Program Guidance:

Stormwater Master Planning

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1.0 Stormwater Master Planning

1.1 Introduction

Stormwater master planning is an important tool with which communities can assess and prioritize both existing and potential future stormwater problems, as well as use to consider alternative stormwater management solutions. A stormwater master plan is prepared to consider, in detail, what stormwater management practices and measures are to be provided for an urban drainage area or a large development project.

Stormwater master plans are most often used to address specific single functions such as drainage provision, flood mitigation, cost/benefit analysis, or risk assessment. These plans prescribe specific management alternatives and practices. Multi-objective stormwater master planning broadens this traditional definition to potentially include land use planning and zoning, water quality, habitat, recreation, and aesthetic considerations. The broadest type of stormwater master plan is the comprehensive watershed plan which is described in detail in this resource guide.

For any stormwater master plan, it is important at the outset to: (1) clearly identify and quantify the objectives and issues the plan will address; (2) recognize the constraints (technical, political, legal, financial, social, physical) that limit the possible solutions; and (3) develop a clear technical approach that will address the key issues and needs while staying within the constraints to potential solutions.

1.2 Types of Stormwater Master Planning

There are several basic types of stormwater master plans that can be prepared. Below are descriptions of representative examples of master plans.

1.2.1 Flood Assessment Master Plans

Flood assessment is the simplest form of stormwater master planning, where only the essential components, alignments, and functions of a drainage system are analyzed. The focus of these studies is on water quantity control and flood prevention and/or mitigation.

Frequently, a flood assessment study analyzes both existing conditions and projected future buildout conditions. The study is based upon estimates (usually modeled) of peak and total discharges for selected return frequency runoff events. The selected events should be based on local standards. Both the hydrology and hydraulics of the system are analyzed to determine water surface profiles and elevations. This, in turn, assists in determining probable locations where impacts can be expected to occur. Frequently, an alternatives analysis will be performed as part of the master plan to provide potential solutions to mitigating the flood impacts. This typically involves the modeling of proposed modifications or development scenarios.

Examples include examining the effects of detention on flooding and providing improved flood protection (e.g., flood proofing structures, levees, etc). A local community might develop HEC-1 and HEC-RAS models for the hydrology and hydraulics of a watershed for the purposes of estimating the full buildout floodplain and regulating new development on this basis rather than the ever-changing “existing conditions” approach.

1.2.2 Flood Study Cost/Benefit Analysis Master Plans

Another type of master planning builds on a flood assessment master plan to determine acceptable risks and the associated costs. Using information developed in the flood analysis, economic and/or environmental impacts can be assessed. This initially entails establishing a relation between water surface elevation and associated damage (often referred to as stage-damage curves). Based on this relationship, an acceptable level of risk is determined, from which design discharges and associated water surface profiles and elevations are established. Acceptable levels of risk might be based upon the likelihood of loss of human life, impacts to residences, impacts to non-residence structures, or damage to utilities. This information then helps determine the ultimate drainage infrastructure that will be needed to achieve the planning goals. Both a formal benefit-cost analyses and a more subjective "cost-effectiveness" approach could be used. Based on the design criteria, preliminary designs can be developed which in turn yield initial cost estimates for the infrastructure.

For example, a community might look at different flood protection strategies along a stream and estimate the costs and flood damage savings for each alternative in an effort to select the most appropriate solution(s) for that community.

1.2.3 Water Quality Master Plans

Master planning for stormwater quality is becoming increasingly important, as nonpoint source loads are a critical component of watershed-wide water quality assessments. It may become necessary to be able to estimate pollutant loads from stormwater runoff for Total Maximum Daily Loads (TMDL's), as well as for the expansion of wastewater treatment facilities. A water quality master plan can provide the foundation from which to develop broader water quality assessments. Stormwater quality studies will typically analyze water quality impacts to receiving waters (and groundwater) and develop structural and nonstructural strategies to reduce or minimize the pollutant loads. Studies usually involve the development, calibration, and verification of a water quality model. The level of model sophistication can vary from simple to complex. Often, a cost/benefit analysis will be performed as a component of the water quality study to quantify the efficacy of various strategies.

For example, a community might develop a simple spreadsheet-based loading model to perform planning level analyses of loadings of pollutants, potential removal by stormwater controls, and the impacts of development strategies—or they may use a more complex continuous simulation water quality model and supporting monitoring to develop a combination of point and non-point source loading estimates in support of a watershed assessment or TMDL.

1.2.4 Biological/Habitat Master Plans

Biological/habitat master planning is similar to a water quality master plan. However, rather than focusing on water chemistry, the focus is on the aquatic biological communities and supporting habitats. Biological assessments are being implemented on a more frequent basis to assess overall water body health. Biological studies provide the ability to assess both acute and long-term effects of nonpoint source impacts to a receiving water in the absence of continuous monitoring data. The resulting data can be used in the design and development of habitat improvement and stream restoration projects, riparian buffers, structural control retrofits, etc.

For example, a community may desire to improve the quality and aesthetics of a stream. Biological monitoring and habitat assessment establishes the baseline health of the stream and can be compared to a reference stream in the area. This information is assessed to determine causes of impairment (often paired with chemical monitoring) and methods to reduce impairment are investigated. The plan might then include riparian corridor planning, land use zoning changes, and planned habitat restoration.

1.2.5 Comprehensive Watershed Master Plans

The comprehensive watershed approach is the most general type of stormwater master planning as well as the most extensive. The intent of comprehensive watershed plan is to assess existing water resources health and to make informed land use and stormwater planning decisions based on the current and projected land use and development within the targeted watershed and its associated subwatersheds. Watershed-based water quantity and water quality goals are typically aimed at maintaining the pre-development hydrologic and water quality conditions to the extent practicable through peak discharge control, volume reduction, groundwater recharge, channel protection, and flood protection. In addition, watershed plans may also promote a wide range of additional goals include the streambank and stream corridor restoration, habitat protection, protection of historical and cultural resources, enhancement of recreational opportunities, and aesthetic and quality of life issues.

Watershed-based studies often involve a holistic approach to master planning, where hydrology, geomorphology, habitat, water quality, and biological community impacts are analyzed and solutions are developed. A detailed discussion of watershed-based master planning is provided below.

2.0 Comprehensive Watershed Planning for North Central Texas Communities

2.1 Introduction

Due to the realization that urban stormwater quantity and quality management need to be addressed at a larger scale, communities are increasingly turning towards the development of comprehensive watershed and subwatershed plans. These plans usually encompass broader management issues such as land use planning and zoning, recreational and aesthetic opportunities, water supply protection, and habitat management.

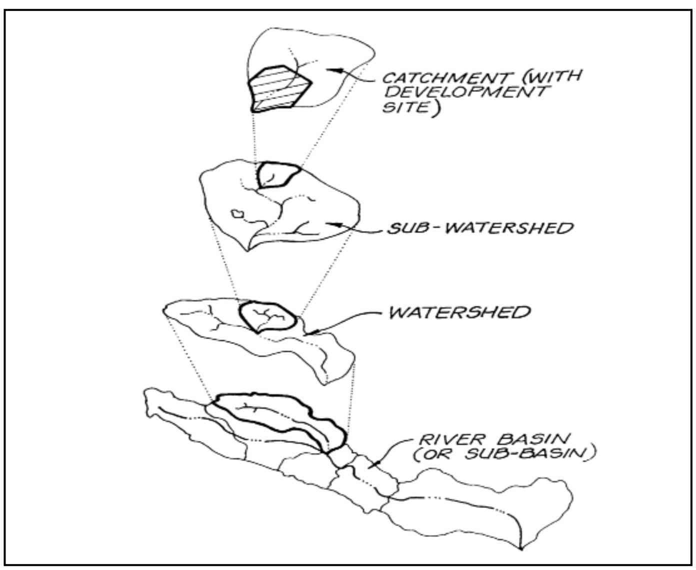
2.2 Scale of Watershed Management

Watersheds are typically defined according to the resource area or downstream water body of interest. Although there are no maximum size limits for defining a watershed, a manageable watershed for local planning efforts is usually no greater than 100,000 acres (~150 square miles). It is important to remember that larger watershed boundaries require the involvement of more jurisdictions and stakeholders.

It is recommended that planning take place at both the watershed and smaller "subwatershed" scales (see Figure 2-1). Typically, the broad, "big picture" planning takes place at the watershed level, and the more refined objectives and implementation plans are pursued at a subwatershed level (see Table 2-1). Finally, individual projects and controls are carried out at the project or catchment level.

Often times it may be more efficient to plan at the watershed scale and to assess the effectiveness of plan implementation at the subwatershed scale, where indicator response is more apparent. For example, many of the non-traditional goals of a multi-objective watershed master plan, such as establishment of inter-jurisdictional greenways, wildlife corridors, and forest conservation areas, are easier to conceptualize and implement at the watershed scale.

A community undertaking a watershed planning effort will need to determine whether the project area under consideration is part of a larger watershed or river basin with its own management goals. If so, the community needs to ensure that the planned activities complement the broader scale efforts. On the other end of the scale, a local government must also make sure that development and neighborhood level stormwater management



projects and activities are incorporated into and complement the overall watershed plan.

Figure 2-1 Watershed Management Units

(Source: Center for Watershed Protection, 1998)

Table 2-1 Description of the Various Watershed Management Units

Watershed Management Unit	Typical Area (square miles)	Sample Management Measures
Catchment	0 to 5	Site design measures & structural controls
Subwatershed	5 to 30	Stream classification and management
Watershed	30 to 150	Watershed-based development standards
River Basin	Greater than 150	Basinwide planning

2.3 The Watershed Planning Process

Watershed and subwatershed plans provide a framework for managers and decision-makers to determine what the goals and strategies of the plan should be and how and where various management and protection tools need to be implemented to achieve the goals and strategies. Developing watershed and subwatershed plans should ideally occur in a rapid, cost effective manner. A suggested eight-step approach to watershed planning is presented below. It is important to remember throughout the process that it is critical to have public involvement and "buy in." Without community support, it may be difficult to implement a plan.

2.3.1 Identify initial goals and establish a baseline

Prior to initiating a watershed plan, some broad goals should be identified that define the purpose of the plan initiative. For example, a goal of a plan may be to preserve and maintain a high quality segment of stream in a community, protect drinking water quality in a water supply watershed, or meet a water quality TMDL. Other goals may be a response to negative impacts being observed within a watershed such as property flooding or channel erosion and degradation. Prior to addressing the initial goals, it is necessary to gather basic information to determine a starting point to develop the plan. Information about possible stakeholders, current land use and impervious cover, and technical (e.g., previous hydrologic/hydraulic studies, floodplain studies, water quality studies, etc.), staffing, and financial resources can help guide the first steps of the plan. Once the broad goals have been identified and defined, specific tasks that may need to be performed include:

Task 1: Define Watershed and Subwatershed Boundaries

Defining the watershed and subwatershed boundaries sets the stage for completing the rest of the watershed baseline. The product of this task is a simple map that outlines the boundaries of the watershed and each of its subwatersheds (see example in Figure 2-2 below). Producing this map is a necessary first step to answering questions such as "Which political jurisdictions and citizens should participate in this watershed planning effort?" and "What are the land use patterns in the watershed and each of its subwatersheds?"

Task 2: Identify Possible Stakeholders

Early on, it is important to identify the partners, or stakeholders, that will be involved in some way to make watershed plans happen. Early stakeholder involvement guides the development of the watershed plan to incorporate the needs of the community and promote resource protection. By involving possible stakeholders early on in the process, managers can gage who wants to participate in developing the plan, what they can offer to the process, or what obstacles participants may present. Stakeholders might include other government agencies, businesses and industry, nonprofits, and neighborhood leaders and interested citizens.

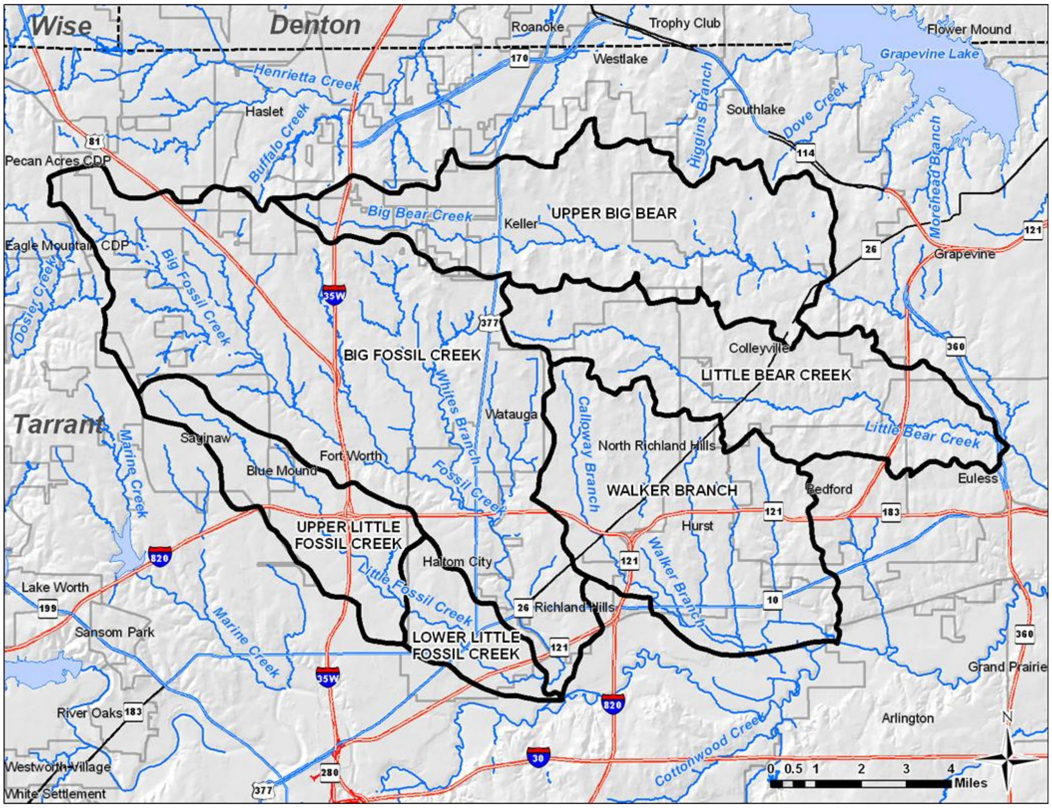


Figure 2-2 Example of a Watershed Map with Subwatersheds Delineated

The watershed and subwatershed boundaries delineated in Task 1 are a good place to start identifying possible stakeholders. A quick review of the map helps determine which jurisdictions and neighborhoods fall within the watershed boundaries. Direct outreach to citizens living within the watershed boundaries can also spark interest within the community. Stakeholders can provide resources, expertise, or knowledge to guide the development of the plan. Also, it is important to include stakeholders from the local development community since some decisions of the plan, such as new ordinances or zoning, will directly impact them. It is also wise at this time to look beyond the boundaries of the watershed under study to see how the plan may help achieve the broad water resource goals of larger river basins.

Task 3: Estimate Existing Land Use and Impervious Cover

Estimating existing subwatershed land cover is a recommended baseline task in preparing a watershed plan, since this data can be used in modeling stormwater runoff and estimating pollutant loadings. Existing impervious cover provides an estimate of current conditions in each subwatershed and serves as an important benchmark to assess future land use changes. Land use and impervious cover percentages can be used to initially categorize subwatersheds, help managers set expectations about what can be achieved in each subwatershed, and guide decisions in the watershed.

Task 4: Assemble Historical Monitoring Data in the Watershed

Good monitoring data that accurately characterizes the resource quality in a subwatershed are needed throughout the watershed planning process. Historical monitoring or modeling data are often available from past efforts. For example, the Texas Parks and Wildlife Department (TPWWD) Resource Protection Division may possess fishery data and water quality data that may have been collected for a host of regulatory programs. Collecting historical data may significantly reduce the costs of initial baseline monitoring. Historical data may also provide information about the response of the water resource to land use change over time. This record can help managers evaluate current decisions in the context of the impacts of past decisions on the resource.

Task 5: Assess Existing Mapping Resources

Maps depicting current conditions—including land use, potential pollution sources, problem areas, etc.—in each subwatershed, as well as management decisions made during the planning process, are an integral part of the watershed plan. The effort to produce these maps depends on what data are already mapped, and in what form. Also, some field measurements may not be required if recent maps of these features already exist.

Regional development authorities, state agencies, universities or environmental agencies may already have some maps, either in paper or digital form. The North Central Texas GIS Data Clearinghouse (http://www.dfwmaps.com/clearinghouse/) is a good source of existing digital GIS data. Stakeholders are also a source to find existing mapping resources. Assigning one individual or a small group the task of assembling and manipulating mapping data is an effective way to set this baseline.

Task 6: Conduct an Audit of Local Watershed Protection Capability

The final element of the watershed baseline is a critical evaluation of the local capability to implement watershed protection tools and management alternatives. This evaluation or audit examines whether existing local programs, regulations, and staff resources are capable of implementing the watershed plan. If not, it identifies key areas that need to be improved. The scope of the audit can include an analysis of local master plans, ordinances, the development review process, performance criteria for stormwater controls and management practices, program funding, and staffing levels. The effort needed for the watershed audit depends to a great extent on the size and complexity of the local program(s), the number of staff employed, and the pace of development activity.

2.3.2 Set up a watershed management structure

Establish the institutional organization responsible for the overall management and implementation of the watershed plan. Choosing the most effective watershed management structure to guide the development of the watershed and subwatershed plans is one of the more complex decisions a community or watershed planning team confronts. Successful watershed planning requires a strong organization to act as the driving force to focus the resources of a diverse group of stakeholders to implement the plan.

It is crucial to choose a watershed management structure that can be sustained over the life of the watershed planning and implementation process, as well as to revisit and update the plan as project goals are achieved or circumstances change.

A core set of features are needed to make watershed management structures effective:

- Adequate permanent staff to perform facilitation and administrative duties
- A consistent, long-term funding source to ensure a sustainable organization
- Including all stakeholders in planning efforts
- A core group of individuals dedicated to the project who have the support of local governmental agencies
- Local ownership of the watershed plan fostered throughout the process
- A process for monitoring and evaluating implementation strategies
- Open communication channels to increase cooperation between organization members

The first two features, permanent staffing and long-term funding, are probably the most important. Clearly, having a permanent staff and adequate funding go hand in hand. Regardless of the size, a successful management structure should define inter-agency and governmental partnerships and agreements needed to support the organization over the long term.

2.3.3 Determine budgetary resources available for planning

Conduct an analysis to determine what level of staffing, financial and other resources are available to conduct the plan. Balance the available resources against the estimated cost of developing the plan.

One of the most important challenges confronting a community or watershed planning group is how to develop watershed and subwatershed plans within existing budget constraints. The watershed planning team needs to identify what sources of funding are available and to develop budgets for the subwatershed and watershed plans. Several current and future revenue sources may be available to finance the development of a watershed plan. This revenue may include both staff time and general funds. In early meetings, it is important to get clear commitments from each involved agency or group as to what resources they can commit to the watershed planning effort. Substantial savings can be realized if volunteers are available to conduct some of the analyses, if existing staff time is reallocated to work on the plan, or if the plan is part of a larger planning effort where some costs can be shared.

2.3.4 Project future land use change in the watershed and its subwatersheds

Forecast future development, land use, and impervious cover in each subwatershed. This analysis will influence the goal setting process in Step 5.

As previously mentioned, land use in a watershed and its individual subwatersheds has a strong influence on water quality and aquatic ecosystems. In this step, it is recommended that the community forecast future land use and impervious cover based on available planning information such as future land use plans or master plans. Local comprehensive plans required under state law can be a valuable source of information for future land use projections.

Impervious cover projection is one indicator that can be used to determine if the quality of water resources will degrade from current conditions. If the analysis indicates that impervious cover will increase to such an extent that it will likely cause subwatershed quality to decline, a management plan to mitigate these future impacts should be developed.

2.3.5 Fine tune goals for the watershed and its subwatersheds

Use known information about impacts to the watershed, and the goals of larger drainage units (e.g., river basins), to refine and develop goals for the watershed. In addition, determine objectives for each subwatershed to achieve watershed goals. The general goals identified in Step 1 should be added to and modified to reflect the results and inferences of the data collected and analyses performed in Steps 1– 4.

Goal setting is among the most important steps in watershed planning, and the management structure should ensure full involvement from stakeholders at this stage. Goal setting should proceed from the broad basin and sub-basin goals to the more specific goals needed for the watershed. These goals, in turn, need to be translated into even more specific objectives for each individual subwatershed. To set appropriate and achievable goals, the watershed planning team needs to perform several tasks, including:

Task 1: Interpret Goals at the River Basin Level That May Impact the Watershed

Watershed plans should be developed within the context of regional water resource management goals for river basins. The Texas Commission on Environmental Quality (TCEQ) should be consulted early in the process to assist managers with these goals. Although not every river basin goal or objective may impact the watershed plan, managers should be aware of larger basin plan, and consider them when developing their own goals and objectives. Some examples of river basin goals that may directly influence the goal setting process at the watershed level include:

- Flood control
- Meeting state water quality standards / designated use
- Wildlife habitat enhancement
- Greenway establishment

Task 2: Develop Specific Goals for the Watershed

The goals set at the watershed level are the "bottom line" of the watershed plan. While these goals may be similar to those developed at the river basin level, they are usually more specific and quantifiable. Examples of watershed goals include:

1. Reduce flood damage from current levels
2. Reduce pollutant loads from the current level
3. Maintain or enhance the overall aquatic diversity in the watershed
4. Maintain or improve the current channel integrity in the watershed
5. Prevent development in the floodplain
6. Allow no net loss of wetlands
7. Maintain a connected buffer system throughout the watershed
8. Accommodate economic development in the watershed
9. Promote public awareness and involvement

These goals apply to the watershed as a whole, but may not always apply to every subwatershed within it. In addition, a watershed plan may have more unique multi-objective goals, such as developing a trail system for walking, biking, and jogging, preserving historically significant areas, and establishing outdoor education programs to foster community awareness and involvement. With diverse goals such as these, the importance of broad-based stakeholder involvement becomes all the more apparent.

Task 3: Assess if Subwatershed Management Objectives Can Be Met with Existing Zoning

Controlling and managing land use is an important tool to meet watershed management objectives. If a target development or impervious cover goal has been established for a watershed, managers will need to review current zoning and/or projected future land use to determine if these goals can be met. One method is to conduct a built out analysis of current zoning to determine the projected land use and/or impervious cover in each subwatershed. This analysis can be used to identify which management objectives can be met with existing zoning.

Task 4: Determine if Land Use Patterns Can Be Shifted Among Watersheds

If the current zoning is not compatible with the management objectives, development may need to be shifted to other watersheds or subwatersheds. One way to accomplish this goal is by upgrading the zoning in watersheds that are designated to accommodate growth, while downgrading the zoning in those watersheds that exceed the management goals. The effect is to shift development away from the streams and other water resources that will be most impacted by development, and toward areas where there is not as great of an impact. Other possible options include preserving undisturbed conservation areas (e.g., through land trusts, conservation easements, etc.) in a watershed, or by implementing strategies to reduce impervious cover.

The process described above is not simple. While controlling land use may be the most effective way to protect watersheds and subwatersheds, it can also be the most controversial recommendation in a watershed or subwatershed plan. Any change in zoning will require input from citizens, the development community, and local government. Furthermore, actually changing zoning can take a long time. Communities will need to use the legal tools they have available to change zoning appropriately, such as transfer of development rights, overlay zones, and floating zones.

2.3.6 Develop watershed and subwatershed plans

A watershed plan is a detailed blueprint to achieve objectives established in the last step. A typical plan may include: revised zoning, stormwater design criteria and requirements, potential regional structural stormwater control locations, description of new programs proposed, stream buffer widths, monitoring protocols, and estimates of budget and staff needed to implement the plan. The four tasks needed to establish the watershed plan include:

Task 1: Select Watershed Indicators

Indicator monitoring provides timely feedback on how well aquatic resources respond to management efforts. Simple indicators can be selected to track changes in stream geometry, biological diversity, habitat quality, and water quality. For example, macroinvertebrate sampling is a relatively quick and inexpensive method to assess biological diversity. It can also be used to qualitatively assess aquatic habitat and water quality. A wide range of indicators can be used to assess the performance of management plans. The most appropriate indicators will depend largely on the management categories of the individual watersheds.

Task 2: Conduct Watershed-Wide Analyses and Surveys, if Needed

In some situations, a watershed plan may need to incorporate special analyses at the watershed level to supplement basic monitoring and analyses. A manager may decide to include a flood management analysis, pollutant load reduction analysis, or recreational greenway analysis. Other analyses that may be desirable include:

- Fishery and habitat sampling
- Stream reconnaissance surveys
- Stormwater structural control performance monitoring
- Bacteria source surveys
- Stormwater outfall surveys
- Detailed wetland identification
- Pollution prevention surveys
- Nutrient budget calculations
- Surveys of potential contaminant source areas
- Hazardous materials surveys
- Stormwater retrofit surveys
- Shoreline littoral surveys
- In-lake monitoring
- Hydro-geologic studies to define surface/groundwater interactions

Task 3: Prepare Subwatershed and Aquatic Corridor Management Maps

Maps that present the plan in a clear, uncomplicated manner are a key product of the subwatershed planning process. Maps range from highly sophisticated GIS maps to simple overlays of USGS quadrangle sheets. Mapping can generally be conducted at two scales, the subwatershed scale, and the aquatic corridor scale.

Subwatershed maps represent an entire subbasin on a single map, and should be a component of all watershed plans. These maps represent the natural features and institutional information needed to produce a watershed plan. Aquatic corridor maps are produced at a much finer scale than subwatershed maps, and represent only the area immediately adjacent to the stream corridor or shoreline. Aquatic corridor maps are highly recommended, particularly when stream buffers or floodplain development limits are an important consideration in the watershed plan.

Task 4: Adapt and Apply Watershed Protection Tools

Just as different goals need to be established depending on a watershed's management category, so do the various tools used to protect that resource. For example, while structural stormwater controls are recommended as a component of all management plans, the types of controls used will be different depending on the specific characteristics of a given watershed. The suite of watershed protection tools will be presented later in this resource guide.

2.3.7 Adopt and implement the plan

Determine what steps are needed to effectively implement the plan. Implementation of the recommendations of a local watershed management plan can take place through a number of related mechanisms:

- In some communities the watershed or master plan is adopted (often by reference) in its stormwater ordinance and essentially becomes an overlay district wherein development decisions must follow plan recommendations for various parts of the watershed. In others it is not mandatory, but is referred to when rezoning and plans approval decisions are made by staff and zoning boards.
- The local long-term capital improvement plan can be derived from the recommendations of the plan. Special assessment districts, fee-in-lieu charges, system development charges, or other funding mechanisms can be established to help pay for specific improvements identified in the plan.
- Comprehensive plans can be modified to incorporate the recommendations of the watershed or stormwater master plan into long-term land use planning, transportation plans, etc. Parks and open space plans can use the results of the plan to insure the multi-objective nature of the plans is implemented combining engineering function with aesthetics and recreational opportunities.
- Some communities use the computer models of the drainage system developed in a watershed or master plan in a real-time format as tools to assist in decision making about the need for detention, downstream impact assessment, zoning approvals, etc.
- An ad hoc inter-staff team is often effective in coordinating the provisions of the plan across local government departments.
- Various recommendations in the plan may be implemented through non-profit citizen groups who “adopt” the watershed. These groups can be instrumental in gaining public acceptance and involvement, carrying out the recommendations of the plan, obtaining funding, and providing surveillance and reporting of watershed activities.

The best ways to ensure that a plan is implemented are to incorporate the right stakeholders, realistically assess budgetary resources, develop a scientifically and economically sound plan, and mandate its use in the development process. A good plan in itself does not guarantee implementation. As the plan is being developed, and afterwards, watershed planners need to work to ensure that local governments have both the regulatory authority and the resources to implement the plan. It is important that the plan is not isolated from other government planning and construction activities.

The implementation of a watershed plan typically costs about ten times as much as the planning process. Some stable funding source needs to be identified to support plan implementation. One of the greatest costs of watershed implementation is the staff resources needed to continue monitoring in the watershed, design and build structural controls and retrofits, and enforce the ordinances and laws that might be called for in the plan.

2.3.8 Revisit and update the plan

Periodically update the plan based on new development in the watershed or results from monitoring data.

A one-time watershed study only identifies what problems exist in a watershed. Many local governments, for one reason or another, take on watershed planning without realizing that it is an ongoing process rather than a report.

Each subwatershed or watershed plan should be prepared with a defined management cycle of five to seven years. Individual plans are prepared in an alternating sequence, so that a few are started each year with all plans within a given region or jurisdiction ideally being completed within a five to seven year time span. A management cycle helps balance workloads of watershed staff and managers, by distributing work evenly throughout the cycle’s time period.

3.0 Integration of Site and Watershed-Level Stormwater Planning

3.1 Introduction

Integrating site level development and watershed level planning can be a significant institutional challenge. It is likely that local governments will need to reevaluate their standard operating procedures for stormwater management and evolve towards a less compartmentalized mentality that strives for open communication between departments and agencies. In addition, inter-jurisdictional cooperative efforts are often needed, where communication and consensus building among stakeholders is critical.

Many local stormwater programs already have both development requirements and watershed level planning components. However, the challenge is to develop a set of incentives and/or requirements that site planners and engineers will adopt and follow in order to comply with watershed level planning efforts. In addition, watershed plans should be developed and implemented in a manner that considers the potential adverse impacts of site development. In other words, watershed protection measures should coincide with the development cycle (i.e., planning, design, construction, and post-construction).

3.2 Using the Local Review Process to Comply with Watershed Plans

An important, yet frequently overlooked, task facing local regulators and plan reviewers is to ensure that local review requirements are tied to the watershed plan. There are four major occasions during the site development process where local regulators should check for agreement and consistency with existing watershed plans. These checks serve as an enforcement mechanism for watershed plan implementation. The four key review occasions are:

- *integrated Stormwater Management (iSWM) Conceptual Site Plan Submittal*
- Preliminary / Final *i*SWM Site Plan Submittal
- Permit Acquisition
- Final Record / As-Built Plat

By utilizing this series of checkpoints throughout the local review process, communities can help to ensure that existing watershed plans are consistently referred to and that necessary measures can be taken to comply with the goals and objectives of the plans. Multiple checkpoints also provide some assurance that the sometimes diverse goals and objectives of a watershed plan are adequately reviewed by qualified and appropriate regulators.

integrated Stormwater Management (iSWM) Conceptual Site Plan Submittal

It is recommended that an *i*SWM Conceptual Site Plan be prepared, reviewed, and approved by the local review authority. At this review checkpoint, qualified staff should ensure that the preliminary designs being proposed not only meet all of the on-site stormwater management requirements of the local jurisdiction, but that the plan also considers broader issues associated with applicable watershed plans. For example, if fecal bacteria loads are a concern within the watershed, the plan reviewer should look to see that proposed stormwater control practices have a demonstrated ability to provide adequate bacteria removal. From a flood control standpoint, the reviewer would ensure that there are no conflicts with the proposed development and mapped floodplain boundaries from the watershed plan.

Preliminary / Final iSWM Site Plan Submittal

At this checkpoint, the local review authority must confirm that the proposed stormwater management system from the conceptual site plan has been adequately designed and analyzed to meet the watershed goals. For example, a watershed plan may have structural stormwater control maintenance goals. If maintenance agreements are not already a component of the local stormwater management criteria, this would be a case where the reviewer could require specific maintenance conditions for the development.

Permit Acquisition

There are a host of permits that may be required for a development project, such as clearing and grading, building, construction TPDES erosion and sediment control, wetlands, floodplain, etc. The permitting stage is another important checkpoint to ensure consistency with watershed plans, as permitting authorities are often part of a separate local department. In some cases, permitting will involve state and federal agencies (e.g., Corps of Engineers 404 wetlands permits). By definition, there are criteria that must be met for a permit to be issued; however, it should not be presumed that these criteria are consistent with, or as stringent as, the goals and objectives of a watershed plan.

In some cases, it may be desirable to have conditions attached to a permit so that the goals of the watershed plan can be met. For example, a watershed may have historically experienced significant sediment loading from uncontrolled construction sites, and consequently, a goal of the watershed plan is to promote construction site phasing by limiting the amount of contiguous cleared area to a specified number of acres. Under this scenario, the issuer of the clearing and grading permit might place a condition on the permit that restricts the amount of land cleared at a given time.

Final Record / As-Built Plat

A final method to ensure that the goals of a watershed plan are being implemented at the site level through the review process is to record any significant easements, buffers, or resource protection areas on the final record plat or as-built (i.e., legal document). This helps to maintain important protection areas through any land acquisition or transfer deals. Protection areas that might be recorded on a final plat include conservation easements, riparian buffer zones, and other open space conservation areas.

4.0 Inter-jurisdictional Watershed Planning

Because watershed boundaries do not coincide with political jurisdictions, more than one city or county must often be involved in watershed planning efforts. Successful watershed management can only occur if all jurisdictions within a watershed boundary are involved at some level and committed to the same set of goals.

The challenge is to develop effective inter-jurisdictional watershed plans that are proactive, well-defined, well-funded, and adequately staffed. The key ingredients to meet the challenge are:

- Develop a broad-based consensus for the need to protect and manage the specified watershed. Establish a memorandum of understanding (MOU) or a memorandum of agreement between interested/concerned jurisdictions and agencies.
- Obtain some level of funding commitments from signatory parties.
- Establish a technical committee to develop and coordinate watershed management efforts.
- Consistently evaluate and update the watershed plan efforts.

An example of an inter-jurisdictional watershed planning effort in North Central Texas is the Big Fossil Creek Watershed Feasibility Study. The Big Fossil Creek Watershed is a 73 square mile watershed located in northern Tarrant County. The watershed drains into the West Fork of the Trinity River. The study was a cooperative effort among the nine local governments in the watershed including Fort Worth, Tarrant County, North Richland Hills, Haltom City, Watauga, Saginaw, Haslet, and Keller with the US Army Corps of Engineers (USACE).

The study area was one of the fastest growing urban areas in the country which made the creek corridor increasingly vulnerable to flooding problems. The southern, or downstream, half of the watershed was almost fully developed with growth anticipated in the upper portion of the watershed at the time of the study. As this increase in development occurred, downstream communities would face a growing risk of damage to property and potential loss of life due to flooding.

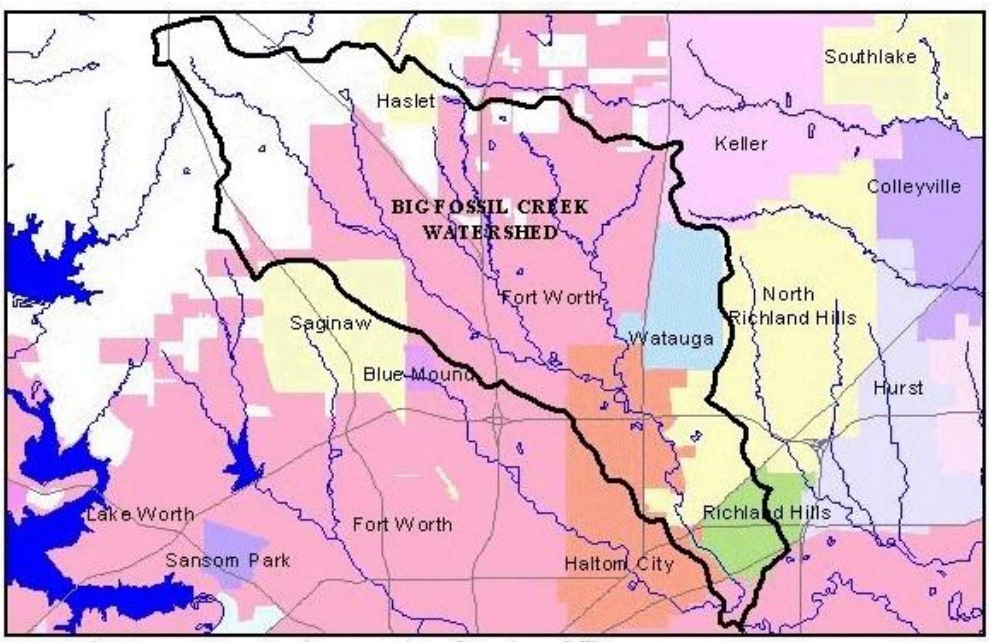


Figure 4-1 Big Fossil Creek Watershed

The study systematically evaluated a range of flood damage reduction solutions to address safety aspects of Big Fossil Creek, while identifying associated water quality, ecosystem restoration, and recreational opportunities.

The cooperative effort had 4 basic objectives:

1. Provide direction to participating local governments to stabilize and reduce impacts of future floodplain development.
2. Identify local flooding problems and develop/evaluate flood damage reduction alternatives including buyouts, floodproofing, channel modifications, levees, and detention reservoirs.
3. Identify local water quality problems and develop/evaluate ecosystem restoration alternatives including riparian corridor expansion, buffer strips, wetland protection and creation, and easements.
4. Develop a preliminary recreation and open space plan for proposed project lands.

These objectives were based on the protection of the Big Fossil Creek as an important regional resource that affects the overall public safety, quality of life, and welfare of residents in the Big Fossil Creek watershed. This type of study can result in better-managed growth throughout the watershed and, ultimately, a reduction in the risk of property damage and loss of life during future storm events.

5.0 Implementation of Watershed Plans

5.1 Introduction

Watershed plan implementation is an involved process that requires the simultaneous consideration of many issues including watershed management and protection tools, stakeholder involvement, cost, and the assessment of plan performance. The following discussion provides detail about key components of plan implementation.

5.2 Tools of Watershed Management and Protection

Once a watershed management plan has been developed, a community requires the necessary means to implement the plan and accomplish its goals. The following toolbox can provide a local government with some of the methods and mechanisms that can be used to achieve watershed plan goals. Though each of these tools will generally be used in some form in every watershed, they will most likely be applied in different ways in various communities and from one watershed to the next.

5.2.1 Land Use Planning / Zoning

Zoning and land use planning are the most widely used tools for managing growth and development that communities have at their disposal. The watershed management plan can be adopted by the community and referred to when rezoning and plans approval decisions are made by staff and zoning boards. This can be used to preserve sensitive areas, maintain or reduce the impervious cover within a given subwatershed, and redirect development toward subwatersheds that can support a particular type of land use and/or density.

A wide variety of land use planning and/or zoning techniques can be used to manage land use and impervious cover within a watershed. These techniques are summarized in Table 5-1.

Table 5-1 Land Use Planning Techniques

Land Use Planning Technique	**Description**	**Use as a Watershed Protection Measure**
Watershed Based	Zoning restrictions specific to a particular watershed or subwatershed.	Can be used to protect water resources in a particular watershed and/or relocate development.
Overlay Zoning	Superimposes additional regulations or specific development criteria within specific mapped districts.	Can require development restrictions or allow alternative site design techniques in specific areas.
Impervious Overlay Zoning	Specific overlay zoning that limits total impervious cover within mapped districts.	Can be used to limit potential stormwater runoff and pollutants from a given site or watershed.
Performance Zoning	Specifies a performance requirement that accompanies a zoning district.	Can be used to require additional levels of performance within a watershed or at the site level.
Large Lot Zoning	Zones land at very low densities.	May be used to decrease impervious cover at the site or subwatershed level, but may have an adverse impact on regional or watershed imperviousness and may promote urban sprawl.

Transfer of Development Rights (TDRs)	Transfers potential development from a designated "sending area" to a designated "receiving area."	May be used in conjunction with watershed based zoning to restrict development in areas and encourage development in areas capable of accommodating increased densities.
Limiting Infrastructure Extensions	A conscious decision is made to limit or deny extending infrastructure (such as public sewer, water, or roads) to designated areas to avoid increased development in these areas.	May be used as a temporary method to control growth in a targeted watershed or subwatershed. Usually delays development until the economic or political climate changes.

5.2.2 Land Acquisition and Conservation

Land acquisition and land conservation are important elements of any watershed management program. They allow a community to protect critical environmental areas and stormwater management resources. There are several techniques that can be used to conserve land, which provide a continuum ranging from absolute protection to very limited protection. Representative land conservation techniques include land purchases, land donations, conservation easements, and public sector stewardship. A community can also promote the protection of conservation areas on individual site developments by advocating the integrated site design concepts described in the Design Manual for Site Development.

5.2.3 Riparian Buffers and Greenways

The creation of a riparian buffer system is key in mitigating flood impacts and protecting water quality and streambanks in urban areas. Technically speaking, a buffer is a type of land conservation area, but it has added importance in a stormwater management sense in its ability to provide water quality, flood prevention and channel protection benefits.

Buffers create a natural "right of way" for streams that protect aquatic ecosystems and provide a safe conduit for potentially dangerous and damaging floodwaters. Buffers provide water quality benefits and protection for streams, rivers, and lakes. Buffers also serve as valuable park and recreational systems that enhance the general quality of life for residents. Finally, buffers can provide valuable wildlife habitat and act as wildlife corridors for smaller mammals and bird species that are present in urban areas.

Establishing a comprehensive and contiguous buffer system, or "greenway," should be a goal of virtually all watershed plans. To achieve this goal, effective and clear guidance and enforcement must occur at the site level, especially for smaller headwater streams.

5.2.4 integrated Site Design Techniques

A community can promote a suite of integrated site design practices and techniques to reduce the amount of stormwater runoff and pollutants generated in a watershed, as well as to provide for nonstructural treatment and control of runoff. The watershed plan should specify which integrated site design techniques are most applicable in individual subwatersheds to meet the plan's goals and objectives.

5.2.5 Structural Stormwater Controls

Structural stormwater controls are constructed stormwater management facilities designed to treat stormwater runoff and/or mitigate the effects of increased stormwater runoff peak rate, volume, and velocity due to urbanization. A watershed plan needs to ensure that stormwater controls are being properly designed, constructed, and maintained in the watershed. Watershed plans can help to determine if special or additional criteria are required for the selection and design of structural controls, and can provide guidance on the location of potential regional facilities or necessary structural control retrofits within the watershed.

5.2.6 Erosion and Sediment Control

Construction site erosion and sediment control is a critical component in reducing the total suspended solid (TSS) loading to receiving waters and improving overall water quality in a watershed. Thus, a watershed plan should include provision for full implementation of an erosion and sediment control program and enforcement of state and federal requirements. Integrated site design practices that reduce the total area that is cleared and graded should be promoted. Diligent plan review and strict construction enforcement are key to the success of local E&S programs.

5.2.7 Elimination of Non-Stormwater Discharges

In some watersheds, non-stormwater discharges such as greywater from commercial entities and illicit connections can contribute significant pollutant loads to receiving waters. Key program elements in a watershed plan include inspections of private septic systems, repair or replacement of failing systems, utilizing more advanced on-site septic controls, identifying and eliminating illicit connections from municipal stormwater systems, and spill prevention.

5.2.8 Watershed Stewardship Programs

The goal of watershed stewardship is to increase public understanding and awareness about the watershed plan and goals. A watershed public information and education program strives to increase stakeholder awareness of their role in the protection of water resources, promote better stewardship of private lands, and develop funding to sustain watershed management efforts.

Basic programs that communities should consider to promote greater watershed stewardship include:

- Watershed and stormwater/non-point source pollution education
- Pollution prevention
- Adopt-A-Stream programs
- Watershed maintenance and cleanup activities

5.3 Stakeholder Involvement Techniques

Stakeholder involvement and interaction is essential to the implementation of watershed plans. A citizen advisory committee (CAC) is an important feature of an effective watershed management structure. A typical CAC is open to broad citizen participation and provides direct feedback to the management structure on public attitudes and awareness in the watershed. Meaningful involvement by a CAC is often critical to convince the community and elected leaders of the need for greater investment in watershed protection.

Some of the possible functions of a citizen's advisory committee are:

- Organize media relations and increase watershed awareness:
  - press releases
  - informational flyers
  - watershed awareness campaigns
  - liaison between citizen groups and government agencies
- Provide input on workable stewardship programs
- Coordinate programs to engage watershed volunteers, such as:
  - stream monitoring
  - stream clean-ups
  - adopt-a-stream programs
  - tree planting days
  - storm drain stenciling

- Explore funding sources to support greater citizen involvement
- Provide recommendations to City Council on variance requests related to stormwater issues

Another common feature of an effective watershed management structure is the reliance on a technical advisory committee (TAC) to support the overall watershed planning effort. A TAC is routinely made up of a public agency staff and independent experts who have expertise in scientific matters. Some of the possible functions of a technical advisory committee are:

- Evaluate current and historic monitoring data and identify data gaps
- Coordinate agency monitoring efforts within the watershed to fill these gaps
- Interpret scientific data for the whole watershed management organization
- Assess and coordinate currently approved implementation projects
- Provide support to the City Council and Planning & Zoning Board on stormwater issues

Various recommendations in a watershed plan may be implemented through non-profit citizen groups who "adopt" the watershed. These groups can be instrumental in gaining public acceptance and involvement, carrying out the recommendations of the plan, obtaining funding, and providing surveillance and reporting of watershed activities.

5.4 Cost (Budget)

As with the watershed planning process, a serious challenge confronting a community is how to implement watershed and subwatershed plans within existing budget constraints. As part of the planning effort the watershed planning team will need to identify the sources of funding that are available and develop budgets for both the subwatershed and watershed plan implementation efforts.

5.5 Performance Monitoring and Assessment

There are several different monitoring techniques or indicators that can be used to assess the performance of a watershed plan. The range of monitoring extends from the more complex chemical or toxicity testing methods to more simplified physical or biological techniques.

Table 5-3 provides a list of watershed monitoring techniques or indicators that can be used in watershed monitoring, as well as the initial planning process. The list covers a wide range of alternatives that can be utilized to assess positive and/or negative trends in water quality, aquatic integrity, and watershed health.

Regardless of the specific indicators selected, it is important to use scientifically valid assessment techniques, quality controls, and valid sampling protocols to ensure that results are repeatable, consistent, and compatible with other data collection efforts.

To effectively monitor the performance of the watershed plan, it is recommended that water quality and biological monitoring be performed on an aggregate basis at key locations in the watershed and not on a site-by-site basis. Monitoring for the TPDES MS4 program and numerous other studies have confirmed the extreme variability of stormwater quality and physical stream/habitat conditions due to many influencing factors. These factors are most variable at a single individual site. At the larger watershed level, however, some of the variability is dampened allowing for a better evaluation of plan implementation on stream and watershed health.

Table 5-3 Potential Watershed Indicators	
Water Quality Indicators: Water quality pollutant monitoring Toxicity testing of contaminants Non-point source loadings Frequency of water quality violations Sediment contamination Human health criteria	**Physical and Hydrological Indicators:** Stream widening/downcutting Physical habitat changes affecting biodiversity Impacted dry weather flows Increased flooding frequencies Stream temperature changes
Biological Indicators: Fish assemblage Macro-invertebrate assemblage Single species indicator Composite indicators Other biological indicators	**Social Indicators:** Public attitude surveys Industrial/commercial pollution prevention Public involvement and monitoring User perception
Programmatic Indicators: Number of illicit connections identified/corrected Number of structural controls installed, inspected, and maintained Permitting and compliance	**Site Indicators:** Structural control performance monitoring Industrial site compliance monitoring

6.0 Regional vs. On-site Stormwater Management

6.1 Introduction

Using individual, on-site structural stormwater controls for each development is the typical approach in most communities for controlling stormwater quantity and quality, as is described in chapter one of the *i*SWM Design Manual for Site Development. The developer finances the design and construction of these controls and, initially, is responsible for all operation and maintenance. However, the local government is likely to become responsible for maintenance activities if the owner fails to carry them out.

A potential alternative approach is for a community to install a few strategically located regional stormwater controls in a subwatershed rather than require on-site controls (see Figure 6-1). For this resource guide, regional stormwater controls are defined as facilities designed to manage stormwater runoff from multiple projects and/or properties through a local jurisdiction-sponsored program, where the individual properties may assist in the financing of the facility, and the requirement for on-site controls is either eliminated or reduced.

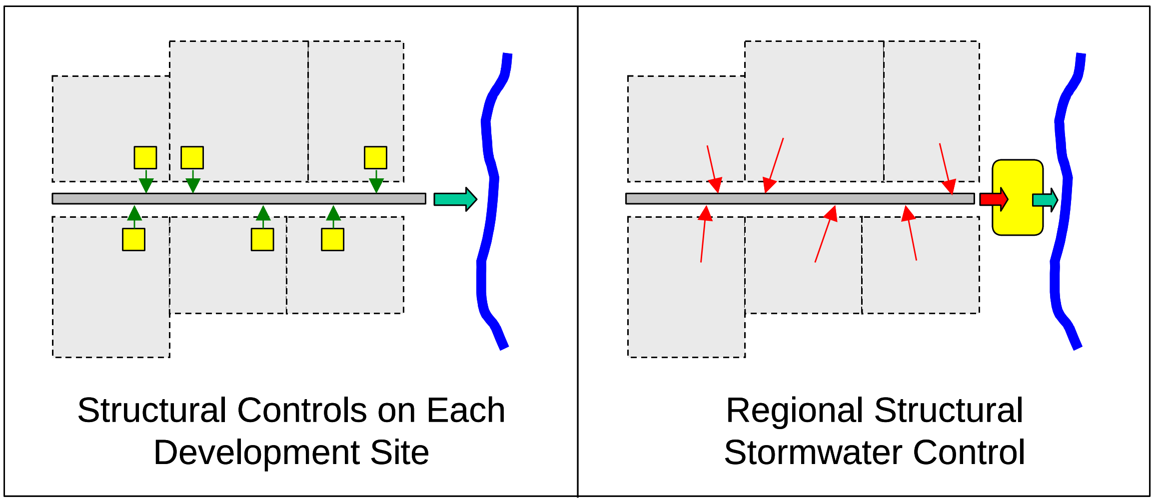


Figure 6-1 On-site Versus Regional Stormwater Management

6.2 Advantages and Disadvantages of Regional Stormwater Controls

Regional stormwater facilities are significantly more cost-effective because it is easier and less expensive to build, operate, and maintain one large facility than several small ones. Design and construction of regional controls are estimated to cost from $1,250 to $2,000 per acre of residential development and $1,750 to $2,500 per acre of nonresidential development. Regional stormwater controls are generally better maintained than individual site controls because they are large, highly visible and typically the responsibility of the local government. In addition, a larger facility poses less of a safety hazard than numerous small ones because it is more visible and is easier to secure.

There are also several disadvantages to regional stormwater controls. In many cases, a community must provide capital construction funds for a regional facility, including the costs of land acquisition. However, if a downstream developer is the first to build, that person could be required to construct the facility and later be compensated by upstream developers for the capital construction costs and annual maintenance expenditures. Conversely, an upstream developer may have to establish temporary control structures if the regional facility is not in place before construction. Maintenance responsibilities generally shift from the homeowner or developer to the local government when a regional approach is selected. The local government would need to establish a stormwater utility or some other program to fund and implement stormwater control. Finally, a large in-stream facility can pose a greater disruption to the natural flow network and is more likely to affect wetlands within the watershed.

Below are summarized some of the "pros" and "cons" of regional stormwater controls.

6.2.1 Advantages of Regional Stormwater Controls

- **Reduced Construction Costs** – Design and construction of a single regional stormwater control facility can be far more cost-effective than numerous individual on-site structural controls.
- **Reduced Operation and Maintenance Costs** – Rather than multiple owners and associations being responsible for the maintenance of several stormwater facilities on their developments, it is simpler and more cost effective to establish scheduled maintenance of a single regional facility.
- **Higher Assurance of Maintenance** – Regional stormwater facilities are far more likely to be adequately maintained as they are large and have a higher visibility, and are typically the responsibility of the local government.
- **Maximum Utilization of Developable Land** – Developers would be able to maximize the utilization of the proposed development for the purpose intended by minimizing the land normally set aside for the construction of stormwater structural controls.
- **Retrofit Potential** – Regional facilities can be used by a community to mitigate existing developed areas that have insufficient or no structural controls for water quality and/or quantity, as well as provide for future development.
- **Other Benefits** – Well-sited regional stormwater facilities can serve as a recreational and aesthetic amenity for a community as an excellent backdrop for multi0use parks.

6.2.2 Disadvantages of Regional Stormwater Controls

- **Location and Siting** – Regional stormwater facilities may be difficult to site, particularly for large facilities or in areas with existing development. In-stream facilities, particularly above a water supply reservoir, will require water rights permits through TCEQ which could prevent implementation, drive up costs, and cause delays during planning and permitting stages.
- **Capital Costs** – The community must typically provide capital construction funds for a regional facility, including the costs of land acquisition. Dam safety permits, if needed, required through TCEQ will drive up costs and the time necessary to plan and permit a facility.
- **Maintenance** – The local government is typically responsible for the operation and maintenance of a regional stormwater facility.
- **Need for Planning** – The implementation of regional stormwater controls requires substantial planning, financing, and permitting. Land acquisition must be in place ahead of future projected growth.
- **Water Quality and Channel Protection** – Without on-site water quality and channel protection, regional controls do not protect smaller streams upstream from the facility from degradation and streambank erosion.
- **Ponding Impacts** – Upstream inundation from a regional facility impoundment can eliminate floodplains, wetlands, and other habitat.

6.3 Important Considerations for the Use of Regional Stormwater Controls

If a community decides to implement a regional stormwater control, then it must ensure that the conveyances between the individual upstream developments and the regional facility can handle the design peak flows and volumes without causing adverse impact or property damage. Full-buildout conditions in the regional facility drainage area should be used in the analysis.

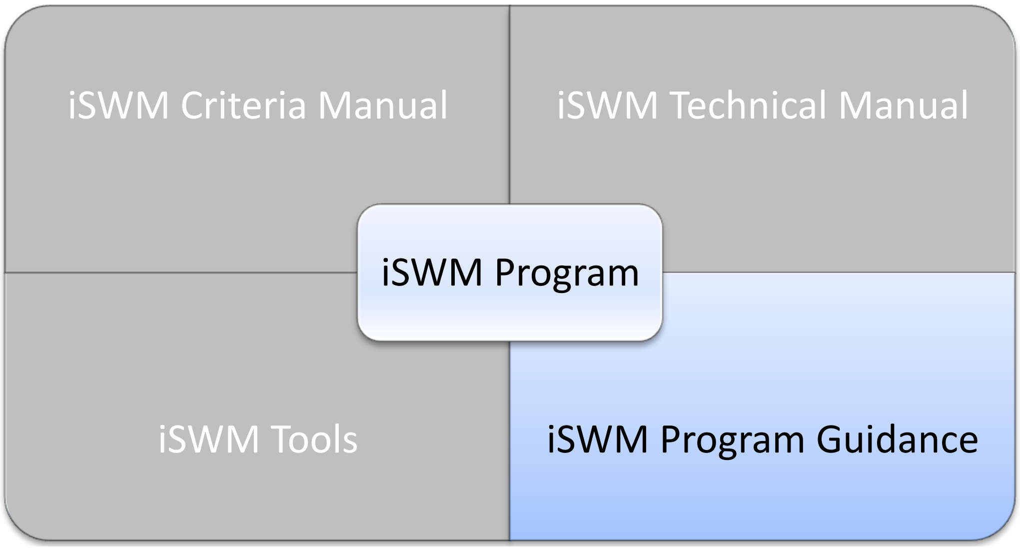
In addition, unless the system consists of completely man-made conveyances (i.e. storm drains, pipes, concrete channels, etc) then on-site structural controls for water quality and downstream channel protection will need to be required for all developments within the regional facility's drainage area. Federal water quality provisions do not allow the degradation of water bodies from untreated stormwater discharges, and it is U.S. EPA policy to not allow regional stormwater controls that would degrade stream quality between the upstream development and the regional facility. Further, without adequate channel protection, aquatic habitats and water quality in the channel network upstream of a regional facility may be degraded by streambank erosion if they are not protected from bankfull flows and high velocities.

Based on these concerns, both the EPA and the U.S. Army Corps of Engineers have expressed opposition to *in-stream* regional stormwater control facilities. In-stream facilities should be avoided if possible and will likely be permitted on a case-by-case basis only.

It is important to note that siting and designing regional facilities should ideally be done within a context of a stormwater master planning or watershed planning to be effective.

The iSWM Program

The iSWM Program for Construction and Development is a cooperative initiative that assists municipalities and counties to achieve their goals of water quality protection, streambank protection, and flood mitigation, while also helping communities meet their construction and post-construction obligations under state stormwater permits. The iSWM Program has been developed by the North Central Texas Council of Governments (NCTCOG) to help communities create sustainable communities through a comprehensive approach to stormwater management. The four parts of iSWM are shown below



iSWM Criteria Manual

provides a description of the development process, the iSWM focus areas and locally adopted design criteria allowing municipalities a flexible approach to apply at a local level

iSWM Technical Manual

provides technical guidance including equations, descriptions of methods, fact sheets, etc. necessary for design

iSWM Tools

provides web-served training guides, examples, design tools, etc. that could be useful during design

iSWM Program Guidance

provides reference documents that guide programmatic planning rather than technical design

All these documents and more can be found at http://iswm.nctcog.org/.

North Central Texas Council of Governments

616 Six Flags Drive, Suite 200
Arlington, TX 76005-5888
(817) 640-3300