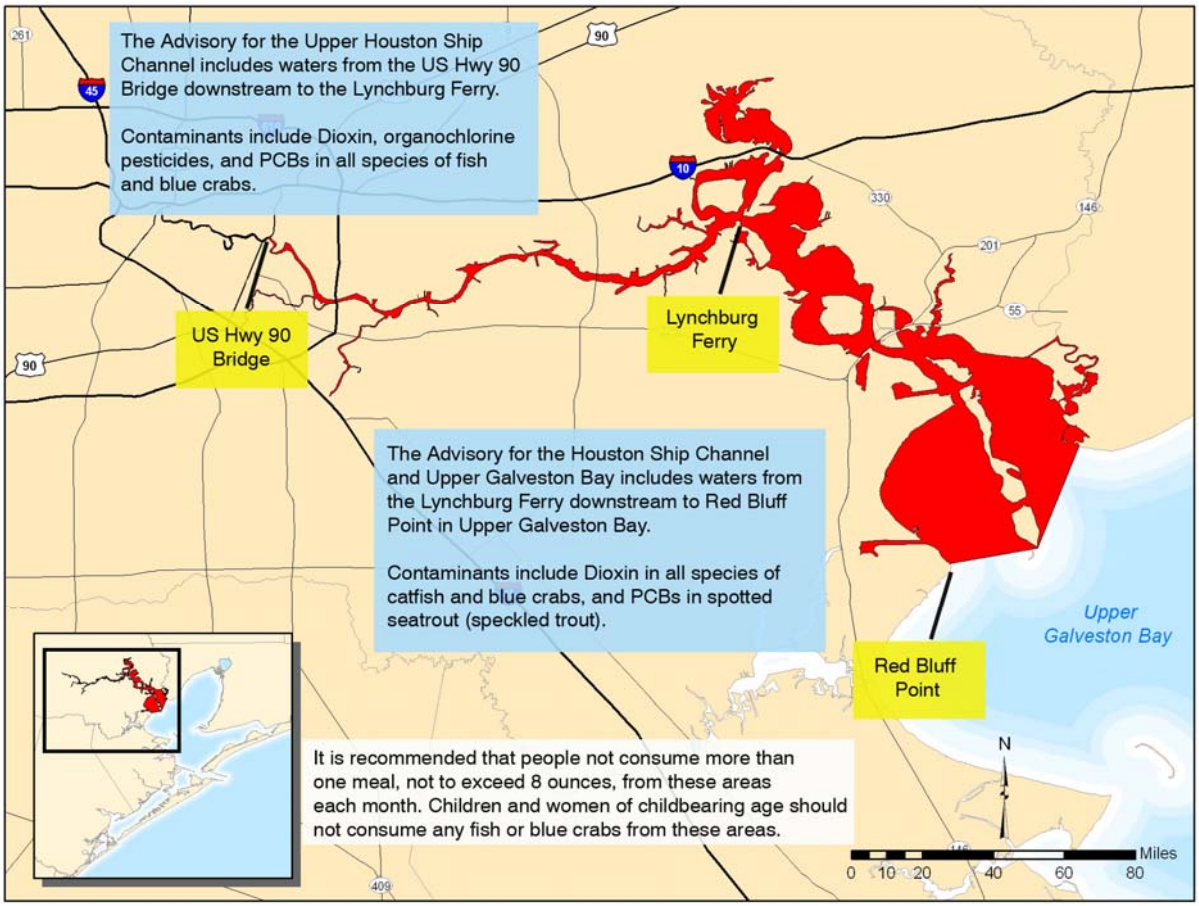
| Metal | 1970s | 1980s | 1990s | 2000s |
|---|---|---|---|---|
| Arsenic | | | | |
| Cadmium | | | | |
| Chromium | | | | |
| Copper | | | | |
| Lead | | | | |
| Mercury | | | | |
| Nickel | | | | |
| Silver | | | | |
| Zinc | | | | |

Table 10. Detail of nine heavy metals in sediments of the Houston Ship Channel. Table created by the Galveston Bay Indicators Project, Houston Advanced Research Center. Data source: Texas Commission on Environmental Quality.

### Public Health Issues

Three seafood consumption advisories for Galveston Bay and its tributaries have been issued by the Texas Department of State Health Services (DSHS) since 1990. While the majority of bay and tributary surface waters are not included in seafood consumption advisories, the DSHS advises that consumption of seafood taken from the Houston Ship Channel and portions of Upper Galveston Bay poses an increased risk of adverse human health effects. All three seafood consumption advisories in 1990, 2001, and 2005 were issued for these areas (Figure 1). Contaminants of concern include dioxin, organochlorine pesticides, and PCBs. Species of concern include blue crab, catfish, spotted seatrout, and other species of finfish. Additionally, the DSHS prohibits the commercial harvest of shellfish from this area.

Figure 1. The Area, Species, and Contaminants Included in Galveston Bay Seafood Advisories Issued by the Texas Department of State Health Services in 1990, 2201, and 2005. Map created by the Galveston Bay Indicators Project, Houston Advanced Research Center. Data source: Texas Department of State Health Services.



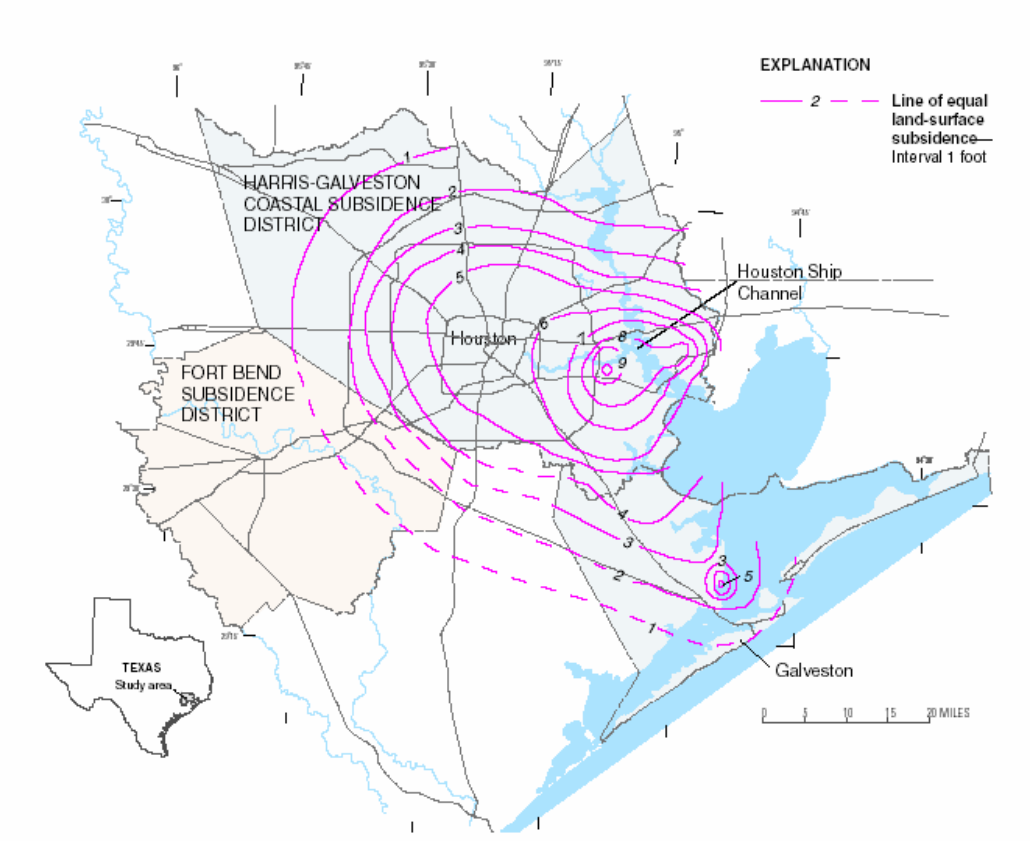

## Other Issues

Flooding is a major issue in these urban watersheds. Much of the housing and commercial development along the banks of the bayous in urban Houston was completed before the presence of detailed floodplain mapping. To combat repeated flooding and hasten the movement of water from the urban center to Galveston Bay during extreme weather events, bayous were channelized and lined with concrete. This had the effect of moving water downstream faster, but after high rainfalls resulted in flooding problems for downstream residents. The federal, state, and local agencies responsible for building and maintaining the flood control infrastructure are now implementing flood control projects using more green space and less “hard” engineering. Examples include wet bottom detention ponds and regional water detention projects such as the Willow Waterhole Greenway Project near South Post Oak and U.S. Highway 90.

Land subsidence due to extraction of groundwater has been a major issue in the areas of this subwatershed grouping, particularly near Jersey Village where subsidence has caused the land

under the municipality to sink in a bowl shape and near the San Jacinto Monument on the Houston Ship Channel. Subsidence there has resulted in the conversion of wetland habitat into open water. A wetland restoration project at the Monument makes beneficial use of dredge material to rebuild the substrate for wetlands vegetation.

Figure 2. Subsidence in the Houston-Galveston region occurring between 1906 and 1987. Map created by the Harris-Galveston Coastal Subsidence District.




As in other areas of the bay, invasive species such as Chinese tallow and fire ants out compete or prey on native species with the potential to reduce biodiversity. A recent study completed by the Texas Parks and Wildlife Department found several species of exotic fish in three Houston bayous, including Greens Bayou. Species included *Plecostomus* (armored catfish) and Rio Grande cichlid, popular aquarium fish, and tilapia a popular food fish. While the ecological impacts of these three species on area bayous are largely unknown, it is thought that *Plecostomus* have the greatest potential to cause harm through their need to burrow into stream banks for nesting. It is thought that the burrows could destabilize the shoreline further degrading water quality.

## Conclusion

This area of the Lower Galveston Bay Watershed is one of the most heavily impacted in terms of urban and industrial point source and nonpoint source loadings to local waterways. Numerous stream segments are on the state list of impaired waters due to elevated levels of fecal coliform bacteria in surface water and industrial contaminants in fish and crab tissue. Several seafood consumption advisories have been issued by the Texas DSHS since 1990 due to elevated levels of PCBs and dioxin. Industrial organic compounds in sediment are elevated to levels indicative of high risk of adverse impacts to benthic organisms that dwell in or on the sediments. In addition to water and sediment quality problems and elevated health risks due to consumption of seafood, other issues of concern are urban flooding, land subsidence, habitat loss, and invasive species. Much work needs to be done if the trends in environmental contamination in this area of the Lower Galveston Bay watershed are to be reversed.