AQUIFER-BASED GROUND-WATER MANAGEMENT

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INTRODUCTION

Across the USA ground-water is an increasingly critical resource that is being developed and used in non-sustainable way. Ground-water use in the USA has increased significantly during the past 3 decades and is likely to increase dramatically in the future due to: (a) increased population in semi-arid parts of the country where there is little unappropriated surface water, (b) the US production of renewable, non-hydrocarbon fuels increases (approximately 4 gallons of water are required to produce one gallon of ethanol) and (c) global climate change which may cause dramatic increases in ground-water production to offset decreases in surface water supply. Ground water is an undervalued resource and current ground water management policies typically do not include goals that promote sustainable use of the resource.

Ground-water management is significantly constrained by the absence of a coordinated, comprehensive strategy / policy with respect to the valuation, development, use, and monitoring of the resource. Ground-water management is fragmented among many State, Federal and local programs. An aquifer-based approach to ground-water management provides a real-world approach to a common decision making process for programs that have ground-water management responsibilities.

KEYWORDS

ground water, aquifer, water resource management

THE GROUND-WATER RESOURCE

Ground water accounts for more than 98 % of the world's available fresh water. Total ground-water withdrawals in the US exceeded 83 billion gallon per day in 2000, an increase of 14 % from 1985 (USGS, 2004). Ground-water withdrawals for irrigation have doubled since 1950 and exceeded 50 billion gallons per day in 2000.Ground-water use for public water supply was about 16 billion gallons per day in 2000, an increase of more than 400% since 1950. Ground water is the source of drinking water for more than 140 million residents in the US and is the source of more than 99% of domestic water supply in the US.

Ground-water and surface-water

Ground water and surface water are hydrologically connected in most types of hydrogeologic settings. The hydraulic nature of the interconnection between ground water and surface water is significantly affected by the type of aquifer within which the ground water occurs, the local /regional climate and the topography. Surficial, unconsolidated aquifers in regions with perennial streams typically have a dynamic hydraulic relationship with the stream and other surface waters (lakes, wetlands). Ground-water discharge provides, on average, more than 50 % of the baseflow in nation’s streams and rivers. Ground water discharge is also essential for supporting ecological communities in ground water-dependent ecosystems which include communities of plants, animals, and other organisms whose existence and distribution depends on access to or discharge of ground water, including springs, fens, seeps, areas of shallow ground water, cave and karst systems, hyporheic and hypolentic zones, and ground water-fed lakes, streams, and wetlands. These ecosystems are very vulnerable to reductions in ground water levels.

Ground water is a highly integrated (connected) part of the water cycle / budget within a watershed. In high relief, mountainous areas underlain by fractured rock, ground-water and surface water can best be conceptualized within the context of watershed boundaries. However, it is important to note that ground-water divides do not necessarily correspond to surface water divides. It is also important to note that more than one aquifer may occur within a single watershed, and conversely, a single aquifer can underlie more than one watershed.

ISSUES / PROBLEMS WITH CURRENT APPROACH TO GROUND-WATER MANAGEMENT

Ground-water management has traditionally been primarily the responsibility of State and local governments. In most state governments the withdrawal and use of ground water is administered by a different agency than the regulation / protection of ground-water quality. Within State DEQs and Public Health Departments, which typically are responsible for protecting ground water and cleaning up contaminated ground water, it is common for ground-water management to be split among numerous programs. For example, SDWA programs focus on ground-water used for drinking water, CERLA and RCRA programs focus on cleaning up ground-water contamination, non-point source programs focus on agricultural impacts to ground water, storm-water management programs utilize infiltration basins to dispose of storm water, and wetlands programs focus on protecting wetlands, which are most often ground-water discharge areas.

Ground-water management responsibilities are also fragmented within the Federal government. In fact, the Federal government’s role in ground-water management is derived from 16 different Federal statutes and is spread across many agencies. As with State and local governments there is no single “centralized” agency or program that can provide a holistic, sustainable approach to management.

Overall, this fragmentation often results in a poorly coordinated, sometimes contradictory approach to ground-water management. In fact, ground-water management often proceeds without all parties recognizing that they are managing the same resource. For the most part, current management strategies are not holistic in the sense that there is no recognition that actions taken in one part of an aquifer (i.e., withdrawals, waste water disposal, allowing land uses which prevent recharge) may have adverse impacts in another part of the aquifer.

The key purpose of this paper is to suggest and describe an aquifer –based framework for implementing ground-water management responsibilities. This same framework would be useful for coordinating activities between all Federal, State and local programs that have ground-water management responsibility.

A BETTER APPROACH - AQUIFER-BASED MANAGEMENT

Aquifers and aquifer systems are the natural units of management for ground water just as a stream, lake and watershed are natural units of management for surface water. An aquifer is defined (USGS) as: a geologic formation, group of formations or part of a formation that will yield usable quantities of water to a well or spring. It is obvious from this definition that most geologic formations will function as an aquifer, at least over part of its' occurrence. Aquifers have mappable boundaries that are delineated based on geologic features (formation boundaries), hydrologic features (flow system divides) and water quality. Aquifers have hydrologic characteristics/properties that are routinely assessed by standardized methods. Under non-perturbed conditions the total annual recharge to an aquifer is balanced by the total annual discharge from the aquifer. Within an aquifer there are aquifer zones, which can be defined as sub-divisions of aquifers with differing hydrologic conditions. Aquifer zones include recharge and discharge areas and confined vs. unconfined areas. Aquifer zones are ecologically important in identifying ground-water interactions with surface water systems, including wetlands. The USGS and State Geological Surveys have mapped and assessed hundreds of aquifers and aquifer systems in the US. The results of these assessments are included in numerous USGS publications.

It is not logical to attempt to manage a part of an aquifer without sufficient understandings about the entire aquifer. The different local, State and Federal programs that have authority and responsibility for ground-water management should have a common understanding of the nature of the occurrence ground water within the areas of jurisdiction. The following basic information is useful for managing ground water on an aquifer basis:

- A map of the aquifer or aquifer system which depicts the aerial extent of the aquifer, and describes the geology of the aquifer.
- Delineation of recharge and discharge areas
- A sound understanding of the hydrology of the aquifer (confined vs. unconfined, hydraulic properties, interaction with surface waters, ecological importance, etc.)
- Real time tracking of water levels and water quality in aquifer
- Data on the chemistry of the ground water in different parts of the aquifer, including areas of known contamination
- Information on location and annual yield of ground-water supply wells (domestic and PWS)

It is quite common for an aquifer, or especially an aquifer system to underlie multiple jurisdictions. All programs that make decisions related to the development, use and

protection of ground water should be routinely aware of all actions that affect a given aquifer. For example, management should recognize that actions taken in the recharge area can affect the quantity and quality of ground-water discharge. An aquifer based approach provides for a common unit of management to avoid contradictory management goals, objectives and actions.
Asset management - An aquifer can be viewed as a water storage facility (an asset) that requires sound, comprehensive management to make sure that there is sustainable use of the ground water stored in the aquifer. An aquifer needs to be managed in a way similar to other water supply system facilities:

- A basic understanding of the asset
- An asset management plan
- Be able to manage system failures
- Financial self- sufficiency

An aquifer based approach helps to mitigate the disconnect between the delivery of safe water and managing the source of water.

Management goals

Ground water management would be more sustainable if there were a common set of goals that guided local, State and federal programs that have arolew in managing the resource. This paper recommends that the following basic goals be applied to assure sustainable use of the resource:

- Allowable annual withdrawals should be based on sustaining the use of the aquifer for water supply and ecological needs
- Integration of ground-water quality and ground-water quantity /supply in decision making.
- There has been significant improvement in technologies that can be used for aquifer storage and recovery. Management should promote this practice.
- Full cost pricing should be applied to ground-water development and use. This requires a clear recognition that aquifer mining reduces the amount of ground water that is available on an annual basis and therefore increases the cost.
- Recharge areas need to be managed differently from discharge areas. Managing land use is a key element in managing aquifers.
- Integration of ground water and surface water into a comprehensive management system. If ground water within a watershed is not managed in a sustainable way there will be significant constraints on surface water management within the watershed.

In order to assure the sustainable use of ground-water resources, it is vital that the Local, State, Tribal and Federal agencies that have some level of responsibility for ground-water management, implement programs that provide comprehensive protection and management of the resource and a framework for coordinating programs and activities under Federal, State, Tribal and local statutes and ordinances. Effective ground-water management programs must consider the use, value and vulnerability of ground water resources as well as social and economic values. Managing ground water on an aquifer basis provides a means to achieve a comprehensive approach to management.

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