The Boynton Beach ASR System -- Lessons for the Utility and Regulatory Community in South Florida

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Abstract

The Boynton Beach ASR system has been successfully storing and recovering treated water since October 1992, the first ASR system in southeast Florida. More than 5 years have passed, and only now are new ASR systems in south Florida coming online. This time lag has provided an opportunity to review operational data, and gain insight that may be extrapolated to other ASR facilities in south Florida. As utilities and regulators become more comfortable with the ASR technology, more widespread implementation is likely. From a regional perspective, the South Florida Water Management District continues to consider ASR as a beneficial tool for storing large quantities of raw ground and surface water currently lost to tide.

Thirteen (13) cycles of recharge, storage, and recovery have been implemented at the Boynton Beach ASR system, at rates of approximately 0.5 to 2.0 mgd. Total volume of potable water stored per cycle is approximately 40 million gallons, with a peak efficiency of 91 percent recovered per cycle. As such, the City has used their ASR system to meet peak demands quite effectively. Performance of the Boynton Beach ASR system is discussed herein. Specific water quality parameters and the effects of storage in a brackish aquifer are discussed. Local health departments in south Florida have recently taken a cautious approach to ASR implementation. Presentation and discussion of Boynton Beach ASR operational data may alleviate some of these concerns. The Boynton Beach experience can be pointed to as a success story that may lead to more widespread implementation of ASR in south Florida.

Introduction

The City of Boynton Beach, Florida is located on Florida's southeast coast. Nestled between Boca Raton and West Palm Beach, the utility serves approximately 75,000 residents. Raw water is derived from wells completed into the Surficial Aquifer System, with well depths ranging from 50 to 200 feet. Some of these wells are subject to saltwater intrusion, given their proximity to the coast. Figure 1 is a site map of the City's East Water Treatment Plant (WTP) showing the production and ASR well locations.

The City was proactive in recognizing the importance of a storage mechanism such as ASR to meet peak or emergency demands, thereby delaying the need for more expensive capital improvements such as premature plant expansions. For example, a recent lightning storm caused two production wells to go offline. With the flip of a switch, the ASR system produced the 2.5 mgd flow usually provided by these production wells. ASR has provided the City with a highly reliable and readily accessible water source.

System Description

The primary component of the ASR system is the ASR well. It is constructed of a 16-inch-diameter, carbon steel casing cemented in place to 804 feet below land surface (bls), with open-hole construction to 909 feet bls. Transmissivity of the storage zone was estimated at 70,000 gpd/ft. This productive zone may correlate to the Suwannee Limestone of the Floridan Aquifer System, and is confined above by approximately 475 feet of clays known as the Hawthorn Group. A 4-inch PVC monitor well (screened from 300 to 320 feet bls) monitors the first productive layer above the top of the Hawthorn Group clays per FDEP requirements.

Plant piping was installed to supply the ASR well with potable water from the high-service distribution lines north of the ASR well. Piping was also installed to allow flow to the backwash recovery basin or to the recarbonation basin with minimal disinfection, if required.

System Operation

The City operates its ASR system to meet seasonal and peak demands. ASR systems have been evaluated in terms of "cycles" (i.e., consecutive periods of recharge, storage, and recovery). The City conducted these cycles at varying recharge/recovery rates (0 to 2.5 mgd) coinciding with water availability. Earlier cycles were conducted at different recharge/recovery volumes, making percent-recovery comparisons between cycles difficult. This is not true with Cycles 5 through the present, where the City determined operationally that a 40 MG storage volume met their needs

Cycle Test Results

Figure 2 presents a graph of recovery efficiency versus the number of cycles conducted. Clearly, recovery efficiency has improved with successive cycles, a common occurrence at ASR systems. A more telling statistic is the cumulative, unrecovered volume of water (i.e., the volume of water left in the storage zone). From this data, it appears that approximately 200 MG of potable water was never recovered, but was required to be left in the ground to achieve almost complete (91%) recovery. This 200 MG is termed the target storage volume. Given the 40 MG volume per cycle used at Boynton Beach, it may be concluded that approximately 5 times the cycle volume needs to be stored before complete recovery is achieved. This has been achieved either through successive cycles at the Boynton Beach ASR facility.

Water Quality

Water quality sampling/analysis is considered critical to the evaluation of ASR system performance. Recently, regulatory agencies have required extensive sampling/analysis of ASR and monitor wells to achieve a better understanding of the interaction of recharge and native water within the storage zone. In fact, estimates of laboratory analytical costs for the Broward County Office of Environmental Services (BCOES) ASR project approach $100,000 annually.

Parameters of interest for each cycle were analyzed, and are discussed below.

Specific Capacity. Over the first 3 cycles, a slight rise in recovery specific capacity (13 to 17 gpm/ft @ 1,000 gpm) was observed. This may be the result of further removal of suspended sediments from the aquifer or buoyancy effects of storing potable water within the brackish aquifer. Additionally, increasing the storage volume resulted in an increase in wellhead pressure.

Chlorides. As has been documented at other ASR sites, recovery efficiency improved with subsequent cycles of a similar nature. Figure 3 is a graph of chloride concentration versus time during cycles 5 through 11. The slope of the chloride trend line for each cycle is relatively uniform, but becomes increasingly fresh with subsequent cycles.

Color. Color generally decreased during recovery due to mixing of stored water with the relatively color-free brackish water of the storage zone.

Hardness. Hardness in recovered water generally increased, closely tracking chloride trends. Figure 4 shows results of Cycles 5 and 7, indicating the similar trends observed for chlorides and hardness during recovery of stored water. However, the slope of the hardness trend line is much shallower than the chloride trend, indicating that the initial hardness of the stored water is closer in value to the hardness of the native water. This increase in hardness is due to the effects of the limestone matrix of the storage zone. This would not be true if the storage zone were a quartz sand aquifer, for example. Therefore, an increase in hardness can be expected during recovery at other ASR sites in Florida.

Turbidity. Turbidity levels were consistently high at the start of each cycle – a typical occurrence at ASR wells that have been stagnant for some time and constructed of steel casings such as at Boynton Beach. Turbidity levels generally decreased to less than 1 NTU within the first 24 hours of recovery commencement, and less than 1 thereafter for the duration of the cycle. One exception is the occasional variability of the recovery rate noted previously. For example, Cycle 7 data indicate fairly uniform turbidity data (0.1 NTU) at the recovery rate of approximately 500 gpm. However, when flow rate was increased to 1,100 gpm towards the end of the cycle, turbidity spiked at 2..66 NTU briefly, before returning to 0.2 NTU rather quickly.

Ammonia (NH_3). The presence of ammonia (NH_3) in recovered waters was observed to be variable. For example, Cycle 5 and 11 NH_3 concentrations are fairly uniform. Cycle 8 data indicate a gradual decrease in NH_3 concentration, although the levels are admittedly low to begin with. Review of NH_3 concentrations during recharge do not yield much insight into this phenomenon, though NH_3 is added to raise pH at many water plants for finished water. It appears that the gradual decrease in NH_3 concentrations may be the result of bacterial denitrification – though these bacteria need a source of TOC to keep them active. This denitrification could be an important side-benefit of ASR systems for utilities. For example, some utilities such as the City may experience difficulty in maintaining satisfactory chloramine residuals in their distribution systems aggravated by excess NH_3 levels in raw water supply. Introduction of low-nitrogen water from an ASR well into the distribution system may result in more stable NH_3 levels, and more aesthetically pleasing water to end users.

General. Water quality parameters can be generally grouped into two types, based on the data presented herein. The first group of parameters exhibit high values at the start of recovery, with levels gradually decreasing with time of recovery. These parameters include turbidity, TSS, iron, and color. The second group of parameters increase gradually over time, indicative of mixing of recharge water with the brackish native water of the storage interval. This second group includes chloride, sulfate, hardness, and sodium. In the future, it may be possible to select one or two parameters from each group as indicator parameters and eliminate the others from the analytical suite, thereby saving laboratory costs.

Conclusions

The Boynton Beach ASR system has filled a very definite niche in the City's water treatment and delivery system. The ASR system provides a highly reliable supply, exceeding 2 mgd of stable, low-ammonia water which blends readily with the treatment process. It has proven most valuable during times of peak seasonal demand, especially when that demand is coupled with falling water table elevations in the surficial aquifer. The reliability of the well is also aided by the aquifer characteristics of the storage zone, which to date has shown no evidence of clogging. At current recovery levels approaching 90%, ASR provides a very inexpensive alternate water source.

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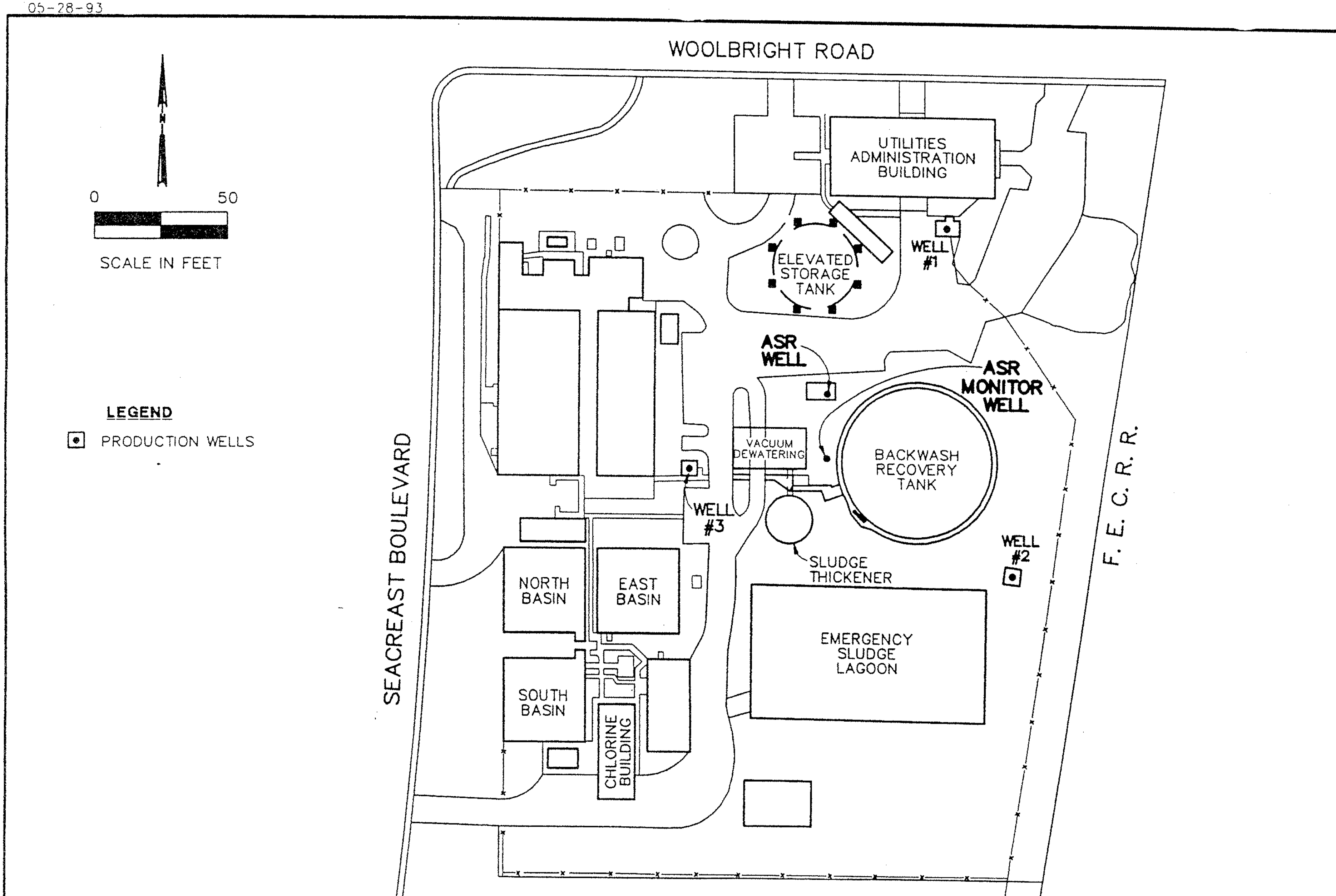

FIGURE 1

SITE PLAN
CITY OF BOYNTON BEACH
EAST WATER TREATMENT PLANT

CH2M HILL

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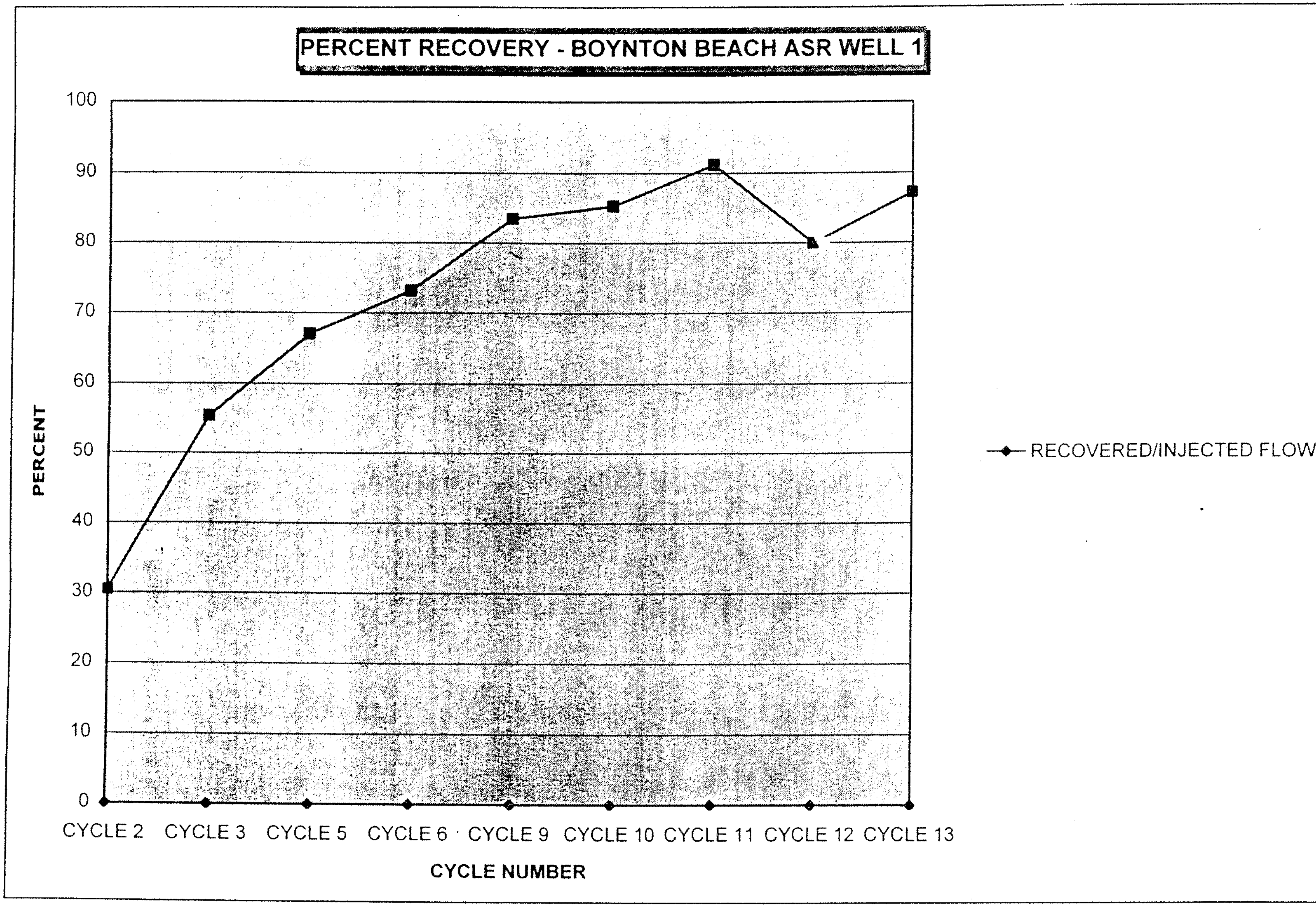

Figure 2
Recovery Efficiency of the Boynton Beach ASR System

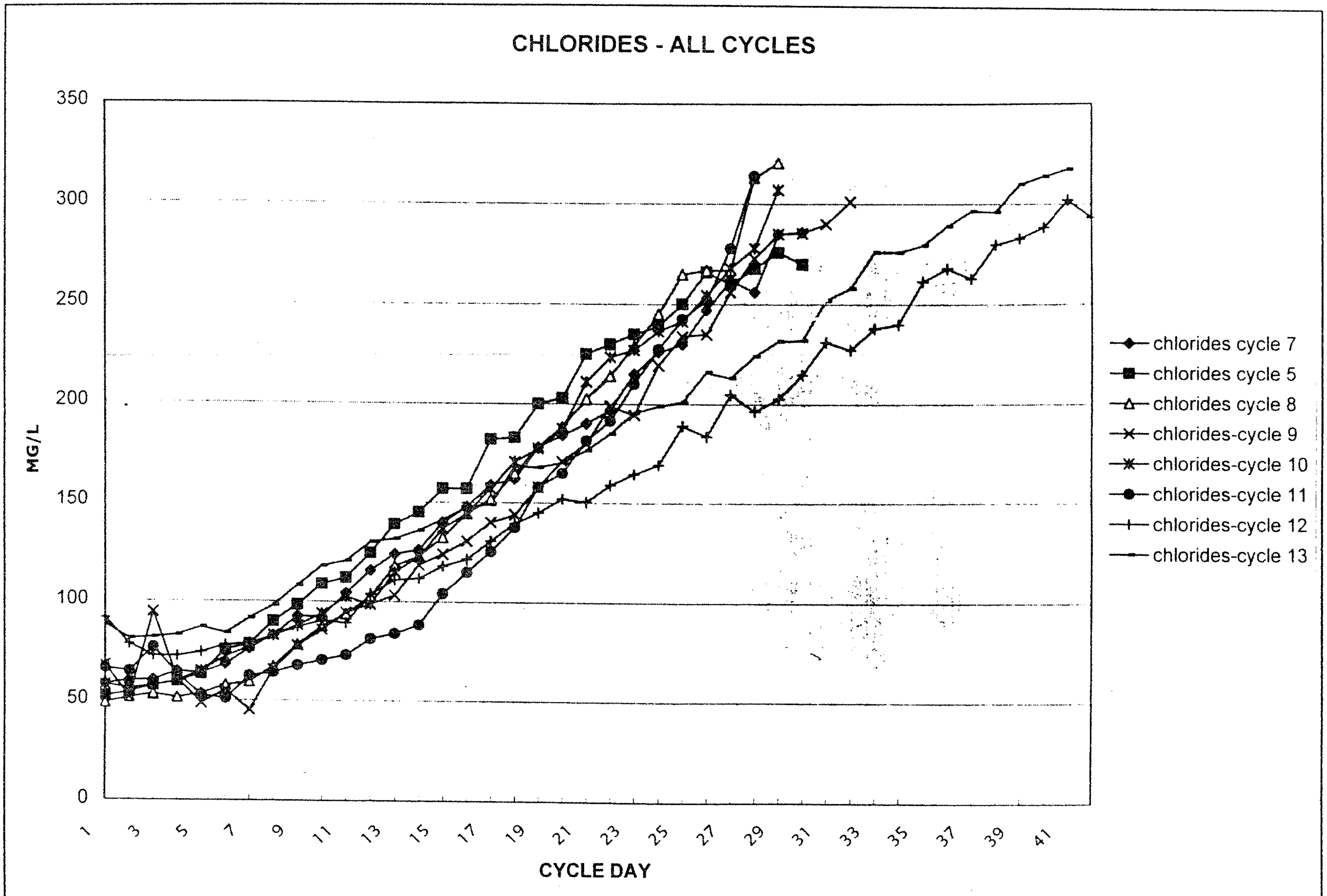

Figure 3
Chloride Concentrations During Recovery, Boynton Beach ASR System

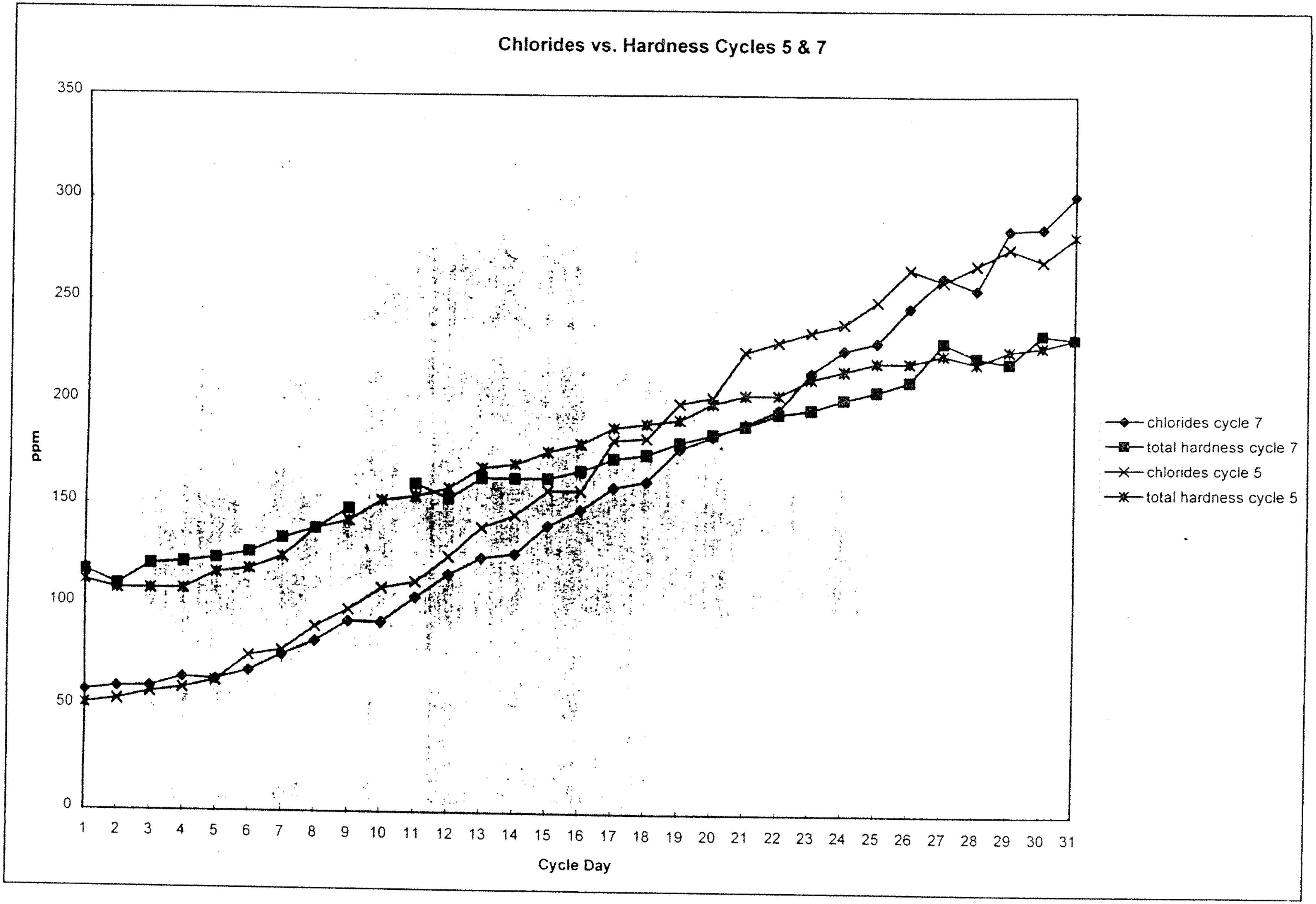

Figure 4
Chlorides and Hardness Concentrations During Recovery, Boynton Beach ASR System