

4 Water Quality Assessment

4.1 Effects of Urban Stormwater Runoff

Stormwater runoff from urbanized areas often has negative effects on downstream waterways and receiving waters. The extent and type of such effects vary, but they are often significant relative to other sources of pollution and environmental degradation. Urban stormwater runoff has both physical and chemical effects that impact water quality, water quantity, habitat and biological resources, public health, and the aesthetic appearance of urban waterways.

Adverse effects on receiving waters associated with stormwater discharges fall into one of the three following general classes:

- Short-term water quality effects during and after storm events. Such changes include temporary increases in the concentration of one or more pollutants, toxics or bacteria levels.
- Long-term water quality effects. These are cumulative effects associated with repeated stormwater discharges from many sources.
- Physical effects on the receiving waterbody. Examples include erosion, scour, deposition, plant and aquatic species changes, and other effects associated with increased frequency and volume of runoff that alters aquatic habitat.

A further discussion of these effects follows.

4.1.1 Water Quality Effects

Water quality effects pertain to changes in water chemistry and can significantly reduce the capacity of a waterbody to support life or to maintain its existing ecosystem diversity. The introduction of pollutants into a given waterbody is the most common means by which water quality is degraded, and the extent of degradation depends on the type(s) and concentrations of the pollutants.

Pollutants associated with urban runoff potentially harmful to receiving waters fall into the categories listed below:

- Solids
- Oxygen-demanding substances
- Nitrogen and phosphorus
- Pathogens
- Petroleum hydrocarbons (oils and greases)
- Metals
- Synthetic organics (pesticides, herbicides, etc.)

These pollutants degrade water quality in receiving waters near urban areas, and often contribute to the impairment of use and exceedances of criteria included in State water quality standards. The quantity of these pollutants per unit area delivered to receiving waters tends to increase with the degree of development in urban areas. As shown in Table 4-1 below, contaminants enter stormwater from a variety of sources in the urban landscape.

Table 4-1. Contaminant Sources

Contaminant Type	Contributing Sources
Sediment and Floatables	Roof systems, streets, lawns, driveways, roads, construction activities, atmospheric deposition, drainage channel erosion
Pesticides and Herbicides	Residential lawns and gardens, roadsides, utility right-of-ways, commercial and industrial landscaped areas, soil wash-off, etc.
Organic Materials	Roads, residential lawns and gardens, commercial landscaping, animal wastes
Metals	Automobiles, bridges, atmospheric deposition, industrial areas, soil erosion, corroding metal surfaces, combustion processes
Oil and Grease/Hydrocarbons	Roads, driveways, parking lots, vehicle maintenance areas, gas stations, illicit dumping to storm drains
Bacteria and Viruses	Lawns, roads, leaky sanitary sewer lines, sanitary sewer cross-connections, animal waste, septic systems
Nitrogen and Phosphorus	Lawn fertilizers, atmospheric deposition, automobile exhaust, soil erosion, animal waste, detergents

The concentrations of pollutants found in urban runoff are directly related to the level of development within the watershed. This relationship is shown in Table 4-2, a compilation of typical pollutant loadings from different urban land uses¹³.

Table 4-2. Typical Pollutant Loadings from Urban Runoff by Land Use (lbs./acre-year)

Land Use	TSS	TP	TKN	NH ₃ -N	NO ₂ +NO ₃ -N	BOD	COD	Pb	Zn	Cu
Commercial	1000	1.5	6.7	1.9	3.1	62	420	2.7	2.1	0.40
Parking Lot	400	0.7	5.1	2.0	2.9	47	270	0.8	0.8	0.04
High Density Residential	420	1.0	4.2	0.8	2.0	27	170	0.8	0.7	0.03
Medium Density Residential	190	0.5	2.5	0.5	1.4	13	72	0.2	0.2	0.14
Low Density Residential	10	0.04	0.03	0.02	0.1	NA	NA	0.01	0.04	0.01
Freeway	880	0.9	7.9	1.5	4.2	NA	NA	4.5	2.1	0.37
Industrial	860	1.3	3.8	0.2	1.3	NA	NA	2.4	7.3	0.5
Park	3	0.03	1.5	NA	0.3	NA	2	0	NA	NA
Construction	6000	80	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

NA: Not Available - insufficient data to characterize loadings.

Other water quality parameters are not necessarily related to pollutants but are also very important to the overall health of aquatic ecosystems. These include such parameters as pH, temperature, dissolved oxygen, and salinity.

¹³ Homer et al., 1994 in Protocol for Developing Nutrient TMDLs (USEPA 1999)

4.1.1.1 Short-Term Water Quality Effects

The short-term effects of pollutants on receiving waters vary widely, ranging from minor changes in temperature or salinity to complete loss of species or habitat, in the case of a major oil spill or other serious contamination event. In most cases, these changes usually only last for a few days or weeks following a storm event. However, repeated introduction of pollutants can lead to long-term effects, which are much more difficult to address.

4.1.1.2 Long-Term Water Quality Effects

Long-term water quality effects are those resulting from either large-scale contamination events or repeated introductions of smaller pollutant loadings over time. In either case, significant amounts of pollutants are introduced into a receiving water. Depending on the type of pollutant, they may bioaccumulate in aquatic plant and animal species, be deposited into sediments, reduce dissolved oxygen levels, or provide food for aquatic weed species. These effects can last for many years, can seriously impair the health and use of a waterbody, and are difficult to correct.

4.1.2 Physical Effects

While water quality effects are not usually observed by the general public, the physical effects of stormwater runoff are more visible. Stream channel and channel bank erosion provide direct evidence of water velocity impacts caused by urban stormwater. The volume of urban stormwater runoff increases directly with the amount of impervious area and the level of development within a watershed. As development continues, urban streams are often forced to accommodate larger volumes of stormwater runoff that recur on a more frequent basis. This leads to overloading the stream capacity and results in channel instability. The change in watershed hydrology associated with urban development also causes channel widening and scour, and the introduction of larger amounts of sediment and pollutants to urban streams.

Visible impacts include eroded and exposed stream banks, channel slope failures, fallen trees, sedimentation, and recognizably turbid or murky conditions. The increased frequency of flooding in urban areas also poses a threat to public safety and property. Both water quality and water quantity impacts associated with urban stormwater negatively affect aquatic and riparian (shore edges or similar) habitat in urban streams. Rapid salinity changes, higher levels of pollutants, increased flow velocities and erosion, alteration of riparian corridors, and sedimentation associated with stormwater runoff can all negatively impact the integrity of aquatic ecosystems. These impacts include the degradation and loss of aquatic habitat, and reduction in the numbers and diversity of wildlife species.

Public health effects are for the most part related to bacteria and disease-causing organisms carried by urban stormwater runoff into waters used for water supplies, fishing and recreation. Water supplies can potentially be contaminated by urban runoff, posing a public health threat. People coming in contact with contaminated water at beaches and other recreational sites can become seriously ill. Beach closures caused by urban runoff have a negative impact on the quality of life and can impede economic development as well. Similarly, the bacterial contamination of shellfish beds poses a public health threat to consumers, and shellfish bed closures negatively impact the fishing industry and local economies.

Debris and litter floating in urban waterways and deposited on stream banks and beaches are aesthetic impacts that are particularly noticeable to the general public. Stormwater is a major source of floatables that include paper and plastic bags and packaging materials, bottles, cans, and wood. The presence of floatables and other debris in receiving waters during and following storm events reduces visual attractiveness of the waters and detracts from

their recreational value. Nuisance algal conditions including surface scum and odor problems can also be attributed to urban stormwater in many instances.

Stormwater runoff from urban areas can contain significant concentrations of harmful pollutants that can contribute to adverse water quality impacts in receiving streams. Effects can include such things as beach closures, shellfish bed closures, limits on fishing and limits on recreational contact in waters that receive stormwater discharges.

4.2 Best Management Practices

BMPs are techniques, approaches, or designs that promote sound use and protection of natural resources to meet program goals and levels of service (LOS). BMPs are also required for permitting of both new development and retrofit of existing systems. The BMPs discussed in this section offer the most potential for application in the City. Since this SWMP deals primarily with existing systems in urbanized areas, emphasis was placed on BMPs that are better suited for that situation. Where possible, BMP descriptions and design information were taken from the latest version of the SJRWMD Permit Information Manual, dated June 1, 2018.

The use of a specific BMP depends on the site conditions and objectives such as water quality protection, flood control, or volume control. In many cases, there are multiple goals or needs for a given project. Therefore, multiple BMPs can be used in sequence to develop a “treatment train”. The treatment train concept is intended to maximize the use of available site conditions from the point of runoff generation to the receiving water discharge in order to maximize water quantity (flood control), water quality (pollutant load reduction), and wetlands benefits.

4.2.1 Best Management Practices (BMPs) Considerations

This section presents descriptions of various BMPs that are either currently in use or should be considered for use in the City SWMS. There are many BMPs available beyond those presented here, but the list was limited to only those BMPs that the City is already using or those for which the City can receive significant pollutant reduction credit under the CIRL BMAP if implemented. The BMPs are grouped as non-structural (regulation or ordinances) and structural (constructed facilities).

4.2.1.1 Non-structural Source Controls

- Land use planning
- Public information programs
- Stormwater management ordinance requirements
- Fertilizer application controls
- Pesticide and herbicide use controls
- Solid waste management
- Directly Connected Impervious Area (DCIA) minimization
- Erosion and sediment control on construction sites

4.2.1.1.1 *Land Use Planning*

Land use planning and management presents an important opportunity to reduce/minimize pollutants in stormwater runoff and control flooding by using a comprehensive planning process to integrate City goals into the development

and redevelopment process. Management measures may include modification or restrictions of certain land use activities and modification of existing City land development codes, perhaps even more restrictive than SJRWMD requirements. Land development codes to include larger storage volumes, stormwater harvesting, or other requirements for new developments or redevelopments can, in time, have significant positive effects on the City's SWMS. Greater restrictions may be warranted where development can affect impaired, threatened, or significant water bodies such as the IRL. Because increased pollutant loadings and flooding correspond to increase in impervious cover, land use planning and local land development codes can become effective control measures.

4.2.1.1.2 Public Information Program

A public information participation plan provides the City with a strategy for informing its employees, the public, and businesses about the importance of protecting stormwater from improperly used, stored, and disposed pollutants. Many people do not realize that yard debris or trash thrown into ditches today will worsen tomorrow's flooding and pollute surface waters. Municipal employees must be trained, especially those that work in departments not directly related to stormwater but whose actions affect stormwater. Residents must become aware that a variety of hazardous products are used in the home and that their improper use and disposal can pollute stormwater. Likewise, improper disposal of oils, antifreeze, paints, and solvents can end up in streams and lakes, poisoning fish and wildlife. If care is taken by individuals to properly dispose of yard debris, trash and hazardous materials, many problems can be reduced in magnitude or avoided. Increased public awareness also facilitates public scrutiny of industrial and municipal activities and will likely increase public reporting of incidents. Businesses, particularly smaller ones that may not be regulated by Federal, State, or local regulations, must be informed of ways to reduce their potential to pollute Stormwater. A key element of this program is public awareness of the benefits of roadside swales. These BMPs cost-effectively provide both water quantity and water quality benefits. The perception by many citizens is that shallow ponding (four to six inches) for one or two days after storms during the wet season is a problem. In reality, this shallow ponding and infiltration is the onsite storage that saves money by reducing pipe sizes and cost-effectively providing water quality treatment.

4.2.1.1.3 Fertilizer Application Control

Fertilizer application control is a voluntary control mechanism by citizens who use fertilizer as part of their landscaping activities. Fertilizer application controls are implemented through a public information program by making the public aware of the principals of environmental landscape maintenance and the problems associated with overuse of fertilizers. Overuse of fertilizers will cause excessive runoff of nutrients to surface waters thereby wasting money for the homeowner and potentially degrading the receiving water body. This is especially true during heavy rainfall periods that produce yard and neighborhood flooding. Information programs should also be extended to professional fertilizer users.

The City has implemented fertilizer application controls through its Integrated Pest Management (IPM) program, as well as its fertilizer ordinance. See Section 1.4.2.6 for more information. However, further education and enforcement of these items are necessary.

4.2.1.1.4 Pesticide Use Control

Pesticide use control is also a voluntary control by citizens who use pesticides as a part of their housekeeping and lawn maintenance activities. Some pesticides are priority pollutants (e.g., Endrin, Lindane, and Silvex), which can be toxic. Overuse of these chemicals can cause excessive runoff to surface waters and entry into the food chain. Many professional applicators of pesticides are using approved pesticides in a safe and proper manner. An information program on pesticide use will help to reduce the amount of pesticides entering the stormwater system.

The City has implemented pesticide use controls through its Integrated Pest Management (IPM) program, as well as its fertilizer ordinance. See Section 1.4.2.6 for more information.

4.2.1.1.5 Solid Waste Management

In some instances, problems can arise from trash and other debris flowing into and obstructing open channels, culverts, and storm sewers. It is recommended that the public be informed of the adverse impacts of littering and poor solid waste management. This can also include pet droppings and illegal dumping into storm drains, wooded areas, and ditches. Pet droppings can be a source of coliform bacteria and pathogens.

4.2.1.1.6 DCIA Minimization

Another non-structural BMP option would be for the City to minimize the amount of Directly Connected Impervious Area (DCIA) on a site and promote the use of green buffer zones around paved areas for infiltration. For example, roof runoff from structures can be directed to green buffer zones or shallow swales around houses. Requiring retrofitting of roof drainage systems for all existing and new construction would likely be difficult, but changing City building codes to require roof discharge to green areas for all new construction or significant repairs/alterations could be easier to accomplish. In addition, parking lots and driveways can be graded to landscaped/grassed areas or swales, reducing direct runoff to the storm drainage system.

4.2.1.1.7 Erosion and Sediment Control on Construction Sites

Erosion and sediment control on construction sites provides for the protection of receiving waters from sediment loads. Proper control during construction can be accomplished with gravel filter weirs, sediment fences, and temporary berms or swales. The City has implemented erosion and sediment controls through City Ordinance No. 54-3-11.2 an ordinance requiring erosion and sediment control on construction sites.

4.2.1.2 Structural Stormwater Controls

- Retention systems
- Dry detention systems
- Underdrain systems
- Wet detention systems
- Wetland Systems
- Exfiltration trenches
- Grassed swales and channels
- Water quality inlets and baffle boxes
- Skimmers
- Dams
- Aeration Systems

4.2.1.2.1 Retention Systems

The SJRWMD defines a retention system as a storage area designed to store a defined quantity of runoff, allowing it to percolate through permeable soils into the shallow ground water aquifer. Soil permeability and water

table conditions must be such that the retention system can percolate the desired runoff volume within a specified time following a storm event. After drawdown has been completed, the basin does not hold any water, thus the system is normally "dry." Unlike detention basins, the treatment volume for retention systems is not discharged to surface waters. Examples of retention systems include:

- Man-made or natural depressional areas where the floor is graded as flat as possible and turf is established to promote infiltration and stabilize the basin slopes (see Figure 4-1)
- Shallow landscaped areas designed to store stormwater
- Vegetated swales with swale blocks or raised inlets
- Pervious concrete with continuous curb

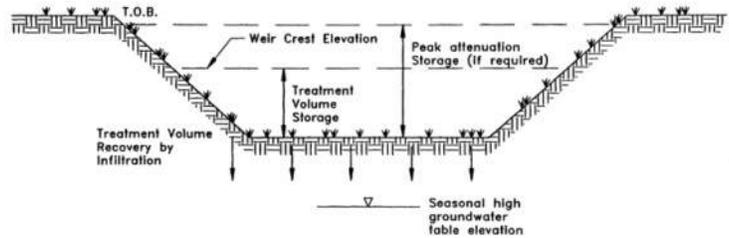


Figure 4-1. Typical Retention Pond Design (from SJRWMD)

Stormwater retention works best where soils are highly permeable and the seasonal high water table is situated well below the soil surface (at least 2 to 3 feet below pond bottom). The geology, soils, and groundwater conditions in the City of Sebastian are generally not well suited for the use of retention systems. However, retention systems may be suitable for use at individual urban redevelopment or retrofit sites within the watershed. The application of retention systems should be considered on a case-by-case basis within the study area where soils and water table conditions are suitable. The City currently uses several retention systems in the SWMS.

Potential Benefits of a Retention System

- Mimics the natural water balance of a site by promoting groundwater recharge close to the point of runoff generation.
- Can provide offline or on-line treatment for environmentally sensitive waters (e.g., Class II)
- Reduces peak rate and volume of flood discharge by retaining water onsite.
- Can be used as sediment traps during the construction phase of a project.
- Are reasonably cost-effective in comparison with other BMPs for both construction and maintenance costs (where soils are favorable).
- Effectively reduce pollutant loadings to receiving waters.

Potential Limitations of a Retention Basin

- Require well-drained soils to function properly.
- Unsuitable soils limit drawdown capacity, thereby reducing pollutant removal and flood control capacity.
- Soluble pollutants can be conveyed into groundwater.
- Possible nuisances such as odors, mosquitoes, and nuisance vegetation can occur if not designed, constructed, or maintained properly.

4.2.1.2.2 Dry Detention Systems

Dry detention systems are normally dry storage areas which are designed to store a defined quantity of runoff and slowly release the collected runoff through an outlet structure to adjacent surface waters. After drawdown of the stored runoff is completed, the storage basin does not hold any water, thus the system is normally "dry." A schematic of a typical dry detention system is presented in Figure 4-2.

Dry detention basins are similar to retention systems in that the basins are normally dry. However, the main difference between the two systems is that retention systems are designed to percolate the stored runoff into the ground while dry detention systems are designed to discharge the runoff through an outlet structure to adjacent surface waters.

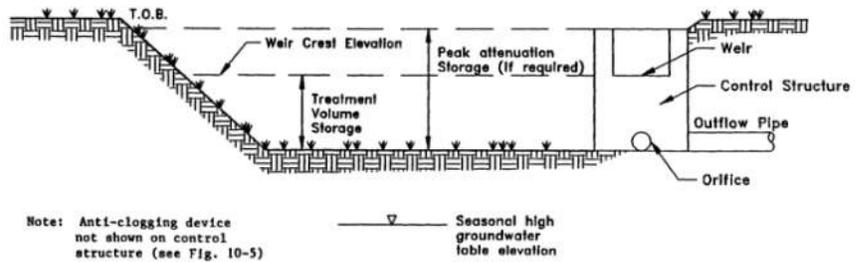


Figure 4-2. Typical Dry Detention Basin Design (from SJRWMD)

Sedimentation is the primary pollutant removal process which occurs in dry detention systems. Unfortunately, only pollutants which are primarily in particulate form are removed by sedimentation. Therefore, the pollutant removal efficiency of dry detention systems is not as great as systems such as retention and wet detention which remove both dissolved and particulate pollutants. Because of the limited pollutant removal efficiency of dry detention, this BMP must only be utilized where no other BMP is technically feasible. For example, use of dry detention must be restricted to the following situations:

- (a) Where high ground water table or soil conditions limit the feasibility of other BMPs such as retention, and
- (b) Small drainage basins (less than 5 acres). For larger projects (greater than 5 acres) other BMPs like wet detention shall be utilized instead of dry detention.

There are several design and performance criteria which must be met in order for a dry detention system to meet the District's requirements, including off-line detention volume, recovery time, outlet structure design, basin bottom and control elevations, length-to-width ratio, and maintenance requirements. Note that SJRWMD currently only permits off-line dry detention basins, which limits their application in some cases.

Potential Benefits of a Dry Detention Pond

- Reduction of downstream flooding problems by attenuating the peak rate of flow.
- Some removal of pollutant loadings to receiving bodies of water for suspended pollutants.
- Reduction in cost for downstream conveyance facilities.
- Creation of fill that may be used on site or sold (pond sediment removal).
- Low frequency of failure as compared with filtration systems.

Potential Limitations of a Dry Detention Pond

- Does not remove dissolved pollutants (nutrients) unless a permanent pool is included.
- Potential safety hazards if not designed and constructed properly.
- No permanent pool to store sediment inflow.

- Occasional nuisance problems such as debris and mosquitoes.
- Regular maintenance is required to prevent nuisance plant species from emerging and to remove accumulated sediments.
- Must be off-line.

4.2.1.2.3 Underdrain Systems

Stormwater underdrain systems consist of a dry basin underlain with perforated drainage pipe which collects and conveys stormwater following percolation from the basin through suitable soil. Underdrain systems are generally used where high water table conditions dictate that recovery of the stormwater treatment volume cannot be achieved by natural percolation (i.e., retention systems) and suitable outfall conditions exist to convey flows from the underdrain system to receiving waters.

A cross section of a typical underdrain system is shown in Figure 4-2. Underdrain systems are intended to control both the water table elevation over the entire area of the treatment basin and provide for the drawdown of the treatment volume. Underdrains are utilized where the soil permeability is adequate to recover the treatment volume since the on-site soils overlay the perforated drainage pipes.

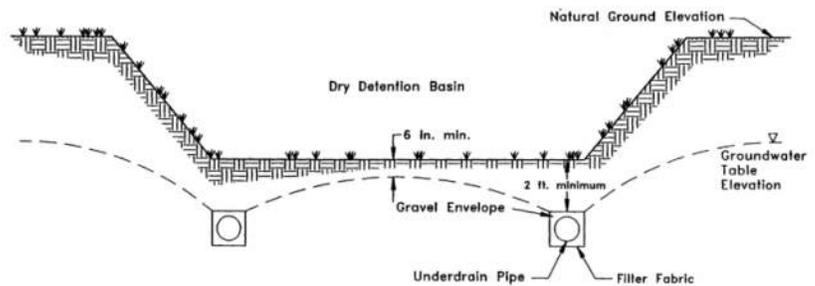


Figure 4-3. Typical Underdrain System Design (from SJRWMD)

There are several design and performance criteria which must be met in order for an underdrain system to meet SJRWMD requirements, including the following:

- The system should be designed to provide for the drawdown of the appropriate treatment volume within 72 hours following a storm event. The treatment volume is recovered by percolation through the soil with subsequent transport through the underdrain pipes.
- The system should only contain standing water within 72 hours of a storm event. The pipe system configuration (e.g., pipe size, depth, pipe spacing, and pipe inflow capacity) of the underdrain system must be designed to achieve the recovery time requirement.
- The underdrain system must be designed with a safety factor of at least two unless the applicant affirmatively demonstrates based on plans, test results, calculations or other information that a lower safety factor is appropriate for the specific site conditions.

4.2.1.2.4 Wet Detention Systems

Wet detention systems are permanently wet ponds which are designed to slowly release collected stormwater runoff through an outlet structure. A schematic of a typical wet detention system is shown in Figure 4-4.

There are several components in a wet detention system which must be properly designed to achieve the required level of stormwater treatment. A description of each design feature and its importance to the treatment process is presented below.

A wet detention system includes a permanent pool of water, a shallow littoral zone with aquatic plants, and the capacity to provide detention for an extended time necessary for the treatment of a required volume of runoff.

In wet detention ponds, pollutant removal occurs primarily within the permanent pool during the period of time between storm events. They are typically sized to provide at least a two-week hydraulic residence time during the wet season. The primary mechanism for the removal of a particulate forms of pollutants in wet detention ponds is sedimentation. Wet detention systems can also achieve substantial reductions in soluble nutrients due to biological and physical/chemical processes within the permanent pool such as uptake of nutrients by algae and rooted aquatic plants, adsorption of nutrients and heavy metals onto bottom sediments, and biological oxidation of organic materials.

Wet detention systems are usually more visually appealing than dry ponds, particularly if there is desirable wetland vegetation around the perimeter of the permanent pool. When properly designed and constructed, wet detention ponds are actually considered as property value amenities in many areas. Also, wet detention ponds offer the advantage that sediment and debris accumulate within the permanent pool. Since this accumulation is out-of-sight and well below the pond outlet, wet detention ponds tend to require less frequent clean outs to maintain an attractive appearance and prevent clogging. Sediment forebay areas (or sumps) are recommended whenever possible.

The City has several wet detention systems in use, but due to the land area needed for these systems they may not be suitable for future systems as undeveloped area is very limited within the City's boundaries.

Potential Benefits of a Wet Detention System

- Reduction of downstream flooding problems by attenuating the peak rate of flow.
- Reduction in pollutant loadings to receiving waters for dissolved and suspended pollutants.
- Reduction in cost for downstream conveyance facilities.
- Creation of local wildlife habitat.
- More aesthetically pleasing than dry detention/retention systems.
- Low frequency of failure.
- Can be used in areas with high water tables and less permeable soils.
- Pollutant removal can be optimized with pretreatment such as retention swales.

Potential Limitations of a Wet Detention Pond

- Land area needed to meet dimensional requirements.
- Potential safety hazards if not designed and constructed properly (gradual slide slopes are desirable).

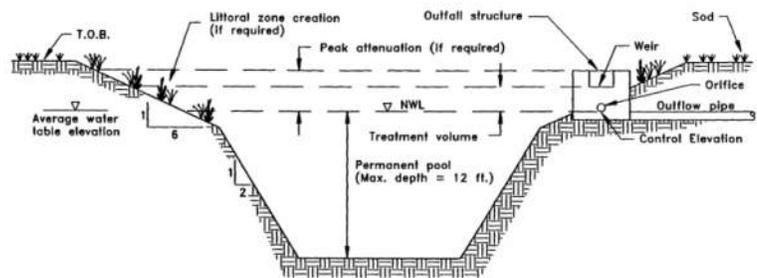


Figure 4-4. Typical Wet Detention System Design (from SJRWMD)

- Occasional nuisance problems such as odors, algae, debris, and mosquitoes.
- Regular maintenance of the littoral zone is required to control nuisance plant species.
- Recurring need for sediment removal from the permanent pool or sediment forebay.

4.2.1.2.5 *Wetland Systems*

Wetland systems incorporate either a natural or man-made wetlands area as part of a comprehensive stormwater management system in combination with other best management practices to provide treatment of runoff. The City's Stormwater Park was designed with a wetland system to improve nutrient removal and effluent quality. For these systems, the SJRWMD must ensure that a proposed wetlands stormwater management system is compatible with the existing ecological characteristics of the wetlands proposed to be utilized for stormwater treatment.

The only wetlands which may be considered for use to provide stormwater treatment are those which are:

- (a) Isolated wetlands; and
- (b) Those which would be isolated wetlands, but for a hydrologic connection to other wetlands or surface waters via another watercourse that was excavated through uplands.

The District must also ensure that water quality standards will not be violated by discharges from wetlands stormwater management system. To achieve these goals, specific performance criteria are set by the SJRWMD for systems which incorporate wetlands for stormwater treatment, including the required treatment volume, recovery time, maintenance of wetland hydroperiod, and others.

The design features of the system should maximize residence time of the stormwater within the wetland to enhance the opportunity for the stormwater to come into contact with the wetland sediment, vegetation, and micro-organisms (Livingston 1989).

Potential Benefits of a Wetland System:

- Reduction in pollutant loadings to receiving waters for dissolved and suspended pollutants.
- High-quality wildlife habitat
- Aesthetically pleasing

Potential Limitations of a Wetland System:

- Higher maintenance effort and cost – control of invasive species, periodic sediment removal, pump systems and control structure maintenance

4.2.1.2.6 Exfiltration Trenches

An exfiltration trench is a subsurface system consisting of a conduit such as perforated pipe surrounded by natural or artificial aggregate which temporarily stores and infiltrates stormwater runoff (Figure 4-5). Stormwater passes through the perforated pipe and infiltrates through the trench walls and bottom into the shallow groundwater aquifer. The perforated pipe increases the storage available in the trench and helps promote infiltration by making delivery of the runoff more effective and evenly distributed over the length of the system. Generally, exfiltration trench systems are utilized where space is limited and/or land costs are high (i.e., downtown urban areas).

Soil permeability and water table conditions must be such that the trench system can percolate the required stormwater runoff treatment volume within a specified time following a storm event. The trench system is returned to a normally "dry" condition when drawdown of the treatment volume is completed. Like retention basins, the treatment volume in exfiltration trench systems is not discharged to surface waters. Thus, exfiltration is considered a type of retention system.

The operational life of an exfiltration trench is believed to be short (possibly 5 to 10 years) for most exfiltration systems. Sediment accumulation and clogging by fines can reduce the life of an exfiltration trench. Total replacement of the trench may be the only possible means of restoring the treatment capacity and recovery of the system. Periodic replacement of the trench should be considered routine operational maintenance when selecting this management practice.

The City has a few exfiltration trench systems within its SWMS, but only on the east side of the Coastal Ridge, where the groundwater conditions are suitable. Due to the high groundwater conditions throughout most of the City and short operational life of these BMPs, they do not appear to be cost-effective and the City should consider other options.

Potential Benefits of an Exfiltration Trench

- They mimic the natural groundwater recharge capabilities of the site.
- Can fit into space-constrained areas of a development site, including under pavement.
- Can provide offline treatment for environmentally sensitive waters (e.g., Class I, Class II, or OFW).
- Can be used to retrofit already developed sites where space is limited

Potential Limitations of an Exfiltration Trench

- Require highly permeable soils to function properly.
- Highly susceptible to sediment and fines loading.
- Have relative short life spans before replacement or extensive restoration/maintenance of systems is required.
- Often more costly than other treatment alternatives, especially when operation and maintenance costs are considered.

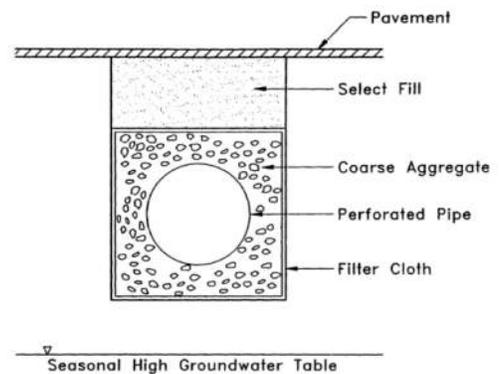


Figure 4-5. Typical Exfiltration Trench Design (from SJRWMD)

4.2.1.2.7 Grassed Swales and Channels

According to the SJRWMD, swales are a man-made or natural system shaped or graded to required dimensions and designed for the conveyance and rapid infiltration of stormwater runoff. Swales are designed to infiltrate a defined quantity of runoff through the permeable soils of the swale floor and side slopes into the shallow groundwater aquifer (Figure 4-6).

Turf is established to promote infiltration and stabilize the side slopes. Soil permeability and water table conditions must be such that the swale can percolate the desired runoff volume from the 3-year, 1-hour storm event. The swale holds water only during and immediately after a storm event, thus the system is normally "dry." Unlike retention basins, swales are "open" conveyance systems. This means there are no physical barriers such as berms or check-dams to impound the runoff in the swale prior to discharge to the receiving water.

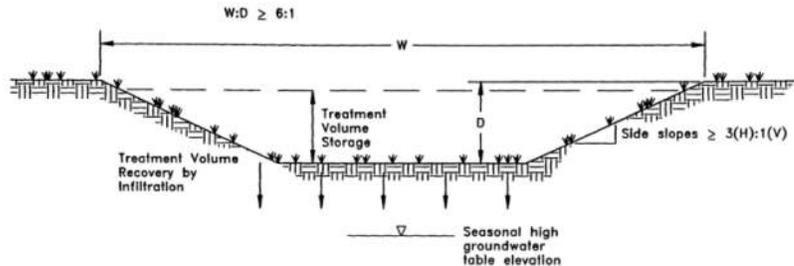


Figure 4-6. Typical Swale Design (from SJRWMD)

Swales are normally used for conveyance systems to transport runoff offsite or to a stormwater facility. They are best suited for sites with soils of moderate-to-high infiltration capacity (usually Hydrologic Groups A or B). Grassed swales and ditches are widely used throughout the City of Sebastian's SWMS, but only really serve as a conveyance structure in most areas because their infiltration capacity is greatly limited due to the high groundwater conditions.

Potential Benefits of Shallow Grassed Swales

- Usually less expensive than installing curb and gutters, and usually less expensive than other water quality treatment controls.
- Hardly noticeable if shallow swales (0.5 to 1.0 ft. maximum depth) are designed and constructed with gradual slopes (3:1 to 6:1).
- Can provide off-line treatment for environmentally sensitive waters (e.g., Class I, Class II, or OFW).
- Can reduce peak rates of discharge by storing, detaining, or attenuating flows.
- Can be used in space-constrained areas such as along lot lines, rear of lots, and along roads.
- Can be used as water quality treatment or pretreatment with other BMPs in a treatment train.

Potential limitations of Shallow Grassed Swales

- Due to the long growing season in Florida, grassed swales are maintenance intensive and incur significant recurring costs for mowing and sediment removal.
- Effective only as a conveyance system in unsuitable soils.
- Possible nuisances such as odors, mosquitoes, or nuisance plant species can occur if not designed, constructed, or maintained properly.
- Aesthetically unpleasing if improperly designed and constructed (deep with steep side slopes-looks like a ditch).
- May not be suitable or may require geotextile matting in areas that serve as vehicle parking areas.

4.2.1.2.8 *Inlet Filters*

Inlet filters are simple BMPs that are designed to fit under the grate in a storm inlet structure and capture and separate solids (i.e., soil, road grit, grass clippings, etc.) and certain pollutants, such as hydrocarbons, from stormwater runoff as it flows into a storm inlet structure. They help reduce the deposition of solids in conveyance pipes and improve water quality within the SWMS. Inlet filters can fit a variety of inlet structures and are readily available. One example of an inlet filter is shown in Figure 4-7 at right and is presented in the section below.

The Flogard™ Inlet Filter manufactured by Oldcastle Infrastructure is a specialized inlet filter used specifically for grated catch basins. The unit is made of stainless steel for long service life and durability. During a storm event, all incoming stormwater and solid material fall into the liner, which retains solid particles and causes pollutants to come in contact with absorbent material. Treated stormwater passes into the catch basin system, and the filter dries after each storm event. Collected debris is suspended and stored in a dry state above static water level until removed during service. According to the manufacturer, servicing only takes a few minutes and can be completed by simply lifting out the filter and dumping it into a container. No vactor truck is required, but recurring labor time and costs should be considered. The purchase price of a Flogard unit for a standard FDOT Type C inlet is approximately \$1,500.00.

Benefits:

- Will not impede inlet water flow
- Captures debris and sediment
- Bypass openings prevent clogging
- Minimal space requirements
- Quick service times at an average of 15 minutes or less.

Potential Limitations:

- High initial cost due to number of inlets (approximately 320 in City’s SWMS) but can be acquired a few at a time to reduce the capital costs.

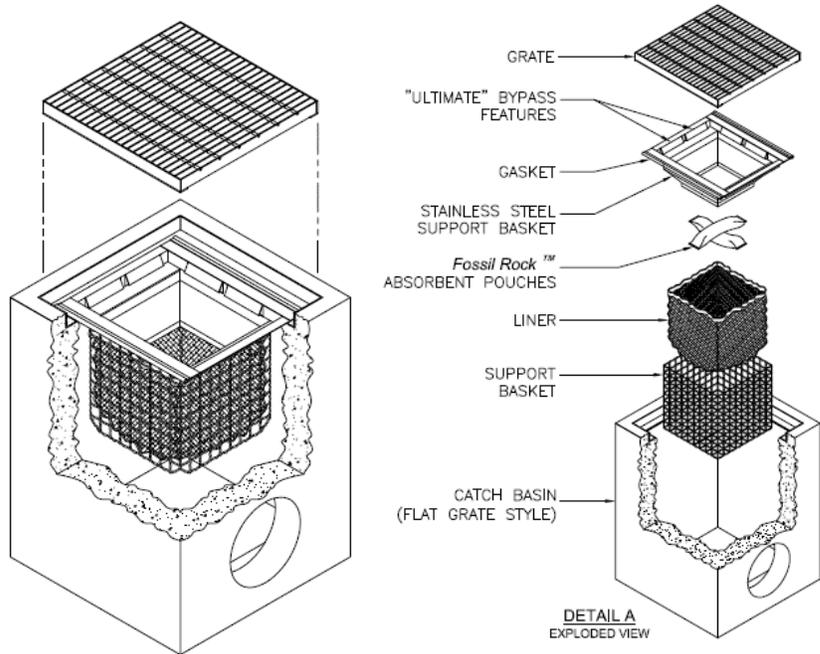


Figure 4-7. Flogard™ Inlet Filter and Exploded View

- Require consistent, regular maintenance cleaning. Units should be cleaned approximately every four weeks but maintenance scheduled should be adjusted depending on storm frequency and observed loading rates.

4.2.1.2.9 *Baffle Boxes*

Baffle boxes are typically installed near or at the storm sewer outfall. They typically consist of a rectangular concrete box divided into three chambers where floatables, sediment, grit, and oil are separated from stormwater runoff as it passes through the chambers before exiting through an outlet to the storm drain system. The first chamber is designed for sediment trapping, and the second chamber is designed for oil separation. Each chamber contains a permanent pool and is accessible through manhole covers. The City currently has eight baffle boxes in its SWMS.

A baffle box is a good choice for a water quality control device in areas where the other more traditional measures discussed previously may not be applicable due to various constraints. The design of a baffle box is identical to a primary clarifier with the addition of a skimmer for floatables. Target pollutant sizes are fine sands and larger size particles. There are limited percent pollutant removal data on these devices, but the sediment and debris removed can be quantified when the box is cleaned.

Maintenance requirements vary by device and application, but generally require a minimum of cleaning the chambers at least twice a year to remove pollutants. The City currently cleans its baffle boxes on a quarterly basis. Frequent maintenance is essential for the effective removal of pollutants using these systems. The cleaning process from these devices includes pumping out the contents of each chamber into a tank truck. If the entire contents are pumped out as a slurry, they are then transferred to a sewage treatment system. If the runoff is separated from the sediments by onsite siphoning, the sediments can be trucked to a landfill for final disposal. These maintenance operations can be costly.

4.2.1.2.10 *Aeration Systems*

The canals and ponds within the SWMS are shallow and warm, with very little water movement. Stormwater runoff during storm events washes pollutants like nitrogen and phosphorus into the water, and their concentrations increase, resulting in algal blooms, increasing BOD, reducing dissolved oxygen content, and many other issues. The City has a few surface aerators in the canals, but they have a low oxygen transfer efficiency and do not have much effect on overall water quality. Diffused aeration systems are much more effective at introducing oxygen to water, which increases oxidation reactions and can significantly reduce the concentrations of phosphorus, ammonia, BOD and COD, and promotes beneficial bacteria. Properly designed and constructed diffused aeration systems could significantly improve water quality and are economical to operate and maintain.

However, aeration systems are not currently eligible for BMAP nutrient reduction credit and should only be considered by the City if implementation is done in coordination with regulatory agencies and BMAP revisions that will result in City nutrient reduction credits. A pilot study using an aeration system in a canal segment might be a potential segway to regulatory acceptance for these systems, which have had demonstrated success improving water quality in canals and ponds in Florida.

4.3 State Water Quality Standards

State water quality standards are established by FDEP and are set forth in chapters 62-4, 62-302, 62-520 and 62-550, F.A.C. Surface and ground water discharges from stormwater management systems, works, and other projects may not cause or contribute to a violation of state water quality standards.

4.3.1 Surface Water Quality Standards

State water quality standards for surface waters are contained in chapters 62-4 and 62-302, F.A.C. The standards apply at the point of mixing of discharge from the system with waters of the State. All surface waters of the State have been classified according to designated uses as shown in Table 4-3. Water quality classifications are arranged in order of the degree of protection required, with Class I water having generally the most stringent water quality criteria and Class V the least. However, Class I, II, and III surface waters share water quality criteria established to protect fish consumption, recreation and the propagation and maintenance of a healthy, well-balanced population of fish and wildlife.

Table 4-3. Florida Surface Water Classifications

Surface Water Class	Description
CLASS I	Potable Water Supplies
CLASS I-Treated	Treated Potable Water Supplies
CLASS II	Shellfish Propagation or Harvesting
CLASS III	Fish Consumption; Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife
CLASS III-Limited	Fish Consumption; Recreation or Limited Recreation; and/or Propagation and Maintenance of a Limited Population of Fish and Wildlife
CLASS IV	Agricultural Water Supplies
CLASS V	Navigation, Utility and Industrial Use

The IRL and the South Prong of the St. Sebastian River are classified as Class II surface waters. Chapter 62-302.300(13), F.A.C. states that “...excessive nutrients (total nitrogen and total phosphorus) constitute one of the most severe water quality problems facing the State. It shall be the Department’s policy to limit the introduction of man-induced nutrients into waters of the State. Particular consideration shall be given to the protection from further nutrient enrichment of waters which are presently high in nutrient concentrations or sensitive to further nutrient concentrations and sensitive to further nutrient loadings...” In addition to nutrient loadings of total nitrogen and total phosphorus, dissolved oxygen levels play a critical role in the overall health of surface waters. A brief discussion of the importance of these parameters on water quality is in the sections that follow.

4.3.2 Nutrient Loadings (Nitrogen and Phosphorus)

According to the EPA, nutrient pollution is one of America’s most widespread, costly and challenging environmental problems, and is caused by excess nitrogen and phosphorus in the air and water. Nitrogen and phosphorus are nutrients that are natural parts of aquatic ecosystems. Nitrogen is also the most abundant element in the atmosphere. Nitrogen and phosphorus support the growth of algae and aquatic plants, which provide food and habitat for fish, shellfish and smaller organisms that live in water.

However, when too much nitrogen and phosphorus enter the environment, the air and water can become polluted. The primary sources of nitrogen and phosphorus from human activities include urban and agricultural runoff, wastewater treatment facilities, and septic systems. Septic systems are a particular concern in the City of Sebastian, as more than 90% of the residences are equipped with them. According to the EPA, when a septic system is improperly managed, elevated nitrogen and phosphorus levels can be released into local water bodies or ground water. An estimated 10 to 20 percent of septic systems fail at some point in their operational lifetimes. The sheer number of septic systems within the City and their typical failure rates make them a significant potential source of

nitrogen and phosphorus loading on the City's SWMS. However, this issue cannot be quickly or easily solved, because the City does not have sufficient wastewater treatment facility capacity or the sewer collection infrastructure necessary for a centralized sanitary sewer system. The City has a septic-to-sewer conversion program, but to date only a few of the existing septic systems have been eliminated.

Excessive nitrogen and phosphorus in the water causes algae to grow faster than ecosystems can handle. Significant increases in algae harm water quality, food resources and habitats, and decrease the oxygen that fish and other aquatic life need to survive. Large growths of algae are called algal blooms and they can severely reduce or eliminate oxygen in the water, leading to illnesses in fish and the death of large numbers of fish. Some algal blooms are harmful to humans because they produce elevated toxins and bacterial growth that can make people sick if they come into contact with polluted water, consume tainted fish or shellfish, or drink contaminated water.

Federal regulations related to nutrient pollution are expected to get more stringent, which will drive State regulations. In a memo dated April 5, 2022, EPA's Office of Water indicated plans to accelerate progress in controlling nutrient pollution in the nation's waters by scaling up existing, foundational approaches and more broadly deploying new data assessments, tools, financing approaches, and implementation strategies.

4.3.3 Dissolved Oxygen

The amount of dissolved oxygen (DO) an aquatic organism needs depends upon species, water temperature, and other factors such as the life stage of an organism. Oxygen demand is a measure of the oxygen used by microorganisms to decompose organic matter, and is expressed either as biochemical oxygen demand (BOD), chemical oxygen demand (COD), or nitrogenous oxygen demand (NOD).

- Biochemical oxygen demand is the amount of dissolved oxygen needed by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period. The BOD value is most commonly expressed in milligrams of oxygen consumed per liter of sample during 5 days of incubation at 20°C.
- Chemical oxygen demand (COD) is a measure of the amount of oxygen that can be consumed by reactions in a measured solution. It is commonly expressed in mass of oxygen consumed over volume of solution and expressed in milligrams per liter (mg/L).
- Nitrogenous oxygen demand (NOD) is a quantitative measure of the amount of dissolved oxygen required for the biological oxidation of nitrogenous material, for example, nitrogen in ammonia, and organic nitrogen in wastewater.

Waters that have adequate DO under natural conditions but that are impaired for DO typically have one or more anthropogenic sources of organic matter that create an oxygen demand. For urban stormwater, examples of organic matter sources include leaves and other yard wastes, pet and animal wastes, fertilizer, sediment containing organic matter (e.g. topsoil), and hydrocarbons (e.g. oil). A median value for BOD in stormwater runoff in urban settings is about 8 mg/L, while a median value for COD is about 22 mg/L.

According to the FDEP's TMDL report, multiple environmental factors control DO concentrations in the IRL. Theoretically, the DO concentration in a given waterbody can be influenced by temperature, salinity, flow, water depth, photosynthesis, respiration, sediment oxygen demand (SOD), the oxidation of organic carbon or inorganic reductants, and low DO ground water input. Typically, low DO concentrations were observed in the lagoon during the summer months (May to September). Occasional DO concentrations lower than 5.0 mg/L were also observed in other months, but with a much lower frequency. While temperature is an important factor responsible for changes in DO, saturation DO concentrations under the typical summer water temperature (28° C) and salinity

(above 3 percent) should still be higher than 6.0 mg/L, as long as no other chemical and biochemical processes are involved (Clescerl et al. 1999). Therefore, DO concentrations lower than 4.0 mg/L in the IRL most likely result from factors other than temperature and salinity.

Florida's Surface Water Quality Standards require that the DO concentration for Class II and III marine waters "shall not average less than 5.0 mg/L in a 24-hour period and shall never be less than 4.0 mg/L. Normal daily and seasonal fluctuations above these levels shall be maintained".

4.4 Total Maximum Daily Load (TMDL) Requirements

As mentioned previously, the FDEP defines a TMDL as a "scientific determination of the maximum amount of a given pollutant that a surface water can absorb and still meet the water quality standards that protect human health and aquatic life." The Indian River Lagoon (IRL) TMDLs are targeted towards seagrass regrowth at water depths where seagrass historically grew in the lagoon. The seagrass coverage in the IRL has decreased over the years because of the degradation of water quality conditions.

Chapter 62-304.520, FAC contains the IRL TMDLs, which are divided into several areas of the IRL. The TMDLs for the Central and southern South Indian River are 278,273 lbs/year of TN and 53,599 lbs/year of TP, which represent a 56% reduction of TN and a 48% reduction of TP based on the year 2000 land use.

As mentioned previously, the Central Indian River Lagoon (CIRL) BMAP addresses adopted TMDLs for certain tributaries to the CIRL, including the South Prong of the St. Sebastian River. Management actions provided by stakeholders, including projects, programs, and activities that may reduce nutrient loads to the CIRL, are included in the BMAP and have to meet several criteria to be considered eligible for credit.

The projects and activities in the CIRL BMAP are critical to the goal of recovering seagrass in the IRL, and their level of completion are tracked to show stakeholder efforts and progress towards the total required milestone reductions. FDEP conducts an assessment of progress towards the BMAP milestones every five years, and plan revisions are made as appropriate. FDEP has established milestones for the years 2025, 2030, and 2035 as follows:

- 5-year milestone in 2025: 35 % or 320,614 lbs/yr of TN and 77,290 lbs/yr of TP.
- 10-year milestone in 2030: 70 % or 641,228 lbs/yr of TN and 154,580 lbs/yr of TP.
- 15-year milestone in 2035: 100 % or 916,040 lbs/yr of TN and 220,828 lbs/yr of TP.

4.5 Water Quality Model Evaluation

4.5.1 Water Quality Model – SWIL

The original BMAP nutrient loads were estimated using the Pollutant Load Screening Model (PLSM) and represented year 2000 loading in most of the IRL Watershed. SJRWMD developed the seagrass depth limits based on historical aerial photographs of the IRL from 1943 through 2001. FDEP used the PLSM and the seagrass depth limits to develop the IRL TMDLs that were adopted by rule.

After the TMDLs were adopted, several MS4 permittees within the IRL Watershed expressed interest in creating a new watershed model to improve upon the PLSM, which resulted in the development of the Spatial Watershed Iterative Loading (SWIL) Model. The SWIL model was proposed to FDEP as an alternative to the PLSM to calculate allocations for the IRL BMAPs and was selected for use. The sections below provide a brief summary of the SWIL modeling and the processes used to update the TMDLs. For more detailed information, please refer to the Indian River Lagoon Basin Central Indian River Lagoon BMAP (FDEP, 2021).

As mentioned previously, the TMDLs for the IRL (in Rule 62.304.520, F.A.C.) include a 56% reduction of TN and a 48% reduction of TP from their starting loads. The TMDL allocations were calculated in two steps, first by using the SWIL Model to establish the total TN and TP load, by project zone. To accomplish this, rainfall inputs from a representative period were used to simulate a wide range of rainfall patterns and amounts over a multi-year period. The SWIL outputs were used to generate a GIS-based Load Estimation Tool (LET) that included annual average loads from the watershed. The LET was then used to calculate updated TN and TP baseloads from all existing project treatment areas in the BMAP. To account for stakeholder credits for the various project types, the August 2020 FDEP BMP Efficiencies Guidance document was used to determine the appropriate credit calculations.

The second step in determining the TMDL allocations was to apply the respective TMDL percent reduction for TN or TP to the starting load, which resulted in the TN or TP reduction value. The TN and TP allocations were then calculated by subtracting the TN or TP reduction value from the TN or TP starting load. Additional adjustments were made to account for TN and TP loads from natural land areas.

Once the total required reductions for each project zone were determined, the percentage of each stakeholder's anthropogenic load relative to the total anthropogenic load for the project zone was calculated to determine their loading contribution, and the percentage of the project zone's required reduction was applied to stakeholders accordingly.

4.5.2 Water Quality Conclusions/Recommendations

The Indian River Lagoon TMDLs were determined by the SWIL model and are included in Chapter 62-304.520, FAC and divided into several areas of the IRL. The CIRL BMAP was developed to specifically address how the total required nutrient reductions would be achieved by the stakeholders in the four CIRL project zones by 2035. To date, the overall progress for TN and TP reductions over all four CIRL BMAP project zones relative to the established milestones appears to be on track. Figures 4-8 and 4-9 show the latest results for Project Zone SEB, which includes the City of Sebastian, where the FDEP reported a 23% reduction of TN load and a reduction of 51% of TP load allocated to Project Zone SEB from stakeholder projects completed through July 31, 2020.

Under the CIRL BMAP, the City of Sebastian's allowable loadings were established as shown in Table 4-4. To accomplish this, the City proposed several management actions (projects) that were included in the BMAP. To date, 16 projects have been completed by the City or are currently underway, resulting in load reduction credits of 5,223 lbs./year of TN (15.7% of required reduction) and 620 lbs./year of TP (10.3% of required reduction).

While the City's performance appears to be lower than the overall progress reported for CIRL Project Zone SEB, it should be noted that the City has not yet received reduction credits for seven completed projects, including the Stormwater Park. That single project may account for a significant part of the City's required reduction goals.

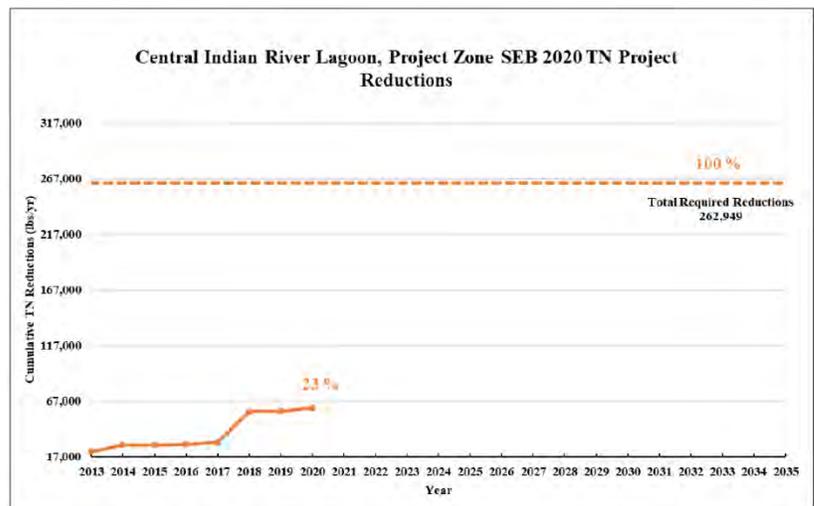


Figure 4-8. CIRL Project Zone SEB - TN Reductions Progress (2020)

The FDEP conducts an annual review of BMAP implementation efforts, and during that review project-specific information may be revised and updated, resulting in changes to the estimated reductions for those projects. The revisions may increase or decrease estimated reductions, and FDEP will work with stakeholders to address revisions as they are identified. In addition, there are several CIP projects eligible for reduction credits included in this master plan that may be proposed by the City as management actions in future updates of the CIRL BMAP.



Figure 4-9. CIRL Project Zone SEB - TP Reductions Progress (2020)

Table 4-4. City of Sebastian TN and TP Required Reductions and Allowable Loadings

Parameter	Starting Load (lbs./year)	Anthropogenic % in CIRL BMAP	Required Reduction (lbs./year)	Required Reduction (%)	Allowable Load (lbs./year)
Total Nitrogen (TN)	61,820	3.86	33,196	53.7	28,264
Total Phosphorus (TP)	8,901	3.84	6,015	67.6	2,886

The City of Sebastian appears to be meeting the allowable loads for TN and TP established in the CIRL BMAP. However, as additional development occurs, additional projects will be needed to ensure ongoing compliance with BMAP requirements.

Some possible projects that could be considered for the BMAP include the following:

- Additional dry detention areas
- Dredging of sediment from existing retention/detention ponds
- Reduction of canal water surface elevation to reduce peak discharge
- Blossom Ditch Drainage Improvements (CIP Project 24) – addition of a Baffle Box to the existing outfall to improve water quality.