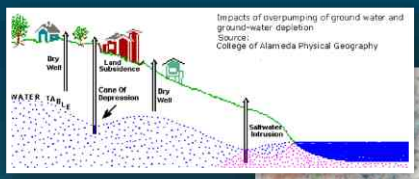
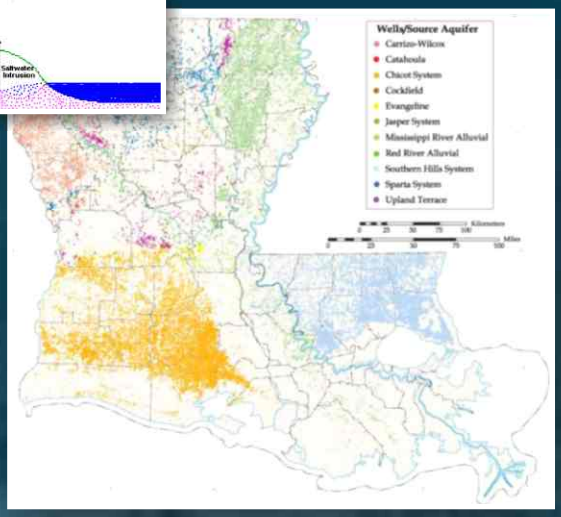
Executive Summary

Recommendations for a Statewide Ground Water Management Plan

December 7, 2011

DNR Contract No. 2215-10-04





Prepared for

Office of Conservation
Louisiana Department of Natural Resources

Prepared by

ecology and environment, inc.
Global Environmental Specialists

Executive Summary

Foreword

In 2002, the Louisiana Ground Water Resources Commission (LGWMC), Ground Water Management Advisory Task Force, and Commissioner of Conservation developed a report titled *Assistance in Developing the Statewide Water Management Plan*. The report was necessitated by the need to develop rules and regulations governing the determination of critical groundwater sources, emergency situation responses, conservation of groundwater resources, and related matters.

Furthermore, the report became the basis for promulgating Act 49 of 2003 regarding surface and groundwater management and conservation. Act 49 of the 2003 Legislative Session directed the Commissioner of Conservation and State of Louisiana to develop a statewide groundwater resource management program that would evaluate current and projected demands, water use conservation programs, alternatives to groundwater use, incentives for conservation, alternative technologies, and education programs.

This Executive Summary follows the same basic outline of the Recommendations for a Ground Water Management Plan document (document) but is condensed to provide a basic level of understanding to focus more specifically on the major findings and recommendations contained within the document's chapters.

Introduction

Conservation and sustainability of groundwater and surface water resources, hereinafter referenced as "water resources", are the focal points of this document. Recent increases in water demand due in part to persistent drought conditions, especially for the northern region of the state, have precipitated a renewed public interest in how the state's groundwater and surface water resources are managed. For purposes of this document, sustainability shall mean that water demand generally does not exceed supply. As such, a comprehensive approach, from updating the water resources baseline conditions to evaluating possible cost-effective water-resource alternatives, is necessary to ensure that water resources are utilized judiciously and in a sustainable manner.

This document contains a compilation and thorough review of the statewide databases on water uses. The State's current system of water use reporting from various users' needs was reviewed in this report. Recommendations for future use and policy are included herein. Among these, the most important encompass the following themes:

- Develop more stringent and discrete well registration and evaluation processes to ensure that conservation and sustainability of water resources are achieved.

- Educate consumers on methods to conserve water resources and how can they benefit from them.

- Build awareness among all water users regarding the value our water resources.

- Develop surface water programs to engage all stakeholders.

- Create potential incentives that can be made available to water resource users.

- Consider initiating discussions on framing and implementing an adequate fee structure for major water users.

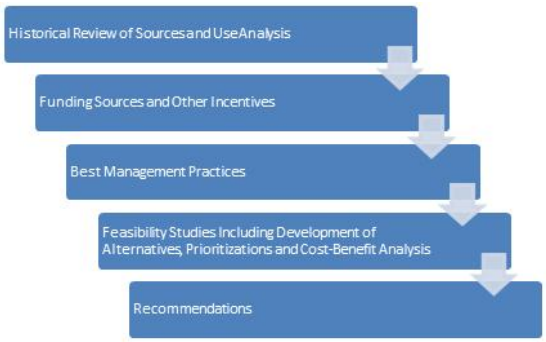
- Develop mechanisms assisting State agencies to forecast groundwater and surface water demands for short- and long-term needs such as coordination and data sharing among monitoring agencies, United States Geological Survey (USGS), Louisiana Department of Natural Resources (LDNR), Louisiana Department of Environmental Quality (LDEQ), and Louisiana Department of Transportation and Development (LDOTD).

- In tandem with the LDNR on-line information system, develop and implement a geographic information system (GIS)-based database to monitor and adaptively manage the resources.

In addition, considered in this document were cost-effective alternatives to groundwater and the use of groundwater from sustainable aquifers; using non-potable surface and groundwater for industrial purposes; and innovative funding mechanisms.

Consideration of innovative ways of conserving and re-using surface and groundwater resources are of paramount importance. This document focuses on conservation and sustainability, and is consistent with the State's vision to preserve the quality and sustainability of its groundwater resources.

The management plan recommendations contained in this document have been developed using a strategic planning process. The strategic planning process is a process by which a plan or vision is formulated to solve an identified problem; decisions are then made on how to best allocate funds and resources to achieve and implement that plan.



Regulatory Setting

Prior to 2001, there was no statewide ground water law, other than a 1972 law authorizing the (LDOTD) Department of Public Works to regulate wells drawing more than 50,000 gallons per day. In 2001, Act 446 provided for a commission and a task force to develop comprehensive ground water law. Act 446 also defined 'critical ground water area' and provided for a process for designation of these areas. In 2003, Act 49 (Louisiana Revised Statutes [R.S.] 38:3097.1-3097.6) modified or eliminated provisions of earlier laws and became the basis for ground water law in Louisiana. Louisiana's ground water and its management is described in Title 43, Natural Resources, Part VI. Water Resource Management, Subpart 1, Ground Water Management. For a detailed description of legal regimes applicable to surface water and ground water in the State of Louisiana including private property rights, refer to the ADSWMP, 2002.

Water Resources Setting

A broad review was performed on historical information from various sources regarding Louisiana's groundwater and surface water management and conservation goals. The literature search was compiled and organized by region and water sources such as groundwater or surface water. In addition, Louisiana Geological Survey (LGS) conducted a review of surface and groundwater resources for this plan. Furthermore, Louisiana aquifers have been studied by the LGS, USGS, and others for more than 80 years. State watersheds have been studied by the United States Army Corp of Engineers (USACE), the USGS, and others for more than 100 years.

Several data sets combining large amounts of hydrologic, hydrogeologic, and water chemistry data are available. For example, the LDNR maintains water well registration and notification databases; the USGS maintains the National Water Information System; the LDEQ maintains the ground water quality and surface water quality databases; and the United States Environmental Protection Agency (USEPA) and the Louisiana Department of Health and Hospitals (DHH) maintain the safe drinking water program databases.

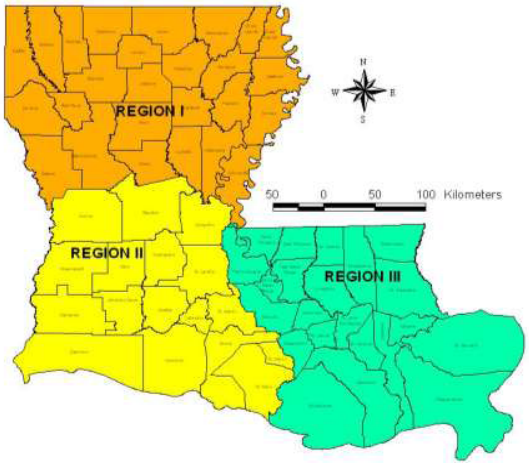
Groundwater flow models have been developed since the 1980s addressing water issues throughout the state. However, most of the models were used for a specific project. With a few exceptions, none have been updated. Few models were developed to holistically study a regional aquifer system, and none were designed to telescope from the regional to a smaller (e.g. sub-parish) scale.

There are approximately 11 aquifer systems that are commonly used for public, domestic, industrial, and irrigation water supplies. These aquifer systems can be grouped within regions established in the *Assistance in Developing the Statewide Water Management Plan*; *Water System Master Plan (ADSWMP).*

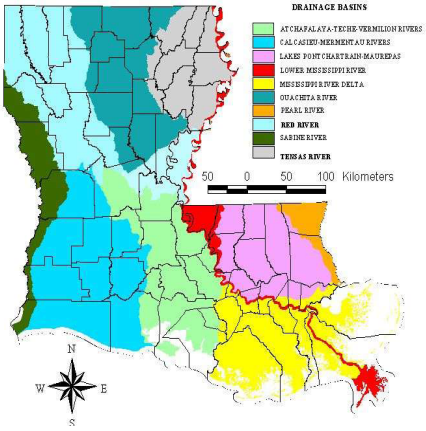
- Within Region I, the Carrizo-Wilcox aquifer and Red River Alluvial aquifer dominate the west, the Sparta Aquifer the center and the Mississippi River Alluvial aquifer the east, with the Upland Terrace aquifer, Catahoula aquifer, and Cockfield aquifer as secondary groundwater sources.

- Within Region II, the Chicot aquifer system is dominant with the Evangeline aquifer, Jasper aquifer system, and Catahoula Aquifer as secondary groundwater sources.

- Within Region III, the Southern Hills aquifer system is dominant with the Mississippi River Alluvial aquifer as secondary groundwater resources.



ADSWMP Regional Classification



Principal Drainage Basins of Louisiana (LGS 2010)

There are 10 recognized surface watersheds in the State of Louisiana including the Atchafalaya /Teche/Vermilion Rivers; Calcasieu/Mermentau Rivers; Lake Pontchartrain/Lake Maurepas; Lower Mississippi River; Mississippi River Delta; Ouachita River; Pearl River; Red River; Sabine River; and Tensas River.

In addition, from West Feliciana Parish, the Lower Mississippi River in Louisiana is confined by levees and has a very small basin area. With the exception of the Red River and smaller bayous in West Feliciana and northwestern East Baton Rouge Parishes, no other Louisiana tributaries flow into the Mississippi River.

Groundwater Resource Use and Impacts

An analysis was conducted of the historic and current (1960-2005) water (surface and groundwater) consumption trends for the diverse universe of water users in the state, including the recent gas development activities in the northern portion of the state.

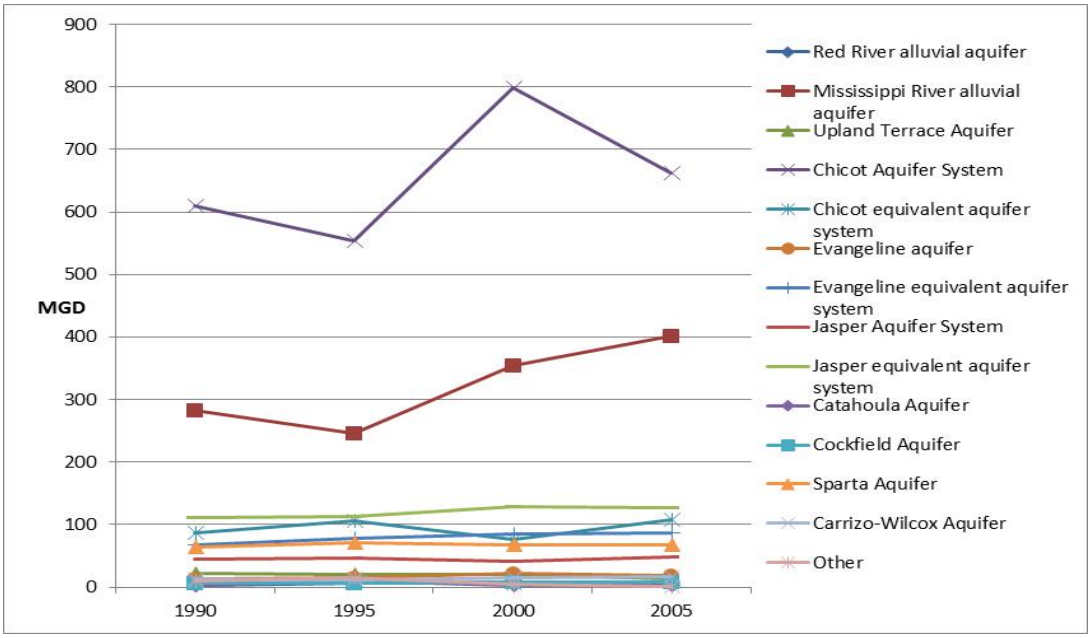
Total water (both surface and groundwater) use in Louisiana increased from 5,417 millions of gallons per day (MGD) in 1960 to a peak value of12, 500 MGD in 1980, but decreased by 3,000 MGD by 1990. The USGS is currently in the pro-

cess of compiling data for 2005-2010, thus only the 2010 USGS aggregate statewide water use data for groundwater aquifers are used in this plan.

Water use in the three regions of Louisiana generally followed the total statewide water use trend, except for Region I where a decrease in water use between 1965 and 1970 was documented before reaching its peak value like Regions II and III in 1980. Water use in the state increased moderately in the 1990s reaching a total of 10,400 MGD by the year 2000.

The two primary total water user groups in Louisiana are power generation and industrial use, accounting for over 80 percent (%) of total water use in the State in 2005. As expected, overall water use for the public supply consumer has increased during each of the USGS/LDOTD's water use surveys.

Surface water accounts for over 80% of the source of water for the primary user groups. Over this time frame (1960-2005), total pumpage reached a peak of 12,500 MGD in 1980. Groundwater and surface water use decreased in the 1985



Groundwater Use by Aquifer (LGS, 2007; E&E, Current Study)

and 1990 reporting periods. However, since 1995, both surface and groundwater use show modest increases, returning to 1985 levels.

Of the total water use (10, 298 MGD) in 2005, approximately 15% was pumped from groundwater and 85% was pumped from surface waters. When examined by source, for 2005 the primary ground water users are:

- Rice irrigation (33%)
- Public supply (22%)
- Industry (17%)

- Aquaculture (13%)
- General irrigation (10%)

Groundwater and surface water use follow similar trends and both resource uses peaked in 1990. Groundwater use in Louisiana follows a similar trend as that of surface water with a peak use in 1990 of 1,780 MGD.

As of the 2005, Region I continues to be the primary user of groundwater. Region II accounts for nearly 60% of the groundwater pumpage in the state. Approximately 20% of the pumpage is recorded in Regions I and III and since 1980 Regions I and III roughly exhibit the same percentage of groundwater usage.
The population of Louisiana grew from 3.25 million in 1960 to an estimated 4.49 million in 2009. Most of the growth occurred between 1960 and 1980 where the population increased by more than 949,000 (29%). Growth flattened out between 1980 and 2000 due to out-migration in the state resulting from the stagnant economic conditions during that time period, with the population increasing by just six percent. The population of Louisiana is projected to grow from 4.5 million in 2010 to 4.8 million by 2030 (2010 Census).

The 1960-2005 surface water and groundwater total withdrawals by parish reflect the population trends described above. A steep rise in withdrawals is evident for the 1960-1980 period with the concomitant decrease in the 1980-1995 period. Interestingly, there appears to be a steeper rise of groundwater withdrawals from 1995-2005 than surface water withdrawals during the same period; this increase is reflected in all three regions, especially in Region I where the historical trend of surface water use versus groundwater use has been a steady inverse relation.

The Haynesville Shale gas formation, located in East Texas, Southwestern Arkansas and Western Louisiana, encompasses over 9,000 square miles and is considered to be the second largest natural gas shale formation in the United States (LDNR, 2011). Water is an essential component of shale natural gas development. Drilling a typical Haynesville deep shale gas well requires approximately 600,000 gallons of water, while hydraulically fracturing a typical Haynesville horizontal deep shale gas well requires an average of five million gallons of freshwater per well. Initially, developers decided to use fresh water from the Carrizo-Wilcox aquifer, which was met with swift opposition and complaints by local residents, including complaints of local water level drawdowns in wells.

In Louisiana, the Office of Conservation is responsible for monitoring the impacts that exploration and production of deep shale gas and oil formations have on ground water resources. The Office requires notification to the Commissioner of Conservation prior to drilling or using water wells hydraulic fracturing of shale formations to retrieve natural gas.

In the late summer of 2008, the Commissioner of Conservation provided additional clarification concerning notification requirements for all ground water use at oil and gas exploration and production facilities throughout the state. Additionally, the Commissioner further encouraged oil and gas operators to use available

surface water resources or other acceptable alternative water sources in Northwest Louisiana whenever possible. Industry has responded positively to this request.

Many fracking wells have been drilled. Many wells have been permitted to drill and many more will be permitted to extract natural gas. This management plan takes into account the potential scale of impacts resulting from Hayenville Shale operations and similar efforts in the state.

In addition, the State is aware of the implications of future drought impacts combined with prospective fracking permits. The State of Louisiana is also aware of the importance of climate events and changes while managing water resources.

Based on review of groundwater use data and other pertinent public record or published literature, real and potential adverse impacts to Louisiana's major aquifer systems water quality or sustainability were identified and summarized in the following table:

Table E-1: Summary of the Aquifer Impacts

Aquifers	Region	Location	Impacts
Mississippi River Alluvial aquifer (North)	**I**		
		Aquifer wide	Water quality (total dissolved solids [TDS], metals)
		Franklin Parish, SE Ouachita Parish	Naturally-occurring chlorides
Mississippi River Alluvial aquifer (South)	**III**	Coastal Parishes	Saltwater intrusion from Gulf of Mexico and potential upward migration of saltwater
		Sporadic throughout	Occurrence of natural gas in shallow sands
		Aquifer wide	Agricultural applications (pesticides/herbicides, fertilizers) Water quality (TDS, metals) Naturally-occurring chlorides
Chicot aquifer system	**II**	Iowa, LA	Shallow saltwater, possibly from Iowa Salt Dome
Chicot Equivalent aquifer system	**II**	Lake Charles	200 ' and 500' sand have been impacted by water level decline from industrial activity/over pumping
		Lake Charles	200 ' and 500' sands exhibit the presence of natural gas
		Lake Charles	700' sand is being impacted by saltwater intrusion
		Opelousas	Possible saltwater intrusion from naturally-occurring chlorides, salt domes in the area
		Coastal Zone	Saltwater intrusion from Gulf of Mexico, subsidence, and land loss
		Eastern edge of Chicot	Contact with Atchafalaya Aquifer provides potential increased TDS impact
Jasper aquifer system	**II**	Leesville	Water level decline
Jasper Equivalent aquifer system (Central Louisiana)	**II**	Alexandria	Water level decline
Cockfield Aquifer	**I**	Southern Winn/Northern Grant Parishes	Water level decline
Sparta aquifer	**I**	Monroe	Water level decline and increased chlorides
		Ruston	Water level decline and increased chlorides

Table E-1: Summary of the Aquifer Impacts

Aquifers	Region	Location	Impacts
		Minden	Water level decline
		Jonesboro Hodge	Water level decline
		Winnfield	Water level decline and increased chlorides
Carrizo- Wilcox aquifer	**I**	Sporadic Throughout	Water level decline and increased TDS/chlorides
		South of Shreveport	Water level decline
Southern Hills aquifer system	**III**	Baton Rouge	Water level decline and saltwater intrusion
		Bogalusa	Water level decline

Note: TDS = Total Dissolved Solids (hardness)

Water Well Prior Notification Requirements

A review was conducted of water well notification law under the Louisiana R.S. 38:3097.3.C (4)(a) requiring that an advance notification of intent to drill a water well be submitted by the well owner to the Commissioner of Conservation at least 60 days prior to drilling the well for certain wells.

Based on this review, recommendations are provided in the Plan to improve not only the water well notification and review procedures, but also streamline the registration and tracking of wells from inception to plugging and abandonment:

- Under Louisiana R.S. 38:3097.3.C (4) (a) it is the responsibility of the well owner to file the water well notification. Perhaps this responsibility could be placed on the driller, since most well owners would be unfamiliar with the requirements. Until notification changes are accepted, it is recommended the well drillers notify well owners of the requirement, allow the assistance of the driller in filing the well notification, and introduce regulations that penalize drillers that install wells without proper approval from LDNR.

- The agency should investigate the feasibility of developing a refined drawdown calculation that could be integrated into a GIS macro within the Strategic Online Natural Resources Information System (SONRIS) system to automate the review.

- Current static water level gradient maps need to be maintained as feasible to accurately identify potential impacts caused by new significant drawdown within an aquifer. These maps could be integrated into the SONRIS GIS system, either as a functional or reference layer, to ensure the relative static water levels are utilized when calculating relative drawdown from proposed wells.

- Because the Water Well Notification form , Water Well Registration Long Form , Water Well Registration Short Form , and even the Well Plugging and Abandonment Form share a significant percentage of common data, it should be possible to make these into one unified form with separate sections for the unique data on each of the original forms. These forms could be integrated in-

to SONRIS to allow for online data submittal and quicker review by appropriate parties, as needed.

- Finally, the well identifier should be maintained from the well notification through the plugging and abandonment of the well. Each well should receive a unique identifier consisting of the parish Federal Information Processing Standard (FIPs) and the sequential well number for that parish. This would allow for a well to be located by its identifier (currently not possible in SONRIS).

Groundwater Management and Sustainability Measures

According to the USEPA (USEPA 2009) aquifers in central Louisiana experienced extended water level declines over the last few decades, but have begun to recover as the result of effective water use registration, evaluation, permitting and conservation programs. These efforts include public education, promotion of conservation and water use permitting in certain areas. Similarly, this same USEPA report indicates the overall use of groundwater in Louisiana has declined from approximately 2,800 MGD pump rate in 1980 to approximately 1,500 MGD, which is approximately the same as the 1960 rates.

However, as described earlier, impacts to the various aquifers in the state due to practices such as over-pumping are still occurring. Among these impacted aquifers, Sparta Aquifer and Chicot Aquifer systems are affected the most and the impacts can be classified as major while Jasper, Cockfield, and Carrizo-Wilcox aquifers are impacted only on a medium level.

Highly Impacted Aquifers:

- Sparta aquifer
- Chicot aquifer system

Less Impacted Aquifers:

- Cockfield aquifer
- Carrizo-Wilcox aquifer
- Jasper aquifer

The impacts to these aquifers impacts are discussed below.

Agricultural applications (pesticides/herbicides, fertilizers): Agricultural activities that cause groundwater impacts include confined animal facilities, pesticide spraying, and fertilizing. The major agricultural impacts that result from these activities are nutrients, pathogens, pesticides, herbicides, and salts. Agricultural applications and related water quality issues are discussed in water resources monitoring programs. Occasionally industrial activities and related water quality issues are mentioned in relation to groundwater. This may be due to the non-point pollution potential of agricultural applications as compared to point source pollution

potential of industrial activities. Point-source pollution is generally well monitored and regulated.

Salt water intrusion: Saltwater intrusion is the movement of saline water into freshwater aquifers. Most often, it is caused by groundwater pumping from coastal wells or from construction of navigation channels or oil field canals in coastal marshes in addition to other causes. Saltwater intrusion occurs in virtually in all coastal aquifers, where they are in hydraulic continuity with seawater or deeper downdip where the aquifers are saline.

Natural Gas: Natural gas may enter groundwater through natural or industrial processes. Natural gas contains mostly methane, however, since it evaporates out of water, methane is not usually considered to present a health threat in drinking water. However, methane gas can become harmful if it escapes from water and becomes an explosive hazard. Other components of natural gas may be harmful to water quality.

Water level decline: Water level decline can occur on a local scale by withdrawing water at a rate higher than the annual aquifer recharge rate resulting in depleting the aquifer over time and causing cones of groundwater depression.

In this document several alternative actions are identified to mitigate these impacts to the State's aquifers. These actions include the development of specific water infrastructure project alternatives and the implementation of groundwater Best Management Practices (BMP).

These infrastructure alternatives are summarized in the following table.

Table E-2: Alternatives for Impacted Aquifers

Chicot System	Jasper System	Cockfield	Sparta	Carrizo-Wilcox
Wastewater Recycling	Wastewater Recycling	Wastewater Recycling	Wastewater Recycling	Red River Surface Water/Increased Use of Red River Alluvial Aquifer
Reservoirs for Rain Harvesting Conservation Measures	Reservoirs for Rain Harvesting Construction of pipelines for Pipeline Conveyance of Red River Water Conservation Measures	Reservoirs for Rain Harvesting Conservation Measures	Reservoirs for Rain Harvesting Construction of Pipelines for Conveyance of Ouachita River Water, and Surface Water from Lake D'Arbonne Reuse of Groundwater Conservation Measures	Reservoirs for Rain Harvesting Conservation Measures

E&E, 2011, this study

The BMPs were identified from several sources including Federal, State, Local plans, guidelines, and standards of practice. Implementation of BMPs will require capital resources. As such, Tax structures may be suitable for Louisiana to reduce the cost of implementing alternative BMP measures to reduce groundwater depletion. The BMPs considered in this document can be grouped in three major areas as follows:

Demand Management: "Demand management is purposeful and beneficial manipulation of level and timing of water usage" (Water Encyclopedia). Programs of demand reduction are also referred to as Water Demand Management (WDM). WDM applies selective economic incentives to promote efficient and equitable water use, and identifies water conservation measures that are aimed at raising local and regional awareness of groundwater sustainability issues. WDM advocates a wide range of measures that go beyond conservation to broader sustainable resource management. It applies to the protection of water quality sources; reduction of wastage both in infrastructure leakage and by users; improvement of water allocation among competing uses, and creation of appropriate pricing mechanisms.

Supply Augmentation: There are several methods for augmentation of water supply sources. The traditional methods include the use of storage structures on land such as dams, ponds, etc. Another method is the induced recharge of aquifers by artificial methods. The use of desalination plants is also another unconventional source of fresh water.

Water Reuse: According to the USEPA water recycling is reusing treated wastewater for beneficial purposes such as agricultural and landscape irrigation, industrial processes, toilet flushing, and replenishing a groundwater basin (referred to as groundwater recharge). Water recycling offers resource and financial savings. Wastewater treatment can be tailored to meet the water quality requirements of a planned reuse. Recycled water for landscape irrigation requires less treatment than recycled water for drinking water.

Based on the groundwater use analysis, identification of aquifer impacts and review of mitigation strategies provided in this document, the following are the more immediate recommendations addressing the aquifer impact issues identified in Table E-1.

As a short term measure (0-5 year), BMPs (Demand Management; Supply Augmentation; and Water-Reuse) programs are recommended for the two aquifers that have recently been identified as requiring more immediate attention at this time, mainly:

- The Sparta aquifer, and
- The Carrizo-Wilcox aquifer

These mitigation strategies should encompass:

- Demand management programs to:
  - Protect water quality
  - Reduce wastage ([e.g. conveyance leakage] by all users)
  - Implement conservation measures
- Supply Augmentation to:
  - Develop surface water projects such as reservoirs
  - Develop induced recharge in conjunction with impoundments projects and
  - Identify usable sustainable surface water sources.
- Water Reuse to:
  - Plan and implement urban storm water capture and recycle programs with cities and municipalities, and
  - Assess current wastewater streams for conjunctive use and alternative for grey-water use program

The experience developed in planning and implementing the BMP in the Sparta and Carrizo Wilcox aquifers will be invaluable in developing similar programs across the state.

Supply Gap Estimation and Alternatives Implementation

The implementation of the alternatives described in this plan requires infrastructure development, which involves capital and operations and maintenance (O&M) costs. To that end, a supply gap analysis as well as a preliminary a cost model developed to assess the economic feasibility of the alternatives was prepared. In addition, in this section federal, state, and local funding sources that could be applied to fund the water infrastructure alternatives are identified and summarized.

It is recognized that alternatives have to be developed and implemented to meet the additional demand for groundwater that is being pumped from the impacted aquifers. This additional demand is estimated as a supply gap and is defined as the amount of groundwater that is to be replaced by alternative sources of water. The supply gap is calculated by determining current sustainable yields of impacted aquifers. Summarized in the following table are the estimated supply gaps of impacted aquifers based on 2010 water use.

Table E-3: Estimated Supply Gaps of Impacted Aquifers

Aquifer	2010 Level Use* (MGD)	Sustainable Use as of 2010 (MGD)	Current Gap (MGD)	Current Gap MGD/yr.
Chicot aquifer system	757.9	416.9	341.0	124,468
Jasper aquifer system	184.9	101.7	83.2	30,375
Cockfield aquifer	6.9	3.8	3.1	1,135
Sparta aquifer	64.9	35.4	29.6	10,785
Carrizo-Wilcox aquifer	19.5	10.7	8.8	3197

*USGS, 2011 (personnel communication)

Groundwater availability models (GAM) or groundwater yields models are not available in Louisiana for aquifers in general and impacted aquifers in particular.

The supply gap estimation was carried out for impacted aquifers are based on several assumptions and on one study on Sparta aquifer (McKee et al., 2004). McKee determined that the supply gap for the Sparta Aquifer is approximately 45% of the 2002 water use. Sparta Groundwater Study (2004) forecasted approximately 45% of the current water use (2010) as supply gap for Sparta aquifer. Chicot aquifer system shows a withdrawal of approximately 370 MGD during the rice farming season that is responsible for considerable water level decline (Lovelace, 2004; USGS, 2005). This decline can be assumed as supply gap and is approximately 50% of the sustainable yield.

From the above observations, it can be assumed that 45% of the 2010 water use for Sparta aquifer and Chicot aquifers can be assumed as supply gap. 45% of the 2010 water use is also considered as supply gap for other less impacted aquifers. This assumption is on the conservative side. As part of a framework such as this document, this approach may be sufficient. However, detailed availability modeling and yield estimations for aquifers are necessary to evolve adequate sustainable management decisions for groundwater resources.

In the absence of current groundwater availability models for aquifers in Louisiana, it is suggested that the McKee approach, detailed in this document, is the best way to obtain a feasible forecast and estimate sustainable yields. Ideally, once the alternatives for groundwater are implemented, the sustainability of each aquifer can be reevaluated along with the information from the availability models. This would provide the State with a management tool to reevaluate the supply gaps and adopt appropriate measures for aquifer sustainability.

Initiating and completing groundwater availability models in Louisiana will establish and define future aquifer conditions to be used in defining the sustainability of the aquifer(s) and identify potential quantity of alternative water source requirements for the area of need. It is recommended that groundwater availability model be developed for the two aquifers that recently been identified as requiring more immediate attention at this time, mainly:

- The Sparta aquifer, and
- The Carrizo-Wilcox aquifer

A general analysis of the financial viability and comparative cost of alternative projects intended to fill the estimated water supply gaps are described in this document. Summarized below are the proposed alternatives for closing the estimated supply gaps for each of the five aquifers impacted by over pumping and other sustainability issues:

Table E-4: Impacted Aquifers and Alternatives

Aquifer	Alternatives
Chicot aquifer system	Wastewater Recycling Reservoirs for Rain Harvesting Conservation Measures
Jasper aquifer system	Wastewater Recycling Reservoirs for Rain Harvesting Pipeline Conveyance of Red River Surface Water Conservation Measures
Cockfield aquifer	Wastewater Recycling Reservoirs for Rain Harvesting Conservation Measures
Sparta aquifer	Wastewater Recycling Reservoirs for Rain Harvesting Pipeline Conveyance of Ouachita River Surface Water and or Lake D'Arbonne Surface Water Conservation Measures
Carrizo-Wilcox aquifer	Red River Surface Water use or Red River Alluvial Aquifer Reservoirs for Rain Harvesting Conservation Measures

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It is these alternatives that are subjected to financial viability analysis and cost comparisons. For this analysis it is assumed that each of the alternatives is scalable; that is, each can be scaled up sufficiently to meet the entire supply gap for a particular aquifer. Therefore, only one alternative is required (i.e., the lowest cost alternative) to fill the water supply gap for each aquifer.

As detailed in this document, for each alternative a financial model was constructed to determine the financial viability and the cost of the alternatives. The model considered such project parameters, such as water supplied per year, total capital costs, total annual O&M costs, years to construct and years required to reach 100% capacity, as well as free cash flows, which provide the best measure of the cash provided by a project.

The way in which costs were estimated results in the same price for water (in dollars per thousand gallons) for a given alternative across all five aquifers – with the exception of the lower costs for reservoirs in the Chicot Aquifer System, which reflect the lower capital cost per million gallons and lower O&M costs associated with the large reservoirs proposed for that aquifer system. Based on the assumptions used and financial modeling methodology used in this analysis, the lowest cost alternatives by aquifer are listed below:

- Chicot aquifer system - Reservoirs for rain harvesting;
- Jasper aquifer system - Pipeline conveyance of Red River surface water;
- Cockfield aquifer - Wastewater recycling;
- Sparta aquifer - Pipeline conveyance of Ouachita River/Lake D'Arbonne surface water; and
- Carrizo -Wilcox aquifer- Red River surface water/use Red River alluvial aquifer.

As part of this document, one task was to identify and summarize federal, state, and local funding sources that could be applied to fund the water infrastructure alternatives described above and recommended to reduce groundwater depletion in the state through:

- Pipeline conveyance of surface water /surface water diversion
- Surface water recharge of depleted aquifers
- Rainwater harvesting
- Wastewater recycling

Over 31 Federal and State funding sources were identified and reviewed as to their potential applicability to funding the proposed alternatives. For example, the federal government has set up funds to help finance the programs and upgrades, such as the Clean Water State Revolving Fund which was established in 1987. This fund enables state and local governments to get low interest loans in order to fix aging wastewater treatment facilities and sewer pipes. States are required to match funds they use by at least 20%.

Also, as an aid to states, local agencies, municipalities, utilities, and environmental organizations in selecting the best financing option to fund their water quality and drinking water projects, the Financing Alternatives Comparison Tool (FACT) is a financial analysis tool developed by the USEPA and available on-line that helps identify the most cost-effective method to fund a wastewater or drinking water management project. This tool produces a comprehensive analysis that compares various financing options for these projects by incorporating financing, regulatory, and other important costs.

Other funding strategies were also summarized such as Public-Private Partnerships (PPP). PPP has been used in many communities with private sector companies assisting in the design, rebuilding, and operation of publicly-owned water and wastewater systems. A PPP involves a contract between a public sector authority and a private party, in which the private party provides a public service or project and assumes substantial financial, technical and operational risk in the project.

The federal government has no unified PPP policy and programs, as each department has its own unique statutory and regulatory framework to implement PPP, with general guidance set by the Office of Management and Budget.

At the state level only 23 states have legislation in place authorizing PPP. For example, in Louisiana, under law Louisiana R. S. §§ 48:2072 (C), (D)48:2084 to 48:2084.15 authorizes the Louisiana Transportation Authority to pursue PPPs for transportation facilities, including ferry, mass transit, rail or similar systems.

It is recommended that legislation be enacted to provide the appropriate water authority(s) the ability to pursue PPP to fund water infrastructure projects.

Recommendations

Recommendations were developed and categorized in two Tiers, as described below and summarized in their respective tables.

- Tier 1 Recommendations (Table E-5). These are short term solutions (1-5 year) that are implementable within existing Louisiana laws and regulations.

- Tier 2 Recommendations (Table E-6). These are long term solutions (5-30 year) that require legislative law and/or regulatory and law amendments. These recommendations are mainly policy related.

Conclusion and Retrospective Overview

The most significant and fundamental groundwater resource management issue facing Louisiana is the lack of timely and continuous acquisition of comprehensive aquifer-wide groundwater level measurements, water well production and groundwater quality data. Although the state has implemented various methods of obtaining such information, it is clear that the current methods fall short of producing a continuing volume of data in a coordinated manner available in a time frame sufficient for implementing a more efficient and effective means of managing the state's groundwater resources to ensure both short and long term aquifer sustainability. Establishing improvements in data acquisition and dissemination must be adequately addressed in order for the state to develop and implement a successful groundwater management strategy and therefore should be addressed as a matter of priority.

Table E-5: Tier 1: Short-Term Solutions (1-5 Year)

Issue	Discussion	Recommendation
STAKEHOLDER WORKSHOPS COMMENTS		
Stakeholders felt that current Legislation for evaluating sustainability by the Office of Conservation is not adequate and should carry a provision to deny groundwater use by a user if the use is deemed to be unsustainable.	The current Groundwater Resources Management statutory law and Louisiana Administrative Code regulations collectively provide for an effective means for the Agency to evaluate proposed ground water use and, when necessary, restrict ground water use, to prevent adverse impacts to aquifer sustainability.	Continue to improve upon the current procedure to evaluate the sustainability of the ground water resources under the current strict guidelines.
Based on discussions during the workshop and analysis of the available data for the preparation of this report, it was evident that there is an obvious lack of groundwater availability models and accurate data reporting by users. There was a consensus among the stakeholders to use academic and federal agency resources for larger scale groundwater/aquifer modeling.	The objective of the development of this document includes the identification of specific areas of the state's groundwater aquifer systems that may warrant regional or larger scale groundwater aquifer modeling to assist in the management of resource sustainability for those areas delineated in the Plan.	The Groundwater Management Advisory Task Force should study and identify the: ▪ Type and frequency of modeling suggested per area identified in this document; ▪ Initial and, where applicable, annual maintenance (model updating) costs to implement each suggested modeling project per area delineated in this document; ▪ Sustainable funding sources for each project; and ▪ All feasible resource management alternatives for each area identified in this document, and provide a written summary of their findings to the Groundwater Resources Commission.
Managing groundwater resources require adequate characterization of aquifers. Towards meeting this objective, there is a requirement of defining aquifer sustainability and sustainable yield criteria and establish resources to manage the same.	None	The Office of Conservation should: ▪ Research other state and federal legal definitions for aquifer sustainability and sustainable yield criteria; ▪ Implement aquifer modeling if warranted; ▪ Consider proposing regulatory amendments to utilize both concepts under Louisiana Groundwater Management regulations.
Stakeholder involvement and public awareness is critical in evolving management strategies and implementing new and established effective and efficient methods to reach the public.	None	The Groundwater Resources Commission and the Office of Conservation should request and encourage the Secretary of the Louisiana Department of Education and the Louisiana Board of Elementary and Secondary Education (BESE) to take all necessary actions to ensure that ground water conservation education be specifically and directly included in the required teacher grade level expectations (or its replacement) for elementary and/or middle school students from 3rd grade through 6th grade. If funds are available, this effort should be expanded to strategic grades.
Stakeholders felt that there is a need to establish an agency representative standing committee to recommend water quality and quantity emergency actions.	None	The Groundwater Resources Commission should pass a motion to recommend that the commissioner of Conservation initiate, assemble, and maintain an ad-hoc standing committee of agency representatives from DHH, Office of Public Health (OPH), LDEQ, LDNR Office of Conservation LDNR Office of Mineral Resources, and Louisiana Department of Wildlife and Fisheries, NRCS, LDAF to serve to facilitate communication between agencies for emergencies involving ground water resources.
In order for water users to utilize surface water instead of ground water there is a need to implement positive publicity to water users choosing surface water alternatives.	None	The LDNR should develop and implement a groundwater conservation stewardship recognition plan.
As part of the data collection and analysis as a strategy for surface water resource management, stakeholders state that there is a need to increase Surface Water Quantity Measurement temporally and spatially.	None	The LDNR, through its Office of Mineral Resources and in consultation with the USGS should investigate current state practices for measuring surface water quantity and report its findings, including any feasible and practical recommendations to improve current practices for the same, to the Groundwater Resources Commission and Commissioner of Conservation.
There is a need for greater accountability for self-reporting requirements.	None	The Office of Conservation forms that are currently used by well owners and operators to notify the agency of proposed ground water well locations and groundwater use should include signature and certification by the responsible party. This procedure is consistent with legal certification language used by other local, state, and federal governing agencies for related matters.
As an alternative to ground water use, stakeholders would like to see reservoir development.		Additional efforts may be initiated to locate and implement reservoirs in strategic locations.
WATER WELL NOTIFICATION AND EVALUATION		
Water well notification	Under R.S. 38:3097.3.C (4) (a) it is the responsibility of the well owner to file the water well notification at least sixty days prior to well installation. It has been suggested that this responsibility be placed on the driller, since most well owners would be unfamiliar with the requirements. Currently, domestic wells are automatically exempt from prior notification requirement, as are drought relief, rig supply, replacement wells, and other wells that the commissioner may deem fit for exemption (although large wells cannot be exempted). This leaves a pool of more astute well owners that would typically have more knowledge of well notification requirements. Thus, owners of all other new wells for uses such as for public supply, irrigation, and industrial purposes must comply with prior notification requirements.	It may be more appropriate to require the well driller, , who is licensed and should be more familiar with the process, to provide the agency with sixty day prior well installation notification for all non-exempt well installations. At a minimum, water well drillers should notify well owners of the notification, assist the well owner as necessary, and be prevented from installing wells without proper notification to LDNR.
Water well drawdown calculations	Office of Conservation water well installation and groundwater use evaluation is a structured review process which requires, at a minimum, the reviewing staff to perform calculations for	The evaluation procedures form should be revised to clearly document staff's use of drawdown calculations performed for both the nearest well and the shallowest wells within the quarter-mile radius area of

Table E-5: Tier 1: Short-Term Solutions (1-5 Year)

Issue	Discussion	Recommendation
	determining water level drawdown impacts at the well nearest to the proposed well location. Should staff determine the need, additional wells within the standard quarter-mile area of review may also be assessed for potential water level decline impacts or other potential adverse impacts to support agency conclusions of more complex proposed well locations and water production demands. However, based on review of the agency's evaluation process, it is not readily apparent that the agency's evaluation procedures include more in-depth assessment to include water level decline calculations for other wells located within the quarter-mile area of interest as may be needed to address varying well depth, yield, and proposed withdrawal rates, to ensure that potential adverse impacts of the proposed well will not be underestimated. Although it is understood that agency decisions resulting from well evaluation protocol includes consideration of potential adverse cumulative impacts due to the presence of multiple nearby active (pumping) wells, this consideration is not readily apparent on the evaluation guidelines document. Although groundwater numerical models, e.g., MODFLOW, can be used to calculate drawdowns in the well field, this method may be cumbersome to update and implement for evaluation of individual wells.	review to assess potential well interferences for proposed wells. The evaluation procedures form should also be revised to provide clear documentation of a larger radius, or area of review, when large cones of depression are expected. More robust documentation to support agency decisions based well evaluations should be considered by the agency, including the integration of analytical element models in SONRIS to evaluate the cumulative impacts of pumping, sustainability of the aquifer, and potential delineation of wellhead protection areas. Analytical element models, e.g., the wellhead analytical element model (WhAEM), may be an appropriate tool to calculate the cumulative impacts of pumping from multiple wells, as well as additional analytical elements including recharge, drain, and no flow boundaries. WhAEM can also quickly calculate capture zones and be used to delineate wellhead protection areas. US EPA supports the Center for Subsurface Modeling Support (http://www.epa.gov/nrmrl/gwerd/csmos/index.html), which provides descriptions and links for groundwater models.
Static water level gradient maps	None	Current static water level gradient maps should be developed and maintained as feasible to accurately identify potential impacts caused by new significant drawdown within an aquifer. These maps could be integrated into the SONRIS GIS system, either as a functional or reference layer, to provide a more efficient means of determining the relative static water levels to use when calculating relative drawdown from proposed wells.
Well registration	Since the Water Well Notification form , Water Well Registration Long Form , Water Well Registration Short Form , and the Well Plugging and Abandonment Form share a significant percentage of common data it would be possible to make these into one unified form with separate sections for the unique data on each of the original forms	The following changes could be implemented to improve the well registration process, including: ■In addition to the parish and coordinates, the form(s) should require a street address and/or directions from an intersection or applicable landmark. ■ Because the Water Well Notification Form, Water Well Registration Long Form, Water Well Registration Short Form, and the Well Plugging and Abandonment Form share a significant percentage of common data, it may be appropriate to consolidate these forms and provide separate sections requesting applicable information. ■These forms could be integrated into SONRIS to allow for online data submittal and quicker review by appropriate parties, as needed.
Well identifier	None	The well identifier should be maintained from the well notification through the plugging and abandonment of the well. Each well should receive a unique identifier consisting of the parish FIPs and the sequential well number for that parish. This would allow for a well to be located by its identifier, from inception to its plugging and abandonment which is currently not possible in SONRIS.

Table E-6: Tier 2: Long-Term (5 to 30 Years)

Issue	Discussion	Recommendation
The State of Louisiana does not have a program to develop GAMs for areas of groundwater concern.	The development and maintenance of detailed groundwater availability modeling and yield estimations is a valuable tool used to provide sound objective information for management decisions to address aquifer sustainability issues.	It is recommended that Louisiana develop a program to fund the development of aquifer-wide groundwater availability models for impacted aquifers especially for the Sparta and Carrizo-Wilcox aquifers. This program may be extended to additional aquifers that have projected supply gaps.
The State of Georgia's Water Plan (The Water Plan) establishes a regional approach to guide water management in Georgia through the creation of 10 water planning regions, with each region establishing a Planning Council, which in turn will their region's plan, called "Water Development and Conservation Plans" that will guide water management decisions in their region. This approach is an effective way of managing groundwater and surface water resources. The current groundwater management plan for Louisiana is a comprehensive state-wide plan, which will serve as a guidance framework. An approach similar to the State of Georgia's Water Plan is needed to manage Louisiana's water resources more effectively. Currently State of Louisiana aquifers are categorized under 'Regions," which is an administrative delineation. Separate plans based on watershed/aquifer/regional (regions) approach should be evolved. In addition, separate councils representing these regions could be considered as management option to guide water management decisions under the leadership of the Department of Natural Resources.		Appropriate actions may be initiated to create watershed and aquifer based regions and develop strategic regional resource management perspectives.
Stakeholders suggested that the drillers be required to provide prior water well notification to the Office of Conservation.		Should it be determined that water well owners, not well drillers, will continue to be required to provide advanced notification of propose water well installation to the agency, it is recommended that the Office of Conservation propose a rule amendment to LAC Title 56 Part I requiring a water well driller to obtain proof prior to commencing well installation operations that; a) their respective client (well owner) has complied with the pre-installation notification requirements of LAC 43:VI.701 and b) The Office of Conservation has completed its evaluation and provided the well owner a written determination on proposed ground water withdrawal at the well location. The regulatory amendment should require the water well driller to document that such proof was provided by the well owner by certification on the well construction registration form provided to the agency. The regulatory amendment should also clearly state that water well drillers failing to obtain and document proof of the above prior to constructing a water well will be subject to possible enforcement action and assessment of civil penalty issued under the general authority of the Groundwater Resources Management Law and Subsurface Waters – Well Drillers Law, Chapters 13-A-1 and 13-B respectively of Title 38 of the Louisiana R.S., and under the specific authority set forth in Section 3097.3 (F).
Inadequate data reporting system as well as strengthening of water level measurements and enforcement of laws and regulations prompted stakeholders to suggest that there should be comprehensive water metering for all users, statewide water level measurements, agency inspections, and reporting and database entry.		The Groundwater Resources Commission should consider approving the issuance of a letter of recommendation to the Louisiana legislature to amend current statutory law for Groundwater Resources Management Law, Chapter 13-A-1 requiring well owners of all active large volume industrial, irrigation, and public supply groundwater wells that drawing water from at least impacted aquifer systems to: ▪ Install flow monitoring devises on said wells; ▪ Record groundwater withdrawal volumes; and ▪ Report groundwater withdrawal volumes from each well to the agency on a quarterly to semi-annual basis.
For the sustainability of certain aquifer systems alternative use of surface water resources will be necessary. In the opinion of the stakeholders, there is a need to mandate surface water use cooperative endeavor agreements for judicious use of surface water resources.		New Legislation is recommended to extend and build upon the current provisions of ACT 955 of 2010 pursuant to fair and judicious use of surface water resources in the public domain. Such legislation should recognize the interconnectivity of ground water and surface water resources and the importance of that interconnectivity relative to the objective of any such legislation.
It is the stakeholder's opinion that for effective groundwater resource management there is a need to increase task force membership and role in water policy and management decision.		It is recommended that the Groundwater Resources Commission and the Commissioner of Conservation update and revise the role of the Ground Water Management Advisory Task Force, and provide recommends, as appropriate, to enact new legislation.
Although surface and ground water may be hydraulically connected, their interconnectivity is not recognized in legislation and related policy.		New legislation is recommended to extend and build upon the current provisions of ACT 955 of 2010 pursuant to fair and judicious use of surface water resources in the public domain. Such legislation should recognize the interconnectivity of groundwater and surface water resources and the importance that interconnectivity relative to the objective of any such legislation.

Table E-6: Tier 2: Long-Term (5 to 30 Years)

Issue	Discussion	Recommendation
Stakeholders who participated in the workshops felt that the Sparta Aquifer Groundwater Commission statutory authority should be enhanced.		The Sparta Aquifer Groundwater Commission may consider meeting with their legislators to propose draft legislation to amend the statutory authority of the Sparta Groundwater Commission to function in an identical capacity as the Capitol Area Groundwater Conservation Commission and seek assistance from the chair of the Louisiana Senate Natural Resources or House of Representatives Natural Resources and Environment to identify potential author(s) and sponsorship.
Louisiana law Louisiana R.S. §§ 48:2072 (C), (D) and 48:2084 to 48:2084.15 authorizes the Louisiana Transportation Authority to pursue PPPs for transportation facilities, including ferry, mass transit, rail, or similar systems.	Public-Private Partnerships (PPP) are used in many communities and through them private sector companies assist in the design, rebuilding, and operation of publicly-owned water and wastewater systems. A PPP involves a contract between a public sector authority and a private party, in which the private party provides a public service or project and assumes substantial financial, technical, and operational risk in the project.	Legislation could be enacted to provide the appropriate water authority(s) the ability to pursue PPP to fund water infrastructure projects.
Financial incentives and funding opportunities		The following financial incentives are recommended to promote groundwater sustainability in areas of groundwater concern: ▪ Trust fund for surface / groundwater use fees to subsidize surface water use; ▪ Cost-share funds to facilitate the development surface and wastewater reuse alternatives; ▪ Credit system for alternative users; ▪ Provide incentives / tax reductions to encourage surface water alternatives; and ▪ Incentives to retain forests and agriculture to benefit watersheds.