ENVIRONMENTAL STUDY OF AN URBAN STREAM - BLUCHER PARK CORPUS CHRISTI, TEXAS

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Ms. Emilie Payne
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Dear Emilie,

Enclosed for you is a report on the Blucher Park project which my undergraduates conducted last fall. Thank you for instigating this, and for providing so much information to the students.

Sincerely,

Jennifer Prouty

Jennifer S. Prouty, Ph.D.
Environmental Science Program

JSP/go
Enclosure(s)

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Abstract

This paper reports on a baseline study of an urban perennial stream which drains through Blucher Park in Corpus Christi, Texas. Researchers measured discharge of the stream, dissolved oxygen, total dissolved solids, and levels of the dissolved nutrients nitrite, nitrogen, phosphate, and phosphorous over a three week period. After a rainfall, discharge increases, causing marked erosion to both the stream bank and stream bed. A cement drainpipe and outfall structure installed to aid drainage off a bordering street is the site of extensive park slope erosion which now threatens the adjacent street. After a rain event, dissolved oxygen increases as the increased discharge aerates the stream water. Levels of dissolved phosphate increased in the stream after a rain event, probably due to increased pollutants carried by storm water runoff. Nitrogen and nitrite levels fall in the stream after a rain event, probably due to flushing by storm water runoff. The stream contains large amounts of trash, some of it dumped intentionally and some the result of storm water outflow from surrounding areas. Most is nonbiodegradable.

Introduction

This project is a baseline study of a perennial stream which flows through an urban park in Corpus Christi, Texas. Aspects of the stream studied included stream bank and slope erosion, storm drainage runoff, water quality, and anthropogenic debris.

The City of Corpus Christi (population: approximately 262,407) lies on the southern margin of Corpus Christi Bay in coastal South Texas (Figure 1). The climate is semiarid and subtropical, with an average annual rainfall of 27-30 inches. The regional topography is low-lying with elevations along the coast rarely exceeding 40 feet above sea level. The Pleistocene Beaumont Formation underlies most of Corpus Christi. The Beaumont Formation consists of fluvial sands interbedded with floodplain silts and clays, yielding locally variable permeabilities and permitting the existence of a few perennial seeps and springs throughout the area.

The Blucher Park area, the focus of this study, contains one such perennial stream that supports an abundance of wildlife and is an important natural habitat for migratory and native birds. Blucher Park is one of many small parks and greenspaces in downtown Corpus Christi. Boundaries of the park (Figure 1) include Blucher Street to the north, Kinney Street to the south, Tancahua Street to the east, and Carrizo Street to the west.

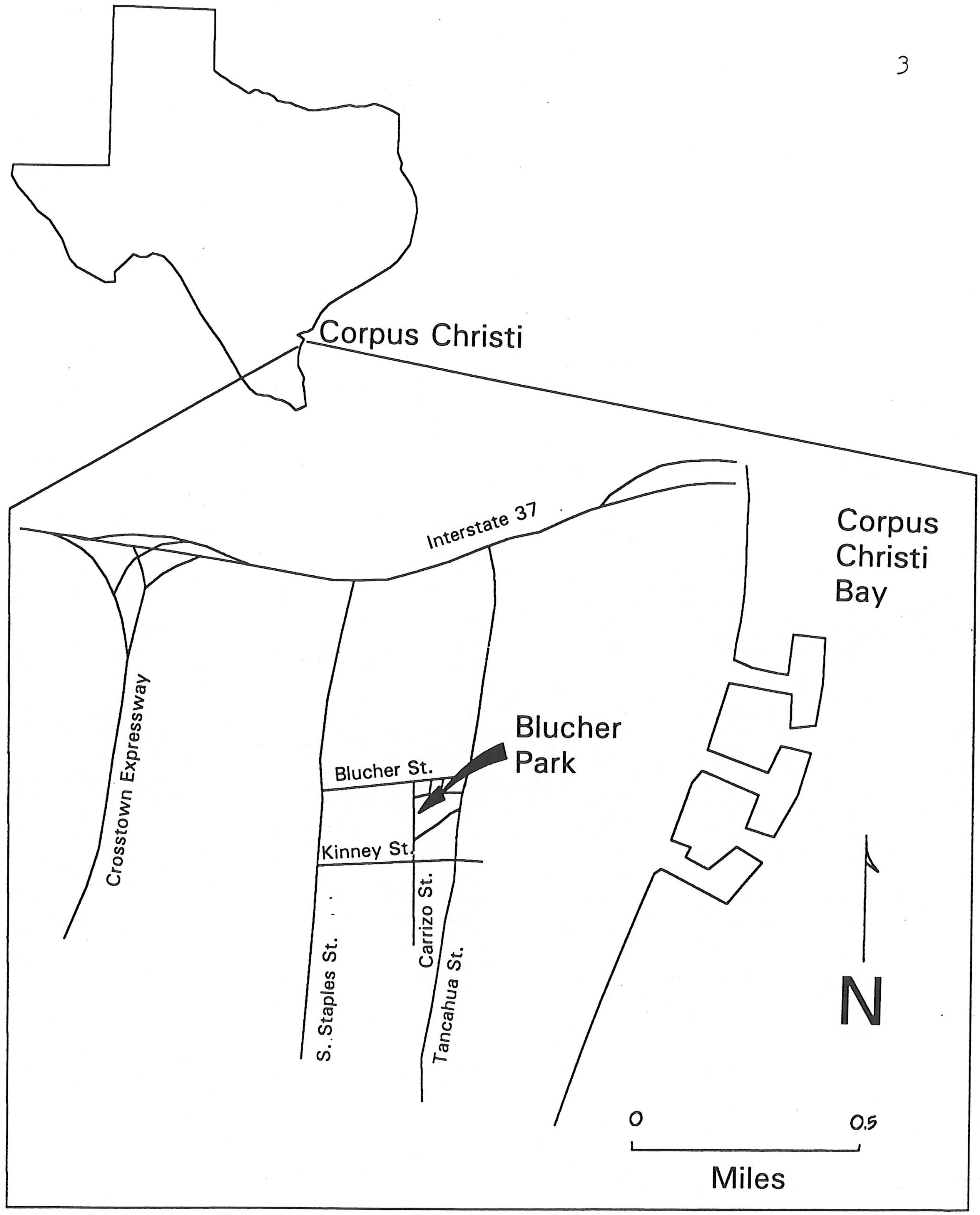

Figure 1. Location of Blucher Park study site in central Corpus Christi.

Procedures

Field measurements took place during five site visits from October 15 through November 4, 1995. Researchers measured flow velocity and stream cross-sectional area during each visit, enabling them to calculate stream discharge. During the three week observation period, the Blucher Park stream maintained a flow velocity fast enough to allow current measurement only once via a standard Price AA current meter. Instead, during other sample days researchers timed the movement of fluorescein dye along a given distance to determine the flow velocity. Multiplication of velocity by total stream cross-sectional area yielded total stream discharge. Researchers also noted rainfall events (as recorded at the Corpus Christi International Airport), for correlation with results.

Measurement of dissolved oxygen, pH, and total dissolved solids took place in the field. A modified Winkler technique with standard reagents from a LaMotte Kit yielded dissolved oxygen content. Testing of pH used a color comparator from the LaMotte kit. A conductivity meter measured total dissolved solids present in the stream.

Collection of water samples for nutrient analysis used clean jars pre-rinsed with distilled water to prevent sample contamination. Following water collection, researchers chilled the samples to preserve them for analysis, then took them to a laboratory at Texas A&M University-Corpus Christi for testing.

Water quality testing for nutrients used a Hach DREL/2000 water kit and spectrophotometer. The procedure manual supplied with the kit describes procedures used. Nutrients measured included nitrite, nitrogen, phosphate, and phosphorous.

Results

Discharge measurements.

Tables 1 and 2 list results of discharge and water quality measurements from October 15 through November 4, 1995. Discharge of the stream varied from 0.016 cfs to 0.870 cfs. The topography of Blucher Park enables runoff to drain quickly after a major rain, so that discharge due to rain is short-lived. Eight inches of rain fell from October 28 to October 29. This set a record for the most daily rainfall received by the Corpus Christi area. The discharge recorded on Monday, October 30, 1995 was higher than previously measured due to the large amount of rain received on October 29. Researchers were unable to get to the park until noon, October 30 because of street flooding. According to Emilie Payne (Audubon Society of Corpus Christi, personal communication, 10/95), water overflowed the stream banks early Monday morning, but subsided by noon when researchers took flow measurements.

A second rain event took place on November 4 when a total of 0.40" fell. Researchers were able to measure stream discharge during this event, and recorded discharge over twice that

Sampling Date	Last Rainfall Dates	Last Rainfall Amounts	Stream Discharge (Q)
10/15/95	10/12/95 10/13/95	0.06 in. 0.07 in.	0.016 cfs
10/26/95	10/23/95	<0.01 in.	--------
10/30/95	10/28/95 10/29/95 10/30/95	0.79 in. 7.92 in. 0.59 in.	0.368 cfs
11/2/95	10/31/95 11/1/95 11/2/95	<0.01 in. <0.01 in. 0.06 in.	0.089 cfs
11/4/95	11/3/95 11/4/95	<0.01 in. 0.40 in.	*0.870 cfs

* Sample taken <u>during</u> the rainfall event.

Table 1. Comparison of Discharge and Rainfall

Date	PH	TDS (ppm)	DO (mg/l)	NO_2/N (mg/l)	N (mg/l)	PO_4^{-3} (mg/l)	P (mg/l)
10/15/95	7.50	1300	2.700	0.035	0.116	1.660	0.553
10/26/95	8.00	1300	2.425	0.088	0.290	0.650	0.217
10/30/95	7.25	450	1.725	0.074	0.244	2.570	0.857
11/2/95	7.25	850	0.300	0.003	0.008	5.925	1.975
11/4/95	7.25	150	8.200	0.014	0.045	0.775	0.258
Mean	7.45	810	3.070	0.043	0.141	2.316	0.772

Table 2. Summary of Water Quality Measurements

measured on October 30. Presumably, the increase in discharge on November 4 occurred because of previous ground saturation, although timing of the discharge measurements to better coincide with peak discharge was probably also important.

Water quality measurements.

Total dissolved solids (TDS) measured 1300 ppm at the beginning of the testing period. The high level of TDS is due to the absence of rainfall before the first sampling. After receiving various amounts of rain at the end of October the TDS fell to 450 ppm on October 30 and 150 ppm on November 4, 1995. The concentration rose to 850 ppm on November 2, between major rain events.

Measured nutrients included dissolved oxygen, nitrite, total nitrogen, phosphate, and total phosphorous. Nitrite rates ranged from a low of 0.003 mg/l to a high of 0.088 mg/l and total nitrogen levels from 0.008 mg/l to 0.290 mg/l. Lowest nitrite and total nitrogen levels occurred on November 2, 1995 between several major rain events; highest levels occurred on October 26, 1995 following a period of little or no rainfall. Maximum and minimum phosphate levels were 5.925 mg/l on November 2 and 0.650 mg/l on October 26; maximum and minimum total phosphate levels were 1.975 mg/l and 0.217 mg/l also occurring on these dates. Thus, nitrite and nitrogen concentration trends were the reverse of phosphate and total phosphorous trends. Researchers noted the lowest recorded level of dissolved oxygen (0.300 ppm) on November

2 and the highest level (8.200 ppm) on November 4, 1995. On many visits researchers saw an oil sheen; bacterial degradation of oil may have depleted oxygen in the stream. Figure 2 summarizes general trends in discharge, nitrite, phosphate, and dissolved oxygen.

Erosion.

Asphalt streets surround the park on all sides. Runoff from area streets, particularly Carrizo Street, flow into the stream (Figure 1). As a result of this runoff, both stream bank and hillside erosion are taking place.

Stream bank erosion occurs due to large amounts of water from storm drainage which periodically rush through the confined stream channel. There is extensive undercutting of the bank and after a heavy rainfall researchers observed areas of stream bank slumped into the stream.

A storm water drainpipe and outfall structure installed on the western (Carrizo Street) park slope is inadequately designed and runoff from heavy rain overtops the curb and runs down the slope in sheets rather than down through the drainpipe to the base of the slope. City personnel had installed a concrete headwall around the drainpipe outfall and reinforced the slope just south of the outfall with additional concrete to retard

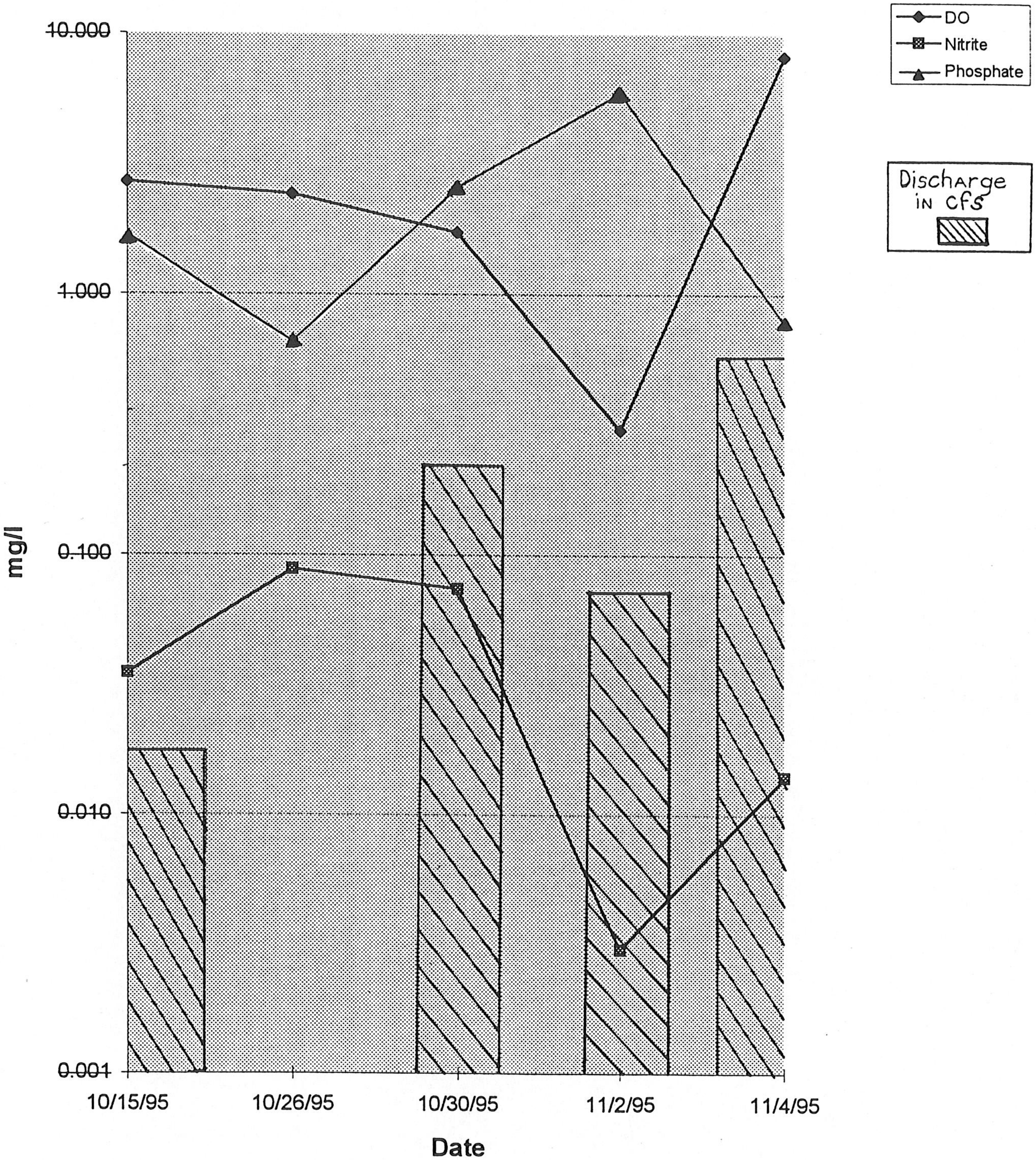

Figure 2.
Comparison of Discharge to
Selected Water Quality Parameters

slope erosion in this area. However, erosion from overland flow down the slope has undercut behind the concrete slope reinforcement. As a result the slope beneath the concrete reinforcement has retreated approximately 12 feet toward the street in the past three years.

Further downslope, the slope runoff and drainpipe outfall discharge from Carrizo Street flow across the land surface a short distance and then pour into the stream bed. Scour by runoff has eroded a small side gully in the stream bank at the pouroff site.

Debris.

There is a large amount of anthropogenic debris along the stream bank. A very small portion is windblown or discarded directly there, but the storm water drainage system washes in huge amounts. Plastic bags, styrofoam cups, and other debris lie entangled in tree branches as high as seven feet directly above the stream. Trash at any one time consists of plastic oil bottles, soda bottles, and wet paper debris. After a rainfall researchers found thousands of cigarette butts, plastic play balls from a McDonald's playground, dozens of egg cartons, styrofoam take-out containers and mounds of grass clippings. Throughout a long period of time large chunks of concrete debris and rubber tires have been dumped in the stream.

Discussion

Stream flow and runoff.

The stream flowing through Blucher Park has received the natural drainage of the area for over 100 years. An 1887 map of the area depicts the stream as Chatham's Ravine. According to Bill Walraven (1978) Chatham's Ravine coursed through Blucher Park and emptied south of what is now Water Street. Walraven also notes that at one time the city considered the stream a source of water but it proved insufficient. As the city continued to grow, it incorporated the ravine into an increased drainage system.

Today the area draining into the stream extends northeast from South Staples Street and empties into Corpus Christi Bay (Figure 3). Storm runoff is not the only contributing source for this stream. The stream maintains a low perennial flow because its bed apparently intersects the water table. Thus, the stream has discharge even without storm runoff. As stream discharge increases with storm runoff, the normally slow flowing stream rapidly becomes a raging torrent. This flashy discharge has enlarged the width and depth of the channel over time.

Typically urban channels are much larger than adjacent rural stream channels due to an increase in urban storm runoff (Neller, 1989). As large volumes of water flow through the narrow channel

Figure 3. City of Corpus Christi-
Regional drainage into
Blucher Park.

in urban areas there is massive downcutting of the stream bed. The downcutting of the stream bed below the water table incorporates more of the saturated zone and increases discharge. Stream bank erosion by undercutting enlarges the stream laterally. Such disturbance of the channel shape induces gullying (Mrowka, 1974).

Erosion.

Various land-use practices can accelerate erosion over the natural rate. According to Cooke (1974) loss of topsoil is a major result of accelerated erosion. As mentioned, storm runoff from Carrizo Street increased surface flow down the slope eroding behind a concrete slope reinforcement, and the slope has retreated some 12 feet laterally towards Carrizo Street over the past 3 years. According to Emilie Payne (Audubon Society, personal communication, 10/95) slope erosion visibly increased after the installation of the cement drainpipe. The slope is now about two feet from the curb and the erosion will soon undermine the margin of Carrizo Street itself.

It is the main purpose of this paper to document impacts to the stream resulting from its urban setting. However a few possible solutions to the slope and stream bank erosion are as follows.

If the water poured more slowly into the stream bed from Carrizo Street, it would not erode such a marked gully in the stream margin. The storm water drainpipe and outfall release a rapidly flowing, concentrated stream of water at the base of the slope. An outlet protector would reduce the speed of concentrated runoff from the outfall by radiating the water flow off the outflow, thus reducing erosion to the side gully of the stream bank.

Maintenance of vegetation on the slope would decrease the velocity of overland slope runoff by increasing surface roughness (Cooke 1974). Vegetation would also reduce further slope erosion by protecting the slope from direct raindrop impact. In any case, reducing the velocity of runoff before it pours across the park and into the stream bed will minimize stream bank erosion. At one time the slope had a vegetative cover, but the slope erosion has disrupted it.

Finally, a major cause of slope erosion is that a tremendous amount of runoff from Carrizo Street concentrates along the one small slope. Replacement of the Carrizo Street asphalt with porous pavement would increase infiltration of runoff before it reaches the park. Where porous asphalt pavements exist, runoff infiltrates through a porous layer into a reservoir layer where it is routed away. Dispersing the street runoff would lower the erosion, slumping, and gully features throughout Blucher Park.

Water Quality.

The water quality of the perennial stream in Blucher Park fluctuates greatly due to the impact of storm water drainage. Storm water runoff is a non-point source of pollution, and contains such things as yard clippings, fertilizers, pesticides, street residue, and hazardous materials. Illegal dumping down manholes or curb drains introduces these pollutants (Walesh, 1989). Since the city uses the stream for drainage, the stream can carry many pollutants. City personnel had recently investigated an oil slick present during this field study; the investigation revealed that the violator was a building supply company located on South Staples (Roland Velaquez, City of Corpus Christi Water Department, personal communication, 11/95). Over the years many other businesses in the surrounding area have dumped oil into the stream (Emilie Payne, Audubon Society, personal communication, 10/95).

Organic waste such as yard clippings and leaves influence nitrite levels. Pesticides and fertilizers that are used both commercially and residentially enhance nitrogen and phosphorous levels. Detergents contain a large amount of phosphate; it washes into the stormwater system from local businesses and residential gray water directly discharged onto lawns.

The City of Corpus Christi must sample and test the storm waters in their drainage system as part of the National Pollutant Discharge Elimination System (NPDES) permitting process. The Environmental Protection Agency (EPA) requires this testing as a means to enforce statutes within the Clean Water Act, first enacted in 1972 to control pollution from point sources. The Clean Water Act was amended in 1987 to address problems associated with storm water discharges (Smoley, 1993). The City has five testing sites that characterize residential, commercial, and industrial areas (City of Corpus Christi NPDES Part 2 Permit Application, 1993). The site most resembling Blucher Park was Cullen Park, in that both sites contain both residential and commercial areas. The city must test for many more pollutants and toxins than this current project addressed. The levels of phosphorous and total dissolved solids found in Blucher Park stream in the current baseline study are higher than those measured by City personnel at the Cullen Park site.

Nutrients tested in this study enhance the growth of cyanobacteria and algae. High levels of phosphate in an aquatic environment can stimulate eutrophication, a condition in which an increased growth of cyanobacteria or algae can disrupt an ecosystem. Nitrite found in the stream may derive from bacteria which produce it by combining ammonia and oxygen. The amount of dissolved oxygen is an indication of water quality and thus the variety of aquatic life it can support. Water with over 8 ppm DO sustains game fish and other aquatic life. A stream with less than 2 ppm DO can only maintain worms and bacteria, fungi, or other decomposers. The DO content depends not only on pollution levels but also on water temperature and aeration. DO can increase after heavy rain due to aeration of water by the resulting increased discharge (Cunningham and Saigo 1992).

Debris.

The large volume of anthropogenic debris also affects the water quality and general ecological health of the Blucher Park stream. As noted, the trees have large amounts of trash hanging in branches from stream flooding. Within the bank confines, wheel stops from parking lots line the stream. Layered in the stream bed and stream bank are tires and broken pieces of concrete. Most of this debris is nonbiodegradable, and will remain in the stream bed unless physically removed. The nature of some of the debris, particularly tires and concrete, indicates that it was intentionally discarded at this site; better enforcement of dumping regulations would minimize additional placement of such items.

Conclusion

The stream flowing through Blucher Park is part of a natural drainage system that the City of Corpus Christi has now incorporated into its urban storm runoff system. A water table intersecting the stream maintains perennial flow within the channel. The flow of the stream increases with surface runoff. Consequently, downcutting of the bed and undercutting of the bank have enlarged the channel.

Poor land-use practices have accelerated erosion within Blucher Park. Placement of a drainpipe and outfall structure to control surface runoff have enhanced slope erosion at the western park boundary. As a result, the slope is locally retreating behind a concrete reinforcement and will soon threaten the pavement of the bordering street. The use of various techniques to increase surface roughness and infiltration capacity would reduce the velocity of runoff and the potential for future erosion.

Water quality of the stream depends on the stream discharge. As discharge increases after a rain event, the amount of dissolved phosphate and oxygen increase. Levels of phosphorous and total dissolved solids found in the stream in this current baseline study are higher than those measured by City personnel at another local site with similar levels of urban development.

Large amounts of debris in the stream are the result of storm water outflow and intentional dumping. Better enforcement of dumping regulations by the City would minimize additional intentional dumping.

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