Green Stormwater Infrastructure (GSI) Master Plan
Upper San Antonio River Watershed Protection Plan Implementation

Michelle E. Garza and Dr. Sheeba Thomas, San Antonio River Authority
Dr. Yu-Chun Su, Lockwood, Andrews & Newnam, Inc. (LAN)

GSI Master Plan Project Purpose

The San Antonio River Authority was awarded a Clean Water Act Section 319(h) Grant by the U.S. Environmental Protection Agency, administered by the Texas Commission on Environmental Quality in 2019 to develop a master plan for the use of green stormwater infrastructure. This three-year grant project builds off recommendations made in the Upper San Antonio River Watershed Protection Plan to implement green stormwater infrastructure to reduce stormwater runoff pollution and addresses measures in the Texas Non-Point Source Management Program.

Traditional stormwater infrastructure is designed to manage stormwater volume, not stormwater quality. Green stormwater infrastructure are constructed features that add the stormwater quality component by mimicking the predevelopment hydrology of an area. Examples modeled on this project are bioretention basins (called rain gardens), bioswales, and extended detention basins. They are designed to clean and reduce local flooding by capturing and treating stormwater runoff pollution before it enters local creeks and rivers.

Since green stormwater infrastructure is still relatively new to the San Antonio River Basin, the Master Plan aims to guide decision-makers on where and how to apply limited resources in the upcoming years to maximize water quality benefits while addressing local flooding concerns.

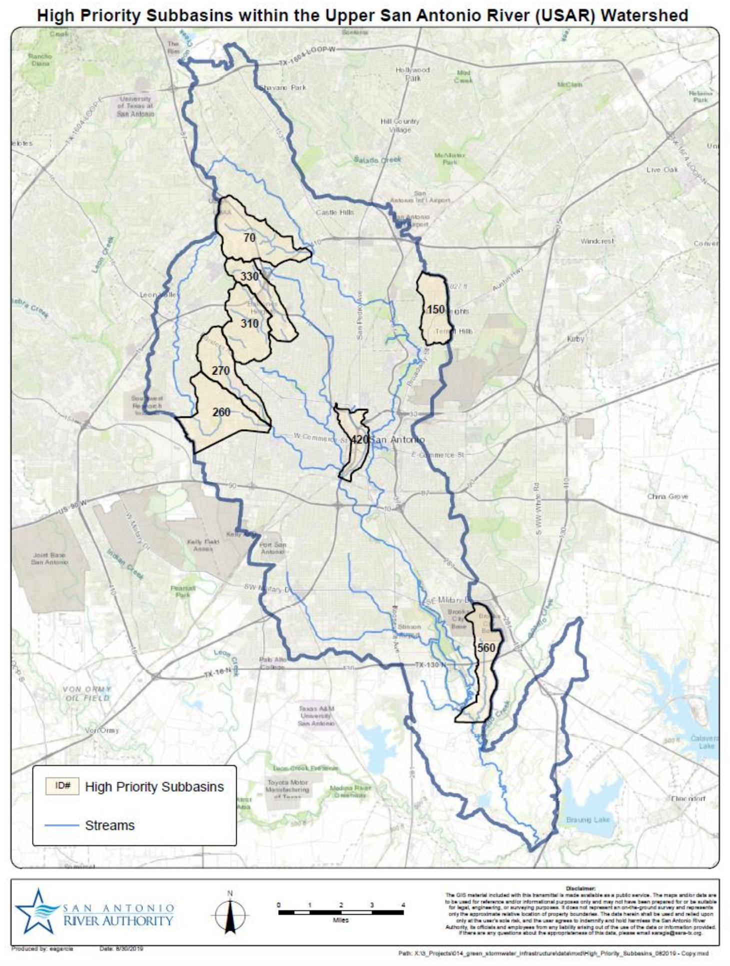
Start with High Priority Subwatersheds

San Antonio River Authority's watershed scale models have identified sub-basins or small watersheds that have the highest stormwater pollutant load reduction potential. This project used existing data and modeling tools to identify and prioritize sites within those areas that have the highest potential for green stormwater infrastructure implementation effectiveness.

Properties considered for implementation included public lands, schools, capital improvement projects, city planning areas, and neighborhoods with supportive stakeholders such as homeowner's association partners.

The project used existing data and modeling tools to identify eight high priority source areas of significant loading and transport of nonpoint source pollutants, GSI opportunities, costs of those opportunities, and GSI prioritization based on criteria. Lockwood, Andrews & Newman (LAN) supported the effort by developing a BMP Ranking matrix to help with scoring potential GSI sites.

High Priority Subbasins within the Upper San Antonio River (USAR) Watershed

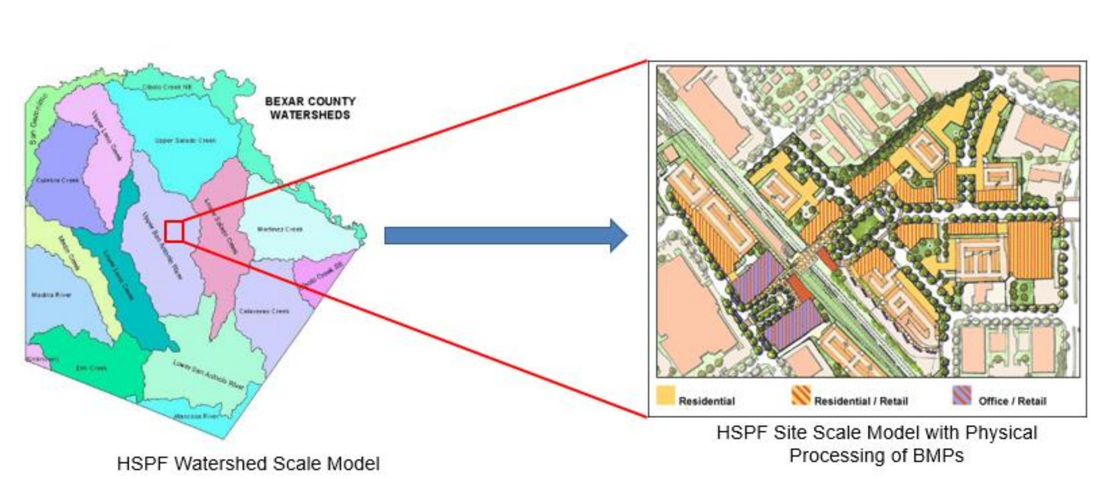


Analysis and Modeling

A Best Management Practice (BMP) performance evaluation HSPF modeling was conducted under the Upper San Antonio River Watershed Protection Plan Implementation – Green Stormwater Infrastructure Master Plan Data Acquisition, Modeling, and Geospatial Quality Assurance Project Plan .

The effort involved developing conceptual GSI designs at eight selected subbasins within the USAR Watershed with one GSI site per subbasin. The image below shows a concept of the watershed to site-scale modeling conducted in this project. The previously developed and calibrated subbasin-scale Hydrological Simulation Program – Fortran (HSPF) model was refined to perform site-scale water quality modeling at each of these eight GSI sites to evaluate BMP performance. The HSPF model was set up to simulate E. coli bacteria, water temperature, dissolved oxygen, carbonaceous biochemical oxygen demand, nitrate nitrogen, ammonia nitrogen, organic nitrogen, total phosphorus, orthophosphorus, and total suspended solids. The target constituent and the focus of the modeling effort is *E. coli.*

Concept of Watershed to Site-Scale Modeling



HSPF Watershed Scale Model

HSPF Site Scale Model with Physical Processing of BMPs

Total Pollutant Reduction Estimated

A continuous simulation of the site-scale HSPF models was performed for the period from 01/01/2007 to 12/31/2010. The outputs from the continuous simulation were used to estimate annual average load removal at each BMP site and the effectiveness of each modeled BMP type in reducing constituent loads. The target constituents were *E. coli* and nutrients. This technical memorandum documents the development of the BMP performance evaluation HSPF models and results.

The workplan for site-scale modeling of the QAPP called for specifying the retention capacity, inflow rate capacity, flow-through rate capacity, and load reduction of the BMPs.

The estimated pollutant load reductions *for E. coli* bacteria and nutrients that these projects would achieve across the watershed is totaled in table 1 below. The Green Stormwater Infrastructure Master Plan also includes an evaluation of Triple Bottom Line costs and benefits (social, environmental, economic) recapped in table 2 below.

Table 1. Amount of Pollutant Loadings Removed from Each Individual Project Site (1 - 8) | Over 50 Years

Pollutant	Units	Site 1 (Subbasin 70)	Site 2 (Subbasin 150)	Site 3 (Subbasin 260)	Site 4 (Subbasin 270)	Site 5 (Subbasin 310)	Site 6 (Subbasin 330)	Site 7 (Subbasin 420)	Site 8 (Subbasin 560)
E. Coli Bacteria	#10^6 org	158,483,250	123,456,900	261,232,825	18,211,850	34,769,700	37,401,150	40,015,600	47,708,450
Total Suspended Solids*	tons	744	39	107	11	12	26	10	100
Total Nitrogen	lbs	313	961	2,517	209	228	295	221	652
Total Phosphorus	lbs	199	230	574	37	43	55	39	134

*Total Suspended Solids pollutant loadings were estimated by Autocase.

Table 2. Amount of Pollutant Loadings Removed from All Project Sites | Over 50 Years

Pollutant	Units	All Sites
E. Coli Bacteria	#10^6 org	721,279,725
Total Suspended Solids*	tons	1,047
Total Nitrogen	lbs	5,396
Total Phosphorus	lbs	1,311

*Total Suspended Solids pollutant loadings were estimated by Autocase.

Stakeholder Engagement

The San Antonio River Authority incorporated stakeholder input from property owners, operators, and community groups to identify and build on common goals and investment priorities for implementing green stormwater infrastructure. This outreach was conducted virtually during the COVID pandemic, utilizing online platforms, yard signs, and flyers to ensure everyone that wanted to participate could.

The River Authority engaged stakeholders in the GSI Master Plan development throughout the project area. Workshop materials were posted on the project website, including announcements, agendas, and presentation materials. Five community workshops, to share results of the modeling and TBL analysis, included;

- Local government staff
- A community located in a high priority source area homeowners' and local government partner
- Private industry professional groups

Stakeholder input was considered throughout the process and included local opportunity, stakeholder needs, and stakeholder restrictions.

Image 1. Community signage used in the stakeholder outreach phase of the GSI Master Plan for site 150 Terrell Heights Community Garden

TBL Cost/Benefit Analysis

Once the site's GSI BMP pollutant reduction ability was established, and construction and operation and maintenance costs estimated, a Triple bottom Line Analysis was done to monetize the costs and benefits of activities in three functions (economic, social, environmental) and to denote a broad array of community benefits listed in the summary chart below showing the results of all eight sites modeled.

The evaluation also considered climate change predictions relating to weather, precipitation, and air emissions and is based on peer-reviewed scientific and economic literature.

	Impact	Site 1 (Subbasin 70)	Site 2 (Subbasin 150)	Site 3 (Subbasin 260)	Site 4 (Subbasin 270)	Site 5 (Subbasin 310)	Site 6 (Subbasin 330)	Site 7 (Subbasin 420)	Site 8 (Subbasin 560)
Financial	Capital Costs	-$318,400	-$263,700	-$754,800	-$132,700	-$155,000	-$263,800	-$181,900	-$2,481,000
	Operations & Maintenance	-$450,800	-$543,600	-$1,498,000	-$161,900	-$194,300	-$185,400	-$240,600	-$811,100
	Replacement Costs	-$223,379	-$190,590	-$530,795	-$57,342	-$68,835	-$68,624	-$89,051	-$284,379
	Residual Value	$21,100	$12,700	$35,500	$3,830	$4,600	$4,590	$5,950	$19,000
Social	Flood Risk	$850	$400	$1,156	$72	$221	$93	$221	$647
	Education	$30,915	$0	$30,915	$30,915	$30,915	$0	$0	$0
	Urban Heat Island	$6,700	$3,080	$8,610	$930	$1,120	$1,110	$1,440	$4,620
	Open Space - Recreation	$7,410	$3,250	$1,190	$190	$1,200	$0	$0	$0
	Water Quality - Induced Recreation	$2,126,544	$1,668,031	$2,731,634	$295,244	$354,365	$353,296	$458,359	$767,218
Environmental	Air Pollution from Sequestration	$880	$400	$1,130	$120	$150	$150	$190	$600
	Carbon Emissions from Sequestration	$71,100	$32,700	$91,300	$9,860	$11,800	$11,800	$15,300	$49,000
	Trash	$17,209	$7,846	$22,017	$2,278	$2,784	$2,784	$3,797	$11,895
	Water Quality - Pollutant Loading Reduction	$4,298	$4,412	$11,507	$934	$1,027	$1,363	$982	$3,194
	Pollination	$4,480	$2,062	$5,754	$622	$747	$744	$966	$3,087
Financial NPV		-$971,479	-$985,190	-$2,748,095	-$348,112	-$413,535	-$513,234	-$505,601	-$3,557,479
Social NPV		$2,172,419	$1,674,761	$2,773,505	$327,351	$387,821	$354,499	$460,020	$772,485
Environmental NPV		$97,967	$47,420	$131,708	$13,814	$16,508	$16,841	$21,235	$67,776
Triple Bottom Line-Net Present Value (TBL-NPV)		$1,298,907	$736,991	$157,118	-$6,947	-$9,206	-$141,895	-$24,346	-$2,717,218

GSI Master Plan

To develop a GSI Master Plan with implementation recommendations based on the analysis of existing data and additional modeling to identify high priority source areas of significant loading and transport of nonpoint source pollutants, GSI opportunities, costs of those opportunities, and GSI prioritization. Activities prioritized in the GSI Master Plan were based on criteria including assessment of stakeholder process, project implementation, programmatic findings, funding, and implementation schedule.

The Green Stormwater Infrastructure Master Plan includes a recommended schedule of implementation, the stakeholder process, costs, funding considerations, and the overall evaluation and prioritization process – all as examples communities can use for their own decision-making.

Ultimately, the goal is for the Green Stormwater Infrastructure Master Plan to become a template for all sub-basins not meeting water quality standards in the San Antonio River Basin.

References

Michelle E. Garza, Stormwater Analyst, Sustainable Infrastructure Unit, San Antonio River Authority. Michelle is the TCEQ project manager for the Upper San Antonio River Green Stormwater Infrastructure Master Plan Watershed Protection Plan Implementation 319 Grant Project.

Dr. Sheeba Thomas has been with the San Antonio River Authority since January 2008. She is a licensed engineer in Texas, a Certified Floodplain Manager (CFM) and a Project Management Professional (PMP). Her expertise lies in several hydraulic, hydrologic and water quality modeling.

Dr. Yu-Chun Su received his Ph.D. in Civil Engineering from The University of Texas at Austin in 1991 and has about 30 years of experience in Environmental and Water Resources Engineering (EWRE). He currently serves as a EWRE Technical Director for LAN. He is a licensed professional engineer in Texas, Louisiana, Arkansas, and Florida, a Certified Professional in Erosion and Sediment Control (CPESC), a Certified Professional in Stormwater Quality (CPSWQ), and a Certified Floodplain Manager (CFM).

To find more information on the Green Stormwater Infrastructure Master Plan, follow this link: https://www.sariverauthority.org/be-river-proud/sustainability/green-infrastructure-master-plan