Water market institutions in Colorado with possible lessons for South Africa*

WL Nieuwoudt
Department of Agricultural Economics, University of Natal, Pietermaritzburg, South Africa

Abstract

State provision of water is subsidised in both South Africa and Colorado and some costs are recovered through rates. Irrigation water in South Africa is not volumetrically priced and little scarcity value is attached to water. However, administrative pricing of water at opportunity costs is unlikely to be successful as opportunity cost varies according to location, reliability, season, use and quality. In a water market, water is not priced by administrators but the market attaches an opportunity cost price to water and thus promotes the highest valued use of the water. This is the case in Colorado. In Colorado an active market for the usufructuary rights of water has developed while water itself remains public property (as is the case in South Africa). The transfer time of Colorado Big Thompson (C-BT) water is short while transaction cost is small. There are two reasons why agricultural water markets do not release water in South Africa. The first is that the only water trades that have taken place are between non-users (sleepers) of water and intensive users. The second reason is that transferring diverted use of water in agriculture does not attach a price (opportunity cost) to the use of water (consumptive use). Administrative volumetric pricing of diverted use of water will also not promote water savings in agriculture for the same reason. Environmental issues (instream uses, quality, recreation) have become more prominent in the Western USA. Although water trades from down- to up-stream may reduce instream flow and harm the environment, the more usual trades are in the opposite direction and are likely to benefit the environment. Institutions need to be created in South Africa, within the parameters of the Water Act, to facilitate trade while providing protection to the environment. The new South African Water Act gives prominence to third-party (environment and human needs) issues, and protects third-parties more than is true in the USA.

Introduction

The SA government has passed a new water bill in 1998 (Act 36 of 1998) which provides the constitutional framework for water markets in South Africa. These reforms have changed the institutions that define rights, exposure to rights of others, privileges and responsibilities. Under the Act, basic human needs and environmental sustainability will be guaranteed as a right. Other important issues relate to equity and the use of water as a scarce resource by the agricultural sector. These issues are not always mutually exclusive and water markets and water institutions may be used to promote economic and socially desirable objectives.

These marketing institutions may not arise endogenously. Indeed, a puzzle in institutional economics is that many societies often fail to adopt the institutional structures of the more successful ones (Greif, 1998). Nobel laureate Coase (1998) asserts that institutions govern the performance of a country; in institutional economics the concern is not about prices but about incentives and the 'rules of the game' that will yield socially desirable outcomes.

Although technical water research has received high priority in the past in South Africa, little is known about the impact of alternative water economic policies. South African water markets, along with those of Australia and the Eastern USA, are based largely on riparian ownership and are not as fully developed as those in the Western USA. Due to the scarcity of water in the Western USA, water markets have a long history of experience and date back to a case by the Colorado Supreme Court in 1882 (Howe, 1997).

The purpose in this research is to study the experience of successes and unresolved challenges of Western water markets, and to draw from this possible lessons for South Africa. The Northern Colorado Water Conservancy District (NCWCD) was chosen as this market has been mentioned by several (Livingston, 1995; Cummings and Nercissiantz, 1992) as an ideal water market. This paper draws on institutional economics and is of an interdisciplinary nature.

Future expected water scarcity in South Africa can be tackled by building more dams (supply side approach) or the more economic efficient use (demand side approach) of water. The latter approach is followed in this paper. A main focus in the research is on sustainable use which requires attention to the environment and water quality.

Evaluation of principles

Water market doctrines

Water rights are generally based on one of three systems: public allocation, prior (appropriative) rights and riparian rights. Public allocation involves administered distribution of water.

Prior water rights as practised in the Western USA are established by actual use and a distinction is made between senior rights and junior rights. According to the priority system, rights first established are senior and must first be satisfied. The priority date, diversionary entitlement, point of diversion, and place and purpose of use delimit appropriative water rights (Huffaker and Whittlesey, 1995). The water rights institution provide certainty in supply as senior (prior) rights are fulfilled before junior rights.

Riparian rights link ownership, or reasonable use, of water to ownership of adjacent lands while rights are a percentage of water available for irrigation. This structure of water rights spreads the risk of variability equally among share holders.

The riparian doctrine only recognises rights of riparian landowners while the rights of other potential users are not protected by

* The financial assistance of the Ernest Oppenheimer Memorial Trust and the Centre for Science Development (CSD), towards this research is hereby acknowledged. The writer is indebted to anonymous reviewers for comments. The author is, however, solely responsible for conclusions and deductions made.

☎(033) 260-5494; fax (033) 260-5970; e-mail: nieuwoudt@agec.unp.ac.za

Received 7 October 1998; accepted in revised form 8 November 1999.

law. The new South African Water Act has changed this legal priority of rights dramatically. Only water required to meet basic human needs and to maintain environmental sustainability, also referred to as the Reserve, will be guaranteed as a right (DWAF, 1999a). Under the new SA Water Act, farmers will have to apply for licenses to use water. Licenses are not to exceed 40 years and water must be used beneficially. In contrast under riparian water law farmers have water rights whether or not rights are exercised.

SA farmers pay water rates/charges/tariffs on land scheduled under government water schemes or irrigation board schemes whether water is actually applied or not and it is unclear whether in the SA context non-use will constitute beneficial use as is the case in Australia. That is, in Australia farmers retain licenses to unused water in spite of the condition that water must be beneficially used (McKay,1999; Agriculture and Resource Management Council of Australia and New Zealand, 1995). As the preliminary water Reserve in South Africa has not been determined by early 1999, transfers of dormant water rights are permissible on a temporary basis and only in areas not considered high stress. In high-stress areas, transfers are not allowed until the relevant procedures are in place (DWAF, 1999b).

Water law

Water markets are rooted in a system of water law that displays three attributes: security, stability and flexibility in protecting transferability of property rights (Hobbs et al.,1994). Security is the ability to identify and gain protection for the right of use. Stability assumes that the right of use will continue to be recognised. Flexibility allows the right of use to be transferred to another use.

Changes in South African water law have affected both the security and stability aspect. This explains why the emerging water market in the Lower Orange River in South Africa ceased trading in 1998 (Armitage et al.,1999). Whether water markets in South Africa will be viable in future will depend on government policies which foster transferability of rights between potential buyers and sellers. In the absence of legal institutions that promote trade, trading will be expensive, while third-parties will not be adequately protected; thus the process will be *ad hoc*. Water laws in the Western USA not only permit trading but foster trading (MacDonnell, 1990). In contrast, South African water law states that provision will be made to enable transfer or trade with ministerial consent (DWAF, 1999a). This, of course, implies that the conditions under which trading may take place in South Africa are still uncertain.

A water right in Colorado is a legally sanctioned right to use water, protected by federal and state constitutions. Colorado law favours water transfers in several ways:

- Water rights are regarded as vested property rights, which may be transferred in the same way as other property rights
- The basis for legal review of rights is limited.
- Water resources are treated as largely interchangeable and their utilisation is promoted (MacDonnell, 1990).

Equity

Equitable concerns are essential features of water markets. In developing countries equity is usually defined in terms of the distribution of benefits to small and larger farmers (Sampath, 1992). Equitable concerns in the USA are the apportionment of interstate waters between states (Howe, 1996) while the USA Congress freed Native American tribes from obligations to repay any of the capital costs of constructing federal irrigation projects (Young, 1998a).

It is essential that South Africa address the equity issue as it would provide more stability to the social fabric of society and the new Water Act is evidence that the government is serious in its commitment to equity. Constitutional changes are aimed at assisting previously disadvantaged communities and it is certain that in future projects welfare implications will be considered. Disadvantaged communities need particular protection in water markets and one such a protective step is to vest rights in the hands of the community so that community-wide decisions are required to sell water (Howe, 1998).

Howe (1996) and Sampath (1992) both conclude that equity and efficiency may be promoted in a water market. It is, however, questionable, whether small-scale farmers in South Africa will gain more water through market forces because of capital and technological constraints.

Water markets

Water can be priced through tradable water rights, attempts to price at opportunity cost through administrative pricing or some other costing technique such as actual operating cost. If water rights are transferable, then the market attaches an opportunity cost to water. This is the preferred strategy in international economic literature (Briscoe, 1997; Thobani, 1997; Anderson and Snyder, 1997; Livingston, 1995; Cummings and Nercissiantz, 1992; Howe, 1997). In the absence of a water market, the value of water becomes incorporated in the price of land and as no volumetric price is attached to water, no incentive exists to use water as a scarce resource.

Price and consumptive/diverted use

In response to an increase in the volumetric price of water a farmer may:

a) shift to crops that are more water efficient, or higher valued;
b) continue with the same crop and acreage and apply less water; or
c) employ more water saving technology by, for example moving from flood to drip irrigation.

However, according to some experts no water is saved by adopting water-saving technologies (point (c) above). Some (Huffaker and Whittlesey, 1995; Frasier et al., 1998) contend that increased on-farm efficiency such as use of water-saving technology creates the illusion of water conservation when, in reality, the consumptive (water taken up by plants) use of water may increase. In a hydrological system, water not taken up by the plant will be returned to the basin or aquifer and be available for other users. Allowing farmers to irrigate a larger area if they use water-saving technology, such as drip irrigation, leads to lower return flow and increased consumptive use of water. This is expected to happen in South Africa as farmers along the Sunday's and Lower Orange Rivers are permitted to irrigate larger areas if water saving technologies are adopted (Armitage et al., 1999).

If the consumptive use increases, then of course less water will be available for other users. Although the opportunity cost price to irrigation water (volume applied) is increased in such a case, the consumptive use is expected to increase. If a price is attached to consumptive use, then the incentive will be given to economise on consumptive use by adopting technologies (a) and (b) above.

A policy of not permitting farmers to irrigate more land in the above situation is an economic **second best** (less efficient to the above) solution, as a further constraint is placed on the farmer's

decision-making. From a practical perspective second best solutions may be adopted. From an economic perspective, if the consumptive use of water is the scarce resource then this resource should face the user charge (or opportunity cost), otherwise the solution is less efficient.

The transfer of water out of a system may affect other users of waters who are not parties to the transaction. While other users may be better off as a result of water trades, their concern is with possible adverse effects. These users may be other consumptive users of water (such as farmers down-stream) or other non-consumptive users such as the environment. Additionally the quality of the return flow may be affected.

Other consumptive water right holders

The transfer of water rights to another user may negatively affect down-stream users who are dependent on the return flow of the previous use. Moreover, changes in the pattern of water use may affect other holders of water rights if their rights depend on existing patterns of use (GAO, 1994). Under Colorado water law a transfer may not cause injury to other parties (no damage principle) and other senior water right holders (irrigations) can legally prevent transfer in the event of injury. To simplify the implementation and enforcement of the no-injury rule, the **consumptive-use rule** was created to protect off-stream water users. Under this rule only the consumptive use of water can be transferred. Although information on consumptive use is more difficult to obtain than on actual use it solves the problem of avoiding injury to other consumptive users (for instance farmers). However, the difficulty in measuring consumptive use and return flow significantly increases the transaction cost of this system (Young, 1998b).

Moreover, if consumptive use rights are transferred other consumptive users are not harmed and thus yet costlier litigation is avoided (Young, 1998b). Therefore in most states in the Western USA, water rights are based on consumptive use with protection of third-party rights to return flows. Transferring consumptive use rights may entail setting river basin and regional standards for the consumptive use of water per irrigated hectare based on crop type, historic water availability, and other local variables. Such standards should be flexible enough to account for variations in water availability and local conditions. These data should be developed by the buyer and seller and third parties should not have to develop the data (Western Water Policy Review Advisory Commission, 1998).

Other non-consumptive right holders (instream and environmental uses and users)

The consumptive-use rule was not designed to protect non-consumptive uses, such as instream uses, from injury during the transfer process (Gillilan and Brown, 1997). The most significant externalities are associated with recreational and environmental water values and with water quality. Benefits generated by instream flows are often public goods not conducive to well-defined property rights and are characterised by non-rivalry and non-excludability.

If a water right is transferred from down-stream to up-stream, then streamflow will usually be less below the new diversion (up-stream) point if the buyer is a farmer or other consumptive (i.e. urban) user. Reductions in instream flows may negatively affect the environment or aquatic wildlife (GAO, 1994). If transfers are conditioned by the 'no damage' principle instream rights are secure, but flexibility in transfers is sacrificed (Livingston and Miller, 1986). The flexibility of being able to transfer a water right adds value to it because the market value of the right reflects not only the value of current use but also that of future opportunities.

The effect of water right transfers on instream flows may or may not be considered during a transfer hearing in the Western USA, depending on the state. Whether this will change in future is unknown (Gillilan and Brown, 1997).

Water quality

Most water diverters are not required to take into account the deterioration in water quality they impose on the stream. It is estimated that the Grand Valley Irrigation Project in Western Colorado was contributing 10 t of salt to the Colorado River per irrigated acre per year (Howe, 1998).

In Colorado, the extension service is charged with the adoption of voluntary best management practices (BMP) by educating farmers on the level and timing and application of nitrogen in order to meet, but not exceed, crop uptake. At present penalties are uncertain. To avoid excessive application, Livingston and Cory (1998) assert that state-initiated monitoring with meaningful fines is required while enforcement effort should be targeted on soils susceptible to leaching.

In the Eastern Cape in South Africa the return flow of irrigation water in the Fish and Sunday's Rivers is so highly polluted with salts that the return flow is not suitable for irrigation. The Department of Water Affairs and Forestry regularly flushes these rivers by releasing water from the Orange River. In Port Elizabeth the water from the Sunday's River is not fit for human consumption due to high pollution levels. Moreover, treatment costs are high.

Provision of appropriate incentives to farmers to reduce pollution is problematic. A pollution tax ("Pigovian") on water applied in these resource-sensitive areas may be considered. The tax may be based on the additional cost of water used to flush the system, plus the treatment cost of the Port Elizabeth municipality down-stream. To simplify monitoring and enforcement it is further suggested that the tax be based on (actual) area under irrigation.

Opportunity cost pricing and acreage water rates

A main problem with opportunity cost pricing is that opportunity costs are subjective and are not objectively observed (Pasour, 1990). Secondly, water supply and demand are seasonal and opportunity cost varies according to location, reliability, season, use and quality (Thobani, 1997). This is especially true in South Africa where rainfall is erratic. Thirdly, markets are driven by cost and income expectations that are not observable. Fourthly, water needs to be metered. A central water authority is required to set the price, monitor use and collect fees and the implementation cost associated with volumetric pricing is relatively high (Tsur and Dinar, 1997). In contrast, there is no volumetric pricing of water which is extracted from rivers in Colorado by water authorities (Young, 1998a).

Briscoe (1997) contends that the appropriate approach for ensuring that the scarcity value of water is transmitted to users, is to clarify property rights and facilitate their leasing and not by rolling opportunity costs into water tariffs. He proposes that South Africa should consider the latter route. The market solution to price water at opportunity costs is tradable water rights. The market institutions for tradable water rights in the Northern Colorado Water Conservancy District will now be discussed.

Northern Colorado Water Conservancy District (NCWCD)

The NCWCD includes irrigated and dryland farming areas and towns and cities in the South Platte River Basin, north of Denver and east of the Continental Divide. Mountain stream runoff is supplemented with transmountain diversions and groundwater pumping. Two major transmountain projects, the Colorado Big Thompson (C-BT) and the Windy Gap together provide 444 million m^3 annually of supplemental water to users in the NCWCD (NCWCD, 1998). C-BT water allotments are much sought after in Northern Colorado because of the ease in transferring C-BT rights to other uses (Hobbs et al.,1994). If municipalities in the NCWCD want to purchase C-BT water they are also required to purchase local water (base flow) (Ward, 1998).

Transfers are subject to approval by the NCWCD Board of Directors. In practice, transfers from irrigation to municipal or industrial use are routinely granted, after examination of the need, by the new user, for a supplemented water supply. Transfers from one tract of irrigated land to another are subject to a determination that the new acreage has a base existing supply of water and that supplemental water is needed (Hobbs et al., 1994).

The C-BT project, excluding the Windy Gap, has been designed to deliver 384 million m^3 (310 000 acre feet) of water, converted into 310 000 shares. The price of C-BT water is thus expressed in terms of 1/310 000th of the annual supply. The quota of water actually delivered under each C-BT unit is set each year by the Board of Directors.

Lessons can be learned from Colorado water markets as transfers in some instances are simple and inexpensive and require little time as far as C-BT water is concerned. The C-BT water market administered by the NCWCD is sophisticated while C-BT water is supplied to an area characterised by an arid climate and as vast as the state of Connecticut. Transfers outside the NCWCD have been costly in many instances. Some of the features of this market will be discussed.

Ownership of C-BT water

The C-BT project was constructed between the United States as the constructor and title owner and the NCWCD as repayment entity, operator of facilities and distributor of project water. Although the United States government is the owner of the project and the water, the NCWCD is granted the perpetual right to use all water available for irrigation, municipal, industrial and domestic purposes (NCWCD, 1998).

The Board of Directors of the NCWCD has powers to make and enforce all reasonable rules and regulations for the management, control, delivery etc. of water. All land owners pay an annual levy on acreage under irrigation (property tax) for repayment of the fixed costs of providing the infrastructure and the operation and management.

Infrastructure

Physical circumstances, as well as the economic value of water in alternative uses, determine the gains from trade. The cost of transporting water necessary to complete a transfer may render the transaction uneconomical (Livingston, 1995). The C-BT project delivers supplemental water to 607 000 ha within NCWCD boundaries. This water market is interlinked as the main reservoirs obtain water from the same supply source (Adams Tunnel). Water is delivered through the C-BT system to 29 cities and towns and to 100 ditch and reservoir companies (NCWCD, 1998). Within this large basin C-BT water is computer-controlled and the values of the marginal product of water of users will be equal.

Transaction cost

Transaction cost of transfer of ownership of C-BT water is estimated at less than 1% if brokers are not involved in the sale while, if brokers are involved, the transaction cost could be as high as 10% of the purchase price (Berryman, 1998). A water lease within a ditch company's area can be arranged by phone in a manner of minutes (Eckert, 1998) and costs \$12 per 1 000 m^3. Transfer of ownership of C-BT water takes about two to three months, with the NCWCD recording all transactions. The NCWCD does not act as broker but a number of private brokers do exist. Further, regional newspapers carry information on sale and lease opportunities and the set-up is analogous to housing and land markets (Kemper and Simpson, 1998). Information search cost is low. The NCWCD operates a dispatch centre, which is available on a daily basis to receive and process water orders (Kemper and Simpson, 1998).

The price of water in 1998 was \$2 400 per 100 m^3, giving a rate of return of only 0.5% on the purchase price. The low rate of return is due to urban purchase of water for future use. This water is leased back to agriculture at a low price.

If local water were transferred between ditch companies or different uses (agriculture to urban), transaction cost are likely to be high if the sale would be contested. In many instances litigation cost can be avoided if potential purchasers first consult with possible third parties (Berryman, 1998).

Water transfers in the NCWCD

As diversion costs are high for individual farmers, non-profit co-operative organisations called mutual ditch companies were created. Typically, these companies own and manage the delivery of water and facilitate market transactions by performing monitoring, distribution and enforcement functions (Kemper and Simpson, 1998). Individual farmers own shares in the company and when water is transferred it is usually the shares in the company that are transferred (Young, 1998a). When a farmer needs C-BT water, he contacts his ditch company's secretary who in turn collects orders for the day and informs the District Dispatch Centre (Kemper and Simpson, 1998). In this decentralised market, C-BT water is not delivered to each farmer directly but to the ditch company's intake. Ditch companies range in size from 250 ha to 22 000 ha.

As CBT water is imported, it is **new water** and no third-party claims to this water exist. Thus the return flow of consumptive and non-consumptive users need not be considered (Berryman, 1998). Further, streamflow has increased in the NCWCD as a result of higher return flow. The absence of third-party claims on C- BT water makes this water easily transferable within the NCWCD without litigation expenses of claims being contested. Of the 1049 million m^3 of water presently available within the NCWCD 271 million m^3 or 25% is C-BT water. Third-party implications need to be considered for the non C-BT water which is referred to as **local water** or **base water**.

However, local water can be transferred within a ditch company area without consideration of third parties or return-flow as there are no negative impacts of such a transfer (Nettles, 1998). Parties must, however, apply to a water court to transfer local water between ditches or if the water is to be used for a different purpose (say irrigation to urban). In this case only consumptive use is transferred. Consumptive use is based on historic return flow in individual cases and the court will determine how much can be transferred, based on information from water engineers. Given the

ease of transfer of C-BT water and the cost of transferring local water between ditches, little local water is transferred between them (Nettles, 1998).

Although C-BT water is highly transferrable within the NCWCD, this water cannot be transferred outside the NCWCD. Local water can be sold outside the NCWCD but third-party implications need to be considered.

This is illustrated by a highly publicised case involving the purchase of water by the Denver suburb of Thornton from a water company in the Poudre River in 1985. The amount Thornton was prepared to pay far exceeded the agricultural value of the water. Both buyer and seller agreed to the sale but third-parties contested the transfer on the basis that it would affect the timing and amount of return flow. Thirteen years after the purchase, the sale is still in limbo (Berryman, 1998) and untold amounts have been spent by agencies defending their legal positions. Denver could not have bought the highly transferable C-BT water as this water cannot be transferred outside NCWCD (C-BT) territory (Ward, 1998).

Other third-party and instream uses (non-onsumptive)

Colorado Water Law includes instream flow protection, which is considered a beneficial use of water. However, the main conservation agency in Colorado namely the Colorado Water Conservancy Board (CWCB) has only been concerned with maintaining instream flow to protect cold water fisheries. Thus interests such as other wildlife, water quality, recreation, wilderness and aesthetics have no protection beyond that required by fish (National Research Council, 1992). Rights held by the Board are further of a junior nature since rights were obtained in recent times (Nettles, 1998). Under prior appropriation junior (more recent) rights can only be fulfilled after the senior (older) rights have been exercised.

Instream flows have two dimensions: the first deals with the quantity of water available for recreation, fishing, water fowl and scenic purposes; and the second deals with the quality of water available for pollution dilution.

Water rights

Rights can be transferred in different ways. Rights may be in the form of prior rights to streamflow, shares in a ditch company, or rights in water stored while water may be sold, leased or loaned.

Short-term leases of direct flow rights are most frequently observed within ditch companies or amongst owners of ditches drawing from the same source. As C-BT water is stored at the upper end of the large network of ditch companies, leases of water can easily be implemented with gravity deliveries at little extra cost. Temporary loans of water are possible and repayment is in accordance with the loan agreement (Young, 1998a).

Rights to storage water are a further development which are in addition to flow rights and are thus complementary to other rights. Reservoirs can capture unappropriated water (excess water or water with junior rights). Once water is in storage it may be used at any time by its owner.

Change in demand

Cities own 50% of the water but normally only use 30% of the water, with the non-used portion leased back to agriculture (Berryman, 1998). They have bought more water rights than needed at present as insurance against drought and also allowing for future expected urban growth. Cities thus have adopted risk adverse behaviour.

Agricultural use of water has declined from 95% in 1956 to 71% in 1997, while municipal and industrial use increased from 5% to 29% (NCWCD, 1998). This implies that important trades are between agriculture and non-agriculture. Irrigated hectares remained constant from 1957 to 1971 at 291 000 ha but then declined to 242 000 ha in 1997 (NCWCD, 1998) as transferred water rights out of agriculture have to be accompanied by fallowing land.

While the water market has led to a permanent transfer of water, seasonal rentals have also increased. The percentage of the water delivery quota rented or "moved around" increased from 30% in 1959 to 70% in 1992 (Kemper and Simpson, 1998).

Groundwater institutions

Groundwater, the withdrawal of which will not deplete streamflows, is treated as private property and will not be discussed here. Groundwater rights referred to in this section are rights that affect surface water rights, also called **tributary rights**. Due to the common ownership of the latter groundwater rights, over-exploitation is a problem and the challenge is to create institutions that will prevent this. Observing institutions in the market place is instructive as these institutions have already overcome some delicate issues. A very practical approach to privatise these groundwater has been adopted by the Central Colorado Water Conservancy District (CCWCD). For an institution to function it needs to be based on legal principles and acceptable by participants, both apply in the latter case.

According to the CCWCD approach, the prior appropriation of surface water rights was extended to groundwater. According to this system "first in time, first in right", rights which have been established first are senior to those established later. Most surface water rights (ditches) were developed in the 1800s while groundwater rights (wells) were installed in the mid-1900s. The pumping of groundwater causes "injury" to surface water users which under Colorado law could demand the closing of wells.

In order to maximise utilisation of both surface and groundwater, the Colorado Legislature passed an act allowing for augmentation of groundwater. The CCWCD was formed by public petition and vote to give implementation to this (CCWCD, 1998). This institution purchases water from senior rights holders (farmers) and then releases the water at recharge sites. The augmentation plan covers over 1 000 wells and over 1 942 km^2. Members have an annual depletion of approximately 91 million m^3 (CCWCD, 1998).

Colorado Water Law requires that a well should have a permit and that its pumping rate be certified and reported. The legal description of the well includes the date when water was first put to beneficial use, amount of water pumped, area irrigated etc. Farmers pay a tax on acreage under irrigation from a well, as well as a property tax. The quantity and quality of water are monitored for each well. The area is, however, vast, which makes monitoring not always possible (Linker, 1998). Groundwater samples are taken several times a season from 150 wells to detect seasonal trends in concentration of nitrate and pesticides. Results so far show no significant findings of pesticides (NCWCD, 1998).

However, according to Livingston and Cory (1998) nitrate is a problem. Nitrate concentration levels have increased from 1957 - 65 to 1989. In the latter period only 30% of the samples had concentration levels below EPA standards.

Cost-efficiency of institutions

In a water market there is a trade-off between resolving environmental concerns and keeping transaction cost low. In most western states of the USA, transfers are considered by the State Engineer while in Colorado, court approval must be sought. The latter

requirement explains why one third of US water lawyers practise in Colorado. The only water trades in the NCWCD that take place are between users where legal approval is not necessary. Trade is only in C-BT water or between farmers within the same ditch company.

Simple changes in ownership may occur without restriction. Transfers involving changes in other attributes such as the purpose or place of use are, however, subject to legal review. Water rights may be changed with respect to point of diversion, the type, place or time of use, or between direct flow and storage rights. The water court must approve a change request if the applicant demonstrates that there will be no injury to other water rights or if terms and conditions can be imposed that will eliminate injury. Two possible sources of injury are:

- depletion of streamflow and
- change in timing of flows.

Any change in point of diversion on a highly appropriated stream, is likely to alter stream conditions (MacDonnell, 1990). Many victims may not have sufficient incentives to organise themselves as benefits are dispersed (harm is spread amongst a large number of environmental users) and the transaction cost of organising them is high.

Institutions in the form of rules of the game must establish incentives that promote social desirable outcomes. Livingston (1998) considers three sets of rules:

Rule 1: The environment is a constraint and some areas are protected. Protect for instance that part of the river that is sensitive.

Rule 2: General rule of "no damage". The burden of proof is then on the individual which is costly.

Rule 3: The State acquire water rights and streamflow is augmented when needed. The State could purchase senior rights giving the environment the same protection as other senior rights holders. Engineers are familiar with hydrological implications of transfers and using the latter route may be more cost-effective.

Legal cost is high if water is transferred outside NCWCD boundaries. Experts (Howe, 1998; Young, 1998b; Hobbs et al., 1994) contend that the legal constraints preventing NCWCD water to be sold outside the NCWCD create an inflexible system. One of the main attributes of water law is flexibility which allows the right of use to be transferred to another use (Hobbs et al., 1994). Livingston (1998) and Howe (1998) are of the opinion that the decision-making unit should be large enough to capture possible externalities and that water markets should encompass larger parts or entire river basins.

Office of the State Engineer

The State Engineer has statuary authority for administering the waters of the state. This office is responsible for the administration and distribution of these waters in accordance with the principle of "prior appropriation". Officials are required by law to see that waters of the state are available for the use and benefit of the people.

Using data from monitoring stations, the office ensures that ditch companies do not divert more water than allowed for, given the seniority of its members; each year more than 1 500 wells are monitored (Division of Water Resources, 1998).

Due to high legal cost of transfers in Colorado, if C-BT water is not involved or if transfers are not within a ditch company domain, several experts have proposed that the transfers in Colorado should be handled by the State Engineer as in other states and not by water courts (Livingston, 1998; Grigg,1998; MacDonnell, 1990; Howe,1997). Transfer applications that involve injury to others relate primarily to technical factual issues rather than legal issues (MacDonnell, 1990) and the findings of the State Engineer are usually accepted by all parties (Howe, 1997). The average time from application for transfer to final approval is typically twice as long in Colorado than in New Mexico and Utah where the State Engineer approves transfers. Court proceedings are long and costly. Further in Colorado, 62% of transfers are protested but only 8% in Utah and 6% in New Mexico (Howe, 1997). Others (Young, 1998b; Ward, 1998) see merit in court approval of transfers while Young (1998b) contends that transaction cost of transfers cannot be compared between states as the complexity of transfers differs. A broader set of interests implicated by transfers needs to be included (MacDonnell, 1990; Livingston, 1998; GAO, 1994).

Efficiency and environmental impacts

Whereas the availability of C-BT water in the NCWCD has simplified transfers, transfers in the Arkansas River in Southern Colorado are complex and difficult. Rights transfers from irrigators to urban users involve complicated exchanges over long distances and jurisdictional boundaries which give cause to extensive negotiation and litigation (National Research Council, 1992).

Transmountain diversion projects bring in 247 million m^3 of water into the Arkansas River Basin in Southeastern Colorado but only 62 million m^3 of this water provided through the Twin Lakes Reservoir have been marketed. A decree was obtained in the water court to change the purpose of use from irrigation to multiple use of Twin Lakes water rights and Twin Lake stock suddenly became one of the most flexible sources of water in the area (National Research Council, 1992).

Neither the State Engineer nor the water court historically has dealt with water quality issues; however, these issues are arising more frequently. Presently, the diversion of water for beneficial use in Colorado cannot be restricted for water quality protection.

The water court system allows anyone with potential water rights injury to become a party. Legal and engineering costs sometimes bar access to courts for individuals, while broader community concerns are not addressed by organisations representing individual rights. Colorado is the only western state that has no law directing that public interest be taken into account in some form during water transfers although broader community concerns are been given more consideration in recent times.

Although these third-party effects are now playing a more important role, there is not an integrated mechanism for weighing, avoiding and mitigating impacts on third parties. Actions of third-parties are often not consistent and predictable and can impede or prevent transfers or developments that are socially and economically beneficial (National Research Council, 1992). Third-party influences can also vary with the type and relative wealth of the developer as the high legal cost of contesting claims can make it difficult for poor communities to contest claims (Ward, 1998).

Basin of origin issues are handled case-by-case, causing uncertainty. Project proponents often do not know the potential cost of modifications and affected parties do not know which of their claims will be resolved satisfactorily (National Research Council, 1992).

The United States General Accounting Office (GAO,1994) compared various strategies for addressing the adverse impacts on third parties and concluded that effectiveness varies and that no one strategy is best. Moreover, each transfer situation is unique, so that strategies may effectively address certain impacts in some circum-

stances but not others.

Amongst the strategies given favourable ratings were:

- public interest review;
- establish minimum streamflow; and
- zoning (preventing transfers from sensitive areas) (GAO,1994).

These stategies will now be discussed.

Public interest review

Many states in the USA consider the impact on public interest through a public interest review. Typically proposed transfers are announced through public notice and concerned parties can submit protests describing concerns. The concerns may be addressed further at a public hearing. Whether a transfer is in the public interest is usually decided by the state engineer or other water resource officials (GAO,1994). A public interest review can address most third-party concerns if all concerned third parties have opportunity to become involved (Livingston, 1998). It is difficult to get all affected third parties represented in the process. Where benefits are concentrated, groups may be better organised but if benefits are dispersed, the incentive for a group to organise themselves may be low as predicted by transactions cost theory. Environmental groups may fall in this category. A lack of reliable data on environmental impacts can limit the effectiveness of addressing these impacts. A negative aspect of extensive review is that it can add significant cost, delays and uncertainty to the approval process.

Minimum streamflow

Some states in the USA establish minimum streamflows or lake levels to protect environmental conditions. This is seen as an effective solution for avoiding degradation of surface water conditions but is not sufficient as a general solution to all conditions. This strategy has low transaction cost as transfer applicants only must demonstrate that transfers meet specific standards. However, once standards are exceeded, transfers cannot occur and some transfers are prohibited regardless of the value (GAO, 1994).

Zoning

Environmental values in sensitive areas can be protected by zoning. The issue then is to determine which areas should be zoned and who should make zoning decisions. Zoning raises the possibility of government failure (Pasour, 1990). As with the previous strategy, zoning has low transaction cost but may prohibit certain types of transfers regardless of their value (GAO, 1994).

Transfers could also be taxed and the proceeds used to mitigate impacts of transfers. Taxes are timely and certain and do not prohibit transfers. However, all transfers are taxed whether impacts are positive or negative which is non-discriminatory.

Transaction costs incurred to redress third-party claims serve a beneficial role when effected third-parties are given a voice in the review process. However, there may be opportunities to reduce transaction cost by clarrifying state policies. The cost of mitigating third-party effects may be internalised as a cost of the transfer but this does not mean that externalities must be eradicated. Though ubiquitous, most externalities should be ignored by law and they usually are (Buchanan and Stubblebine, 1962).

Lessons for South African water markets

Water markets may encounter ideological opposition as water traditionally has been regarded as a public good. The Colorado example shows that a market can develop for the usufructuary rights of water while water itself remains public property. The highly transferable C-BT water is owned by the US Government. This is important for South Africa since, according to the new Water Act, the South African Government will act as the custodian of the nation's water resources and its powers in this regard will be exercised as a public trust. The Colorado example also shows that a water market requires both government involvement and active water-user participation. The government can assist in providing institutional support but water needs to be managed at the lowest appropriate level.

SA farmers pay water rates on land scheduled under government water schemes or irrigation board schemes regardless of whether water is used. This policy has merit and should be continued as it allows the state to recover some of its expenditure. However, current water rates in South Africa do not achieve cost recovery and, as in the Western USA, water is subsidised to agriculture. If water is not volumetrically priced no scarcity value is attached to water. Irrigation water is thus under-priced in South Africa.

Administrative pricing of water at opportunity costs is unlikely to be successful as opportunity cost varies according to location, reliability, season, use and quality. Opportunity costs are also subjective and are not objectively observed (Pasour, 1990) and therefore cannot be calculated. In a water market, water is not priced by administrators but the market attaches an opportunity cost price to water and thus promotes the highest valued use of the water. This has equity implications for the broader population as they benefit if agriculture uses water more economically efficiently, and releases water.

Equity is, however, better addressed by non-market means. An example is the new Water Act of 1998 which has defined the rights of the different user groups of water and thus have important equity implications. Further, the current land redistribution programme in South Africa will also redistribute water rights as the value of water is incorporated in the price of land. Where inequalities exist regarding access to water, then these must be corrected through political negotiation. Water markets can only operate after all the role-players have agreed on the initial apportionment of rights.

In spite of the absence of legal institutional support, water markets have started to emerge in the Lower Orange River and in the Fish and Sunday's Rivers in the Eastern Cape. Current ownership uncertainty of water in South Africa is not conducive to transfers. For example it is uncertain under the new Water Act, whether farmers who have not used their water rights will still retain them and be able to sell them.

There are two reasons why agricultural water markets do not release water in South Africa. The first is that the only water trades that have taken place in these rivers are between non-users of water and intensive users. It may take time before all **sleeper rights** (water not used) are activated. This 'problem' also exists in Australian water markets (McKay, 1999).

The second reason is that transferring diverted use of water in agriculture does not attach a price (opportunity cost) to the use of water (consumptive use). The transfer of diverted use (water actually applied) provides irrigators an incentive to irrigate yet larger areas by adopting technologies that reduce application rates. The result is that the consumptive use of water increases and water prices thus do not promote the use of water as a scarce resource. In South Africa diverted use is transferred and irrigation farmers are permitted to irrigate larger areas if they adopt water conservation technologies such as drip irrigation. Administrative volumetric pricing of diverted use of water will also not promote water savings in agriculture for the same reason.

In the Western USA water is transferred based on consumptive use (excluding C-BT water) to protect other consumptive users who may be harmed by diminished return flow if water is diverted

from a fully appropriated stream. This consumptive-use rule was, however, not designed to protect non-consumptive uses such as instream uses from injury during the tranfer process. The most significant externalities are associated with recreational and environmental water values and with water quality. Environmental issues have become more prominent in the Western USA and a trade-off exists between security of environmental rights and flexibility of water transfers as protection of instream rights will constrain transfers.

Although water trades from down- to up-stream may reduce instream flow and harm the environment, the more usual trades are in the opposite direction and are likely to benefit the environment. Institutions need to be created in South Africa to facilitate trade while providing protection to the environment. The new South African Water Act gives prominance to third-party (environment and human needs) issues, and protects third parties more than is true in the USA.

Water engineers have played a major role in water markets in both the USA and in South Africa and this research supports their continued role. Their role is important as third-party issues are often of a technical nature. The findings of the State Engineer are usually accepted by all parties in the Western States, while water courts have delayed the transfer process and made it expensive. Poor communities may also not find it financially feasible to contest claims in court.

Literature

AGRICULTURE AND RESOURCE MANAGEMENT COUNCIL OF AUSTRALIA AND NEW ZEALAND (1995) Water Allocations and Entitlements. Task Force on COAG Water Reform, Occasional Paper Number 1, October.

ANDERSON L and SNYDER P (1997) *Water Markets. Priming the Invisible Pump*. Cato Institute, Washington, DC.

ARMITAGE R, NIEUWOUDT WL and BACKEBERG GR (1999) Establishing tradable water rights: Case studies of two irrigation districts in South Africa. *Water SA* **25** (3) 301- 310.

BRISCOE J (1997) Managing water as an economic good. In: M Kay, T Franks and L Smith (eds.) *Water: Economics, Management and Demand.* E & FN Spon, London.

BERRYMAN A (1998) Personal comment. Head Engineering Services Branch, Northern Colorado Water Conservancy District, Loveland Colorado.

BUCHANAN JM and STUBBLEBINE WC (1962) Externality. *Economica* **29** 371-84.

CCWCD (1998) *Well Users Guide to Augmentation.* Publication of the Central Colorado Water Conservancy District, Greeley, Colorado.

COASE R (1998) The new institutional economics. *The Am. Econ. Rev.* **88** (2) 72-74.

CUMMINGS RG and NERCISSIANTZ V (1992) The use of water pricing as a means for enhancing water use efficiency in irrigation: Case studies in Mexico and the United States. *Natl. Resour. J.* **32** 731-755.

DEPARTMENT OF WATER AFFAIRS AND FORESTRY (DWAF) (1999a) National Water Act http://www-dwaf.pwv.gov.za.

DEPARTMENT OF WATER AFFAIRS AND FORESTRY (DWAF) (1999b) Transfer of Water Use Rights. Letter sent by Director-General to Regional Directors, (Feb).

DIVISION OF WATER RESOURCES (1998) *Colorado Water Rights*. Greeley, Colorado.

ECKERT J (1998) Private communication. Agriculture and Resource Economics, Colorado State University, Fort Collins.

FRASIER WM, WHITTLESEY NK and HAMILTON JR (1998) Stream Flow Effects of Improving Irrigation Efficiency. Unpublished Paper. Colorado State University, Fort Collins.

GAO (1994) Water Transfers: More Efficient Use Possible if Problems are Addressed. United States General Accounting Office.Washington DC. 20548.

GILLILAN DM and BROWN TC (1997) *Instream Flow Protection*. Island Press. Washington, DC.

GREIF A (1998) Historical and comparative institutional analysis. *Am. Econ. Rev.* **88** (2) 80-84.

GRIGG NS (1998) Private comments. Former Director, Colorado Water Resources Institute, Fort Collins, USA.

HOBBS GJ (Jr.), HOBBS T and RALEY PC (1994) Institutional roles and water marketing in Colorado and the Western United States. Paper Presented to World Bank Group, Water Legislation: An Integrated Approach, September 8-9, Washington.

HOWE CW (1996) Water resources planning in a federation of states: Equity versus efficiency. *Natl. Resour. J.* **36** 29-36.

HOWE CW (1997) Increasing efficiency in water markets: Examples from the Western United States. In: TL Anderson and PJ Hill (eds.) *Water Marketing- The Next Generation.* Rowman & Littlefield Pub., New York.

HOWE CW (1998) Protecting public values under tradable water permit systems: Economic efficiency and equity considerations. To be published in *University Denver Water Law Review.*

HUFFAKER RG and WHITTLESEY NK (1995) Agricultural water conservation legislation: Will it save water. *Choices* (4th quarter) 24-27.

KEMPER KE and SIMPSON LD (1998) The Water Market in the Northern Colorado Water Conservancy District - Institutional Implications. Unpublished, World Bank. Washington.

LINKER S (1998) Personal comment. Central Colorado Water Conservancy District, Greeley, Colorado.

LIVINGSTON M (1998) Personal comment. Head of Department Economics, University of Northern Colorado, Greeley, Colorado.

LIVINGSTON ML (1995) Designing water institutions: Market failure and institutional response. *Water Resour. Manage.* **9** 203-220.

LIVINGSTON ML and MILLER TA (1986) A framework for analysing the impacts of Western instream water rights on choice domains. *Land Econ.* **62** 269-77.

LIVINGSTON ML and CORY DC (1998) Agricultural nitrate contamination of groundwater: An evaluation of environmental policy. *Am. Water Resour. Assoc.* **34** (6) 1311-1317.

MacDONNELL LJ (1990) *The Water Transfer Process As Management Option for Meeting Changing Demands*. Vol 1. To be published by US Geological Survey. Colorado Water Resources Institute, Fort Collins.

McKAY J (1999) Personal comment. E-mail address jennifer.mckay @unisa.edu.au.

NATIONAL RESEARCH COUNCIL (1992) *Water Transfers in the West: Efficiency, Equity and the Environment.* National Academy Press, Washington DC.

NCWCD (1998) *General Information.* Publication of Northern Colorado Water Conservancy District, Loveland, Colorado.

NETTLES D (1998) Personal comment. Division of Water Resources, Office of the State Engineer. Greeley, Colorado.

PASOUR EC (1990) *Agriculture and the State: Market Processes and Bureaucracy*. Holmes and Meier, New York.

SAMPATH RJ (1992) Issues in irrigation prices in developing countries. *World Dev.* **20** (7) 967-977.

TSUR Y and DINAR A (1997) The relative efficiency and implication costs of alternative methods for pricing irrigation water. *The World Bank Econ. Rev.* **12** (2) 243-262.

THOBANI M (1997) Formal water markets: Why, when, and how to introduce tradable water rights. *The World Bank Research Observer*, **12** (2) 161-179.

WARD RC (1998) Private communication. Director, Colorado Water Resources Institute, Fort Collins, USA.

WESTERN WATER POLICY REVIEW ADVISORY COMMISSION (1998) Final Commission Report. http://www.den.doi.gov/wwprac/reports/final.htm.

YOUNG R (1998a) Water Allocation in Colorado: The Potential of Market Mechanisms for Providing Water for the Environment. Unpublished, Colorado State University, Fort Collins.

YOUNG R (1998b) Private comments. Colorado State University, Fort Collins.