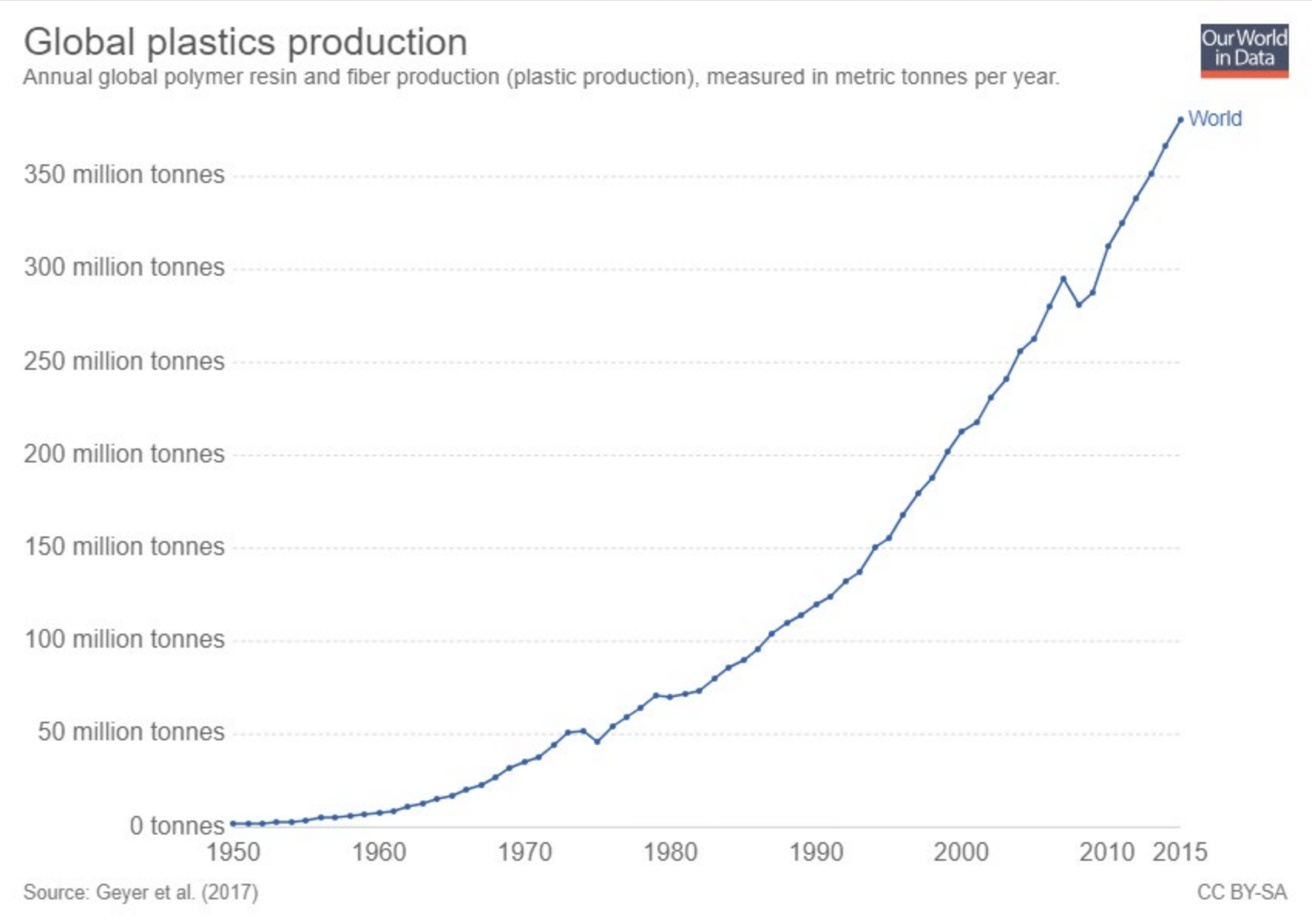
MICROPLASTIC POLLUTION IN URBAN SURFACE WATERS: A SHORT-TERM MONITORING STUDY ON A SMALL WATERSHED SCALE

JASMINE K. STOVALL & SUSAN P. BRATTON


Global plastics production
Annual global polymer resin and fiber production (plastic production), measured in metric tonnes per year.
Our World in Data
World
350 million tonnes
300 million tonnes
250 million tonnes
200 million tonnes
150 million tonnes
100 million tonnes
50 million tonnes
0 tonnes
1950
1960
1970
1980
1990
2000
2010
2015
Source: Geyer et al. (2017)
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MICROPLASTICS DEFINED

- Microplastics (MP) are polymer-based particles ranging in size from 50 µm to 5 mm

- MP may exist in two main forms:
  - Primary → manufactured on the microscopic scale
  - Secondary → formed as a result of the breakdown of primary macroplastics overtime

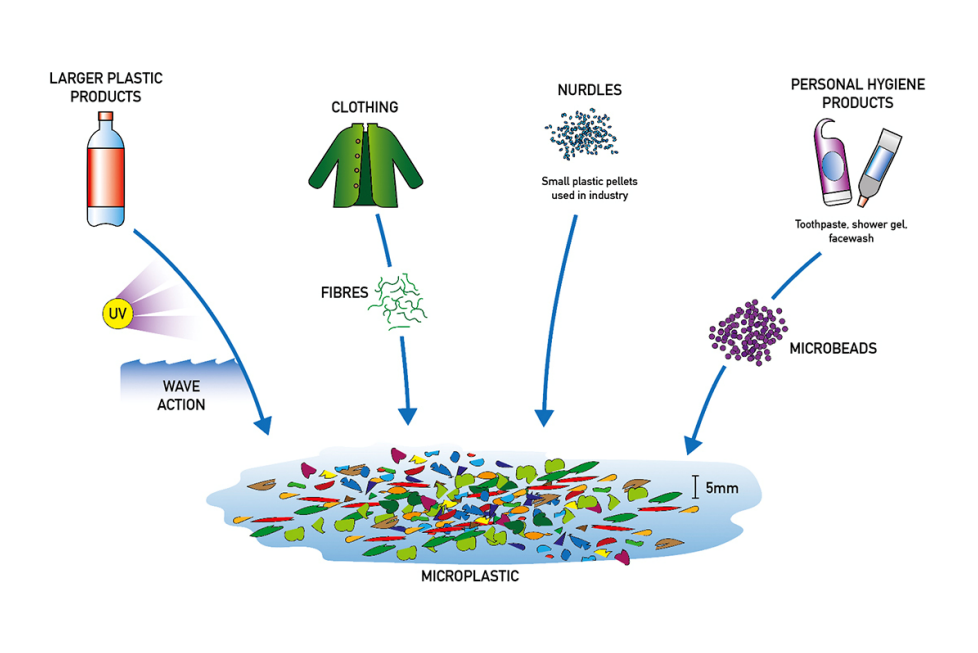


Image Source: Encounter Edu

SOURCES OF MICROPLASTICS

MP can enter into and be transferred within aquatic systems via numerous pathways

Improper waste management

Surface, stormwater, & agricultural runoff

Fishing materials

Industrial abrasives

WWTP discharge

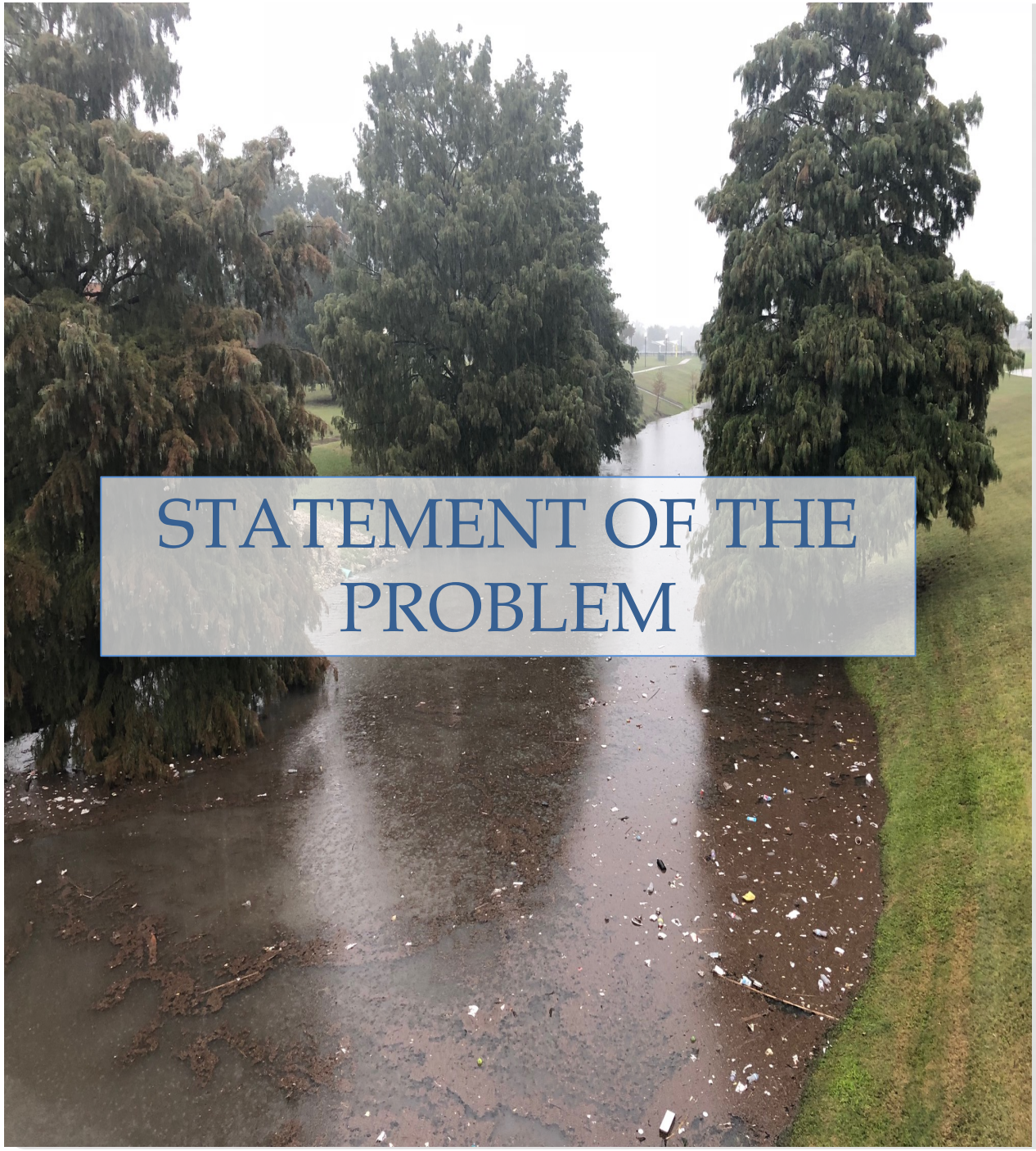
Aerial transport

Industrial waste effluent

MICROPLASTICS IN THE LITERATURE

- Marine MP studies began as early as the 2000's
- Ubiquitous MP presence throughout oceanic environments worldwide
- Interactions between MP and marine organisms have been investigated
- MP pollution in freshwater systems have only recently become of concern
  - Inland waters may be a source of origin for marine MP
- A shift of focus in the literature to MP pollution in freshwater systems has recently occurred

Image Source: Royal Society of Chemistry



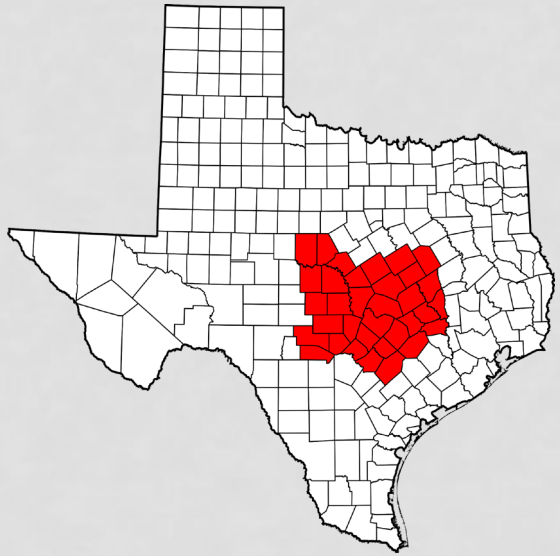
STATEMENT OF THE PROBLEM

- Characterization and abundance of MP in freshwater systems remains largely understudied
- Little to no small scale monitoring studies regionally
  - Urban, freshwater systems
  - Above and below sewage effluent comparisons
- This research is in response to the lack of existing data and understanding pertaining to MP pollution in urban surface waters within the central Texas region and the Gulf of Mexico.

PURPOSE OF THE STUDY

1. Examine and compare MP pollution levels in urban freshwater systems above and below local point-source wastewater effluents
2. Investigate patterns in spatial distribution
3. Evaluate the influence that factors such as urbanization may have on the origin and transport of MP within small watersheds

Microplastics defined as "artificial polymers (e.g. polyester or nylon), and manufactured products (i.e. manufactured natural and non-natural material), that range in size from 50 to 5000 µm" (Peters and Bratton, 2016).

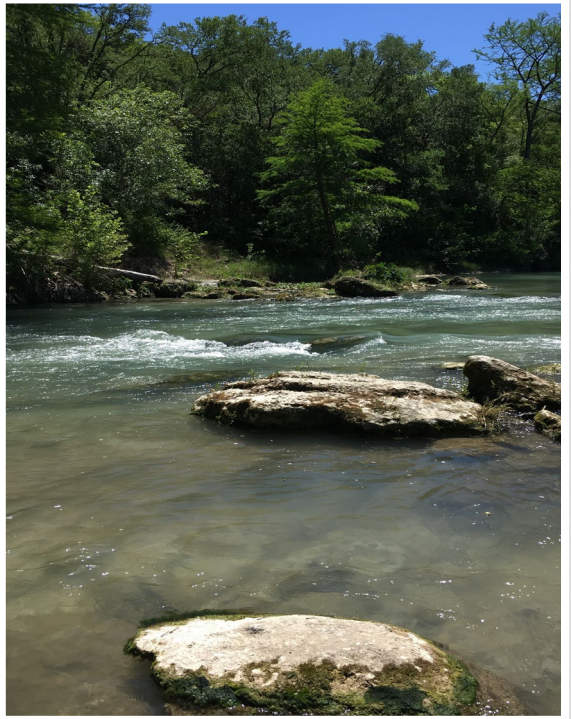


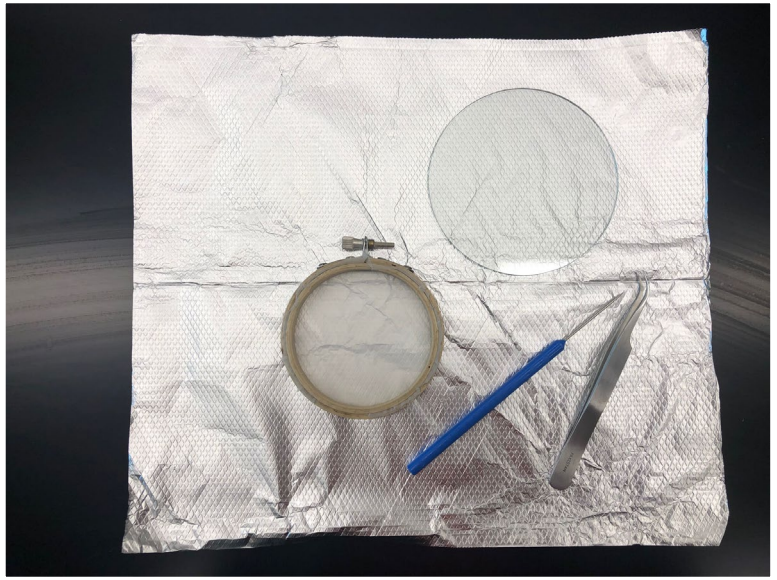
STUDY LOCALES

General Descriptive	Waco Creek (WC) – Locale #1	Wilson's Creek (WsC) – Locale #2	Proctor Springs (PS) – Locale #3	Buena Vista Pond (BVP) – Locale #4	San Marcos River (SMR) – Locale #5
Water Source	Run-off	Run-off, low discharge spring	Groundwater	Run-off	High discharge spring
No. of Sample Sites	6	2	3	1	6
No. of Sampling Rounds	7	4	5	4	3
Sampling Dates	Sept. 2017, Oct. 2017, Mar. 2018, Apr. 2018, June 2018 & July 2018	July 2017, Mar. 2018, Apr. 2018 & June 2018	July 2017, Mar. 2018, Apr. 2018, June 2018 & July 2018	July 2017, Mar. 2018, Apr. 2018, & June 2018	Apr. 2018, June 2018, & July 2018

METHODS: PREPARATION AND COLLECTION

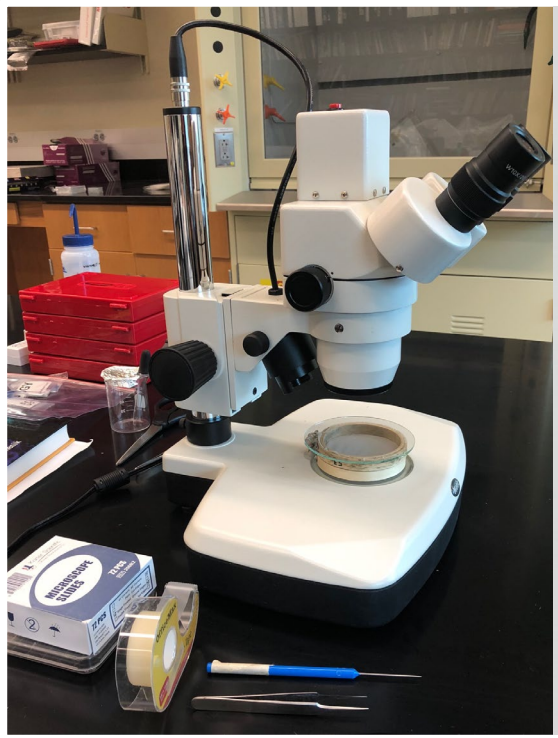
- 779 surface water samples collected
- Sample volume = 800-mL
- 5 micro-habitat types
- Two replicates at each sample site
- Samples filtered through a 53 µm mesh filter
  - Covered with a 4-inch diameter glass round
  - Sealed in aluminum foil

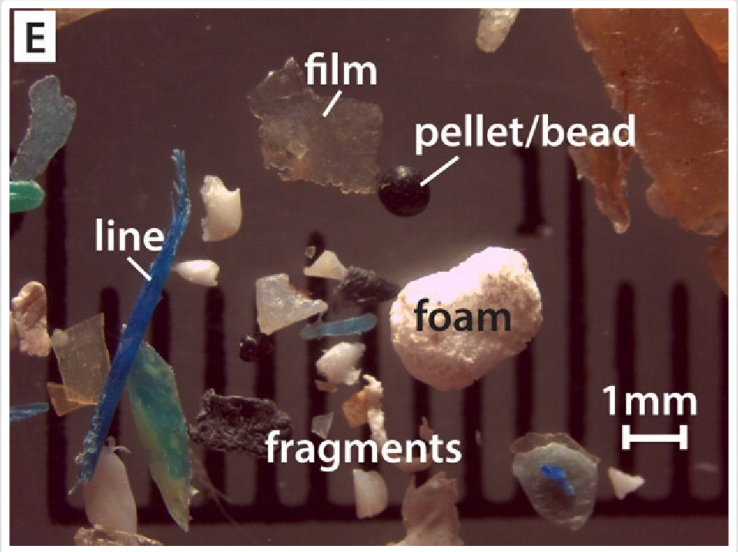




METHODS: PREPARATION AND COLLECTION

- Visual observation used to assess physical site characteristics
- Depth, distance from the bank, plastic abundance and type of debris were measured where the sample was collected
- Temperature, pH, conductivity, TDS, DO and current recorded at each sample site





METHODS: LABORATORY ANALYSIS

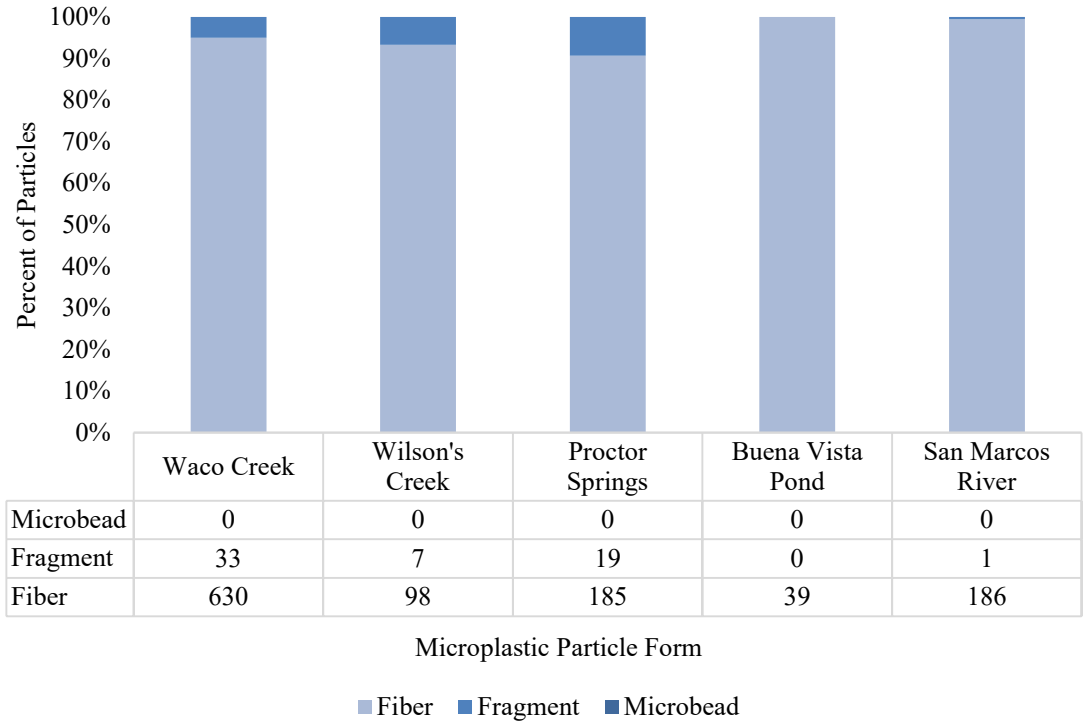
- Filters visually analyzed via stereomicroscopy
- MP extracted by hand, transferred to a microscope slide and sealed with cover slip
- Particles characterized by form, color and condition

METHODS: QA/QC

- Filters, glass covers, and foil wraps were triple rinsed with deionized water and visually examined via microscopy
- The colors of each team member's clothing and shoes were recorded
- Samples were stored, transported, processed and analyzed with glass covers on at all times, with the exception of fiber extraction
- Any occurrences of contamination in field from ambient air were considered part of the sample.

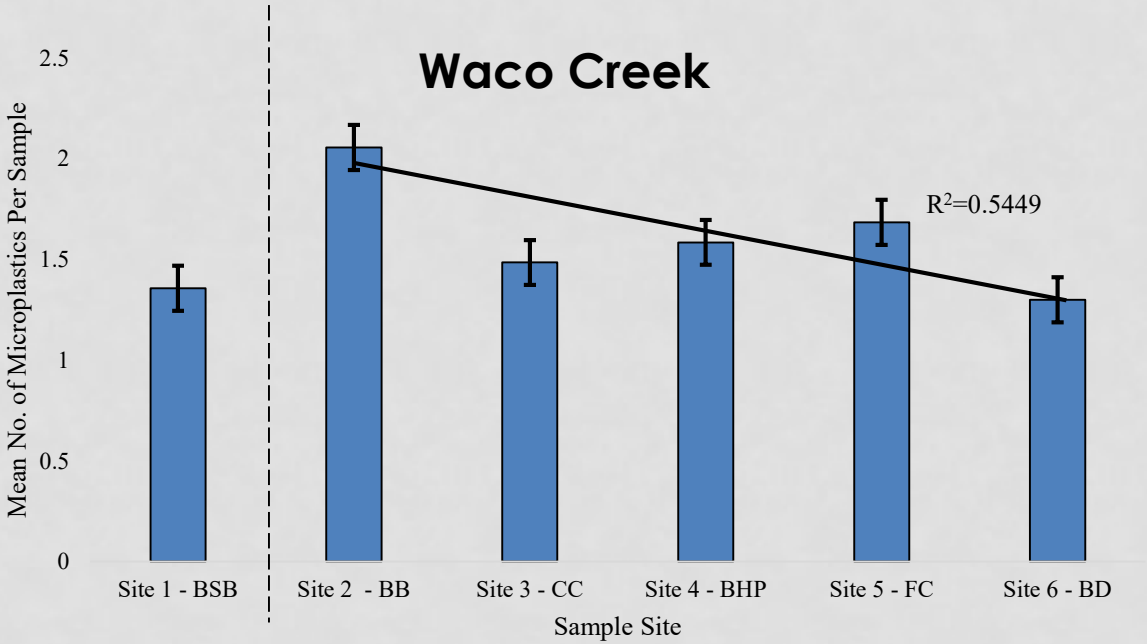
RESULTS

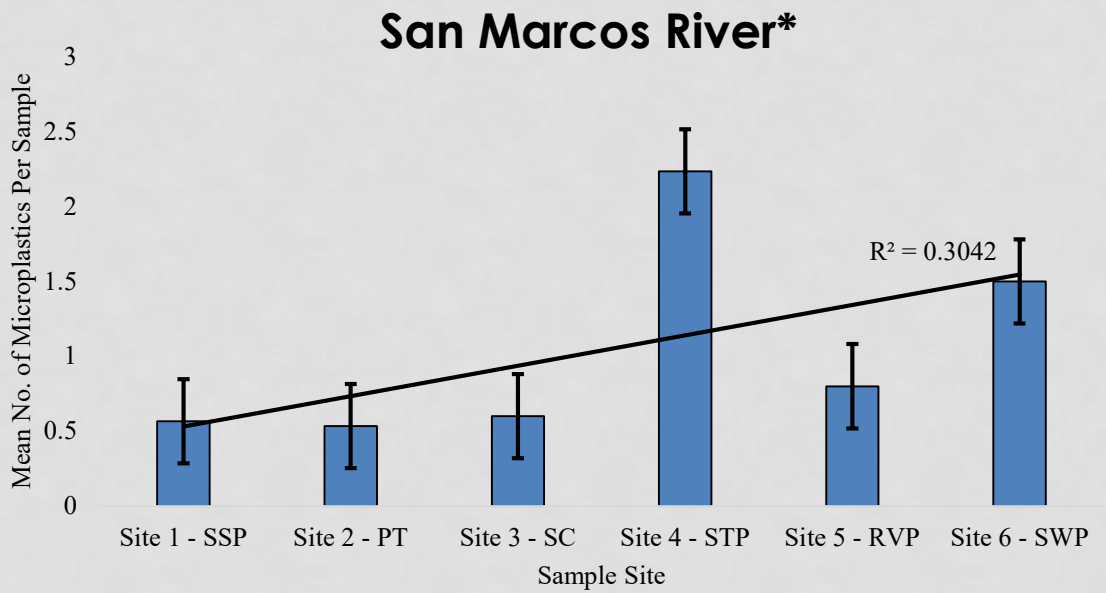
- 1,198 MP were recovered across all five study locales
- Fibers (95.0%) and fragments (5.0%)
- ~57% of all samples were contaminated with MP



Study Locale	Present		Absent	
	Frequency	Percent	Frequency	Percent
Waco Creek	251	59.8	169	40.2
Wilson's Creek	49	62.0	30	38.0
Buena Vista Pond	17	42.5	23	57.5
Proctor Spring	43	71.7	17	28.3
San Marcos River	86	47.8	94	52.2

Microplastics vs. Sample Site

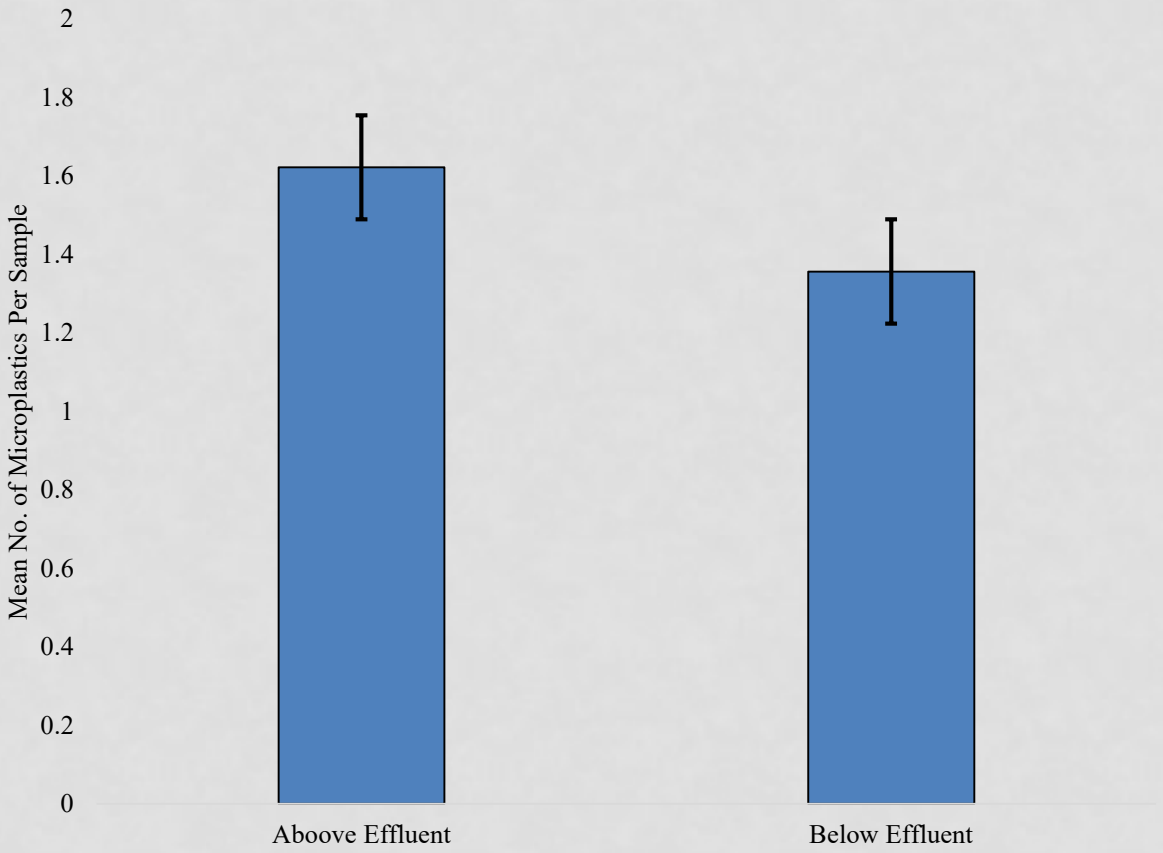




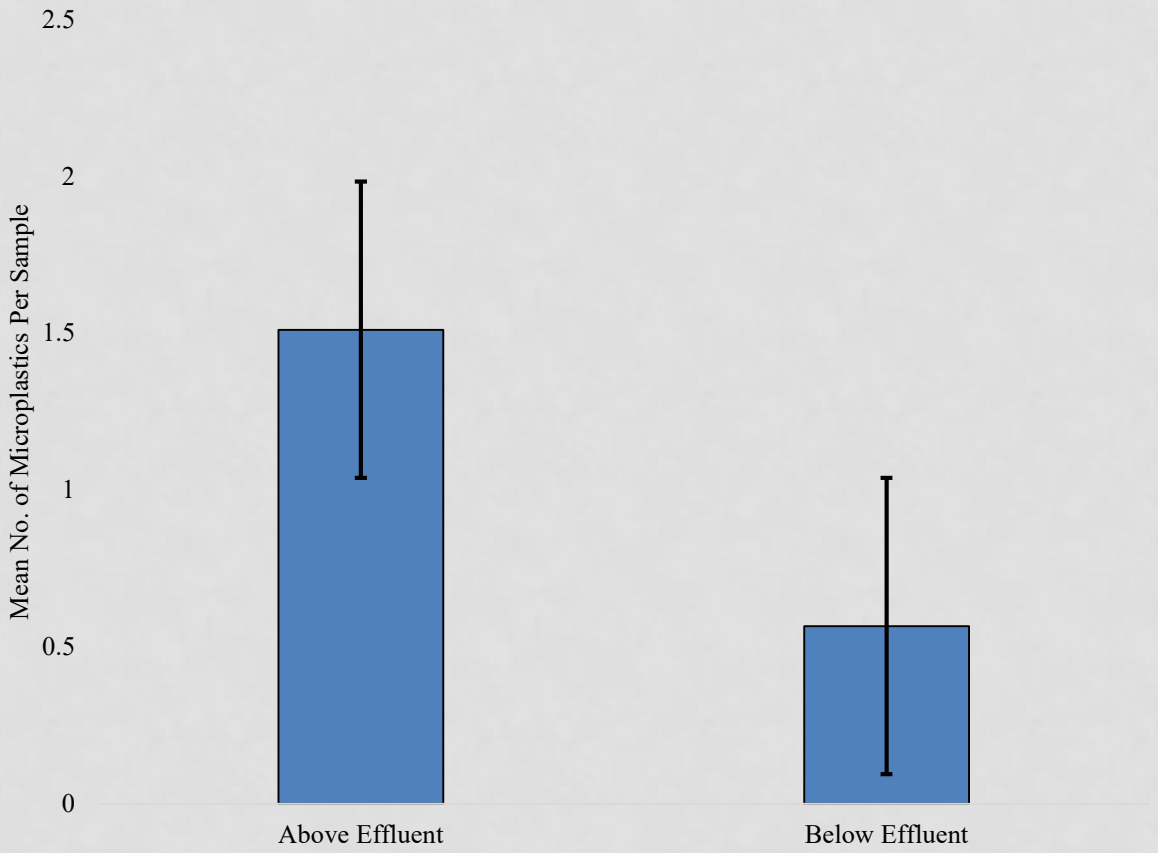
* Indicates significance

Microplastics vs. Sewage Effluent

Waco Creek

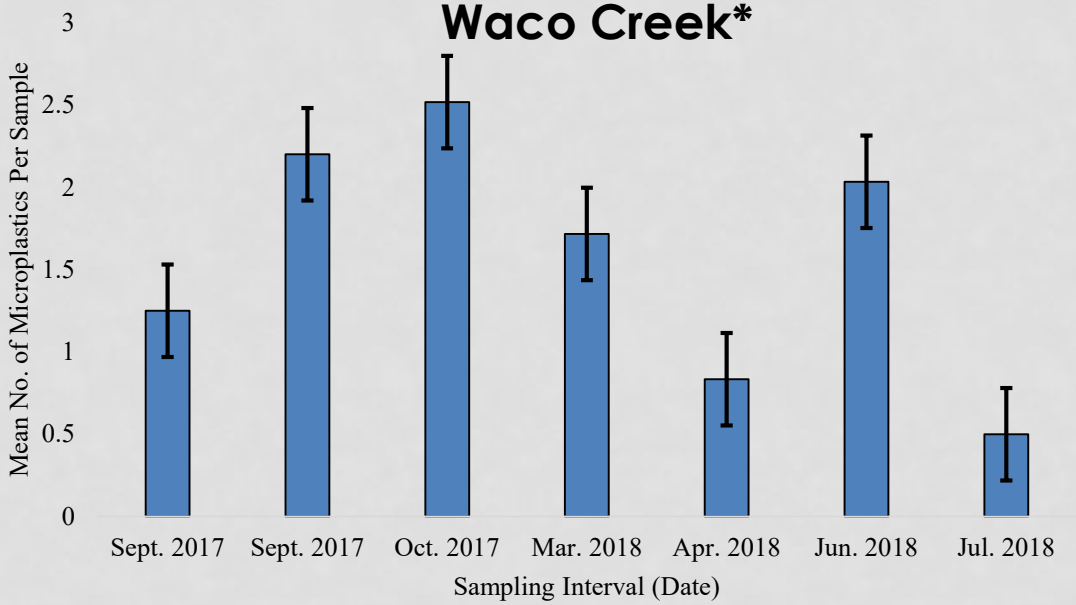


San Marcos River*

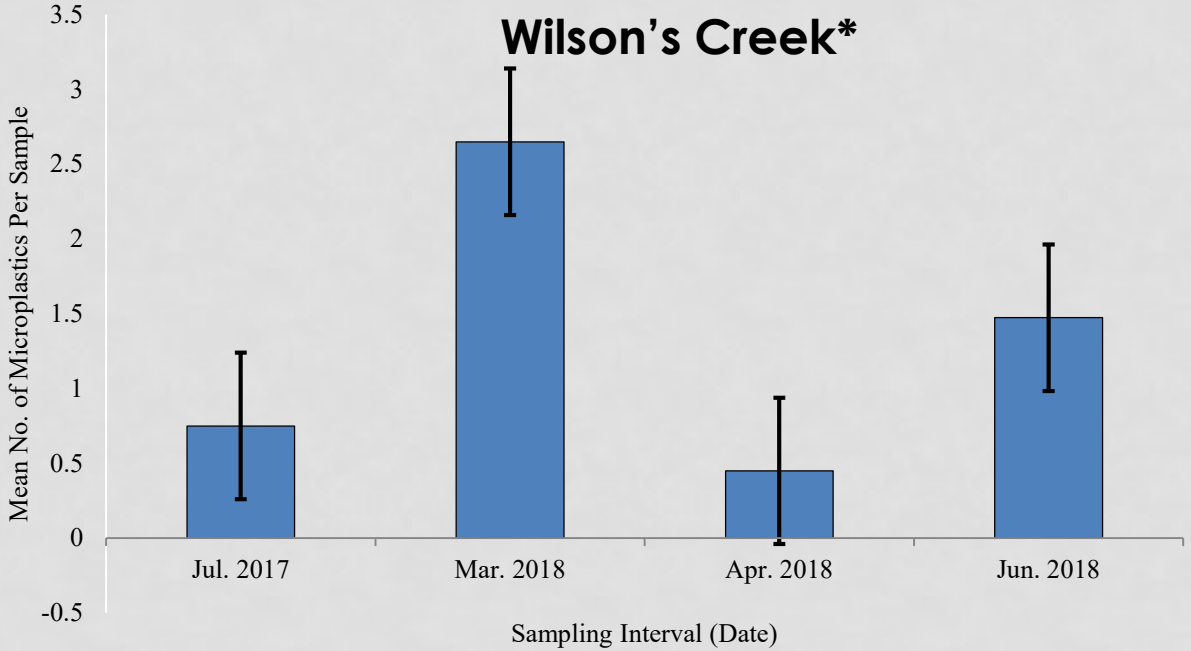


* Indicates significance

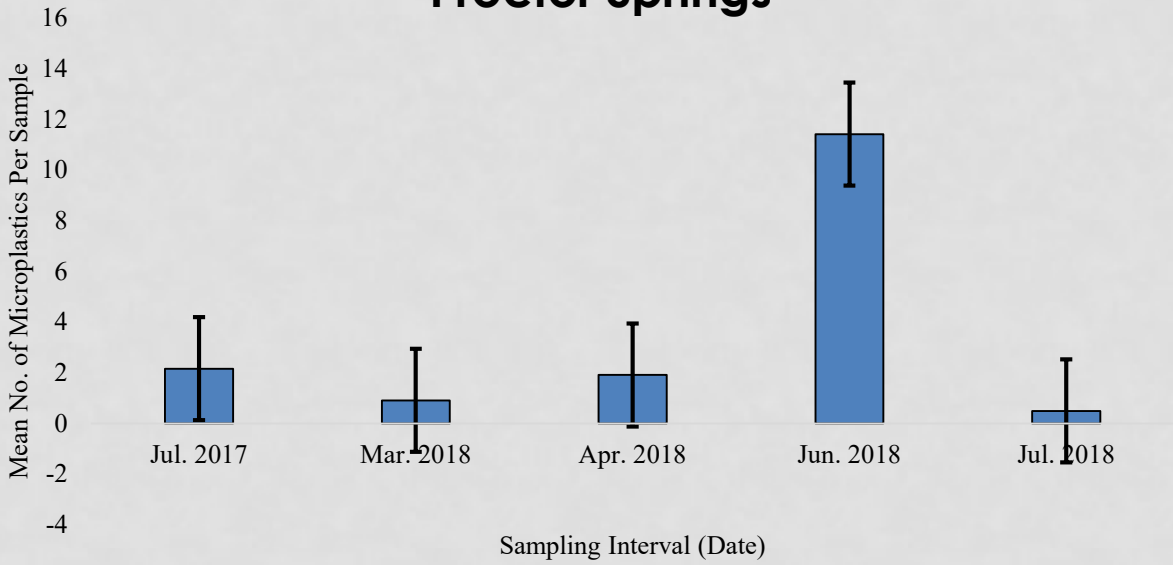
Waco Creek*



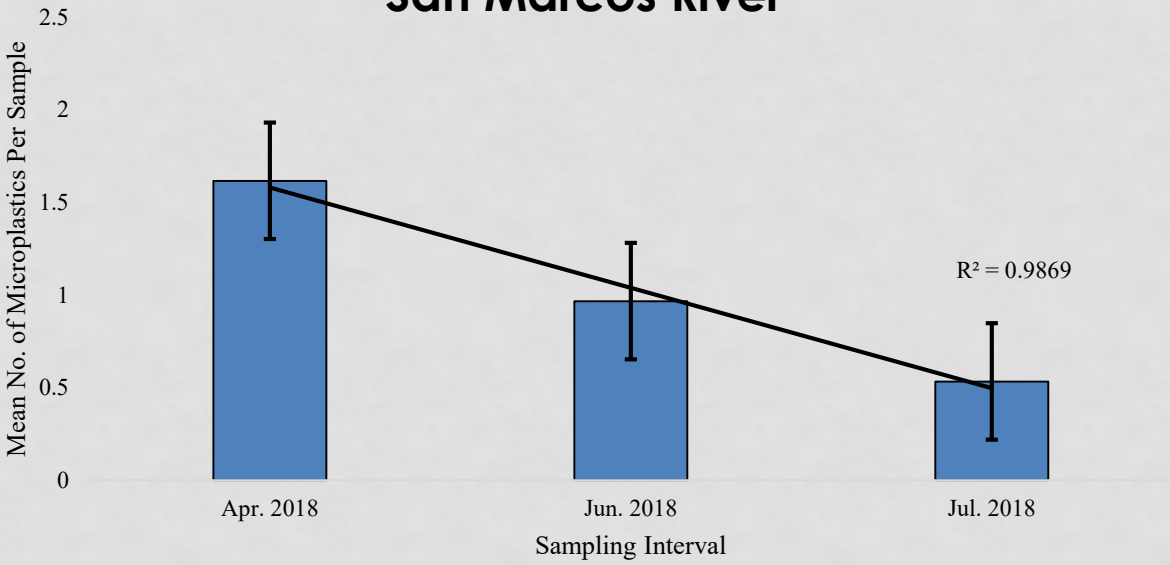
Wilson's Creek*



Proctor Springs*



San Marcos River



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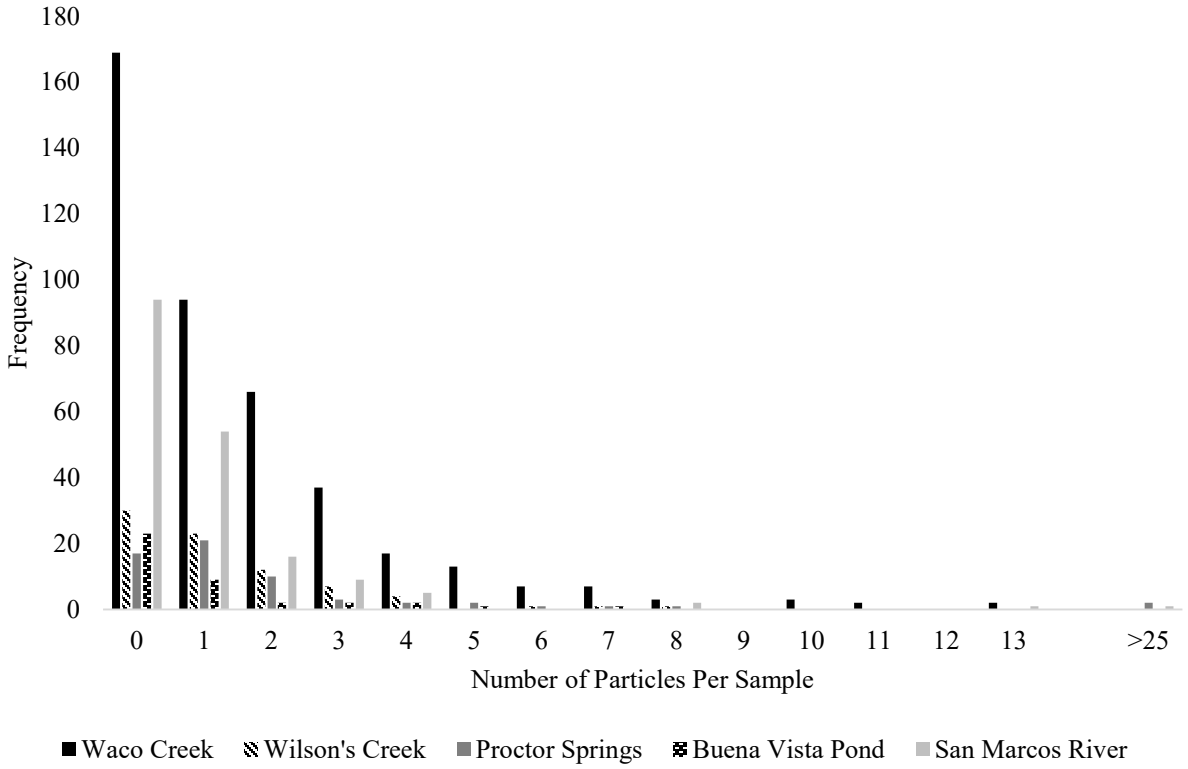
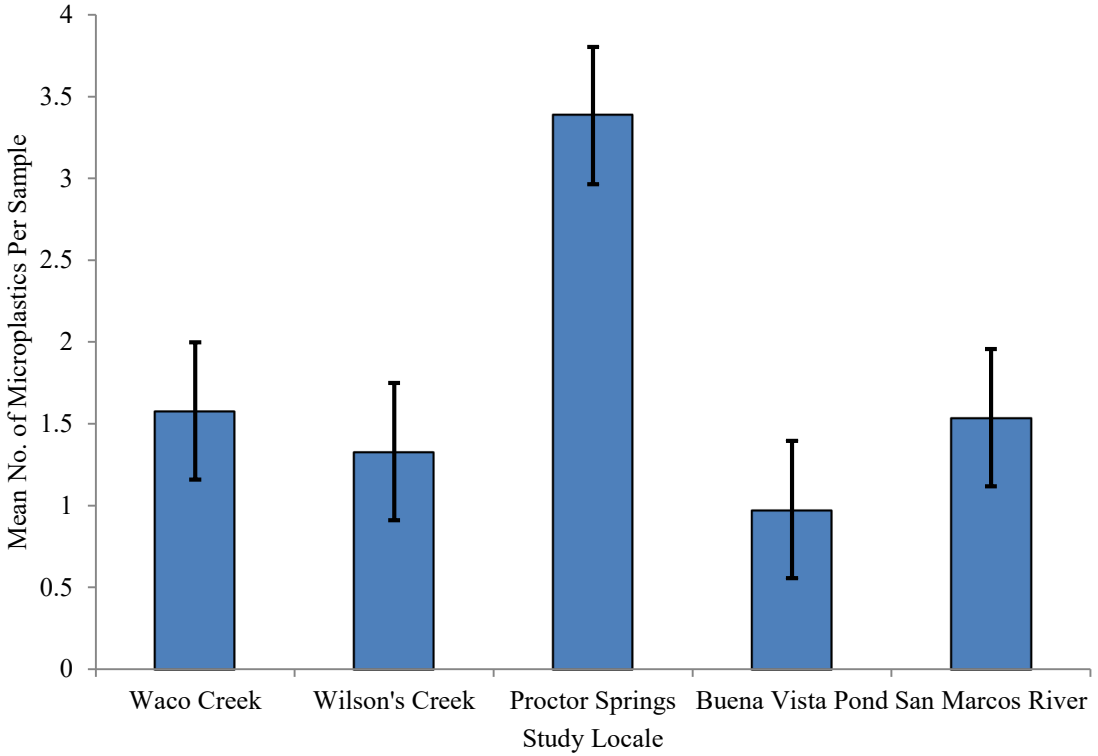
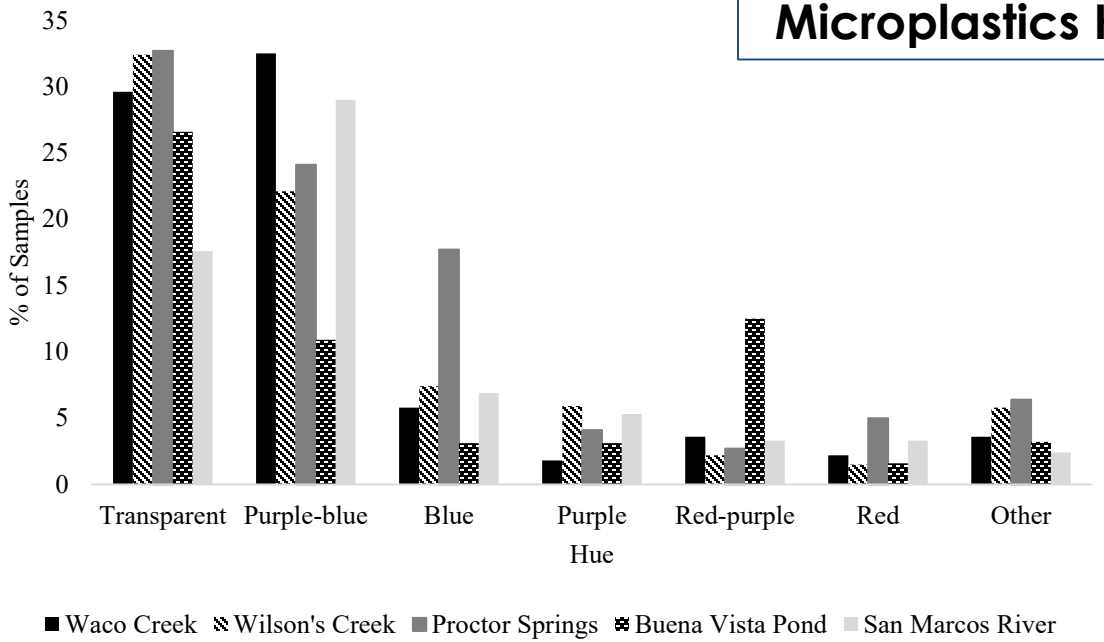
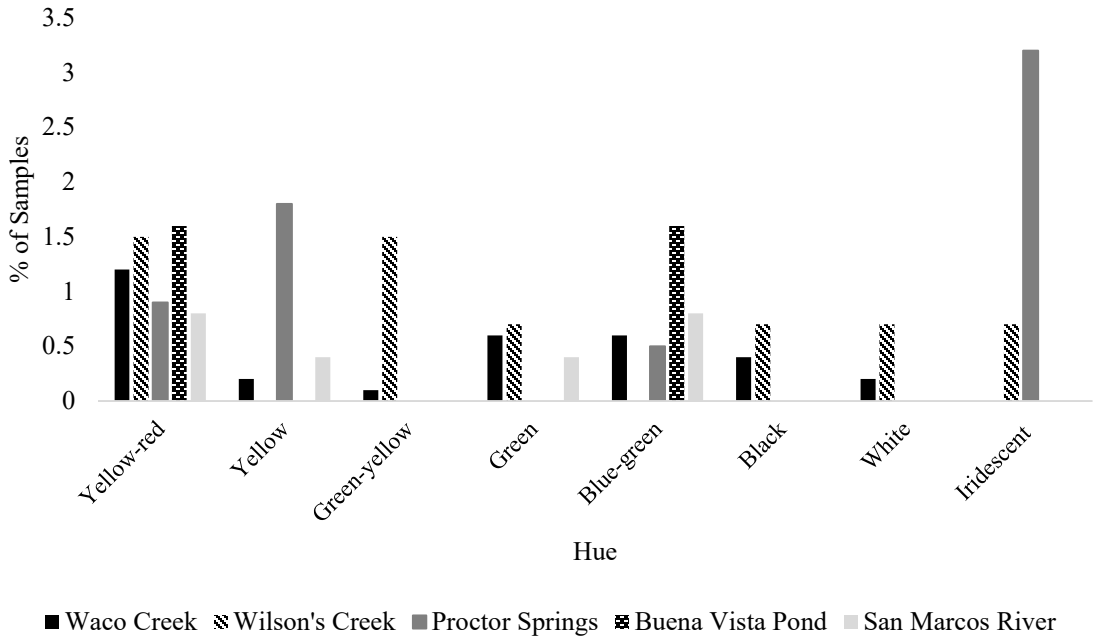
Microplastic Frequency vs. Study Locale

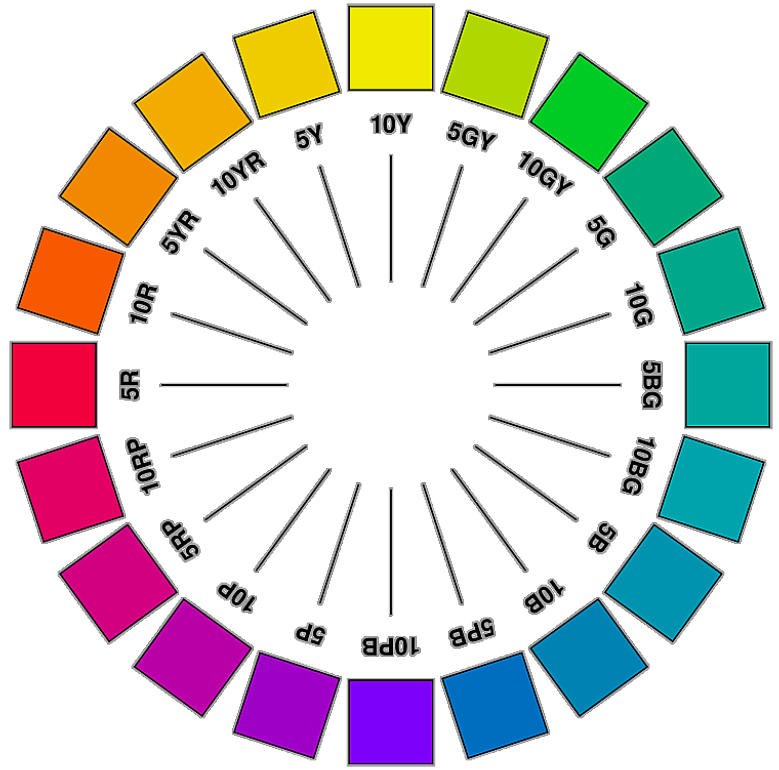




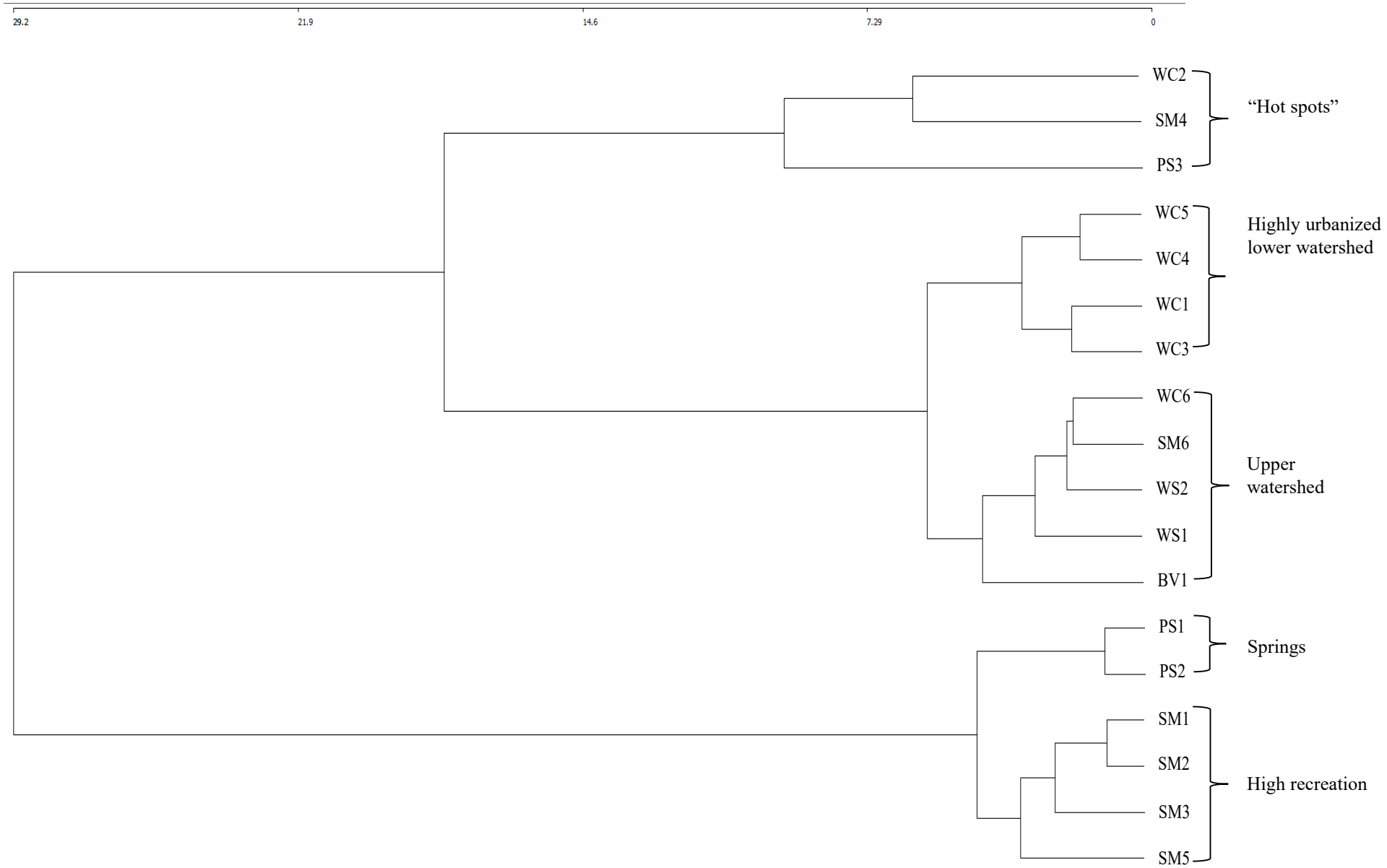
Microplastics Hue Classification







Munsell Color System
Image Source: kisspng


29.2
21.9
14.6
7.29
0
WC2
SM4
PS3
"Hot spots"
WC5
WC4
WC1
WC3
Highly urbanized lower watershed
WC6
SM6
WS2
WS1
BV1
Upper watershed
PS1
PS2
Springs
SM1
SM2
SM3
SM5
High recreation

CONCLUSIONS

- Widespread pollution throughout the systems
- Localized effects of land use and human activity drive subtle changes in MP influx levels
- Hot spotting at high traffic recreational sites show that similar land use type may result in analogous input sources, plastic types and colors
- Seasonality, land use and the associated local human activity have a stronger influence on overall microplastic frequency within the system
- Actual spatial positioning within the watershed likely influences particle color and form
- More research, effective mitigation practices, governmental attention and public awareness are still very much urgent needs.

FUTURE RESEARCH

- Projects focusing more on temporal variables and seasonal events rather than spatial variables
- Chemical analysis and polymer ID of recovered MP
- Investigating possible relationships between chemical characteristics of stream and chemical properties of MP within the system

ACKNOWLEDGEMENTS

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ENVIRONMENTAL SCIENCE

- Undergraduate Research Assistants
  - Jessica Bateman
  - Hannah Dye
  - Lauren Medlin
  - Madison Ohler
  - Jonah Salazar
  - Rafael Sandoval
  - Jordan Vanderpool
- City of Waco Water Department

KEEP IT OUT OF THE STREAM

SEVEN WAYS YOU CAN KEEP MICROPLASTICS FROM BECOMING AN EVEN BIGGER ISSUE.

SKIP THE PLASTIC BAG

The average working life of a plastic shopping bag is about 12 minutes before it's discarded; these bags can survive for up to 500 years in the ocean where turtles and other marine animals mistake them for food. Take reusable bags to the store and try reusable containers instead of sandwich bags for snacks and storage.

LOSE THE STRAW

Every day more than a billion plastic straws are used for 20 minutes or less and then tossed into the garbage. One of the most disposable objects on earth lasts for centuries in landfills and the environment. Straws are among the most prevalent pieces of marine pollution. The solution is simple: Skip the straw or bring your own metal straw.

GIVE YOUR FLEECE THE NIGHT OFF

A single fleece jacket can shed as many as 1,900 synthetic fibers in a single wash. These fibers are thick in the air, water, and soil. Wash your synthetic clothes less frequently, and use a gentle cycle to reduce the abrasion that causes fibers to break off. Look for products like the Wexco filter, which catches laundry fibers down to 160 microns in size.

ORAL CARE

Even if you put your toothbrush in the recycle bin, there's no guarantee it will be recycled. Try using a toothbrush made from alternative materials like bamboo, flax and — really — recycled dollar bills.

CAN THE PAINT

Latex and acrylic paint are basically liquid plastic with pigments added. Washing your paintbrush out in a sink sends billions of micro and nano-scale plastic particles down the drain. Experts suggest adding mild soap to warm water in a glass jar and cleaning your brush there. Capture all rinse water in the jar and then dispose of it with other paint at designated spots at your local landfill. Or, try milk paint as an alternative: Add lemon juice to skim milk and filter out the curd, add natural pigment to what is left. It's how old barns and furniture were painted. Your hipster friends will burn with envy.

BYOB

A single one-liter drink bottle could break down into enough tiny pieces to stretch a mile (1.6km) down the beach. Buy glass instead of plastic, or bring along your own reusable bottle.

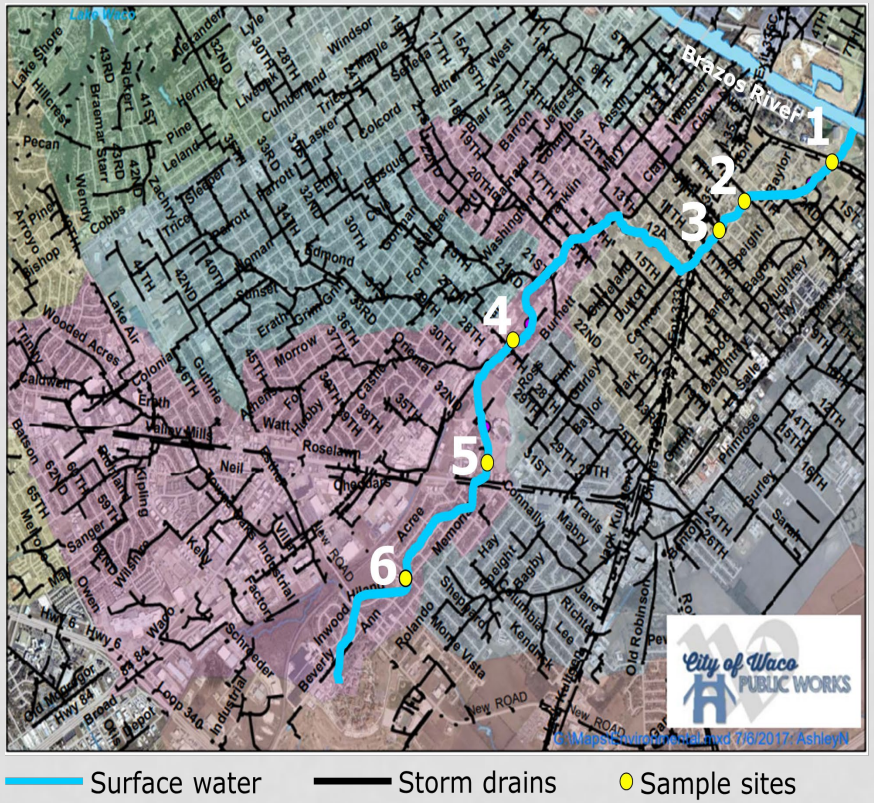
HITCH A RIDE

Close to 2 billion tires are produced annually around the globe. Plastic tire dust is washed into waterways and then the sea. It's one of the main sources of microplastic pollution in the ocean. Share a ride, take public transportation, and encourage your friends to do the same.

Image Source: Orb Media

SITE DESCRIPTIONS: WACO CREEK

Sample Site	Water body type	Overall macroplastic abundance within 5m	Above or below sewage effluent	No./Type of Dams	Type of Drains	Type of Development
Site #1 – BSB Bridge (BSB)	Lake	Largely scattered throughout with debris entanglement	Below	0	Road surface drains & pipes, concrete culvert	Commercial - Roads, sidewalks, parking lots, buildings, bridges
Site #2 – Baylor Bookstore (BB)	Stream	Sparsely scattered (<10 pieces)	Above	0	Road surface drain & pipes, stream in concrete channel	Commercial – Sidewalks & buildings
Site #3 – Common Grounds (CC)	Stream	Largely scattered throughout with debris entanglement	Above	0	Road surface drain & pipes	Commercial - Roads, sidewalks, bridges, buildings
Site #4 – Bell's Hill Park (BHP)	Stream	Largely scattered (>10 pieces)	Above	1 – low barrier	Drain pipes	Recreational - Fishing access points
Site #5 – Floyd Casey (FC)	Stream	Largely scattered (>10 pieces)	Above	0	Concrete culvert	Residential - Roads, sidewalks, parking lot
Site #6 – Beverly Drive (BD)	Stream	Largely scattered (>10 pieces)	Above	0	Road surface drain	Residential - Roads, sidewalks, bridges

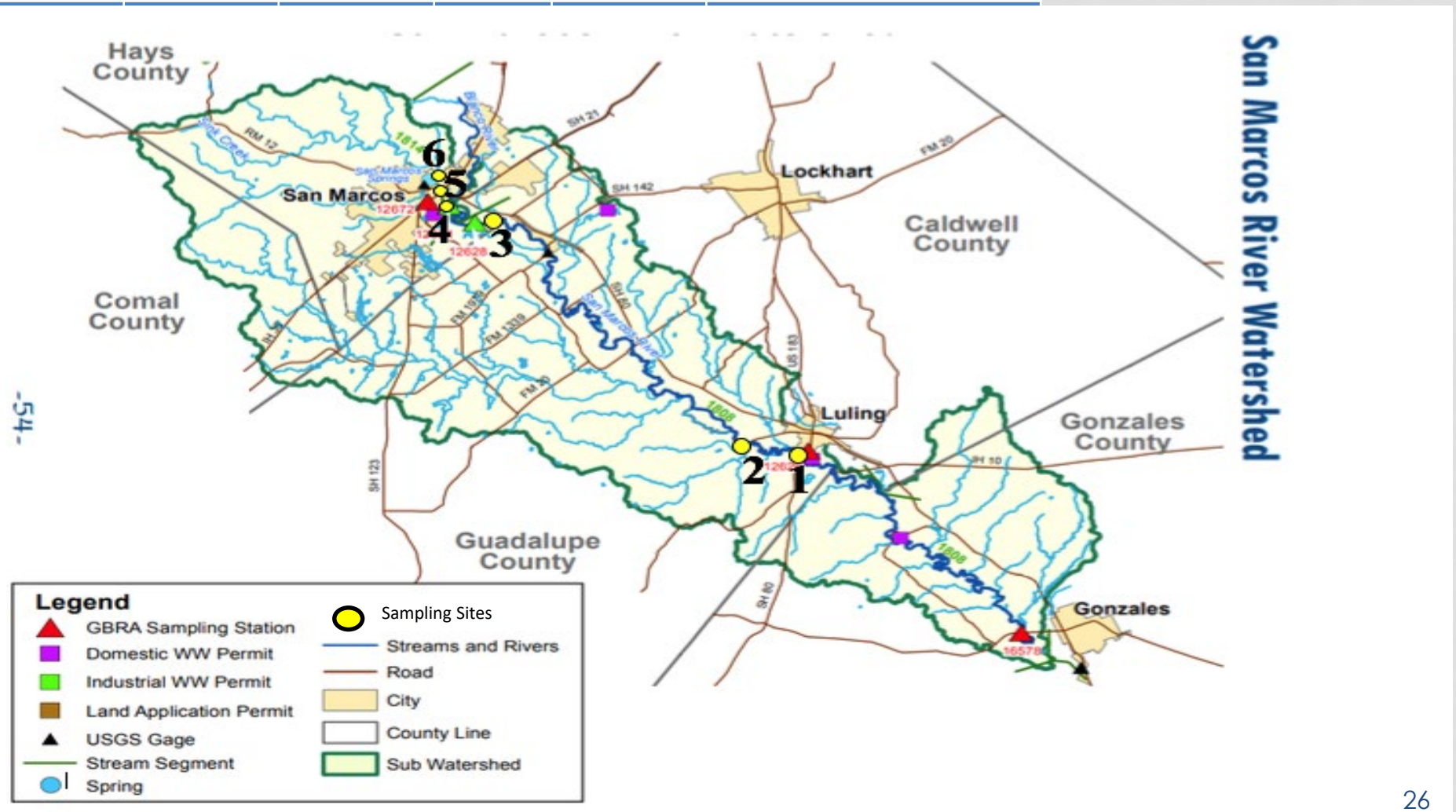


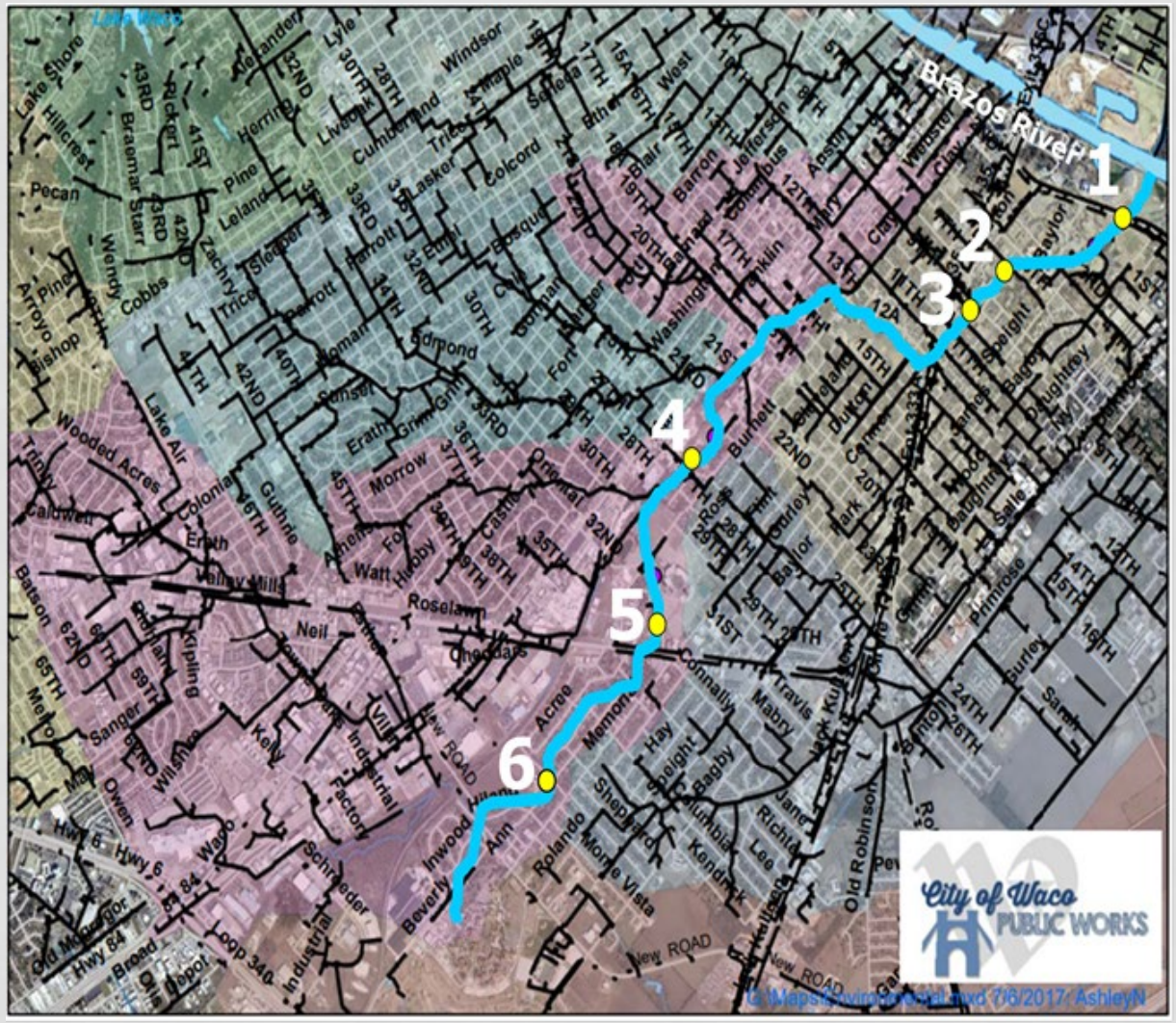
SITE DESCRIPTIONS CONT.

Sample Site		Water body type	Overall macroplastic abundance within 5m	Above or below sewage effluent	No./Type of Dams	Type of Drains	Type of Development
Wilson's Creek	Site #1 – Lower Creek (LC)	Stream	Largely scattered (>10 pieces)	Above	0	0	Recreational – walking trails, roads, bridges
	Site #2 – Upper Creek (UC)	Stream	Largely scattered (>10 pieces)	Above	0	0	Recreational – picnic area, walking trails, parking lot, roads, bridges
Proctor Springs	Site #1 – Upper Seep (US)	Spring	None	Above	0	0	Recreational – picnic area, walking trails, parking lot
	Site #2 – Lower Seep (LS)	Spring	None	Above	0	0	Recreational – picnic area, walking trails, parking lot
	Site #3 – Surface Flow (SF)	Stream	Sparsely scattered (<10 pieces)	Above	0	Stream in concrete channel	Recreational – picnic area, walking trails, parking lot
Buena Vista Pond	Site #1 – Buena Vista Pond (BVP)	Stock Pond	Sparsely scattered (<10 pieces)	Above	0	Road surface drains	Recreational/Residential – sidewalks, roads, fishing access points, benches

SITE DESCRIPTIONS: SAN MARCOS RIVER

Sample Site
Site #1 – Southside Park (SSP)
Site #2 – Luling Paddling Trail (PT)
Site #3 – San Marcos River Scout Camp (SC)
Site #4 – John Stokes Park (STP)
Site #5 – Rio Vista Park (RVP)
Site #6 – Sewell Park (SWP)




Brazos River
1
2
3
4
5
6
City of Waco
PUBLIC WORKS
Surface water
Storm drains
Sample sites