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Adaptive implementation of information technology for real-time, basin-scale salinity management in the San Joaquin Basin, USA and Hunter River Basin, Australia

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ABSTRACT

Pollutant trading schemes are market-based strategies that can provide cost-effective and flexible environmental compliance in large river basins. The aim of this paper is to contrast two innovative adaptive strategies for salinity management have been developed in the Hunter River Basin, New South Wales, Australia and in the San Joaquin River Basin, California, USA, respectively. In both instances web-based stakeholder information dissemination has been a key to achieving a high level of stakeholder involvement and the formulation of effective decision support tools for salinity management. A common element to implementation of salinity management strategies in both the Hunter River and San Joaquin River basins has been the concept of river assimilative capacity as a guide for controlling export salt loading and the establishment of a framework for trading of the right to discharge salt load to the Hunter River and San Joaquin River respectively. Both rivers provide basin drainage and the means of exporting salt load to the ocean. The paper compares the opportunities and constraints governing salinity management in the two basins as well as the use of monitoring, modeling and information technology to achieve environmental compliance and sustain irrigated agriculture in an equitable, socially and politically acceptable manner. The paper concludes by placing into broader context some of the issues raised by the comparison of the two approaches to basin salinity management.

1. Introduction

Pollutant trading schemes are market-based strategies that can provide cost-effective and flexible environmental compliance in large river basins (Boyd et al., 2003; Coria, in press). Although emissions trading as an instrument to control air pollution has been discussed in the published literature for almost a decade and practiced in several European countries since 2005 – experience to date with pollutant trading systems for water pollution control has been limited and concentrated in Australia and the United States (Brady, 2004; Breetz et al., 2004; Ellerman, 2005; Helman, 2007; Hoag and Hughes-Popp, 1997; Hung and Shaw, 2005; James, 1997; Keudel, 2005; Kerr et al., 2000; Nishizawa, 2003; Smith, 1999). Tradable discharge permits are among the most complex and challenging market-based approaches (Kraemer and Banholzer, 1999) on account of the heterogeneity of the river basins to which they are applied, the variety of pollutant sources within each basin and the inherent difficulties in assessing economic impacts. Within river basins – pollution sources are divided into "point" sources (those sources directly discharging into a receiving water at a fixed and geographically identifiable location) and "non-point" sources (those sources discharging into a receiving water in a diffuse manner where the point of discharge cannot be defined geographically or easily measured). Assigning responsibility for non-point discharges, such as those made by agriculture, is very difficult.

Water-borne pollutants can be further characterized as either assimilative or accumulative (Tietenberg, 2000) Assimilative pollutants such as salinity can be accumulated within the environment up to a certain limit above which measurable negative impacts begin to occur. Assimilative pollution is reversible – when the rate export of a pollutant exceeds the rate of import – the assimilative capacity of the environment for the pollutant increases. Accumulative pollution is non-reversible and the environmental damage caused by these pollutants continues to increase. Pollutant trading that utilizes a permitting process has been mostly limited to assimilative pollutants. Much of the published literature in market-based trading of assimilative pollutants derives from the Australian experience in the Murray-Darling Basin (Coria, in press; James, 1997; Nishizawa, 2003; Newman, 2003; Thomas and Jakeman, 1985).

Early attempts at control of assimilative pollutants followed a regulatory "command and control" approach (USEPA, 2003) many of which achieved success at very high cost – mostly associated

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with regulatory monitoring. In the United States State and Federal regulatory agencies have embraced a "polluter pays" philosophy, in part because of fiscal limits to annual clean-up and abatement and environmental compliance budgets and a political philosophy that advocates individual responsibility. Market-based strategies that transfer much of the institutional costs associated with environmental regulation to stakeholders have resonated in countries like the United States and Australia that have large, highly productive agricultural sectors and the communications infrastructure necessary to develop and support a market.

The major aim of this paper is to contrast two innovative adaptive strategies for salinity management have been developed in the Hunter River Basin, New South Wales, Australia and in the San Joaquin River Basin, California, USA, respectively. The paper compares and contrasts the physical and socioeconomic characteristics of each Basin as a means of explaining the different adaptive approaches to salinity management that are being attempted. The central hypothesis is that an assessment of salinity management in the Hunter River Basin can help to guide a more-recent, real-time salinity management program in the San Joaquin Basin.

1.1. Background

Salinity management is an important sustainability issue in arid river basins around the world – especially those that support an agricultural sector reliant on irrigated agriculture (NRC, 1989). The Hunter River Basin of Australia and the San Joaquin Basin of California are two examples of large river basins where information technology, monitoring and modeling are being used in support of regulatory Basin Plans for salinity management. Although arid river basins in south-eastern Australia and the western United States are different in size, configuration and in the manner by which they are regulated and managed – there are many important similarities that invite comparison. Recent high-level exchanges between water managers and industry leaders in the two countries and newly formed interest groups such as the "Australia-USA Water Sustainability and Management Forum" are exploring the Federal-State nexus of water resources supply and management and economic sustainability in both countries. Trade groups and commercial interests connected with this activity are focused on technology transfer and the promotion of green technologies to address common problems of water shortage and land salination. In January 2010, the Regional Director of the Americans for the Australian Trade Commission stated that "California and Australia are inextricably linked by challenges of an accelerating decreasing availability of water and its supply" while also acknowledging the loss of some of the most fertile agricultural land to salinity. In both countries successful adaption to a new paradigm of water shortage could require radical change to a broad array of current practices, policies and institutions.

The first point of convergence for the two countries has been the recent 3-year droughts that ended in 2010. In Australia the City of Melbourne saw water reserves decline from levels of 100% in 1997 to 30% during 2009. The drought years 2006–2009 were the driest four years on record for the river that supplies Australia's second-largest city, a city projected to grow by two million in the next ten years. In Queensland, Australia's fastest-growing State with a current population of 2.7 million, the area received only 7.4% of its average annual reservoir inflow in 2006 and 4% in 2007. This led to drastic emergency urban and rural water conservation efforts and short-term water reallocation measures. California's recent three-year drought, ranked within the driest 10% on record. In California supply shortfalls prompted water rationing for urban customers and cutbacks to agricultural irrigation deliveries that forced many farmers to fallow land or resort to high rates of groundwater pumping. During the past century, California has experienced only two droughts that were more severe and lasted six years: (1929–1934) and (1987–1992). The recent drought caused an estimated $1.15 billion dollar loss in agriculture-related wages and eliminated as many as 40,000 jobs in San Joaquin Valley farm-related enterprises, where most of the nation's produce, fruit and nut crops are grown.

Land salination and salinity impacts on rivers are exacerbated by drought. Reduced mountain snowpack, snowmelt and rainfall runoff produces lower streamflow causing reductions in irrigation water allocations which, in turn, forces greater use of conservation measures such as reuse of irrigation return flows to meet crop evapotranspiration demands. These measures can lead to an increase in the salinity of drainage return flows to the Hunter River and San Joaquin River that drain the Hunter Basin and San Joaquin Basin respectively. Salinity is defined as the concentration of dissolved salts in a water body. Salts degrade water bodies through such activities as domestic use, irrigated agriculture, confined animal waste practices, and other human, industrial, and natural processes. Degradation of surface water supplies can limit the use of water for agricultural, industrial, municipal, and other purposes (NRC, 1989). Certain salt sensitive agricultural crops experience progressive yield declines when the salt concentration of applied irrigation water exceeds a certain threshold resulting in economic losses to the agricultural sector.

1.2. Geography

The Hunter River Basin is the largest coastal catchment in the State of New South Wales, Australia – covering approximately 22,000 km^2. The San Joaquin River Basin, in way of contrast, is an interior catchment almost twice the size of the Hunter River Basin covering 40,500 km^2. Both drainage basins are fed by a number of large tributary rivers. Agricultural production in both areas is measured in billions of dollars to the local economy.

A range of agricultural activities are contained within the Hunter River Basin including wineries, dairying, vegetables, fodder, beef and horse breeding. The Basin also contains more than twenty of the world's largest coal mines and power generating stations. Salt occurs naturally in many rocks and native soils of the region and is leached into groundwater and nearby rivers through activities such as irrigation and coal mine pump drainage. Electricity generation consumptively uses large volumes of river water increasing the concentration of the saline river water.

The San Joaquin Basin is more uniformly agricultural, though with a number of large and fast growing cities. The Basin is divided into two distinct sub-basins by the San Joaquin River each basin has radically different native soils and hydrology. All rivers to the east of the San Joaquin River originate in the Sierra Nevada mountain range and contain water of high quality derived from mountain snowpack. Soils derived from the granitic Sierra Nevada alluvium are sandy in texture and contain few native salts. Soils on the west-side of the River, on the other hand, are derived from marine sediments, contain high levels of native salts and are irrigated with water pumped and conveyed south from the San Francisco Bay Delta. More than 65% of the salt load for the entire San Joaquin Basin is discharged through two west-side sloughs that drain about 5% of the Basin.

In both Hunter and San Joaquin River Basins groundwater pumping can be used to offset surface water deliveries. Most surface water in these Basins has a salinity that ranges from 300 to 600 μS/cm EC – although specific ions such as boron dictate the salt tolerance of locally grown agricultural crops. Irrigated agriculture has been practiced in both Basins for about 100 years, and in both cases has led to a degradation of groundwater quality.

These River Basins were chosen for this study because of the innovative nature of the measures being taken to address salinity problems. Salinity problems have been recognized in the larger