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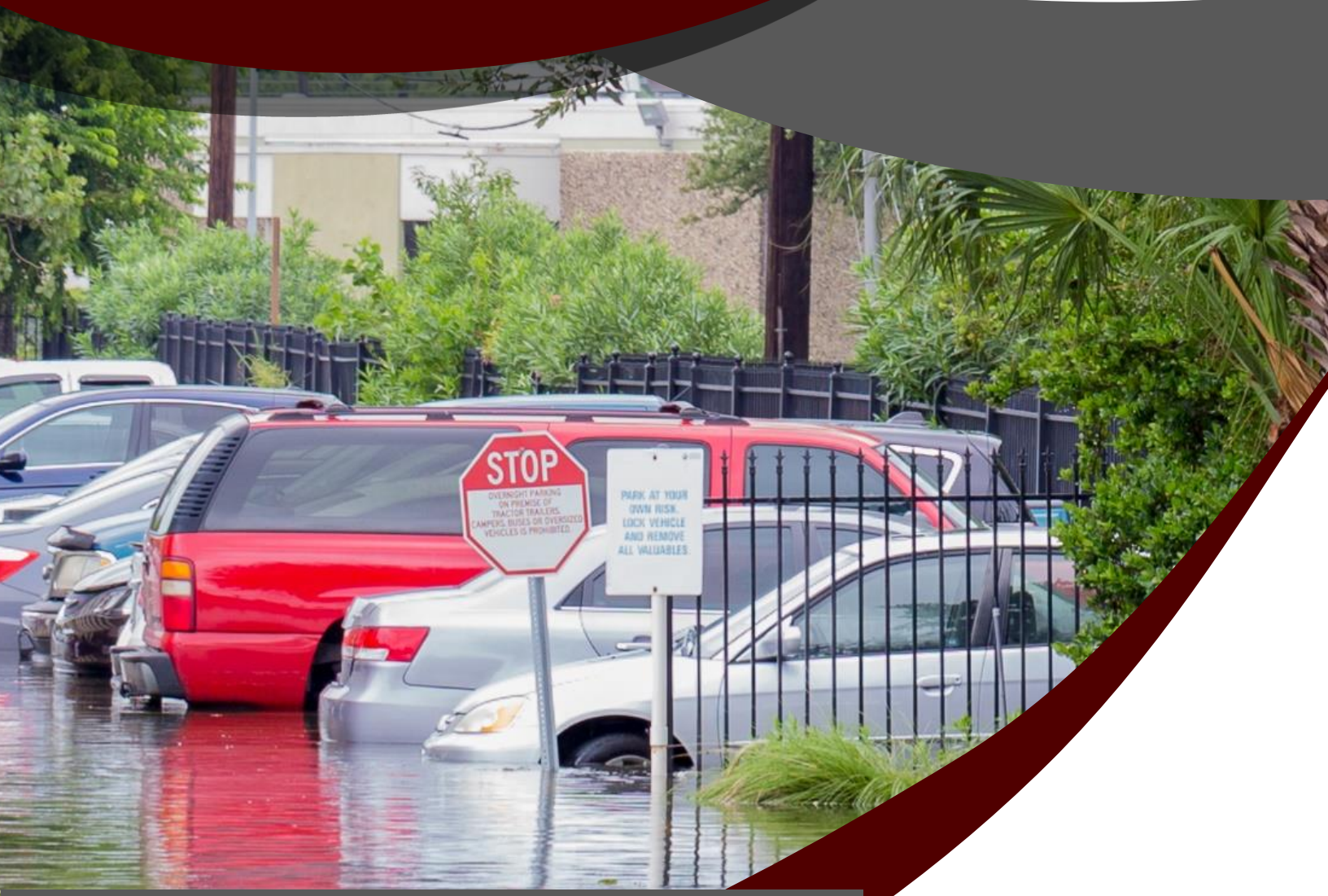

Flood Management in Texas: Planning for the Future

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May 17, 2021

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EXECUTIVE SUMMARY

Introduction

Over the last few decades, flooding in the United States has had devastating social and financial impacts on communities. Insured flood losses alone reached nearly $11 billion between 1999 and 2009 in the US. $48.6 billion in FEMA Public Assistance Grants were spent in the wake of floods each year from 1998 to 2014. These grants were predominantly used to repair or replace public buildings, public utilities, roads and bridges, and water-control facilities like levees, dams, and pumps. However, while flood damages from 1991 to 2000 totaled $45 billion dollars, flood control measures prevented over $208 billion dollars of damage.

Parties seeking to reduce flooding impact through mitigation projects face a myriad of federal, state, and local laws impacting project actualization. This Report examines existing flood-related regulations in Texas and the United States, the Texas State Flood Plan, current flood mitigation strategies in the state, and the potential to implement green stormwater infrastructure. The report offers policy recommendations to clarify and help alleviate the current ambiguities and uncertainties between the Texas State Water Plan and State Flood Plan for future flood mitigation practices, and to simplify the implementation of green infrastructure.

Flood Mitigation

Flood mitigation applications can be classified into two main categories, structural and non-structural. Structural applications focus on reducing the impact of flooding on communities by building levees, floodwalls, and improving drainage systems. Non-structural measures are based on the adjustment of human activities and communities to mitigate flood damage. This includes measures such as directing land use away from flood prone areas, distributing mitigation information, protecting sensitive areas, and insurance programs to help distribute risk. The current federal statutes and regulations governing flood mitigation strategies include the Clean Water Act ("CWA") and its National Pollution Discharge Elimination System ("NPDES"), and municipal separate storm sewer systems programs, as well as state laws and local ordinances.

This Report highlights several policy recommendations for future flood mitigation strategies and the implementation of green stormwater infrastructure in Texas. For flood

mitigation, Texas could implement policies for funding floodplain mapping and pre-release of water from dams. Additionally, Texas could offer programs that give local entities grants to use for projects, or as matching money to secure federal funding for projects.

Current Regulations Impacting Flood Mitigation

At the federal level, several agencies govern flood mitigation under the CWA, the Safe Drinking Water Act, the Rivers and Harbors Act, the National Environmental Policy Act, and the Endangered Species Act. At the state level, the Texas Commission on Environmental Quality regulates the permitting for the CWA NPDES and the municipal separate storm sewer system (MS4). This section looks at how each of these statutes affect flood planning and flooding. There are also regulations under the Texas Water Code and the Texas Administrative Code that regulate regional planning and state plan development. These provisions apply to a regional planning group's ultimate plan development.

The statutes and regulations that could affect the flood mitigation depend on two primary variables: (1) the size of a project (small, medium, large); and (2) whether the project is structural or nonstructural. For illustration: a local municipality's amending its zoning and land use ordinances to mitigate flooding (small, nonstructural) does not implicate the same laws as would developing a greenfield reservoir (large, structural) funded in part by federal dollars.

Overlap and Disconnects Between the State Flood Plan and the State Water Plan

When flood mitigation projects and water supply projects are pitted against each other for similar resources from the state government, there can be substantial strife in attempting to weigh the interest and priorities of all stakeholders. The Texas legislature seems to have already anticipated this problem by mandating that the State Flood Plan identify potential water supply benefits within their projects, possibly for the eventual resolution of resource constraints. Texas has a unique opportunity with the new State Flood Plan to incorporate more than sixty years of knowledge gained through the development of ten State Water Plans, and to make the two plans work together in harmony instead of competing over project funding.

The policy recommendations for harmonizing the two plans focus primarily on the Texas Water Development Board to provide guidance, as well as to liberalize funding sources for projects having both water supply and flood mitigation components. As a comparative analysis, this section includes two case

studies that look at the structure of regulatory systems in Portland, Oregon and the Republic of Korea, and whether these structures could work in Texas to help avoid disconnects between flood and water plans. Further, Texas could create an advisory council consisting of members from both Water Plan and Flood Plan groups to create efficiencies between regional water and flood planning groups.

Green Infrastructure

Flooding is exacerbated as cities continue to develop and add more impervious cover (land where rainfall cannot soak into the ground, blocked by roads, parking lots, etc.). Rainfall in more developed areas produces more runoff, which flows off-site far quicker than in undeveloped areas. When runoff flows over impervious surfaces in developed areas, it picks up pollutants, including car oil and fluids, trash, chemicals, fertilizers, and bacteria, and then carried into nearby bodies of water.

Communities are looking towards green stormwater infrastructure ("GSI") to remedy both water quantity and water quality issues. GSI uses vegetation, soils, and natural processes to improve water quality and manage water quantity. Implementing GSI at a city or county level gives cities several natural areas that can provide flood protection, cleaner water, cleaner air, and natural habitats. As GSI is a strategy for flood mitigation, it is also governed by the CWA, NPDES, and MS4 programs; however, it is most impacted by local ordinances. There currently are several barriers to the widespread implementation of GSI, which should be addressed in future policies. This Report provides policy recommendations for GSI implementation in Texas. At a municipal level, cities could audit and amend their existing codes and ordinances, implement financial incentive programs, and encourage public interest in GSI projects.

Opportunities for Partnerships

Texas has several opportunities to develop partnerships with stakeholders, and these partnerships can ensure water flood mitigation and water use allocation for the future. This section discusses legal mechanisms and policy measures governments may use to encourage inclusive stakeholder cooperation, including successful examples of legal tools and policy measures supporting public infrastructure development and their interaction with private property interests. By developing our partnerships today, we will ensure water flood mitigation and water use allocation for the future.

INTRODUCTION

Flooding in Texas has been a problem since time immemorial. In 2017, Hurricane Harvey caused an estimated $131 billion in damages to the Houston area. Parties seeking to reduce flooding impact through mitigation projects face a myriad of federal, state, and local laws impacting project actualization. Additionally, the Texas Water Development Board has promulgated new regulations to govern regional flood planning.

This report examines the existing regulations, the State Flood Plan, and provides policy recommendations to clarify and help alleviate the current ambiguities and uncertainties between the State Water Plan and State Flood Plan. The primary proposal is for the Texas Water Development Board to provide guidance and liberalize funding sources for projects having both water supply and flood mitigation components.

Lastly, the report examines the efficacy of non-structural and green infrastructure practices and how these programs can serve to complement traditional structural flood mitigation.

I. BACKGROUND

Texas has a long history of floods. The Alamo was moved twice during the 1700s to avoid destruction from flooding. Houston, incorporated in 1836, experienced its first recorded flood in 1837, and Galveston was struck by a hurricane in 1900, killing an estimated 6,000 people. In recent memory, Hurricanes Katrina and Harvey exemplified the catastrophic damage and disruption flooding may cause.[1]

Figure 1. Flooding After Hurricane Harvey[2]

Hurricane Harvey, August 25–31, 2017: More than 30 inches of rainfall fell on 6.9 million people, while 1.25 million experienced over 45 inches and 11,000 had over 50 inches, based on 7-day rainfall totals ending August 31. This historic U.S. rainfall caused massive flooding that displaced over 30,000 people and damaged or destroyed over 200,000 homes and businesses.

Estimated Cost: $131.3 Billion

The cumulative effect of Harvey turned the collective policy spotlight to address flooding in Texas, catalyzing a process that led to groundbreaking flood-focused legislation. Below is the timeline of events relating to the current Texas flood management policy.

2017:	Hurricane Harvey
2018–19:	State Flood Assessment, Report to the Legislature 86th Legislative Session, Texas Water Development Board[3]
2019:	Senate Bills 7 and 8 passed to address statewide funding and planning for flooding[4]
2020:	Flood Planning provisions of the Texas Administrative Code become effective[5]
2023:	Regional Flood Plans due to the Texas Water Development Board

Generally, flood mitigation approaches can be classified into two main categories, structural and nonstructural. Structural focuses on reducing the impact of flooding on communities by building levees, floodwalls, and improving drainage systems.[6] Nonstructural measures are based on policy adjustments governing human activities and communities. Examples of this type of mitigation are directing land use away from flood-prone areas, distributing mitigation information, protecting sensitive areas, and insurance programs to help spread risk.[7] In many cases, a mixture of both structural and nonstructural mitigation strategies are used under a single jurisdictional flood program.

A. Structural Flood Mitigation and Its Drawbacks

Flood mitigation throughout the United States has been predominately focused on structural techniques. Structural approaches to flood mitigation do have beneficial effects, helping to reduce or prevent flood damages. The most common type of structural flood mitigation is dams and reservoirs. However, there are many different types of structural flood mitigation structures. While reservoirs are generally focused on total storage capacity for water conservation (i.e., water to be used for water supply,

hydropower, and recreation), most of Texas's major reservoirs also include some measure of flood control within their total storage capacity.[8]

Additionally, certain dams exist solely for flood control and store water only during and after floods.[9] For example, the Addicks and Barker dams in Houston, Texas, are purely flood control measures.[10] The National Resource Conservation Service has constructed about 2,000 flood retarding dams in rural watersheds of Texas that are currently empty or have only minimal storage during non-flood periods.[11]

However, research has shown that there are limitations to purely structural-based approaches to flood mitigation. One of the first major issues is that excessive flooding can potentially exceed the flood mitigation structure's design capacity, resulting in significantly greater flood damages than if the area had been unprotected.[12]

Secondly, structures like concrete channels or levees can potentially raise a river's flood level. Such channels create water super-highways that increase downstream pulse flows, constrict the waterway and the natural floodplain, leading to shortened flooding time and more significant downstream flooding.[13]

Third, structural measures are often built with high financial and environmental costs. For example, the United States Army Corps of Engineers has spent over $100 billion since the 1940s on structural flood protection projects nationwide.[14] Lastly, the construction of dams and other structural flood control measures can contribute to adverse environmental impacts, including the decline of fish and wildlife ecosystems, water quality, and the function of specific hydrological systems.[15] Recognition of the ecological damage from flood structures has led to movements to remove these structures altogether.[16]

Today, the logistical execution of a greenfield dam or reservoir brings major drawbacks, including available space, conflicts with water rights, and available funding. Most flood control entities will likely find it very difficult to overcome these logistical challenges.

B. Nonstructural Approaches

Because of some of the logistical barriers that structural approaches create, local entities increasingly implement nonstructural methods to complement their flood programs. Nonstructural approaches include education and awareness, land use planning tools, insurance programs, the protection of environmentally sensitive areas, and other emergency and recovery policies for mitigating flood loss.

One of the most widely implemented nonstructural flood mitigation approaches is the National Flood Insurance Program ("NFIP"). The NFIP was established in 1968 as an attempt to stem rising flood losses in the United States. When the NFIP was adopted, local jurisdictions were given additional responsibilities to help manage and regulate areas that are vulnerable to flooding. Under the NFIP, the communities who participate can purchase federal insurance to protect against flood loss. Local jurisdictions are then responsible for adopting and enforcing floodplain management ordinances to reduce the risk to new construction in floodplains. So long as a local jurisdiction adopts some form of protection, the NFIP is responsible for providing insurance to those living in vulnerable areas.

In Texas, about 597,951 properties are covered by the NFIP, which is about 11.4% of the national total.[17] To maintain this coverage, the majority of property owners in Texas pay around $630 a year; this allows the property owners to rebuild if there is a flood that damages their property.[18] Texans have received almost six billion dollars since the NFIP was started.[19] Except for Louisiana and New Jersey residents, Texas property owners have received more payouts from the federal government from flood insurance payments than any other state.[20] The effectiveness of the NFIP as a flood mitigation tool has been repeatedly criticized for encouraging floodplain development and generating repetitive losses with high financial costs.[21]

By implementing certain land-use policies and regulations, communities can reduce the negative impacts of flood events. Appropriate zoning can direct growth away from susceptible areas through development restrictions, density bonuses, transfer of development rights, and clustering.

These provisions and policies are often found in land development codes, zoning ordinances, local plans, and construction codes. Through proactive planning for land use, flood damages can be easily be reduced, and critical hydrological systems can be established to mitigate severe flooding.[22] Additionally, these policies offer measurable protection for natural habitats and water quality.

The other focus of nonstructural approaches to flood mitigation is complimenting traditional land-use policies through public education, flood warning, forecasting, taxation, fiscal policies, and technical assistance. Education generally includes printed materials, websites, training workshops, etc. An excellent example of a nonstructural approach is the "Turn Around Don't Drown®" campaign started by the National Weather Service, which aims to raise awareness of the dangers of driving or walking into flooded areas.[23]

Figure 2. Turn Around Don't Drown Roadway Signage[24]

Fiscal strategies can involve anything from a referendum dedicated to funding flood mitigation programs or acquiring flood-prone lands to obtaining government funding. For example, the Community Block Grant Program is one federal program in which federal funds can be allocated to local jurisdictions for specific flood mitigation projects. Flood warning and forecasting strategies are used by local entities and governments to assess structures, gather data, and predict the consequences of flood events. Various computer models and assessment software can help guide those looking at river flooding, water retention, and storm drainage.

Nonstructural flood mitigation programs are usually executed locally and are another arrow in the quiver to help protect communities against repetitive flood events. Interestingly, despite the range of available land-use planning and other tools, studies show that local governments primarily use basic zoning and subdivision ordinances instead of policies involving land acquisition, financial incentives, or public facilities.[25]

II. CURRENT REGULATIONS IMPACTING FLOOD MITIGATION

This section of the report will focus on the potential interactions and conflicts a flood control project may have with other bodies of law. The statutes and regulations that could affect the mitigation activity depend on project-specific variables. The two primary variables this report focuses on are 1) the size of a project (small, medium, large), and 2) whether the project is structural or nonstructural. For illustration: a local municipality's amending its zoning and land use ordinances to mitigate flooding (small, nonstructural) does not implicate the same laws as would developing a greenfield reservoir (large, structural) funded in part by federal dollars. The following page outlines the categories of flood mitigation projects and lists the most likely federal, state, and local laws that could apply to a particular work.

Flood Mitigation Activities

Large-Scale Structural Projects

New Reservoirs, Dams, Complete Levee Renovation, Seawalls, and other large land-based actions requiring surface disturbance.

Medium-Scale Structural Projects

Reservoir Dredging, Levee Renovation, Catch basins, Wetland restoration.

Small-Scale Structural Projects

Local rain gardens and detention ponds, cisterns and rain-water capture, and green/porous paving.

Non-Structural Projects

Property buyouts and permanent relocation, zoning, subdivision, building codes, and education.

Possible Laws and Regulations

FEDERAL

EPA
Clean Water Act, Safe Drinking Water Act

Army Corps of Engineers:
Rivers and Harbors Act, Clean Water Act Section 404 (dredge and fill)

Council on Environmental Quality
NEPA Review

Fish & Wildlife Service
Endangered Species Act, Lacey Act

Federal Emergency Management Agency (FEMA)
National Flood Insurance Program

Housing and Urban Development
Uniform Relocation Act

STATE

Texas Water Development Board
Texas Water Code and Texas Administrative Code rules for flood planning and funding

TCEQ
Environmental Permitting, Water-Rights, MS4 Permitting

Texas Parks & Wildlife
Statutory authority for management of state wildlife and fisheries resources

Texas Historical Commission
Antiquities code for archaeological surveys

LOCAL

County and Municipality regulations, zoning, land-use regulations, and rights of water-related districts.

A. Federal Environmental Interactions

As discussed above, what laws may interact with a specific flood mitigation project depends on the scale, funding, structure, and location. Following below, this report identifies the specific federal agencies and laws a party may be subject to on a given project.

1. Environmental Protection Agency ("EPA")

There are over a dozen major federal statutes that form the groundwork for the EPA's administrative programs, which provide the agency with extensive regulatory authority, including watershed environmental statutes such as the Clean Water Act ("CWA")[26], the Clean Air Act ("CAA"),[27] and the Safe Drinking Water Act.[28] The EPA's regulatory power to protect the environment extends to all media subject to pollution or contamination—air, water, and soil. It is important to point out that despite EPA's broad authority, some of its regulatory oversight is handled by the Texas Commission on Environmental quality through what is known as delegation.[29] For example, both the NPDES and MS4 permitting discussed below are primarily handled by the TCEQ.

The EPA administers the National Pollutant Discharge Elimination System ("NPDES") stormwater program, which primarily regulates stormwater discharges from three potential sources: municipal separate storm sewer systems, industrial activities, and construction activities. This program is important because specific flood mitigation projects will have to consider whether they will need an NPDES permit (even temporary) before building a project. Obtaining a permit adds regulatory costs and has the potential to delay project implementation.

Additionally, the municipal separate storm sewer system ("MS4") program can present a barrier for expanding flood infrastructure. MS4 permits authorize public entities, such as cities, counties, and transportation agencies, to discharge pollutants from public stormwater systems into the waters of the United States. MS4 permits are particularly applicable to those seeking to implement flood mitigation projects because any water that is discharged from a point source into jurisdictional waters will require a permit

(or an amendment to an existing permit) to be obtained. An example of a standard permit term would require the entity seeking the permit to assess the impact of flood management projects on receiving waters and evaluating retrofits for existing flood control devices.

2. Army Corps of Engineers ("Corps")

The Corps is specifically responsible for administering the permit authority under both the Rivers and Harbors Act[30] and Section 404 of the Clean Water Act.[31] An entity will likely need a Section 404 permit when construction activities result in a discharge into the waters of the United States.

The CWA has various sections that establish permit requirements that prevent obstruction or alteration of any navigable waters of the United States without authorization. The three most frequently used and enforced are Sections 10, 401, and 404. Section 10 covers permits that are required for excavating and filling navigable waters that alter their course, location, condition, or capacity.[32]

Projects that would require a Section 10 permit are structures and plans in which dredging or disposal of dredged material or excavation, filling, or other modifications occur within navigable waters. Section 404 gave authority to the Secretary of the Army, through the Chief of Engineers, to issue permits for discharging or dredging of dredged or fill material into the navigable waters of the United States.[33] Section 401 allows States and Tribes to review, approve, condition, or deny any federal permits or licenses that could result in a discharge into the waters of the United States.[34] The primary purpose of Section 401 is to ensure that all water quality standards are complied with and to prevent potential contamination of vital water sources.

Section 10, Rivers and Harbors Act of 1899[35]	
Activities Covered	Building of any structure in the channel or along the banks of navigable waters of the U.S. that changes the course, conditions, location, or capacity
Section 404, Federal Clean Water Act Letters of Permission	
Activities Covered	Minor or routine work with minimum impacts
Nationwide Permit 3	
Activities Covered	Repair, rehabilitation, or replacement of structures destroyed by storms or floods in the past two years
Nationwide Permit 13	
Activities Covered	Bank stabilization less than 500 feet in length solely for erosion protection
Nationwide Permit 26	
Activities Covered	Filling of up to 1 acre of a non-tidal wetland or less than 500 linear feet of a non-tidal stream that is either isolated from other surface waters or upstream of the point in a drainage network where the average annual flow is less than five cfs
Nationwide Permit 27	
Activities Covered	Restoration of natural wetland hydrology, vegetation, and function to altered and degraded non-tidal wetlands, and restoration of natural functions of riparian areas on private lands, provided a wetland restoration or creation agreement has been developed

Regional Permits	
Activities Covered	Small projects with insignificant environmental impacts
Individual Permits	
Activities Covered	Proposed filling or excavation that causes severe impacts but for which no practical alternative exists; may require an environmental assessment under NEPA

Table 1. Activities Covered by Various Permits

3. Federal Emergency Management Agency ("FEMA")

The Federal Emergency Management Agency exists to protect the United States from disasters and hazards such as acts of terrorism and man-made disasters, as well as natural disaster events (floods, tropical storms, hurricanes, wildfires, volcanic eruptions, landslides, and winter storms).[36] FEMA is an important agency because it administers the National Flood Insurance Program,[37] and it can be a federal source of funding for various projects.[38]

4. Fish & Wildlife Service

This agency's authority relates to the Endangered Species Act. Specifically, Section 7 of the Endangered Species Act[39] bars federal governmental agencies from permitting, funding, or performing any activity that will harm the critical habitat of a listed endangered species or that will jeopardize the continued existence of such species.[40] Because Section 7 attaches to federal permitting or federal funding that is obtainable by private parties, state agencies, cities, or other entities, Section 7 necessarily affects

private parties as well. The Section 7 prohibition applies to any action that "reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species."[41]

A famous Texas example of the impact the Endangered Species Act can have is the creation of the Edwards Aquifer Authority. The Authority was legislatively created in 1993 after a federal judicial decision ordered the U.S. Fish & Wildlife Service to set minimum flows for the Comal and San Marcos springs on which a number of endangered species relied.[42]

B. State Environmental Authority

1. Texas Water Development Board ("TWDB")

Due to this report's coverage of the TWDB's rules below, we include this section simply to acknowledge the Board's role in relation to other agencies. The TWDB does not have direct environmental regulatory authority, although the agency is involved with projects that raise environmental concerns. The TWDB provides financing for water supplies, wastewater facilities, stormwater pollution control, and flood mitigation.[43]

2. Texas Commission on Environmental Quality ("TCEQ")

The Texas Commission on Environmental Quality has broad regulatory powers over water, air, and waste pollution programs. Charged with promoting "the judicious use and maximum conservation and protection of the quality of the environment and the natural resources of the state," the TCEQ encompasses six different program clusters.[44] These program clusters are: (1) Office of Administrative Services; (2) Office of Compliance and Enforcement; (3) Office of Legal Services; (4) Air; (5) Waste; and (6) Water.[45]

Relevant to this report is the TCEQ's jurisdiction over surface and groundwater. The agency's authority includes: the permitting and enforcement of surface water rights; water quality permitting and

enforcement; the creation and ultimate oversight of different water districts; and the monitoring of injection wells.[46]

Flood mitigation activities implicate water quality (discharges from moving soil) and depending on the scale of a project, could affect water rights (in-stream detainment or dam). The TCEQ and its associated regulations are very likely to impact the ultimate implementation of a specific project. For example, the Texas Water Code contains a provision that prohibits the diversion or impoundment of the natural flow of surface waters that causes damages to another person's property from the overflow of the diverted or impounded water.[47] The water code also creates remedies for those injured by any unlawful diversion or impoundments that cause overflow damage.[48] Failure to adhere to TCEQ regulations would expose a party to administrative penalties and possibly an injunction that halts a project.

3. Texas Historical Commission ("THC")

The THC oversees programs designed to preserve the archeological, architectural, cultural, and historical heritage of the State, including the state historical marker program, the state archeological program, the Main Street Program, and the management of the Texas Preservation Trust Fund.[49]

The primary conflict with the THC that a project sponsor/developer may face when installing flood infrastructure comes from the Texas Antiquities Code, which requires an archeological survey to be completed prior to breaking ground on state or local public lands.[50]

C. Local Regulations and Authority

Local and regional governmental entities, such as city municipalities, counties, special districts, water districts, river authorities, and councils of government, can all play a role in flood planning and flood mitigation.

1. Counties

Counties in Texas are granted regulatory authority over numerous areas—solid waste, air, subdivision and platting, and flood insurance

programs. Relevant to this report, counties may create a district that can carry out various environmental functions. Examples of these are drainage districts,[51] levee improvement districts,[52] and water control and improvement districts.[53] The central conflict with a county is one of project specific logistical coordination; where the project sponsor for a flood mitigation project with a large footprint, involving many county stakeholders, may not be able to easily corral parties into cooperation.

2. Municipalities

Municipalities have wide-ranging regulatory authority over environmental activities within their jurisdiction. For example, the Texas Clean Air Act[54] authorizes municipalities to regulate specific actions that affect the environment.

The primary mechanism of regulation is through the enactment of municipal laws or ordinances. Local laws and ordinances supersede county laws within the territorial jurisdiction of a city.[55] However, state law can preempt city ordinances when the Legislature has granted state agencies exclusive jurisdiction to regulate activities.[56] Municipalities may establish ordinances under their police powers that regulate environmental-related activities. Such ordinances, authorized by a city's duty to promote public health and welfare, can include the planning and development of flood control measures,[57] zoning,[58] and general nuisance ordinances.[59] Because of a municipality's flexibility and authority, they are key players in the development of smaller-scale mitigation projects.

3. Districts

Within Texas, there are numerous different types of districts. These entities are separate political subdivisions and are granted certain powers and autonomy. Examples of such districts are the Harris County Flood Control District, the North Texas Municipal Water District, and the Trinity River Authority of Texas.

The types of districts and what they are called vary; however, there are general powers common to these entities: the right of eminent domain;

the right to sue and be sued; to purchase, lease, and sell property; to accept grants; to make contracts; and to develop and operate authority-owned facilities.[60] Districts can play a critical role in flood mitigation. Due to statutory authority, a district would be able to actualize various projects beneficial to flood control through ongoing development and operations.[61]

4. Councils of Government

A "Council of Government" (COG) is created through the Local Government Code. It typically consists of representatives of a city, the surrounding suburban municipalities, and the various counties where these communities are located. COGs serve multiple purposes and deal with a variety of matters, but their essential and primary function is overall regional planning.[62] COGs can be a good resource for stakeholder engagement of the broader community. Relative to this report, large-scale project sponsors should seek input from these organizations.

III. THE TWDB'S STATE AND REGIONAL FLOOD PLAN REGULATIONS

Following Hurricane Harvey, the Texas Senate passed Senate Bills 7 and 8 to address flood planning. Senate Bill 7 appropriated $1.7 billion for flood planning, engineering, and construction, of which $793 million went to the Flood Infrastructure Fund ("FIF"). The FIF provides loans and grants for flood control, flood mitigation, and drainage projects.[63] Further, the legislature tasked the Texas Water Development Board with implementing a State Flood Plan. The board designated fifteen flood planning regions, with the first regional flood plans due in 2023.[64]

A. Requirements of the Texas Water Code

A Regional Flood Plan has numerous general requirements outlined in the Texas Water Code. Section 16.062 requires a planning group to have public meetings to gather recommendations "as to issues, provisions,

projects, and strategies" to be included in a plan. Further, a regional flood plan must:

> (1) use information based on scientific data and updated mapping; and
> (2) include:
>
> (A) a general description of the condition and functionality of flood control infrastructure in the flood planning region;
>
> (B) flood control projects under construction or in the planning stage;
>
> (C) information on land use changes and population growth in the flood planning region;
>
> (D) an identification of the areas in the flood planning region that are prone to flood and flood control solutions for those areas; and
>
> (E) an indication of whether a particular flood control solution:
>
> (i) meets an emergency need;
>
> (ii) uses federal money as a funding component; and
>
> (iii) may also serve as a water supply source.

These requirements are the meat of the legislative amendments to the water code. The purposely broad and general provisions left the detailed rulemaking to the Texas Water Development Board. The Board has since drafted and passed the administrative rules that govern Regional Flood Planning.

B. Requirements of the Texas Administrative Code

The minutiae of regional planning and state plan development are contained in Chapters 361 and 362 of the Texas Administrative Code and have rules ranging from public notice requirements to scientific modeling. Because the laws are voluminous and cover numerous different topics, the following chart outlines Chapters 361 and 362 detailing the subjects covered with hyperlinks to the specific sections.

Chapter 361 Regional Flood Planning		Notes
Subchapter A	**General Information**	
§361.10	Definitions and Acronyms	
§361.11	Designations and Governance of Flood Planning Regions	
§361.12	General Regional Flood Planning Group Responsibilities and Procedures	
Subchapter B	**Guidance Principles, Notice Requirements, and General Considerations**	The regional planning process is subject to the Texas Open Meetings Act and the Texas Public Information Act.
§361.20	Guidance Principles for State and Regional Flood Planning	
§361.21	General Notice Requirements	See also Texas Water Development Board's Public Notice Quick Reference.[65]
§361.22	General Considerations for Development of Regional Flood Plans	
Subchapter C	**Regional Flood Plan Requirements**	
§361.30	Description of the Flood Planning Region	

§361.31	Description of the Existing Natural Flood Mitigation Features and Constructed Major Flood Infrastructure in the Region	
§361.32	Description of the Major Infrastructure and Flood Mitigation Projects Currently Under Development	
§361.33	Existing Condition Flood Risk Analyses in the Region	
§361.34	Future Condition Flood Risk Analyses in the Region	
§361.35	Evaluation of Previous and Current Floodplain Management and Recommendations for Changes to Floodplain Management	
§361.36	Flood Mitigation and Floodplain Management Goals	
§361.37	Flood Mitigation Need Analysis	
§361.38	Identification and Assessment of Potential Flood Management Evaluations and Potentially Feasible Flood Management Strategies and Flood Mitigation Projects	This section extensively details project requirements and quantitative reporting for a potential project.
§361.39	Recommended Flood Management Evaluations, Flood Management Strategies, and Flood Mitigation Projects	

§361.40	Impacts of Regional Flood Plan	
§361.41	Contributions to and Impacts on Water Supply Development and the State Water Plan	
§361.42	Flood Response Information and Activities	
§361.43	Administrative, Regulatory, and Legislative Recommendations	
§361.44	Flood Infrastructure Financing Analysis	
§361.45	Implementation and Comparison to Previous Regional Flood Plan	
Subchapter D	**Adoption, Submittal, and Amendments to Regional Flood Plans**	
§361.50	Adoption, Submittal, Notifications, and Approval of Regional Flood Plans	
§361.51	Amendments to Regional Flood Plans	
Subchapter E	**Negative Effects on Neighboring Areas and Failure to Meet Requirements**	
§361.60	Addressing Negative Effects on Neighboring Areas Within Flood Planning Regions	
§361.61	Addressing Negative Effects on Neighboring Areas Between Flood Planning Regions	

§361.62	Failure of a Regional Flood Plan to Meet Regional Flood Planning Requirements	
Subchapter F	**Regional Flood Planning Grants**	
§361.70	Notice of Funds and Submission and Review of Regional Flood Planning Applications	
§361.71	Board Consideration of Applications, Applicant's Responsibilities, and Contract	
§361.72	Use of Funds	

Table 2. Chapters 361 of the Texas Administrative Code

Chapter 362 State Flood Planning Guidelines		**Notes**
Subchapter A		
§362.1	Applicability	
§362.2	Definitions and Acronyms	
§362.3	Guidance Principles	This section details the numerous principles that could aid in project selection.
§362.4	State Flood Plan Guidelines	

Table 3. Chapters 362 of the Texas Administrative Code

The preceding Texas Water Code and Administrative Code provisions apply to a regional planning group's ultimate plan development. The TWDB modeled the regulations and structure after the well-known State Water Plan. There are concerns that these two plans have significant overlap and create doubt in how projects will be selected and funded. The following section examines these issues.

IV. OVERLAP BETWEEN THE STATE FLOOD PLAN AND THE STATE WATER PLAN

The 2017 State Water Plan mentions flooding only twelve times in the 150-page report.[66] The Water Plan's acknowledgment of flood control and planning is wholly tied to the historical background of the Water Plan. Formal statewide water planning was initiated by the devastating droughts and floods of the 1900s, intensified in the 1950s, and reinvigorated by the drought of 1997.[67] Legislation and funding for water supply development have always been prioritized following extreme economic hardship caused by Texas droughts. Now, following the historic flooding caused by Hurricane Harvey, more attention has fallen on flood mitigation. Texas has a unique opportunity with the new State Flood Plan to incorporate more than sixty years of knowledge gained by the developers of the State Water Plan. As stated previously, the State Flood Plan is modeled procedurally after the State Water Plan. Presently, the opportunity exists for the two plans to work together in harmony instead of competing over project funding.

A. State Flood Plan's Dual Interests in Water Quantity and Water Quality

The enabling statute for the creation of the Texas State Flood Plan requires that the plan "contribute to water development when possible."[68] The Plan must include a ranked list of ongoing and proposed flood control and mitigation projects, and each of these projects must identify if they contribute to water development.[69] Further, Regional Flood Plans must delineate flood control solutions that may serve as a water supply source.[70] By repeating and referencing the importance of water supply throughout the Flood Planning

statute, the legislative body has clearly conveyed the message that they intend the new Flood Plan to work in concert with the goals of the Water Plan. The two plans should fit together like puzzle pieces, each addressing droughts, and floods, respectively, and working together when those goals can be efficiently promoted jointly.

1. Quantity

The Texas Water Plan is legislatively mandated to "provide for the orderly development, management, and conservation of water resources and preparation for and response to drought conditions, in order that sufficient water will be available at a reasonable cost to ensure public health, safety, and welfare; further economic development; and protect the agricultural and natural resources of the entire state."[71] This section of the Water Plan mandate is directly related to the future Flood Plan. The capture of flood waters is a management strategy for the development and conservation of Texas' water resources. Properly captured or diverted flood waters could prove to be an essential source of water resources in the event of a drought, and the effect of proper management of flood water protects both agricultural and natural resources from loss.

2. Quality

The Texas Water Plan is deeply concerned with the development of water resources and the protection of existing resources. Water quality can be threatened by a myriad of potential sources of contamination. One such source of contamination is flood water. Surface and drinking water quality are critical factors in determining the availability of water resources in drought conditions.[72] Individual and community wells and water systems can become contaminated by flood waters carrying waste and chemicals when they back siphon into the supply.[73] This results in both an immediate inability to use and consume water and a prolonged mitigation process that can go on for months.[74]

V. DISCONNECTS BETWEEN THE STATE WATER PLAN AND FLOOD PLAN

The overlap between the State Flood and State Water Plan is narrower in practice than in theory. Storing water in the event of a drought directly conflicts with reserving space for excess water in the event of a flood. For this reason, reservoirs with the dual purpose of water supply and drought mitigation must designate each unit of storage capacity either for flood capacity or for water supply, and one unit can never serve both purposes.[75] Theoretically, with enough scientific modeling improvement, reservoir managers would be able to accurately predict the weekly need from the reservoir and the potential for increased supply through rain or runoff and manage the water level within the reservoir accordingly. This modeling would need to be accurate enough to determine the likelihood of a flooding event weeks in advance to allow the reservoir time to release water in a slow and controlled manner and avoid the risk of the release of water for a flood that never comes, thus depleting the available water supply. The science is evolving quickly in this area,[76] but the weather modeling remains woefully underdeveloped to rise to the level of liability proof.

Additionally, the ideological ideal of what constitutes the "highest and best use" continues to plague water resource managers across the globe. Determining what projects should receive funding, water rights allocations, and land allotments will turn predominantly on the public interest served, financial feasibility, and productivity. When flood mitigation projects and water supply projects are pitted against each other for similar resources from the state government, there will be substantial strife in attempting to weigh the interest and priorities of all stakeholders. The legislature seems to have already anticipated this problem by mandating that the Flood Plan identify potential water supply benefits within their projects, possibly for the eventual resolution of resource constraints.

A. Prioritization of Projects

The prioritization scheme has not yet been announced for the State Flood Plan's proposed projects.[77] The Texas Water Development has stated explicitly that it does not intend to use the same priority system established for the Flood Intended Use Program of 2020.

1. Indications from Initial Flood Intended Use Plan ("FIUP") Funding

Although the legislature has specifically stated that it does not intend to use the same prioritization structure for the State and Regional Flood Plans as it has for the Flood Intended Use Plan (FIUP) and corresponding Flood Infrastructure Fund (FIF), the prioritization details give insight to what types of management strategies might be preferred and what considerations might be made for dual-use projects. The FIUP breaks flood control, flood mitigation, and drainage projects into four categories.

Category one includes flood control planning activities; category two includes planning, land acquisition, and design activities; category three applies to communities that have received federal money for flood-related activities; and category four includes projects that can be implemented quickly and will have an immediate impact on the preservation of life and property.[78] The FIUP gives a higher priority to categories one and four. Additionally, projects with an "integral, reliable, and quantifiable water supply benefit to a specific water user group with an identified need" receive additional priority points.

2. SWIFT Funding for State Water Plan

The Texas State Water Plan has its own fund, the State Water Implementation Fund for Texas (SWIFT).[79] Projects included in the applicable Regional Water Plan and whose management strategy is recommended in the State Water Plan are eligible to apply for financial assistance through SWIFT. The program provides "low-interest loans, extended repayment terms, deferral of loan repayments, and incremental repurchase terms for projects with state ownership aspects."[80]

The Uniform Standards Stakeholder Committee was devised to set the standards for prioritizing the projects included in the Regional Water Plans.[81] The Uniform Standards for regional project prioritizations include weight for the decade of need, project feasibility, project viability, project sustainability, and project cost-effectiveness.[82] The Uniform Standards Stakeholder Committee has also issued guidance on how projects may or may not be bundled.[83] If the proposed project contains different water management strategies and could feasibly be implemented separately, the projects cannot be bundled for prioritization scoring.[84] The concern is that bundled projects could be implemented independently by different entities and benefiting different groups but receive a higher prioritization score than if they had been evaluated separately.[85]

To qualify for SWIFT funding, projects need not only be included in the Regional Plan, but they also need to have their management strategy be recommended in the State Water Plan. The 2017 State Water Plan recommended five different categories of water management strategies, including demand management, reuse, groundwater, sea water, and surface water.[86] These categories are further broken down into different types. These types are:

1) aquifer storage and recovery,
2) conjunctive use,
3) direct potable reuse,
4) drought management,
5) groundwater desalinization,
6) groundwater wells,
7) direct reuse,
8) irrigation conservation,
9) municipal conservation,
10) new major reservoir, other conservation,
11) other direct reuse,
12) other surface water, and
13) seawater desalinization.[87]

Each type relies on specific water needs, location, available water resources, impacts, and costs. The types vary in complexity and required infrastructure investment.[88]

Once the project has been included in the Regional Water Plan and its proposed water management strategy has been recommended by the State Water Plan, the SWIFT application for project funding will be prioritized again by the state. This prioritization scale allows points according to population served, diversity of benefits between rural and urban populations, number of entities served, percent of water supply needs served, local and federal funding contribution, ability for applicant to repay, emergency need, readiness to proceed, effect on water conservation, and the priority assigned in the Regional Water Plan.[89]

3. The Unknown: Dual Purpose Projects

Considering both the enabling statute for the State Flood Plan and the treatment of flood projects with a water supply benefit in the FIUP, it is foreseeable that flood control projects with a water supply benefit would receive some level of priority in the Regional Flood Plan priority scheme. The extent of that benefit is yet to be determined.

Currently, there is no indication as to if or when a separate fund may be created for projects proposed by the State, and Regional Flood Plans like SWIFT for the State Water Plan. Given the level of parallelism between the process for the State Flood Plan and the new State Water plan, it is reasonably likely that this separate fund will become available.

The question remains as to how dual-use projects will be treated within the State Flood Plan and the possible corresponding fund. Currently, it is foreseeable that a dual-use project would be able to be included in both the State Water Plan and the State Flood plan and attempt to achieve prioritization and funding through the separate sources. On a basic level, this could serve to disadvantage flood control projects with a large water supply benefit in the prioritization schemes, thus discouraging these projects' development.

In the Regional Flood Plan, a project with a high-water supply benefit would be allocated points for prioritization for water supply benefit, but the remainder of the project could score low on other aspects of the scheme, resulting in a low prioritization score. The same project seeking addition to the State Water Supply Plan would receive priority points for their water use benefits. However, the guidance from Uniform Standards does not allow projects with bundled management strategies to be prioritized together. The State and Regional Flood Plans do not adequately address flood planning, flood control, or mitigation to determine if this dual-use would qualify as an unapproved bundle. Potentially, under the State Water Plan, the project could be decoupled from the flood control component and thus disqualify flood control from funding under the State Water Plan.

As addressed above, the goals of flood mitigation and water supply may oppose one another, and harmonizing the plans as to the treatment of flood control projects with a benefit to both water supply and flood control must be done in a way that balances the interests of the opposing stakeholders and does not disadvantage single-use projects.

B. Case Studies on How to Avoid Disconnects

The below analysis is provided to determine legal mechanisms and policy measures available to facilitate opportunities for multi-purpose and multi-regional water allocation and flood mitigation infrastructure. Texas is not the only place struggling with the demand for flood control and water supply. Through analysis of other jurisdictional approaches to water management, valuable insight may be gained.

1. Portland, Oregon

Portland has a similar annual rainfall to Dallas-Fort Worth and has similar concerns of water runoff during heavy rains washing pollutants off the streets and into the rivers and streams, upsetting water quality harming the environment, and risk to downstream infrastructure. Portland has tackled this problem by establishing a multi-layered, systematic approach involving

all significant stakeholders overseen by its Department of Environmental Services.[90]

a) Identified the Standard to Meet.

In cooperation with Federal and State water quality standards,[91] Portland has identified and promulgated the exact criteria the storm water system intends to meet.

b) Systematic Approach.

Portland's approach to solving stormwater issues involves residents, business owners, property owners, and all government layers working in concert towards common goals. Zoning ordinances and easement restrictions work in concert to allow and to encourage business and property owners to build and maintain the needed stormwater infrastructure projects as one extensive systematic approach.[92]

c) One Agency providing Oversight.

The department of Environmental Services provides the streamlined oversight[93] often missing in the bureaucracy of major municipalities. Portland's Environmental Services ensures that all government agencies, existing regulations, codes, and ordinances work to support a streamlined process for installing and maintain stormwater infrastructure designed to mitigate downstream harm.

Portland stands as an example of how to encourage all parties to work together towards a common goal for stormwater and water quality management. Entities can emulate Portland's approach—identifying and publishing the standards to be met, empowering a mutual agency supporting network to meet those standards, and placing one agency in charge of enforcing the systems' implementation to meet the published standard.

2. Republic of Korea

The Republic of Korea (South Korea) has made a concerted effort to solve its combined water quality, water flooding, and water drought issues

over the last 50 years. South Korea receives 52 inches of rain each year, primarily in two months.[94] Both flood control and water quality were fundamentally crucial to the safety of the Korean people. The government-owned Korean Water Resources Corporation is credited with much of the success. It has exported technologies used in South Korea to 24 other nations, with many other countries looking to replicate the technologies on display in South Korea.[95]

a) Establishing the Standard.

Although South Korea receives almost twice the average rainfall of other nations, due to population, the amount of water available to its citizens is only 1/6 as much as the international per capita average.[96] South Korea was faced with setting a standard of providing quality water availability to its population-dense economy throughout a multitude of water sheds for domestic, agricultural, and industrial uses.

b) The Integrated Water Resources System.

To meet the standard required, South Korea constructed five flood control dams; 21 multi-purpose dams designed for power generation, flood control, and water supply; and established 48 multi-regional water supply systems managed by the Ministry of the Environment.[97]

c) Central Government Control.

The Ministry of the Environment provides overwatch and decision-making authority as the central planning agency charged with enforcing the water distribution standards. This allows for multiple water transfers across different watersheds to equalize distribution to 96% of the Korean population.[98]

South Korea faced critical water quality challenges due to lacking infrastructure in the aftermath of WWII and the Korean War. It established a government-owned corporation in 1967 to meet the Korean people's need for power generation, flood control, and water distribution.[99] In order to equitably distribute the water supply for the various domestic, agricultural,

and industrial interests, a corporation was established to build the required infrastructure and create an integrated water management system. Additionally, the Ministry of the Environment oversaw system enforcement.[100] Fifty years after meeting the challenge, South Korea's technology is being exported to other developing nations and emulated by many others.[101]

While Portland, South Korea, and other case studies seem to show success stories, these municipalities operate under a very different organization and mindset than Texas. Government-centric, top-heavy approaches could meet resistance from independent Texas landowners. However, an educational perspective initiated at the grassroots level is a strategy to tap into the Texans' collective neighborly attitude. A project sponsor could educate the citizenry on the value of understanding a "One Water" approach to meet the future sustainable water needs of all Texans. This approach may create community buy-in for dual-purpose projects mixing water supply planning and flood mitigation. The idea of One Water is that it "promotes the management of all water within a specific geography—drinking water, wastewater, stormwater, and greywater—as a single resource, a resource that must be managed holistically, viably and sustainably."[102]

The takeaway from the case studies may be that simplicity and unified authority works. The vignettes illustrate how to best managing numerous stakeholders with various agendas in the same direction:

1) Clearly identify the agreed-upon standards to be met,
2) establish systems that will meet those standards, and
3) place (by name and position) personnel responsible for overwatching those systems.

This approach could work in Texas, utilizing the existing statutory authority of Water Control and Improvement Districts. The power of these districts is discussed below under policy recommendations.

C. Policy Recommendations to Harmonize the Plans

One of the core mandates in the new State Flood Plan is to identify projects that would have both a flood control benefit and a water supply benefit. Currently, there is no clear guidance as to how these projects would be funded, and the State Water Plan does not indicate that Flood Control would be considered as a water management strategy. Policy is needed to bring these two plans together in a way that is clear and simple in order to promote the development of projects that benefit interests in both plans and Texas as a whole.

1. Bundled Funding for Dual Use Projects

We propose that the Texas Legislature amend the current Uniform Standards to allow water supply projects to bundle with flood control projects without repercussion. This would enable dual-purpose projects to seek inclusion and funding through both plans without the risk of one component being decoupled from its water supply benefit. This policy's effect would be that the flooding control aspects of the dual project would receive monies from a fund dedicated to the mission of increasing water supply. The State Water Plan contains no consideration for flood management strategies and is not mandated to fund flood control. Money is always a limiting factor in determining who receives SWIFT funds. The allocation of even a single dollar to a project outside of the water supply scope will likely meet staunch opposition from stakeholders involved in water supply planning.

To rectify these conflicting interests, we propose two feasible broad options as mechanisms to accomplish the proposed policy change. The legislature could create a fund separate from the funding for the Water Supply Plan and the Flood Plan. This fund would prioritize dual-purpose projects included in the Flood Plan on their own scale with input from the priority achieved in both the State Flood Plan and the State Water Plan and distribute the funds regardless of the percentage of benefit to each opposing side. This fund could be created from an equal percentage contribution from both the SWIFT fund and the eventual Flood Plan fund.

The second option would be to create enabling legislation that directs the TWDB to evaluate each dual-purpose project determines in their application what percentage of their project contributes to flood control and what contributes to water supply. Funding would be distributed from each Plans Funds by their respective goals' percentage of the total cost, but the entire project would be considered for priority. This option allows each fund to dedicate funds to the project's components that further their goals. The following chart illustrates this synergy.

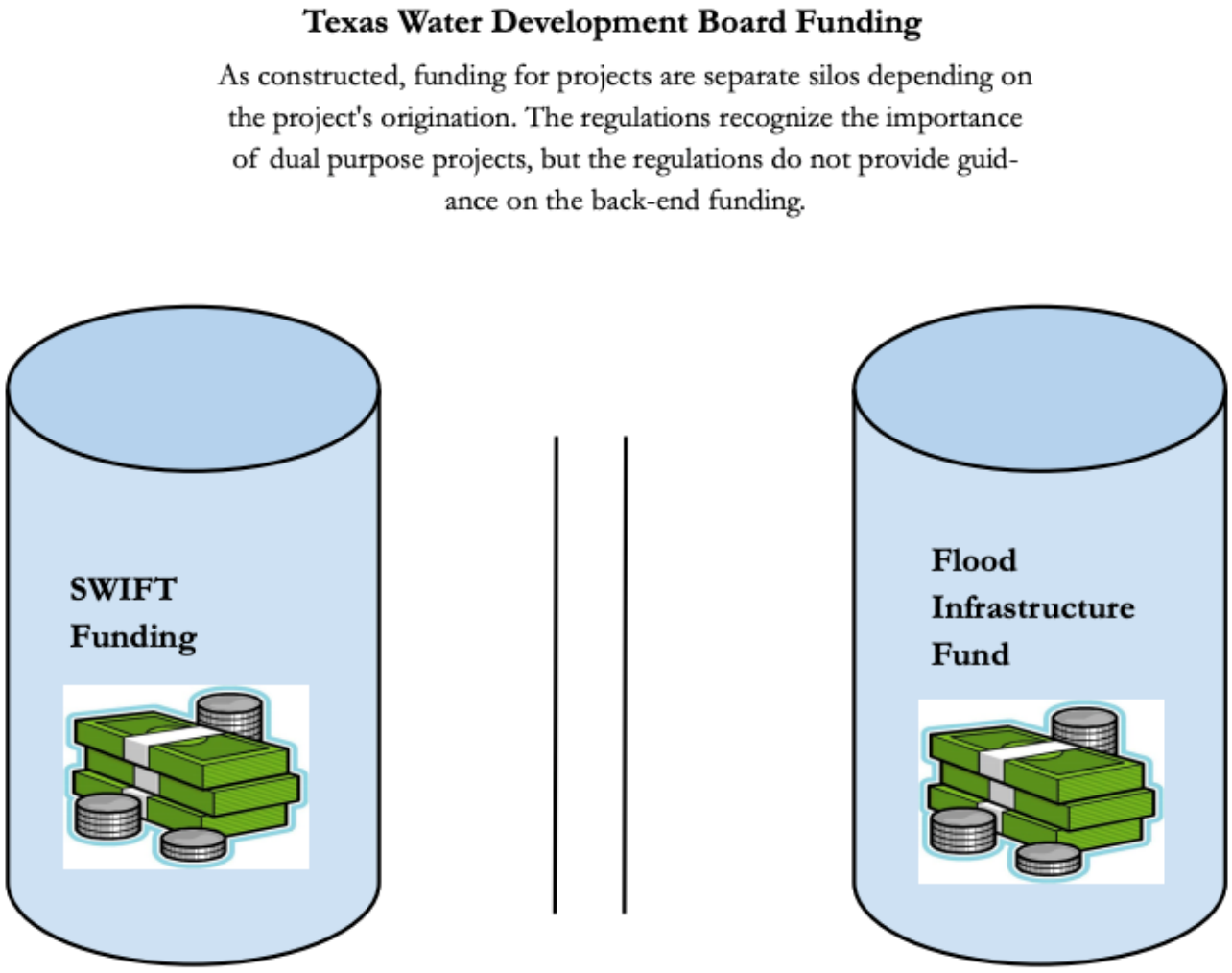


Figure 3. Current Predicted TWDB Funding for Water Supply and Flooding

Recommendation: Dual Purpose Funding

Ideally, the Texas Water Development Board should be able to utilize funding from both SWIFT and the Flood Infrastructure Fund depending on how a particular project benefits water supply. We see this requiring two components:

1) A sponsor's analysis of the approximate percentage mix for a project (e.g., 60% flood, 40% water supply); and
2) The TWDB's capability of apportioning the funds after project review.

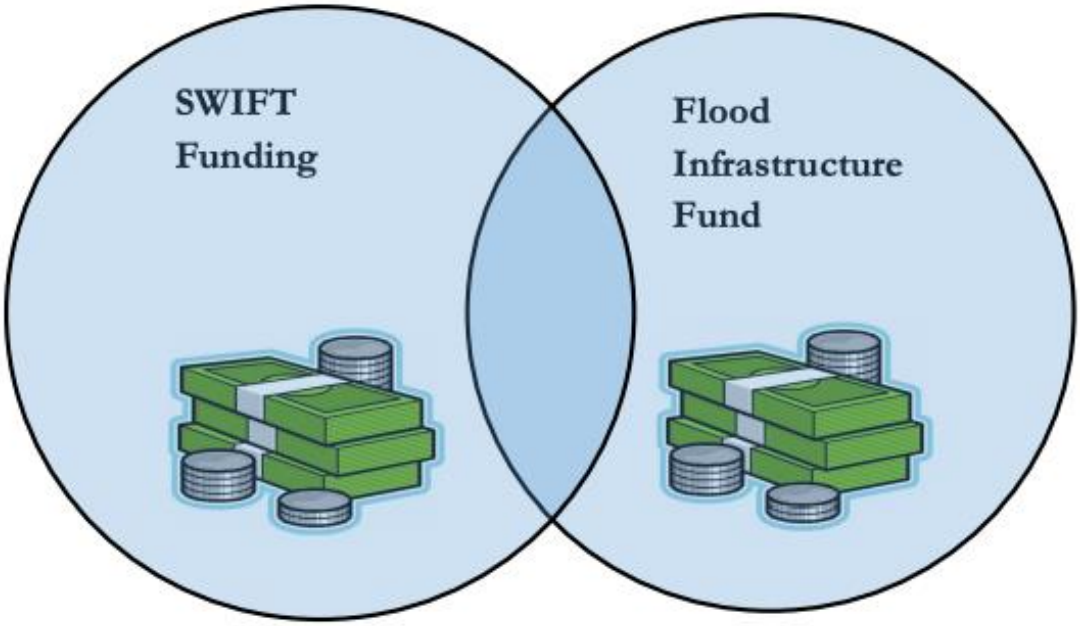


Figure 4. Recommended Dual Purpose Funding Solution

In either of these scenarios, it would be beneficial for the TWDB to create a priority scheme similar to the one used in the FIUP, where projects could qualify for priority points based on their contribution to the other plan's goals. Theoretically, a project that is dedicated 75% to water supply and 25% to flood control would seek inclusion in the State Water Plan and achieve priority points for its flood mitigation benefits. Conversely, a project composed of a 75% flood control benefit and a 25% water supply

benefit would seek inclusion in the State Flood Plan and achieve priority points for its benefit to the water supply. Through this distribution of priority points, the TWDB could encourage sponsors to develop dual use projects to obtain a higher priority. Additionally, the TWDB may accomplish this goal by deducting points from projects in the State Flood Plan that do not contribute to the water supply in any way, or those which have a net negative impact on the water supply.

2. Create Efficiencies between Regional Water and Flood Planning Groups

An advisory council consisting of members from both Water Plan and Flood Plan groups could be created to establish interconnection. This "joint council" could be responsible for ensuring that sponsors for dual-purpose projects receive proper guidance and recommended management strategies from either plan that do not conflict with the other's goals. Additionally, this group could identify the need for hydrologic studies in joint interest areas and work together to minimize cost and time while increasing the comprehensive data received from any third party hired to conduct the research. The needs for water supply and flood mitigation tend to vary widely by locality. Existing regions would be best suited to staff these joint councils because of their ability to identify their territories' unique challenges.

3. The Potential Implementation of "Master" Water Control and Improvement Districts

Research for this report uncovered an interesting and obscure portion of the Texas Water Code that is seemingly unused in today's regulatory environment—the "Master" water control and improvement district. The general provisions for water control and improvement districts ("WCID") are outlined in Chapter 51 of the water code.[103]

Highlighting some of the more unique characteristics, a Master WCID district is granted statutory powers for the following:

- A district may be multi-county;

- It is authorized to construct all works necessary to prevent floods or to supply water for municipal, domestic, and commercial uses;
- Master districts are given contracting, bonding, and taxing authority;
- It is authorized to pump or supply another district any water to which that district has a right; and
- A Master district can sue to protect its water rights![104]

There is tremendous potential to implement this type of district to facilitate more of a watershed-based approach to flood mitigation and water supply development. It is important to note that a Master district does not displace existing authority, but its stated purpose is to enable other districts "to pool their resources when necessary to economically adopt a plan to coordinate the plants, improvements, and facilities of the several constituent districts."[105] This report recognizes that such an approach may meet resistance, as entities are weary to grant away authority. However, considering the Master district's exceptional characteristics and statutory authority, we include it in this report.

VI. LOCAL ENTITIES AND THE STATE FLOOD PLAN

A. Funding Mechanisms for Local Entities to Implement the State Flood Plan

There are numerous funding mechanisms available to assist municipalities in implementing proposed policy measures supporting the regional flood plan. But success for future flood mitigation projects' funding will depend on the collective citizenry's will to make the regional flood plan a top priority. Promulgating a comprehensive and coordinated effort across all layers of society to provide funding must be engaged. Government entities, non-government organizations, and non-profits, along with all Texans, must support the regional flood plans for the funding efforts and mechanisms to be successful.

1. Government Entities

Government entities will provide the more conventional and familiar approaches to funding and legal mechanism incentives. Financing and legal mechanisms available to government entities would include the use of grants, bonds, service fees and credits, fines, sales tax, property tax, rebates, expedited permitting, and zoning considerations. The purpose of this section is not to instruct municipalities on how to use existing funding mechanisms, but to encourage cities to share information both internally across various divisions of local government and externally with nearby municipalities where practical.

Water flows across artificial government boundaries. Critical to a plan's success is establishing an interlocking network of government organizations, inspectors, and public works representatives. This network can develop standards, training, and licensing requirements for a thorough understanding of the tools and techniques available for implementing workable flood mitigation and sustainable use to preserve the water supply.

2. Non-Governmental Organizations and Non-Profits[106]

Numerous non-governmental foundations offer opportunities to apply for grant money, including household names like the Ford Foundation, Rockefeller Foundation, Lennox Foundation, and Clinton Foundation. There are also many non-profit organizations working to provide water management education to Texans. In addition to the well-known Dallas-Fort Worth area organizations Texan By Nature and the Meadows Foundation, other Texas NGOs include the Texas Water Foundation[107], the Texas Rural Water Foundation[108], and the Texas Living Waters Project.[109] Texas A&M University provides in-depth access to a searchable index of non-profit organizations working within Texas.[110]

3. All Texans

All Texans must be encouraged to be a part of the future flood mitigation solutions through education and land improvement options and

incentives to support flood planning goals. Regional flood planning should consider opportunities to involve and engage homeowner associations, neighborhood associations, and other neighborhood and community coalition groups in various urban and rural areas affected by the flood planning process. Ballot initiatives to include a sales tax increase to pay for regional flood plan projects could also be proposed and considered.

Further discussion on opportunities for partnerships and education among these various layers of our society and communities will be discussed in Section VIII of this report.

B. Nonstructural Policy Recommendations for Local Entities

Local communities in the United States are increasingly bearing the responsibility for repetitive flood problems. By adopting and implementing specific structural and nonstructural mitigation measures, local entities can take steps to reduce property damage and human casualties associated with localized flood events. However, local entities face challenges.

Texas is taking steps in the right direction to mitigate floods. Hopefully, the State Flood Plan will help communities prevent flooding events and mitigate the seriousness of flooding that does occur. There are many different ways to approach flood mitigation; as discussed in Section One, the primary approaches are structural and nonstructural. There are various nonstructural methods and policies that could be implemented in Texas that are already being implemented in other states. For example, Minnesota and Illinois pay for floodplain mapping to identify high-risk areas; usually, floodplain mapping is handled by the federal government.[111] This could be beneficial as floodplains change, and with more urbanization, the floodplains are likely evolving more rapidly than the federal government is updating their floodplain maps.

Additionally, Texas could offer programs that give local entities grants to use for their projects or as matching money to secure federal funding for projects. Following Hurricane Harvey and Tropical Storm Imelda,

emergency action was taken to help the communities secure money from the federal government for repairs. If Texas was to implement a permanent program of this type, more flood mitigation projects would likely be implemented before major flooding events occur, ideally mitigating the potential damages. A permanent program can lead to a decrease in the time it takes for communities to recover from flood damages because the procedures will already be in place to help secure matching money for federal funding or start recovering from the damages. Policies that focus more on preventative measures could mitigate the billions of dollars that go into repairing the damages created by flooding disasters.[112]

Another potential policy implementation that could reduce the effects of flooding is implementing a dam pre-release and surcharge policy. Pre-releasing water from dams has been a practice in several places worldwide, including several cities in Australia.[113] The concept of pre-release is the strategic release of water from a dam or reservoir before forecasted rainfall and helps to prevent significant flooding events. Pre-release is not a new method for flood mitigation policies, but it does have some barriers to implementation. The most significant obstacle is that water in a reservoir or dam usually belongs to someone else, a water rights holder, so to pre-release some water from the dam in anticipation of a rainstorm could create some legal implications. Another potential issue is that water is let out of a reservoir or dam in anticipation of a big rainstorm, and then it never rains. The question then arises as to who is responsible for losing the water in the reservoir or dam and what happens in these situations, which will most likely require litigation, so there are potential drawbacks to this approach.

VII. THE POSSIBILITIES PROVIDED BY GREEN INFRASTRUCTURE

As cities develop, more land is covered with houses, buildings, roads, and parking lots, all of which prevent rainwater from soaking into the ground. Consequently, storms result in higher levels of runoff, which exacerbates water pollution and flooding issues.[114] The increase in impervious cover increases the volume of runoff while simultaneously decreasing the duration.

On undeveloped land, runoff is only produced by large storms, and that runoff is discharged over the next few days.

Comparatively, on developed lands, small storms can produce runoff which will flow off-site within a few hours. This accelerated runoff increases the flow into streams, which can result in flooding. Additionally, when runoff flows over impervious surfaces in developed areas, it picks up pollutants, including car oil and fluids, trash, chemicals, fertilizers, and bacteria, which are carried into nearby bodies of water.[115] As cities continue developing and adding more impervious surfaces, stormwater runoff will continue to be an issue. With higher rainfall and increased flooding from climate change, the existing stormwater infrastructure alone is not equipped to handle these problems.[116] Consequently, communities are looking towards green stormwater infrastructure to remedy both water quantity and water quality issues.[117]

A. Green vs. Gray: Infrastructure to Complement, Not Compete

Traditional stormwater infrastructure focuses on moving runoff away from buildings and roads as quickly as possible or mitigating flooding by temporarily storing runoff and slowly releasing it. This is most commonly done with the use of concrete curbs, pipes, drains, and channels.[118] These structures are usually made of concrete and other energy-intensive materials and are dubbed "gray infrastructure" due to their gray appearance.[119] Gray infrastructure provides reliable and safe drinking water, protects communities from floods and storms, and secures water for agriculture with dams and irrigation systems.[120]

Despite these benefits, gray infrastructure can have several adverse effects downstream.[121] Rainwater is converted to stormwater runoff, which collects pollutants from the surrounding urban area, and decreases the water quality. Higher flows from heavy rains can cause erosion and flooding in urban streams, damaging habitats, property, and infrastructure.[122] Impervious cover from concrete and roads prevents the water from infiltrating into the soil, limiting the amount of pollution filtration and decreasing groundwater

recharge. A lack of groundwater then creates a "dry-weather-based flow" in downstream waterways, threatening the freshwater ecosystem. These downstream effects suggest that gray infrastructure does not provide the best solution for the environment, the economy, or society, leading communities to look to other methods.[123]

One such method is green infrastructure, which is broadly defined as "an interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits to human populations."[124] Specifically applied to managing flooding and stormwater, green stormwater infrastructure ("GSI") (also called low impact development) uses vegetation, soils, and natural processes to improve water quality and manage water quantity.[125]

In undeveloped areas, rainwater is absorbed and filtered by the soil and the nearby foliage, resulting in less runoff and higher water quality. Implementing GSI at a city or county level gives cities several natural areas that can provide flood protection, cleaner water, cleaner air, and natural habitats.[126] GSI can also support several societal functions, including "food production, economic productivity, cultural identity, and community cohesion."[127] Unlike gray infrastructure, many of the drawbacks of GSI are specific to implementation and maintenance.

As GSI has not been in use for as long as gray infrastructure, the costs of implementation and maintenance are not as well-known, and it can vary widely depending on the location.[128] Additionally, because geography, hydrology, and weather patterns are different in different areas, there is no one-size-fits-all plan for implementing GSI. The environmental benefits are not certain for every location.[129] These barriers for implementation and regulatory barriers are discussed in more detail in Parts C and E of this Section.

Green and Gray Infrastructure: The Positives

Provides flood protection, cleaner water, cleaner air, and natural habitats	Moves runoff away from buildings and roads as quickly as possible to protects communities from floods and storms.
Rainwater is absorbed and filtered by the soil and the plants, resulting in less runoff and higher water quality	Mitigates flooding by temporarily storing runoff and slowly releasing it
Uses natural processes to improve water quality and manage water quantity	Creates reliable and safe drinking water
Supports societal functions including food production, economic productivity, cultural identity, and community cohesion	Secures water for agriculture with dams and irrigation system
Integrates urban environments with nature	Has been the standard in development in the past, less uncertainties

Figure 5. The Positives of Green and Grey Infrastructure

Green and Gray Infrastructure: The Pitfalls

More costly to implement on legacy developments	Less adaptable in light of climate change
The chosen vegetation needs to take into account the varying weather of the area; not as uniform as Gray infrastructure	Changing climates lead to erosion which can cause the release of pollutants into the collected water
Some existing structures may not be able to handle the weight of green roofs	Heavy rains can cause erosion and flooding in urban streams, in turn damaging habitats, property, and infrastructure that is currently unequiped to handle the streams
More subject to pedestrian impact	Lack of groundwater then creates a "dry-weather based flow" in downstream waterways, which threatens the freshwater ecosystem
Possibility of increased presence of pests such as rodents in urban areas	Impervious cover from concrete and roads prevents water from infiltrating into the soil, limiting the amount of pollution filtration and decreases groundwater recharge

Figure 6. The Pitfalls of Green and Grey Infrastructure

Many urban areas around the world still favor gray infrastructure as it is familiar and reliable.[130] However, as communities continue to expand and climate change brings new problems, the existing gray infrastructure is at risk of failing.[131] But in highly urbanized areas, GSI alone cannot resolve flooding and stormwater issues. Several studies have shown that green and gray infrastructure exists on a continuum, as neither green nor gray can solve all flooding and stormwater issues alone.[132] There is a movement towards a hybrid approach, sometimes referred to as "green-gray infrastructure,"[133] that provides both the environmental benefits of GSI with the certainty of gray infrastructure while also reducing implementation costs and policy barriers. Combining natural systems with gray infrastructure can deliver a stormwater system that is more flexible and resilient in light of changing temperatures and weather patterns.[134]

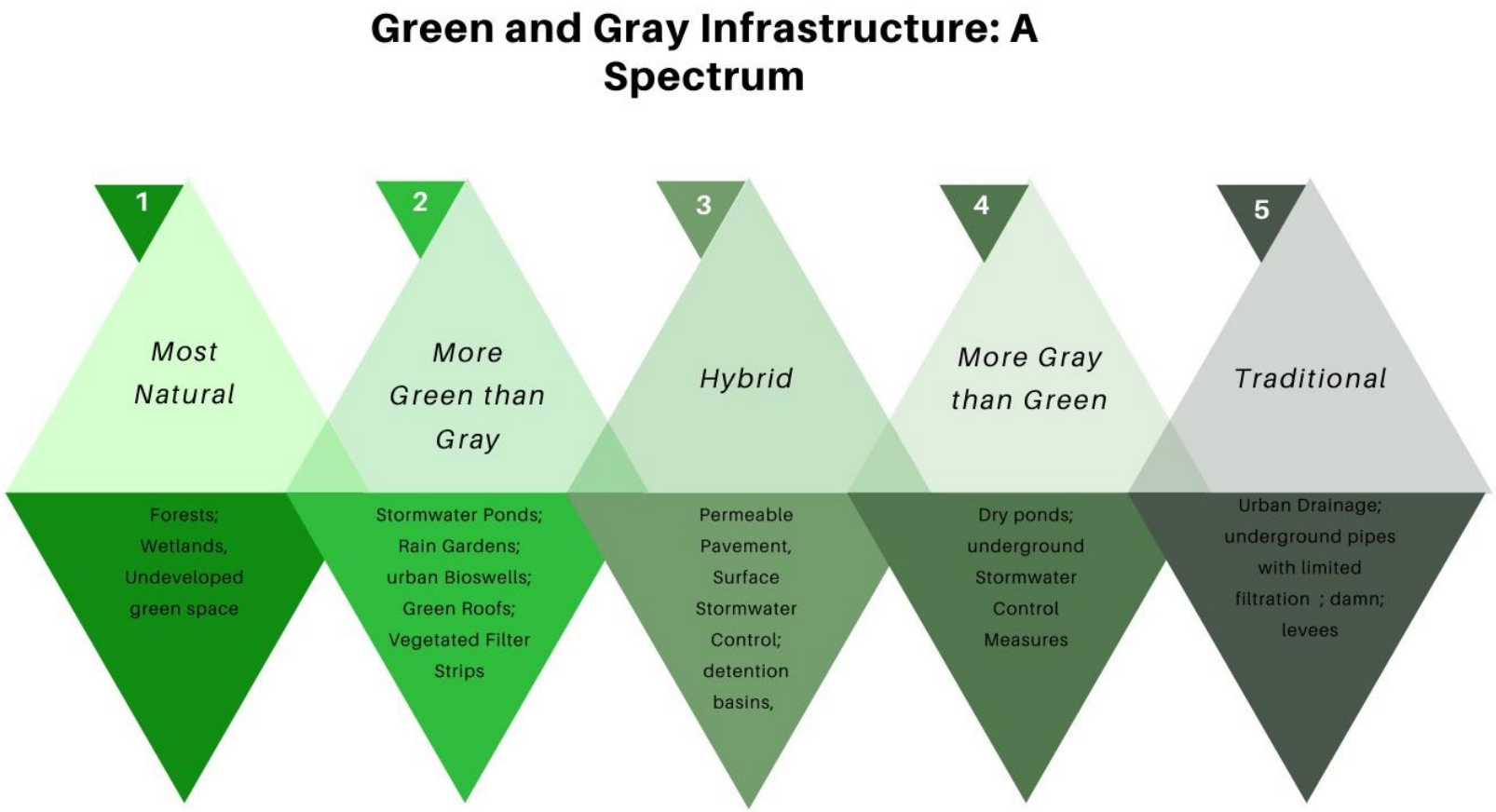


Figure 7. Spectrum of Green and Gray Infrastructure

B. Green Stormwater Infrastructure in Texas

GSI has become much more widely used across Texas throughout the last decade, and Texas cities are creating and implementing policies to encourage its use. There are several types of GSI projects, ranging from small-scale projects that individual landowners can implement to large-scale projects that are implemented by cities or the state. This report focuses on small-scale projects.

Bioretention is an engineered system of filtration media and plants that retains stormwater runoff and filters pollutants and sediments.[135] Bioretention systems reduce the amount of runoff that is discharged into waterways while also improving water quality.[136] Bioretention features used in Texas include rain gardens, bioswales, vegetated filter strips, and planter boxes.[137]

Rain gardens are shallow basins planted with grasses, flowers, and other native plants that collect runoff from roofs, sidewalks, streets, and other impervious surfaces.[138] The water infiltrates into the ground and then evaporates and transpires, and this process helps filter out pollutants and improve water quality.[139] Further, rain gardens provide natural beauty to areas and a habitat for butterflies, birds, and other wildlife.[140] Below is a Rain Garden in San Antonio outside the San Antonio River Authority Building, which is on city property and is maintained by the city.

This rain garden adds aesthetic to the building as well as filtering and slowing down the flow of stormwater. Rain gardens work best in areas that receive a lot of runoff or frequent rain. A private owner can implement their own version of a rain garden on their property, which would allow them to mitigate flooding and increase their property value.[141]

Figure 8. Rain Garden in San Antonio[142]

Similarly, bioswales, also called bioretention cells, are shallow basins with vegetation grown in an engineered soil mixture that is planted above a gravel drainage bed.[143] While rain gardens are usually smaller in scale, bioswales are long and linear and are used along streets and parking lots.[144] Bioswales infiltrate, store, and slow down the flow of stormwater.[145] Below is a bioswale located at the Mission Branch Library in San Antonio.

Figure 9. Bioswale in San Antonio[146]

As it is on city property, it is maintained by the city, like the above rain garden. Similar to rain gardens, bioswales can be implemented easily publicly as well as privately.[147]

Vegetated filter strips are sloped strips of grasses, usually placed along roads and highways.[148] These buffers slow down runoff and give water more time to infiltrate into the soil; however, they do provide less retention and filtration than other methods.[149] Below is an example of a vegetative filter strip off of Mopac in Austin, Texas—this strip is multifunctional as its unique slope attracts the runoff from the highway and then filters the runoff as it is

absorbed by the ground.[150] Because filter strips such as these are generally next to roads, interstates, and other such areas, it is unlikely a private actor would be able to implement these on their own property.[151]

Figure 10. Vegetative Filter Strip in Austin, Texas[152]

Planter boxes are smaller and elevated versions of rain gardens.[153] They are generally filled with gravel, soil, and vegetation, which collects and absorbs runoff.[154] Because of their size and shape, planter boxes are ideal for dense urban areas.[155]

Green Roofs are roofs with vegetation, usually grasses, planted in a thin soil layer on top of a special drainage mat that moves excess rainfall off the roof.[156] Similar to rain gardens, the vegetation on green roofs filters and

slows down the flow of stormwater.[157] They are particularly well suited to dense urban areas with industrial and office buildings, and they have the additional benefit of reducing energy costs for cooling the buildings.[158] Below is an example of a green roof at the Perot Museum in Dallas, Texas.

The roof of the parking garage is full of drought-resistant plants native to Texas, and the plants act as a filtration system for the cisterns underneath that collect the rainwater. This is an example of a private actor implementing a green roof on a commercial building.[159] This is something that could be implemented by owners of similar structures as well as the city's publicly owned facilities.[160]

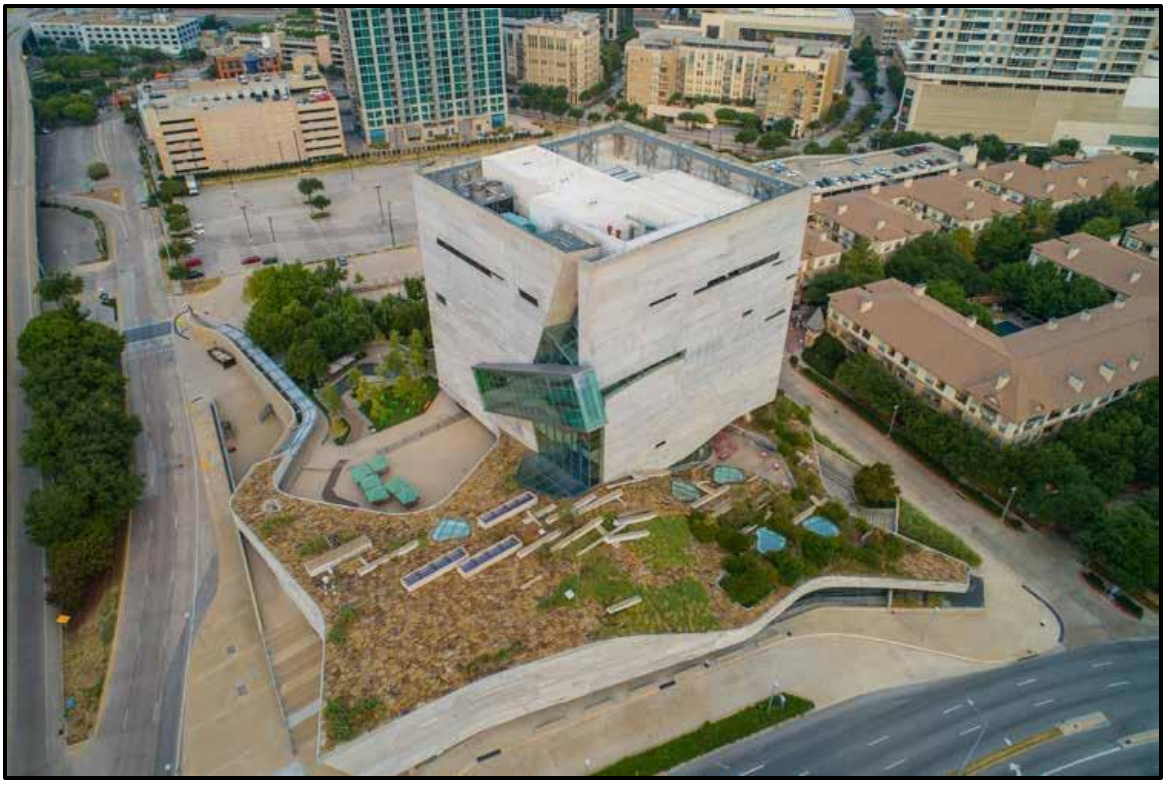


Figure 11. Green Roof in Dallas, Texas[161]

Permeable pavements are paved porous surfaces with a gravel reservoir underneath.[162] The reservoir temporarily stores rainwater while it slowly infiltrates into the soil. As the water soaks through the pavement, the gravel acts as a natural filter and removes pollutants.[163] There are several types of permeable pavements including: porous asphalt/concrete, paver blocks, turf paver, and expanded shale mix. Permeable pavement can be made using recycled materials and industrial byproducts, which are more environmentally friendly than nonpermeable concrete or asphalt.[164]

Figure 12. Permeable Pavement in Dallas, Texas[165]

Additionally, since water soaks through the pavement, there is almost no ice formation, providing a surface safe for walking and driving even in freezing temperatures.[166] The drawbacks of permeable pavement are higher installation cost, higher maintenance requirements, and less durability than traditional pavement.[167] Above is an example of permeable pavement in Dallas, Texas, near City Hall.

This is a public sidewalk, and it was implemented and is maintained by the City of Dallas. The permeable pavement keeps the sidewalk from flooding while also keeping the grass from being overwatered during heavy rain.[168] As shown in the picture, permeable sidewalks may not be as easily implemented for private owners. However, private owners may use permeable pavement for their driveways and call on Homeowner's Associations to see if such pavement may be used in their neighborhoods.[169]

Rainwater harvesting systems collect rainwater and store it for future use.[170] These systems reduce the amount and slow down the flow of rainwater. Because the water is usually used to water yards, which are high filtration areas, they also improve water quality. Rainwater harvesting systems are particularly well suited to arid regions with limited water supply.[171] Below is a cistern located on a private residence in Houston, Texas. This private cistern allows the home owner to collect the rainwater that lands on the house and store it for future purposes, such as garden irrigation.

The use of cisterns allows private individuals the freedom to mitigate their water consumption, especially during times of drought.[172] This cistern is quite noticeable and simple, unlike the cisterns located under the Perot Museum referenced below.

Rainwater harvesting is not illegal in Texas, like it is in some states, so private owners can generally utilize cisterns or other rainwater harvesting systems. The city and other public actors may be able to implement cisterns on a larger scale, but that would have to consider the already existing water collection system.[173]

Figure 13. Rain Water Harvesting Cistern in Houston, Texas[174]

Green Infrastructure	Positives	Pitfalls
Permeable Pavement	• Reduce stormwater runoff volume • Reduce volume of water through exfiltration to the ground • On-site stormwater management • Less pollution of waterways • Possibility of increasing developable area	• May cost more than conventional pavement • Maintenance for possible clogging • Implementation depends on water tables in the area • May require lining if the soil is contaminated
Vegetative Strips	• Reduce or divert stormwater from urban areas to rivers and streams • Reduced reliance on sewer systems • Reduced impervious surfaces, encouraging infiltration for groundwater recharge • Reduce polluted water from entering waterways • Increase community and property values	• High development cost • Potential for biodiversity loss • Increase traffic concerns
Green Roofs	• Reduce/slow down stormwater runoff from urban areas • Reduce risk of flooding • Increase property values • Reduce energy cost related to heating and cooling	• High initial cost • Site dependent • Irrigation may be required depending on vegetation

Rain Gardens and Bioswales	• Reduces volume of stormwater runoff through storage for subsequent evotransportation • Exfiltrates to surrounding soils to reduce runoff • Control hydrologic impacts from frequently occurring rainfall • Reduces pollution of waterways through filtration of pollutants and reduction of total runoff • Increases groundwater recharge	• Can cause overflow if done incorrectly • Requires annual maintenance, but this may reduce in time • Possibility of fertilizer in water
Rainwater Harvesting	• Lowest cost to implement and maintain • Drastic reduction in stormwater runoff • Incredibly adaptable designs • Less waste of water	• Success depends on the occurrence of rain • Initial cost is more expensive than using municipal water • Limited revenue to public utilities

Table 4. Positives and Pitfalls of Green Infrastructure[175]

C. Regulations Affecting the Development of Green Infrastructure

The primary regulatory authority governing the deployment of green infrastructure is municipal ordinances or similar regulations. Municipal regulations governing GSI can be silent on, ambiguous towards, or even conflict with GSI principles.[176] Texas statutes delegate the authority for

implementing stormwater controls to certain counties[177] Because the power is delegated to counties, the legal structure of implementing green stormwater infrastructure varies among different municipalities throughout Texas. The relevant portion of the code is below:

Texas Local Government Code § 573.002:

(a) A county, district, or authority may take any necessary or proper action to comply with the requirements of the stormwater permitting program under the national pollutant discharge elimination system, including:

(1) developing and implementing controls to reduce the discharge of pollutants from any conveyance or system of conveyance owned or operated by the county, district, or authority that is designed for collecting or conveying stormwater;

(2) developing, implementing, and enforcing stormwater management guidelines, design criteria, or rules to reduce the discharge of pollutants into any conveyance or system of conveyance owned or operated by the county, district, or authority that is designed for collecting or conveying stormwater;

(3) assisting residents with the proper management of used oil and toxic materials, including the holding of household hazardous waste collection events;

(4) developing and providing educational tools and activities designed to reduce or lead to the reduction of the discharge of pollutants into stormwater; and

(5) assessing reasonable charges to fund the implementation, administration, and operation of the

> stormwater permitting program as necessary to comply with federal or state program requirements.[178]

Municipal codes and ordinances are generally the largest barriers to implementing GSI. For example, zoning ordinances that dictate single-use or low-density zoning, or height restrictions, force development to spread out, which increases impervious cover.[179] Similarly, dated subdivision codes and road design guidelines that do not consider GSI can increase impervious surfaces and limit the types of GSI that can be implemented.[180]

Parking requirements that set the minimum number of parking spaces lead to parking lots designed for peak traffic periods, resulting in huge swaths of impervious parking lots with spaces that go unused for most of the year.[181] While the most straightforward solution may be to amend and update these codes and ordinances, many municipalities lack government staff, capacity, and resources. Updating codes, inspecting and maintaining stormwater facilities, and researching the effectiveness and potential problems of GSI for specific municipalities require funding and labor that may not be readily available.[182]

The perception that GSI may or may not be effective in a particular city creates a barrier for its implementation. GSI is still widely thought of as an emerging technology, despite being in use for quite some time. Local governments tend to be skeptical of the effectiveness of GSI, consequently, stay in the comfort zone of gray infrastructure. This hesitancy is reflected in municipal regulations such as engineering design manuals that focus almost exclusively on gray infrastructure. While this can be remedied with research and data on GSI's efficacy, the results vary greatly depending on geography, topography, and location.[183]

Another uncertainty stemming from the perceived lack of information is the potential for higher costs. Because municipalities are unfamiliar with GSI, they do not know the implementation costs, the maintenance requirements, or whether a GSI is a good long-term investment. Some cities may balk at high upfront construction and installation costs and simply defer to the known costs of gray infrastructure. Additionally, GSI is commonly

implemented on private property, making it difficult for a public agency to ensure it is adequately maintained.[184]

In line with the uncertainty of costs, an additional barrier to the implementation of GSI's is the uncertainty about the ownership of rainwater. The impact of water rights law on the feasibility of GSI varies from state to state. Under Texas water law, rainfall becomes state water once it enters a watercourse, but prior to that, the landowner can capture and hold rainwater that falls on their land. So, in Texas, smaller-scale GSI projects such as rain gardens and rain harvesting systems do not present a water rights issue.

However, there is some concern that if these small-scale projects are implemented widely, then such a distributed system will cause a decrease in water quantity. There are no concrete studies that show the aggregate water quantity effects of widespread GSI implementation, but this possibility should be considered when designing a green infrastructure policy. The following table highlights typical rules and regulations considered when implementing green infrastructure. [185]

Rule/Regulation	Function
Zoning Ordinances	Specifies the type of land use that can be used on a given parcel
Setbacks	Sets the minimum distance that a building or structure can be from a street, river, floodplain, etc.
Height Limitations	Limits the height of buildings for different zoned areas
Subdivision Codes	Specify development elements such as housing footprint minimums, distance from house to road, width of roads, street configuration, open space requirements, and lot size

Street Standards and Road Design Guidelines	Regulate width of the road, turning radius, street connectivity, and intersection designs
Parking Requirements	Set the minimum number of parking spaces for retail and office parking
Flood Detention/Retention Requirements	Require the use of detention or retention features to slow the flow rate of stormwater from a site
Engineering Design and Maintenance Guidelines	Sets rules for new infrastructure development and maintenance; can limit types of infrastructure and materials that can be used
Water Quality Requirements	Set requirements for treating stormwater for pollutant removal
Conservation/Preservation Plans	Sets aside areas for recreation, habitat corridors, and preservation
Comprehensive Plans	Plans to support zoning codes, usually address land use, open space, natural resource protection, transportation, and economic development

Table 5. Rules and Regulations to be Aware of Regarding Green Infrastructure[186]

D. Case Studies on Green Infrastructure and Municipal Regulations in Texas Cities

1. Austin

Austin began implementing policy beneficial for GSI sooner than most Texas cities. In 1986, the city passed the Comprehensive Watershed Ordinance and developed the Watershed Protection Department in 1991. Austin has flood detention requirements, specifying that "peak flow rates for 2-, 5-, 10-, and 100-year frequency storms cannot create increased inundation of any building or roadway surface, or create any additional

flooding impacts."[187] The city also has some stormwater retention policies, requiring commercial developments to direct stormwater runoff to 50% of required landscaping.

Further, Austin requires water quality controls to be used to treat runoff, which increases with the amount of impervious cover on the land. The water quality control has to provide at least the same treatment as a sedimentation-filtration system.[188]

As of early 2020, the city began offering incentives to private owners to increase the use of nature-based features. The incentives are currently based on the feature itself, and it has been recommended that the city offer a single incentive that applies across the board. This would likely result in greater use of the incentives because private owners are better able to see if they qualify. The current largest incentive is a drainage utility fee discount combined with rules that allow GSI to be implemented on areas that have been labeled 'undevelopable' for environmental reasons.

Second to the utility discount, the city offers a zoning upgrade if the environmental benefit review includes GSI. This results in density bonuses for downtown developments that use green roofs and awards the Austin Energy Green Building points for every GSI. Additionally, the city provides certification to those who take courses on the proper maintenance of GSI projects.[189]

2. Dallas

Dallas requires stormwater detention for any site that requires a building permit. However, Dallas does not have any required water quality standards, nor does it require any stormwater retention. The city was instrumental in creating the North Central Texas Council of Government's ("NCTCOG") integrated Stormwater Management Program ("iSWM"), which encourages the use of nature-based features.

Dallas has incorporated several of iSWM's recommendations into their own drainage manual.[190]

There are several public incentives, including Capital Project Constructions, Street Construction, and educating the public on the GSI features. Besides the incentives, the city has not yet created a comprehensive educational program to support its requirements. Dallas is currently encouraging other cities to follow in their footsteps and make the iSWM criteria easier for developers to understand and implement.[191]

3. Fort Worth

Fort Worth adopted the NCTCOG's iSWM Manual, but it does not currently require a design for water quality protection. The city does require specific designs for streambank protection, flood mitigation, and stormwater conveyance. The city has included GSI features in several public developments, including at the Tarrant County Community College – South Campus.[192] While these developments are beneficial, Fort Worth could improve in educating the public and expanding with stakeholders to use more nature-based infrastructure.[193]

4. Houston

In 1986, Houston began requiring new developments to provide on-site detention to mitigate flooding since property owners were not required to alleviate flooding and were free to build inside floodplains.[194] With the growing popularity of the Bayou Greenways Program[195], the public has started to improve the quality of the stormwater that drains into the bayous. [196] In 2010, Harris County adopted a GSI design criteria manual specifically for private property developments that provide a reduction in required on-site detention features when the development uses GSI. This manual, while a great solution for the county, does not apply within the city limits of Houston, where no equivalent regulation exists.[197]

The city currently requires flood detention and partially requires water quality, and gives partial GSI regulatory credit for private developments. There is still no stormwater retention requirement for pre-existing private developers. [198] However, all new private developments are required to detain stormwater onsite to prevent runoff, which is an enormous problem when hurricanes and storms hit.[199] Currently, nature-based features can be used to satisfy both the detention requirement and water quality requirements, but the only incentive to do so is a drainage fee discount.[200] The city's Engineer's Office heavily encourages developers to adopt GSI throughout the permitting process while enforcing a strong maintenance policy for all public and private projects.[201]

The city should be considering adopting more incentives and recognizing the importance of monitoring and regulating water quality. The mayor of Houston has recently completed a study of green infrastructure that has led to the potential adoption of incentives that could greatly benefit the implementation of GSI in Houston.[202]

5. San Antonio

San Antonio released their Low Impact Development and Natural Channel Design Protocol, which outlines the city's natural resource goals and the goal to integrate environmental quality protection. This plan details zoning, road and street designs, and incentives for those who wish to implement the plan.[203]

The city is the most consistent across the state for its public initiatives and its mandates for nature-based features. They compliment these initiatives with commendable educational programs to ensure that GSI projects are well monitored and maintained.[204] San Antonio passed a nature-based infrastructure mandate in terms of private development, which emphasizes the nature-based infrastructure surrounding their environmentally sensitive waterways, such as the San Antonio River and

the San Pedro Creeks.[205] This is the only mandate for nature-based features in Texas requiring GSIs to meet the water quality requirements.[206]

While there is no city-wide water regulation, several programs regulate areas that are not covered by the city, including San Antonio's MS4 permit, the Edwards Aquifer Protection Program, and the San Antonio River Authority ("SARA"). SARA requires that all sites must either detain the stormwater onsite or pay a fee to support regional projects. It was the first in the city to push for GSI projects along the San Antonio River, and it makes an effort to use GSI on every capital improvement project, where feasible. The city is working with SARA to model watersheds in the metro area to determine where GSI would have the most impact.[207]

E. Funding as the Common Barrier in Implementing Green Infrastructure

At the federal level, there is not much funding for green stormwater infrastructure. Still, there have been bills introduced in the House that included provisions for federal financial assistance for the research and implementation of GSI. [208] The EPA provides a federal-state partnership program to help cities fund their green infrastructure projects: the Clean Water State Revolving Fund ("CWSRF") Loan Program.[209] The CWSRF program is loan-based and has $250 Million available for eligible projects, including up to $26.8 Million in principal forgiveness. Those who apply for funding may receive subsidized green funding with up to 15% forgiveness from green component costs, if their project has eligible components that total 30% of the project's total cost.[210] Not all projects are eligible, but cities, counties, districts, river authorities, designated management agencies, authorized Indian tribal organizations, and public and private entities proposing nonpoint source or estuary management projects are free to apply.[211]

As previously discussed, following Hurricane Harvey, the Texas Senate passed Senate Bills 7 and 8 to address flood planning. Senate Bill 7 appropriated $1.7 billion for flood planning, engineering, and construction, of which $793 million went to the Flood Infrastructure Fund ("FIF"). The FIF provides loans and grants for flood control, flood mitigation, and drainage projects.[212] While FIF does not expressly mention GSI, it includes sustainable infrastructure as an eligible activity, so it could potentially be used to research and implement GSI.

F. Policy Recommendations for Implementing Green Infrastructure

1. Federal and State Policy

To encourage the implementation of GSI at the federal level, the Clean Water Act could be amended to use impervious cover as a metric in measuring pollutants in stormwater. A 2003 study by the Center for Watershed Protection showed that as the percentage of impervious cover on watershed area increases beyond 10%, the downstream water quality decreases. The "impervious cover method" has been used in Maine and Connecticut, and it provides an inexpensive and convenient method for tracking stormwater contributions to surface waters.[213]

If the impervious cover method is used as a metric for measuring TMDLs from private developments, both existing and new developers would be motivated to minimize impervious cover and potentially replace it with permeable pavement or other GSI projects. Additionally, the federal government can update the existing national standards and codes for the design and maintenance of roads, parking lots, and fire safety. Such updates can minimize the area of paved surfaces in parking lots and highways, and they can also incorporate GSI projects.

At either the federal or state level, regulations requiring any planning, zoning, and development to proceed in conformity with the

landscape's hydrologic features should be adopted. Such laws could ensure that development projects cause as little environmental damage as possible and encourage the use of GSI projects to be in compliance, and help improve water quality. Federal or state governments can also provide tax exemptions or credits for GSI project implementation to provide a financial incentive for developers to use GSI.

In Texas, the TCEQ could require GSI projects to be included in municipal flood plans. Because land-use planning, stormwater management, and flood control are not always in conjunction, creating a single state agency could be beneficial for future development and implementation of GSI. At a minimum, the state should require coordination and information sharing amongst these parties to help avoid conflicting policies.

2. Municipal Policy

At a municipal level, cities can audit codes and ordinances and eliminate or amend conflicting provisions or provisions that deter GSI. For example, regulations requiring impervious pavements for driveways and parking lots could be removed or amended to require permeable pavement where feasible. Codes restricting any development on open spaces, such as in specific subdivision codes, can be amended to allow GSI projects, such as rain gardens. Fire codes requiring additional paved streets wide enough for fire trucks could be amended to allow permeable pavement.[214] Removing or amending overly restrictive municipal regulations can provide future developers and homeowners with the freedom to implement GSI.

Similarly, cities can amend existing design manuals and guidance materials to include GSI and to set uniform standards for the design, construction, and maintenance of GSI projects.[215] The inclusion of uniform standards can help overcome uncertainty surrounding costs, discomfort in branching out from the traditional gray infrastructure, and lack of knowledge about maintaining GSI projects. Additionally, access to

this information can incentivize developers to implement GSI and help mitigate the potential risks of poor design or inadequate maintenance.

Municipalities could also incentivize developers with favorable regulations in exchange for implementing GSI projects. These could be through zoning upgrades, expedited permitting, density bonuses, and encroachment allowances onto setbacks.[216] For example, in Austin, GSI projects are allowed to extend onto otherwise undevelopable areas. The Planned Unit Development District Designation Program can upgrade zoning in the regions that use GSI, and downtown buildings can receive a density bonus for implementing a green roof.[217]

3. Public Initiatives

Public initiative programs aim to increase awareness surrounding GSI projects. Cities can implement these by installing public projects and by educating the public.[218] GSI projects installed in public areas raise awareness and exposure to GSI, which can then lead to social acceptance. Increased social acceptance makes designing policies and programs more manageable, and it helps streamline the implementation of GSI.[219]

Similarly, education programs help increase social acceptance. In Texas, existing agencies, such as the TCEQ and the TWDB, could conduct educational workshops and studies showing the efficacy of GSI.[220] Cities could implement programs that:

- Establish education and outreach programs to raise public awareness about the benefits of GSI and how it works
- Set up programs that train current stormwater management staff on GSI maintenance
- Encourage universities to offer research opportunities and courses on GSI
- Implement award and recognition programs to encourage individuals to adopt GSI[221]

4. Financial Incentives

Cities can implement financial incentives to encourage landowners to implement GSI. Because most market-based approaches are voluntary, unlike regulatory changes, cities may face less pushback from residents and developers. The table below explains several financial incentive policies.[222]

Policy Mechanism	Examples
Stormwater Fee and Discounts: enforces a fee on runoff quantity or impervious area; provides discounts for implementing GSI	Fort Worth, TX provides stormwater fee discounts for using GSI Seattle, WA enforces a flat fee for small single family and duplexes; for any other case, the annual fee is based on impervious area
Allowance Market: tradeable allowances of discharge are distributed among landowners; any additional allowances can be sold	Washington D.C. has the Stormwater Retention Credit program, in which landowners receive credits for voluntary reduction of stormwater runoff
Payment for Ecosystem Services: owners are paid for providing services such as flood mitigation, carbon storage, and water purification	Used by several U.S. cities as well as in other countries
Rebates, Credits, and Installation Financing: provides financing, tax credits, or reimbursements to landowners who install GSI	In Seattle, WA, the city pays up to the total cost of rain gardens and cisterns In Austin, TX, the city provides one-time rebates for GSI projects that promote water conservation
Grants and Awards: provides money directly to individual landowners or communities for installing GSI	Chicago, IL's Green Roof Grant provides $5000 to residential and small commercial buildings

Table 6. Financial Incentive Policies for Green Infrastructure[223]

VIII. OPPORTUNITIES FOR PARTNERSHIP

Texas has a unique opportunity to provide leadership and oversight to implementing flood management and water allocation policy measures in advance of our expected population growth to ensure our domestic, agriculture, and industry needs are met. By developing our partnerships today, we will ensure water flood mitigation and water use allocation for the future. We must look at implementing strategies that will involve stakeholders at all levels. We must include government entities, non-governmental organizations & non-profits, and the citizenry at all levels. But it all starts with our governmental leaders choosing to lead and engage with this policy. This section will discuss legal mechanisms and policy measures government may use to encourage inclusive stakeholder cooperation, including successful examples of legal tools and policy measures supporting public infrastructure development and their interaction with private property interests.

1. Working with Government

The first entity the government should work with is itself and ensure all entities, councils, inspectors, and those responsible for interfacing with the community are all operating from the same playbook. Homogeneity may require additional standardized training and checklists for city engineers, inspectors, and code enforcement personnel to attend. Currently, the North Central Texas Council of Governments ("NCTCOG") oversees and promotes an integrated water management approach.[224] The NCTCOG may be a future source to provide oversight training and certification for municipality workers (to include inspectors and contractors) on water management and best available flood control techniques to include both grey and green infrastructure.

2. Working with Industry

Government must assist the broader industry in determining when to use grey infrastructure and when to use green infrastructure. Of course, this necessitates that the city engineers and code enforcement personnel are also well trained on both the grey and green infrastructure options. In addition to

grey infrastructure, incorporating green infrastructure options for industry should be encouraged or considered on every ongoing project. This report suggests offering a training and certification program on green infrastructure to industry leaders to increase industry acceptance further. Both grey and green infrastructure provide effective flood mitigation, and industry workers should be familiar with both options.

3. Working with Agriculture

Government must assist agriculture with understanding flood zones and designated distances from flood zones that must not be developed for agriculture due to flood mitigation requirements. The Texas Administrative Procedures Act will provide for notice and comment to regulatory changes, but best practices to be implemented must also be advertised, discussed, and enforced within the agricultural community as a matter of routine discussion, touch, and concern among community and government leaders.

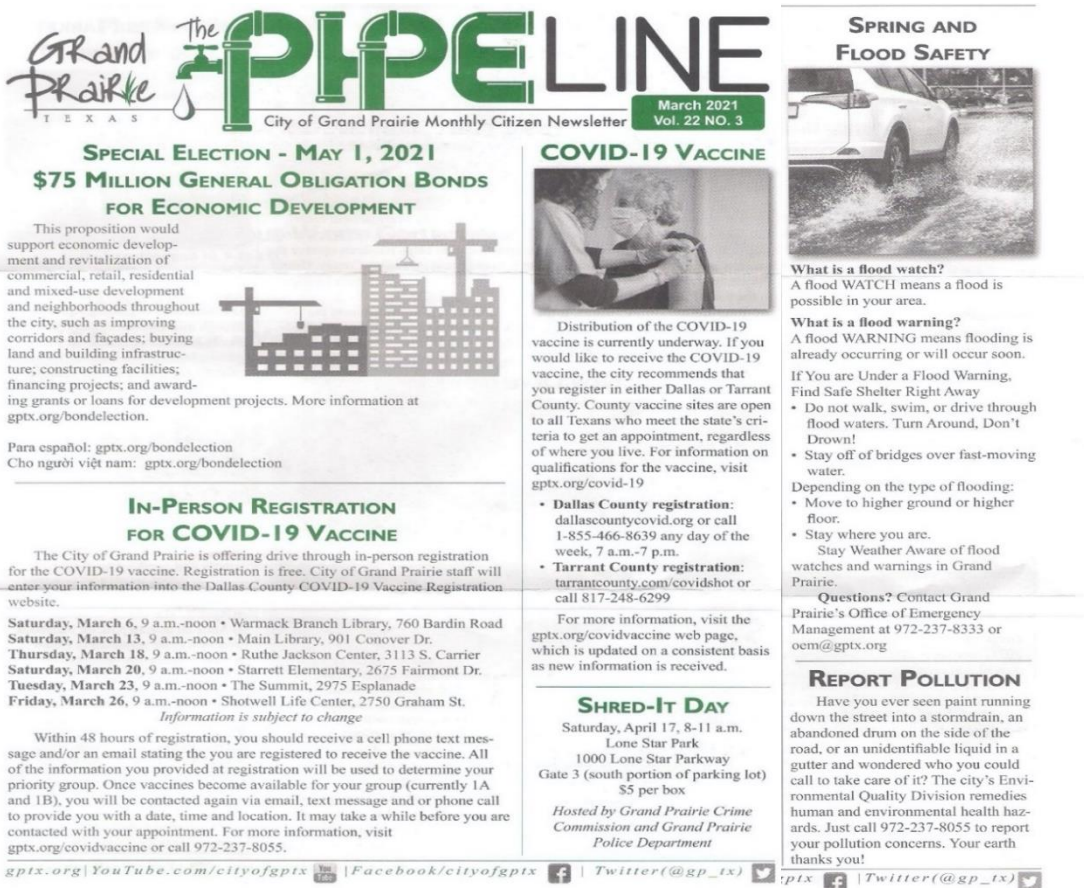
4. Working with Non-Profits

Some of the best minds are found within our non-governmental organizations and our non-profits. Government must encourage partnerships at all levels with these entities and provide advisory board position opportunities for the very brightest that represent these organizations. Non-profits bring funding and up-to-date science to the conversation that government is often unable to leverage. Government leadership must continue to reach out to the NGOs and non-profits within their respective area of operations.

5. Working with the Individual Texan

"In Texas, there is a certain honor of being a Texan that is doing something the best that you can." – Matthew McConaughey[225]

It is paramount that any initiative in Texas includes the Texan that will implement or be impacted by the enterprise. Any strategy that excludes input from the local Texas residents is likely doomed from the start. One way to communicate with Texas residents is to include an informational newsletter with the water bill. For example, the City of Grand Prairie mails a newsletter to each Grand Prairie Citizen who receives a water bill.



Grand Prairie TEXAS

The PIPELINE

City of Grand Prairie Monthly Citizen Newsletter

March 2021
Vol. 22 NO. 3

SPECIAL ELECTION - MAY 1, 2021
$75 MILLION GENERAL OBLIGATION BONDS FOR ECONOMIC DEVELOPMENT

This proposition would support economic development and revitalization of commercial, retail, residential and mixed-use development and neighborhoods throughout the city, such as improving corridors and façades; buying land and building infrastructure; constructing facilities; financing projects; and awarding grants or loans for development projects. More information at gptx.org/bondelection.

Para español: gptx.org/bondelection
Cho người việt nam: gptx.org/bondelection

IN-PERSON REGISTRATION FOR COVID-19 VACCINE

The City of Grand Prairie is offering drive through in-person registration for the COVID-19 vaccine. Registration is free. City of Grand Prairie staff will enter your information into the Dallas County COVID-19 Vaccine Registration website.

Saturday, March 6, 9 a.m.-noon • Warmack Branch Library, 760 Bardin Road
Saturday, March 13, 9 a.m.-noon • Main Library, 901 Conover Dr.
Thursday, March 18, 9 a.m.-noon • Ruthe Jackson Center, 3113 S. Carrier
Saturday, March 20, 9 a.m.-noon • Starrett Elementary, 2675 Fairmont Dr.
Tuesday, March 23, 9 a.m.-noon • The Summit, 2975 Esplanade
Friday, March 26, 9 a.m.-noon • Shotwell Life Center, 2750 Graham St.
Information is subject to change

Within 48 hours of registration, you should receive a cell phone text message and/or an email stating the you are registered to receive the vaccine. All of the information you provided at registration will be used to determine your priority group. Once vaccines become available for your group (currently 1A and 1B), you will be contacted again via email, text message and or phone call to provide you with a date, time and location. It may take a while before you are contacted with your appointment. For more information, visit gptx.org/covidvaccine or call 972-237-8055.

COVID-19 VACCINE

Distribution of the COVID-19 vaccine is currently underway. If you would like to receive the COVID-19 vaccine, the city recommends that you register in either Dallas or Tarrant County. County vaccine sites are open to all Texans who meet the state's criteria to get an appointment, regardless of where you live. For information on qualifications for the vaccine, visit gptx.org/covid-19

- **Dallas County registration**: dallascountycovid.org or call 1-855-466-8639 any day of the week, 7 a.m.-7 p.m.
- **Tarrant County registration**: tarrantcounty.com/covidshot or call 817-248-6299

For more information, visit the gptx.org/covidvaccine web page, which is updated on a consistent basis as new information is received.

SHRED-IT DAY

Saturday, April 17, 8-11 a.m.
Lone Star Park
1000 Lone Star Parkway
Gate 3 (south portion of parking lot)
$5 per box

Hosted by Grand Prairie Crime Commission and Grand Prairie Police Department

SPRING AND FLOOD SAFETY

What is a flood watch?
A flood WATCH means a flood is possible in your area.

What is a flood warning?
A flood WARNING means flooding is already occurring or will occur soon.

If You are Under a Flood Warning, Find Safe Shelter Right Away

- Do not walk, swim, or drive through flood waters. Turn Around, Don't Drown!
- Stay off of bridges over fast-moving water.

Depending on the type of flooding:

- Move to higher ground or higher floor.
- Stay where you are.

Stay Weather Aware of flood watches and warnings in Grand Prairie.

Questions? Contact Grand Prairie's Office of Emergency Management at 972-237-8333 or oem@gptx.org

REPORT POLLUTION

Have you ever seen paint running down the street into a stormdrain, an abandoned drum on the side of the road, or an unidentifiable liquid in a gutter and wondered who you could call to take care of it? The city's Environmental Quality Division remedies human and environmental health hazards. Just call 972-237-8055 to report your pollution concerns. Your earth thanks you!

gptx.org | YouTube.com/cityofgptx | Facebook/cityofgptx | Twitter(@gp_tx)

Figure 14. City of Grand Prairie Monthly Citizen Newsletter March 2021[226]

In the most recent issue of the Grand Prairie publication, *The Pipeline*, bond issuance as a special ballot initiative is discussed and also includes a discussion on floodwaters and pollution.

Another unique way to connect with the community is through established educational centers like the John Bunker Sands Wetland Center.[227] These man-made wetlands stand as an enduring example of the success that can be gained when multiple partners stakeholders collaborate.

Partnerships developed and maintained among all stakeholders will continue to set the conditions for successful implementation of flood management and water supply policies for future generations of Texans.

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