Executive Summary

The Lower Santa Cruz River (LSCR) in northeastern Pima County is Arizona's longest effluent-dependent river. The condition of the LSCR is heavily influenced by effluent management practices. Numerous efforts are underway to restore water quality and river conditions. The Pima County Regional Wastewater and Reclamation Department (RWRD) is currently implementing the $660 million Regional Optimization Master Plan (ROMP) which will upgrade the two major regional wastewater treatment plants discharging to the river. According to ROMP, the upgrades to the Water Reclamation Facilities (WRFs) near Ina Road and Roger Road will significantly improve water quality of the effluent. The upgrade in water quality anticipated by ROMP leads to a commensurate increase interest in reducing the need to mine local groundwater for supply. Tucson Water, Metro Water, Oro Valley Water and Pima County have interest in taking effluent to be used for non-potable uses such as recharge, turf irrigation, and riparian enhancements.

The purpose of this study is to review historical conditions in LSCR and summarize possible changes by water quality upgrade due to ROMP.

In Chapter 1, a history of the study area and background of the study were briefly summarized.

In Chapter 2, historical conditions of stream flow discharge and infiltration were evaluated by using the United States Geological Survey (USGS) stream gauges data collected at Cortaro Rd and Trico Rd and effluent discharge data collected at Roger Rd and Ina Rd. WRFs. The mean annual discharge of the LSCR at Cortaro Rd and Trico Rd showed that large stormflow events occurred in winter, 1993, and summer in 2006. In all years, flows are greater at Cortaro Rd. than Trico Rd., indicating net losses due to infiltration and evapotranspiration between Cortaro Rd and Trico Rd. Annual mean loss was the greatest in Calendar Year 1993, which is a year which experienced the greatest annual mean discharge at Cortaro Rd and Trico Rd. The total annual effluent discharged from Roger Rd. and Ina Rd. WRFs is a significant portion of the annual discharge conveyed in the LSCR. While stormflow is a smaller part of the total volume in the river, storm events are extremely important in partitioning the water between that which infiltrates and that which flows downstream. Scouring of the stream bed removes the clogging layer, which results in much higher infiltration following storm events. The previous studies indicated that infiltration rate is more dependent on the number of scouring events and time since last scour event. A bank repair project conducted by Pima County Regional Flood Control District (RFCD) showed that flow diversion substantially increase effluent infiltration. This suggests that infiltration rate is largely controlled by a clogging layer. The frequency and magnitude of scouring events can be linked to regional rainfall patterns, especially fall and winter rainfall patterns, which suggests a link to larger climate trends.

Historical changes in the morphology of the low flow channels were assessed in Chapter 3. The study reach of the LSCR was divided into seven reaches using major road crossings. Low flow channel area and length were digitized using aerial photos taken in 1998, 2002, 2005, 2008, 2010 and 2011. 20-foot DEMs were created to evaluate elevation changes and sediment

volume changes in low flow channels by using topographic data obtained in 1998, 2005 and 2008. Analysis showed that relatively small changes in location, area and volume occurred in the reach between Trico Rd. and Sunders Rd. The changes in location, area and volume were relatively large in the reaches with inflow from major washes such as Rillito River and Canada del Oro Wash, suggesting that those reaches were relatively unstable during the study period. Previous studies (Parker, 1995; RFCD, 1999; 2008) reported that effluent channel continued to degrade over time. This study also showed that the overall trend has been toward degradation over the period from 1998 to 2008. More degradation occurred between 2005 and 2008, compared to the period between 1998 and 2005.

Chapter 4 reviewed available datasets to describe what is and is not known about the vegetation changes in the LSCR during the period of effluent discharge, with emphasis on riparian and wetland vegetation near the channel. It also described conceptual models (e.g. hydrogeomorphic), if any, and what is known about factors that influence vegetative conditions, drawing on literature from other Southern Arizona rivers. Several plant communities such as Sonoran cottonwood-willow and mesquite forests and saltbush desert scrub have been disproportionately diminished in areal extent by historic land use and water resource use along the LSCR. Native plant species diversity was also reduced following the reduction of natural baseflows and lowering of the shallow groundwater table. Effluent discharged to the LSCR from the Roger Rd. WRF revived some of the wetland and riparian plant communities, and facilitated the spread of non-native wetland and riparian species. At a time when other streams and springs in southern Arizona have gone dry or are experiencing reduced discharges, the effluent-dependent LSCR remains a unique “drought proof” stream. Mesquite bosques persist or have become established in areas of infrequent bank erosion where water availability is augmented either by effluent discharge from the municipal treatment facilities or where agricultural or urban runoff is concentrated. Terraces that are no longer subject to inundation offer sites for persistence or re-establishment of saltbush and other upland desert scrub.

In Chapter 5, historical changes in water quality were summarized by using data provided by Pima County Regional Wastewater Reclamation Department (RWRD) and Arizona Department of Environmental Quality (ADEQ). Sodium adsorption ratio (SAR), total dissolved solid (TDS), major ions, nutrients and dissolved oxygen (DO) were selected to discuss historical change in water quality. The SAR is the proportion of sodium (Na) ions compared to the concentration of calcium (Ca) plus magnesium (Mg). Infiltration decreases with an increase of SAR. Results showed that there was a trend that the average SAR gradually increased over time. The TDS levels changed over time. It was not clear if the TDS level has changed since the CAP water was introduced. The data from 2010 to 2012 showed an increase in Sodium, Sulfate and Chloride. While there are several possible reasons for this increase in Sodium, Sulfate and Chloride, the most likely candidate is the increased use in CAP water. Nutrients, such as nitrogen and phosphorus, are essential for plants and animals. Nitrogen, in the forms of nitrate, nitrite, or ammonia, is a nutrient needed for plant growth. Excessive nutrients in water can cause adverse impacts on water bodies. Ammonia can be toxic to fish even at low concentrations. Result showed that the ammonia concentration near Cortaro Rd. is substantially higher than the ADEQ standard. The nitrate, nitrite and phosphorus concentrations were lower in 2010-2011, compared to the period from late 1980s to early 1990s. The DO levels along the

study reach were relatively low, and that the DO level was higher in 2009 and 2010, compared to 2004.

In Chapter 6, previous studies of macro invertebrate in the LSCR were reviewed. According to the U.S. Environmental Protection Agency (EPA), aquatic invertebrates can be a good indicator of wetland health. Factor affecting aquatic invertebrate community composition (a key indicator of water quality and aquatic conditions) include oxygen, toxic chemicals and nutrients. There have been several efforts to evaluate macro invertebrates in the effluent-dependent Santa Cruz River north of Tucson. The previous studies indicated that the limiting factor for the diversity of macro invertebrate in the LSCR is not effluent quality, but physical habitat. Regardless of efforts to create a "clean" effluent, there are limitations to what can be expected as a response in the aquatic community. Effluent-dependent waters tend to be associated with urban environments, where the impacts of stream ecosystems can come from many sources independent of wastewater treatment plant operations. For example, many urban river channels have been channelized for the purpose of flood control. The previous study pointed out that the low diversity of aquatic macro invertebrates in the LSCR may be as result of a combination of poor water quality with a lack of suitable substrate.

Chapter 7 summarized existing conditions of the wastewater reclamation facilities and anticipated changes due to ROMP. As part of ROMP upgrades, process modifications and changes of the Roger and Ina Rd. WRFs were required to lower ammonia and total nitrogen discharge levels to meet future effluent quality regulations. Regulatory Compliance date for expansion and compliance with the regulatory effluent quality requirements is January 30, 2015 for the Roger Rd. WRF, and January 30, 2014 for the Ina Rd. WRF. A significant element affecting the strategies in ROMP is the need for a reduction in ammonia and nitrogen concentrations discharged into the LSCR in order to comply with current and future environmental regulatory requirements mandated by ADEQ. According to RWRD, nitrogen concentration will be reduced to more than 0.1 times of the existing levels by the upgrades of the WRFs. There are several studies documented about clogging layers in the LSCR. The clogging layers reduce infiltration of surface water in the river, causing disconnection between the stream and aquifer. The findings of the previous studies suggested that the water quality upgrade by ROMP will prevent forming clogging layers, resulting in increasing infiltration rate. The increased infiltration could reduce surface water running in the river without an increase in effluent discharge at the WRFs. The reduced flow in the river could reduce scour or degradation in a low flow channel. On the other hand, high-quality effluent with minimum solid load could carry more sediment than low-quality effluent that is currently discharged from the WRFs. It is uncertain if water quality upgrade will lead to an increase or decrease in sediment transport in a low flow channel. Change in the river condition anticipated by ROMP upgrades is of concern to RFCD.

Effluent is currently allocated to Tucson Water, Oro Valley, Metro, Pima County, Flowing Wells Irrigation District, Spanish Trails Water Co. Tucson Water also intends to develop capability for more extensive 'Indirect Potable Reuse,' which will require them to build additional capacity in constructed recharge facilities to recharge the treated effluent. With this capability, they have the ability will be able to take more reclaimed water for recharge any time throughout the year.

However, it is likely that recharge will be greater when irrigation demand is less, because the current reclaimed system will be used to distribute water to recharge facilities, and flows in the pipes are below capacity in the winter. The land uses adjacent to the LSCR have historically been commercial and industrial. Pima County has identified land adjacent to the river as an economic development zone by providing incentives for infill development. ROMP will restore water quality and improve wetland conditions in the river, which possibly leads to improved public perception of the river and the land adjacent to the LSCR. Water quality upgrade by ROMP will possibly provide socioeconomic impacts to the community.