DEVELOPMENT OF A SUGARCANE INDUSTRY IN THE ORD, WESTERN AUSTRALIA

J M GOSNELL[1] and J H ENGELKE[2]

[1]*PGBI Engineers and Constructors, PO Box 2668, Rivonia, 2128, South Africa*
[2]*Dept of Agriculture, Kununurra, Western Australia*
E-mail: gosnell@venturenet.co.za

Abstract

The Ord River Irrigation Area is 3200 km NE of Perth on latitude 15^0 30' S, at an altitude of less than 100 m, with rainfall of 800 mm. Water is supplied from the vast Lake Argyle, soils utilised for agriculture are predominantly black montmorillonitic clays and topography is generally very flat. Growing conditions are superb for most tropical crops. Out of a total of 11000 ha under irrigation, sugarcane is grown on 4000 ha to supply a mill producing around 55000 tons sugar/annum. The factory was initially constructed on a low-cost new technology basis, unfortunately it gave serious problems and required major modifications. In contrast, the cane harvesting and transport system is highly efficient. Land forming is carried out on all fields to a very high standard and all cane is furrow irrigated. Twenty growers, with an average cane area of 200 ha, focus on highly efficient sugarcane production with low labour input. Average cane yields of 128 t/ha at 14 pol % cane were attained during the period 1996-2001. The first outbreak of sugarcane smut in Australia was recorded in the Ord in 1998 and resulted in the elimination of the two most promising varieties, Q117 and NCo310.

A detailed feasibility study was carried out to develop an additional 30000 ha and construct a new sugar mill with a capacity of 400000 tons sugar annually but these proposals were recently abandoned primarily due to low prospective world sugar prices. However, the existing mill is planning to double its current capacity, which will require a further 4000-5000 hectares of land to be planted to sugarcane.

Keywords: Ord, sugarcane, land forming, smut, furrow irrigation

Overview

Location and climate
The Ord River Irrigation Area (ORIA) is located near the town of Kununurra, at latitude 15^{o}20-40'S and an altitude below 100 m above sea level. It is some 3200 km NE of Perth, close to the Western Australia/Northern Territory state boundary and 100 km from the nearest port, Wyndham. The Ord has long been regarded as a strategically important area for Australia and, as shown in Figure 1, it is closer to Jakarta than to Sydney. The ORIA is ideally located to capture export opportunities presented by its proximity to South East Asia.

As shown in Table 1, the Ord has an extremely hot climate. Mean maximum temperatures exceed 30^{o}C every month of the year and exceed 35^{o}C between September and April. It is of interest to compare temperatures with those at Nchalo, one of the hottest sugar estates in southern Africa. Mean annual rainfall is 800 mm, falling principally between December and March. Evaporation is very high, averaging 2869 mm annually. Climatically, it is an excellent area for growth of sugarcane. Full irrigation is required for eight months and some is needed in the summer during dry spells.

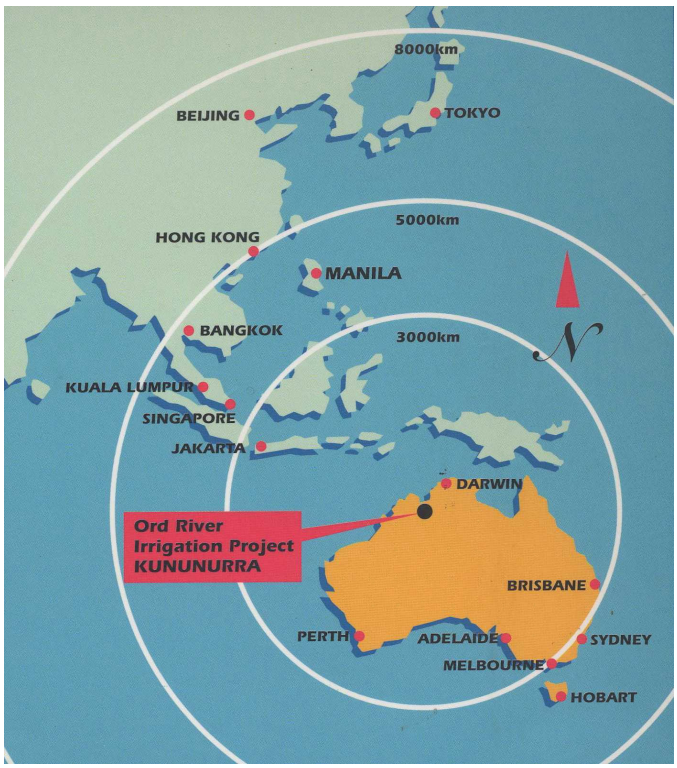

Figure 1. Location of the Ord in Australasia

Table 1. Climatic data for the Ord River irrigation area and Nchalo, Malawi.

	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOTAL
Mean Maximum Temp °C	30.5	32.9	35.8	38.5	38.9	37.8	36.0	35.0	35.5	35.1	32.7	30.5	
Mean Minimum Temp °C	14.1	15.5	19.0	22.8	24.5	24.8	24.4	24.2	23.4	20.7	17.9	15.3	
Rainfall mm	5	0	3	22	62	133	198	199	130	45	8	3	800
Evaporation mm	209	241	294	330	287	275	230	176	195	217	212	203	2869
Mean Max Temp °C - Nchalo, Malawi	27.7	30.0	33.2	35.0	35.8	34.4	32.9	33.3	33.0	31.6	29.9	27.8	

Irrigation water supply

Water is supplied from Lake Argyle on the Ord River, which has a capacity of 10.76 million Ml and can potentially meet all future irrigation requirements of Ord Stage 1 and 2 at 90% security and better. The dam was completed in 1972. Water is supplied via the Kununurra diversion dam (completed in 1963) through the M1 and Packsaddle channels (canals) with a capacity of 2160 Ml/24 h (25 m^3/sec) but is currently only used at 1200 Ml/24h (peak use 1600 Ml). Water quality is excellent.

The controlling authority is Water Corporation of Western Australia, previously a Government Department and now a corporatised Government trading entity with one share held by the Minister for Water Resources WA. Water Corporation developed the irrigation infrastructure of Ord Stage 1 and is now in the process of handing this over (with the exception of the M1 Channel) to the Ord Irrigation Co-operative (OIC), a grower-owned and managed organisation. Government has set water charges at a rate per hectare; in 2001 the charge was AUD$84/ha for irrigable land. The actual cost of water delivery is in the vicinity of AUD$13/Ml or more than double the revenue collected from water sales. After assets are transferred to the OIC, water will be charged on the basis of a rate per hectare plus a volumetric charge that will initially be AUD$6/Ml. During the transition to private ownership, OIC will receive a subsidy, which will be phased out over a ten-year period.

Total annual irrigation water allocation to the OIC for Ord 1, is provisionally around 350,000 Ml. An allocation of approx. 17 Ml/ha/annum at the farm gate has been made for existing developed land. This allows for delivery losses and further area to be developed within Ord 1. Water use requirements of sugarcane have been budgeted at 2200 mm. (22 Ml/ha/annum). Assuming rainfall efficiency of 65%, i.e. 520 mm effective rain, this equates to an irrigation water requirement of 16.8 Ml/ha/annum (1680 mm).

Area available

There are approximately 56000 hectares of arable land under command of the Kununurra diversion dam. Some 14000 ha in the Ivanhoe and Packsaddle Plains have been developed as Ord Stage 1, of which 4000 ha are currently under sugarcane. Of the remaining 42000 ha, approximately 34000 ha are suitable for surface irrigation and sugarcane production. The remainder is more suited to other irrigation methods such as trickle tape and micro-sprinklers. The main potential for future sugarcane development lies in the Weaber, Knox Creek and Keep River Plains (M2 development area), parts of which are in the Northern Territory. These areas are shown in Figure 2.

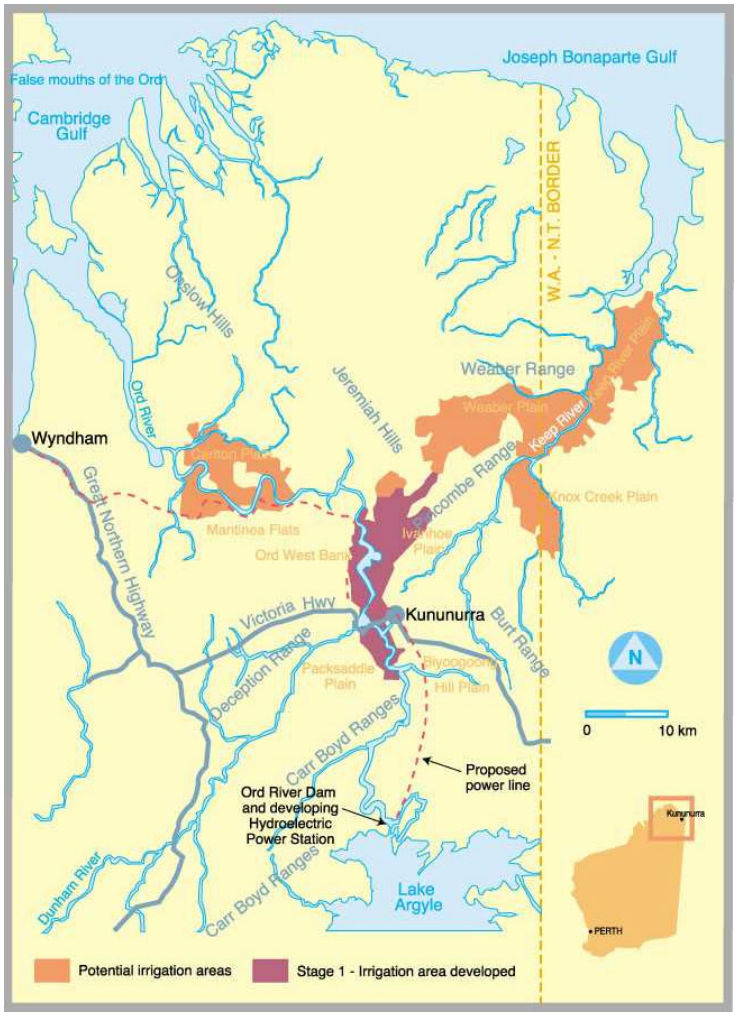

Figure 2. Location of the Ord Irrigation Project

Soils

Detailed soil surveys show that almost all existing and potential sugarcane soils are deep Cununurra and Aquitaine montmorillonitic clays. Cununurra clays crack markedly on drying, are dark, self-mulching, well structured, and weakly gilgaied. The topsoil contains 40-60% clay, is slightly alkaline at the surface, with increasing alkalinity at depth, but conductivity and ESP is generally low in the top metre of soil. Field management is easier on these soils than on the Aquitaine clays, which tend to occur on very flat grades and have been strongly influenced by seasonal inundation in

their formation. They are greyer in colour, crack moderately but less than Cununurra clays, and may have as high as 70 % clay in topsoils. Internal drainage is poor and the soil does not have the same self-mulching characteristics and is less easily worked. Both soils have high cation exchange capacities and are well supplied with calcium, magnesium and potassium. Phosphate and nitrogen levels are low and zinc and sulphur may be deficient. Most of the existing development has been on the Cununurra clays, but experience on the Aquitaine soils shows that extremely good crops can also be grown on these.

Infiltration in these soils is characterised by a very fast initial intake followed by an almost complete sealing once the clay colloids have expanded. Under these conditions, furrow irrigation is the preferred option with minimal deep drainage occurring and it has been very effectively used for most crops in the Ord. In Ord 1, all channels are unlined due to the impervious nature of the clay soils, thus achieving enormous savings. Building foundations can be seriously compromised because of the heaving nature of the clay and requires management. In the M2 design where channels are excavated below the clay layer, a thick blanket of clay will be brought in to minimize infiltration losses.

Great care must be taken with these soils to prevent rising ground water from increasing salinity and sodicity in the soil profile. Localised areas of high permeability can result in significant ground water accessions and need to be managed accordingly. Management of ground water is regarded as a very important part of the Environmental Review and Management Programme (see later) and regular measurements of ground water level and quality are being carried out; it is recommended that ground water should be kept below 2 m. A community management group, Ord Land and Water, has documented strategies and created a Land and Water Management Plan for managing rising groundwater and controlling surface water quality in the drainage system. Good surface drainage is absolutely essential on all these soils, which makes land levelling of the greatest importance.

Topography
Grades on the existing development range from 1:1000 to 1:3000, while those on some of the Aquitaine soils of the proposed area are even flatter, to 1:4500. Very accurate land forming is required under these circumstances and undoubtedly one of the main reasons for the success of Ord 1 is that land levelling has been effectively carried out on the majority of the cropped land.

Development of Ord stage 1

The Kimberley Research Station was established in 1945. Early trials with rice, cotton, safflower, linseed and sugarcane were successful. When the diversion dam was completed in 1963, cotton became the main crop until 1974, when farmers ceased production due to the pressure of chemical resistant insect pests and the removal of Government subsidies. During the following decade, low priced field crops such as sorghum, sunflower, soybean, maize and rice sustained the irrigation area. From the mid-1980s, there has been a major development of horticultural crops, including melons, bananas, mangoes and papayas. These, together with sugarcane and high value hybrid seed crops (sorghum, sunflower and maize) constitute the strength of the agricultural economy today.

The Ord River District Co-operative (ORDC), established in 1963, is a strong and effective organization and has supported the development of these industries, providing farming inputs such as fertilizer and other agricultural needs and services as well as grain cleaning, grading and storage facilities, and assists with crop marketing. It also manages the Wyndham port and operates sugar, molasses and fertilizer storage facilities.

Inception of the sugarcane industry
Sugarcane had been suggested as a suitable crop for the ORIA prior to the establishment of irrigation infrastructure in the region. After the diversion dam was constructed, research and development was instigated on a number of different crops including sugarcane. However, repeated investigations over the years failed to result in a commercial industry. In 1992 the prospects of a sugar industry were re-examined. The key organisation involved in the feasibility study was the ORDC, with support from the WA Government. Consultants used in the feasibility study included Shultz, Tait, Greig & Associates, the Sugar Research Institute and Clough Engineering.

In late 1994 CSR Ltd with the ORDC as a minor shareholder commenced construction of the sugar mill. The first cane was processed in late 1995 and the first full season of crushing was 1996.

Sugar mill design and capacity
The mill design was based on the use of innovative technology, which had the advantages of reducing the capital outlay required and having low operational labour requirements. The mill was designed to crush 560000 tons cane, producing 73000 tons of sugar over a 30-week crushing season. Serious difficulties were experienced, primarily due to the new technology employed, and the first few crushing seasons were punctuated with mill shut-downs caused by technical problems. Over the first three years substantial changes were made to the mill by CSR in order to obtain acceptable performance. Some of the major alterations, which added substantially to the total cost of the mill, included:

- Installation of a 78 in. conventional 5-roller mill at the end of the original milling train, which consisted of four 2-roller mills feeding through closed chutes, i.e. with no inter-carriers
- Replacement of the mud flotation system with a conventional rotary vacuum filter
- Addition of a new Roberts evaporator, thus doubling the heating surface area in the originally installed plate evaporators. These were later discarded and the vessels converted to short vertical tube units
- Installation of a batch seed pan, in addition to the original continuous seed pan.

The mill configuration still results in low extraction, but this has been addressed for the 2002 crushing season by the addition of another 4-roller mill at the front of the milling train. Other factors that contributed to the difficulties experienced in the early stages of development were variable crystal size due to the continuous pan design, also resulting in higher than expected molasses pol, and the pol content of sugarcane was lower than originally anticipated.

Whilst technical difficulties were experienced with the mill, the cane delivery system with full electronic consignment has been a huge success. Haulout crews enter relevant consignment details into a mobile terminal unit and transmit information to the mill via a radio telemetry link. The full trailer with seven bins and a payload of approximately 56 tons is transported to the mill, weighed on an unmanned weighbridge and tipped on to the unmanned feed table by the driver, the data being collated into the mill computer system.

Some factory statistics are given in Table 2

Farming systems and production costs
Management strategies and farming operations have a strong focus on low labour input and minimal tillage operations to keep production costs to a minimum. Key components include land forming, fertilizer application, herbicide application and irrigation.

Table 2. Factory statistics for the Ord Sugar Mill.

	Design	1996	1997	1998	1999	2000	2001
Tons cane delivered	560000	386544	411659	477003	474237	460555	290581
Tons cane crushed/hour	120	93	104	113	120	116	111
Pol % cane	14.9	13.5	13.9	13.2	14.2	14.6	14.8
Fibre % cane	14.4	15	16.4	16	16.4	16.5	17.2
Mixed Juice Purity	86.5	85	85	83.4	85.5	86.7	89.2
Overall Recovery	87.5	69.3	78.6	80.1	82.1	82.9	82.3
Tons sugar produced	73000	36439	45415	51173	55825	55706	35702
Tons molasses		14922	16878	17578	18338	17616	10648

Land forming is critical to the successful growing of cane in the ORIA to ensure even water application and good drainage. Most fields are land formed prior to the first sugarcane cycle and thereafter after each cane crop cycle. Two contractors carry out the majority of the land forming work. The procedure is as follows: following an initial disc-ploughing, a home-built land plane or "smudgy" is used for rough leveling, (this is often carried out by the farmer), then grid survey using Spectraphysics Laser equipment, which produces computerized field designs optimizing grade and soil movement. Large dual wheel 4WD tractors tow laser controlled tandem scrapers moving around 1700 m^3/day; operator skill is critical to the operation. If compaction has occurred, a ”brush-up” (ripping followed by re-leveling) is often carried out. Fields are set to a selected grade, typically of 1:1500 to 1:2500, with furrow lengths of 400-700 m (range 150 to 1200 m). Fortunately, depth of soil is generally sufficient to ensure that no “scalping” occurs with the leveling, which requires typically 400 m^3 soil moved/ha.

For planting, mouldboard ridgers are generally used, creating a wide bed. The planter makes a wide shallow furrow in the top of the bed, lays the cane billets in the furrow and back-fills in one operation. When properly managed, this method of planting uses about 9 tons seedcane/ha and gives excellent stands, which is regarded as key to the whole cane operation. Row spacing is generally 1.8 m, which avoids compaction and stool damage from heavy harvesting equipment. Dual rows have been tried but no material advantage has been found over single rows. Because the lateral movement of water in these soils is so good, the first irrigation is done in the inter-row, thus avoiding the need for a hilling-up operation.

Fertilizer is generally applied in a single operation, generally within four weeks after harvest using a tractor mounted rig. Typical nutrient applications per hectare are 200-240 kg N, 20-50 kg P, 0-20 kg S, 0-5 kg Zn. K is not required.

The use of herbicides is also a key component of the production system. Both pre-emergent and post emergent herbicides are used, some of the most commonly used include atrazine, ametryn, glyphosate, diuron, diquat, paraquat and isoxaflutole.

Once fertilizer and herbicide have been applied, the major management requirement of cane is irrigation. The combination of large fields and current low cost of water makes furrow irrigation a cost-effective method of water application. Black polythene syphons, ranging in diameter from 30 mm to 75 mm diameter are used to deliver the water from the head ditch to the furrows. This is generally accepted as the most efficient system.

ORIA 1 has not been under cane long enough to assess optimum length of ratoon cycle, a critical cost component. Many black clay soils worldwide tend to have short cycles, from 2 to 4 ratoons. Observation suggests that the optimum cycle in the Ord will be 4-7 ratoons, which is remarkably high for this type of soil. It is believed that good surface drainage resulting in good soil aeration, together with good land preparation, crop establishment, ongoing crop maintenance and harvesting techniques contribute to increasing crop longevity. Plant cane normally gives the highest yields, but it is generally older than 12 months and there is a slight reduction in yield with increasing ratoons.

The direct costs of production range from AUD$8 – 11 per ton of cane depending on the farm size and particular farm operations (see Table 3). Overhead costs, not included in the table, are highly variable depending on the farm. All farms are mixed cropping ventures with most having horticultural crops or grain in addition to sugarcane. Harvesting and transport costs are not included as these costs are already deducted from the growers' gross payment before sugar monies are distributed.

Table 3. Indicative costs/ha for some of the major variable costs incurred in the production of sugarcane in the Ord River irrigation area, 2001.

Operation	Cost A$/ha
Fertiliser and application	500
Herbicide and application	90
Irrigation water (12 months)	84
Irrigation labour + expenses	120
Land forming(approx. every six years or as required)	350-500
Planting – cost of planting operation only	600

The major annual cost in growing sugarcane in the ORIA is fertilizer, and application and transport costs are a significant component of this. Other major costs include initial establishment cost, annual herbicide costs, irrigation water and labour. Water costs are likely to increase over the next ten years under the current restructuring proposal (see Irrigation water supply).

The average payment received per ton of cane for the period 1996-2001 has been approximately AUD$14.60.

Cane harvest and transport

Harvesting and transport of cane to the mill is carried out on a 24 hour, 7 days a week basis. The system is based upon the Just-In-Time principle where the mill controls the harvesting and transport operations at the same rate that it is able to crush. A single harvesting and transport unit services all growers and moves geographically through the area encompassing all fields within five rounds during the season. This system results in a delay of approximately 2.5 hours cut to crush, possibly the most efficient in the world.

A fleet of four Austoft harvesters, six in-field powerhauls (eight ton sugarcane transporters), five prime movers and seven trailers, one grader, one break-pusher and support vehicles with 40 employees is capable of harvesting in excess of 500,000 tonnes of cane in a 30 week season. The harvesters elevate the chopped cane into the powerhauls, which transfer by tipping at field edge into the trailer. Harvesting and transport equipment is owned and operated by the same company, Waugh & Dwyer Pty Ltd. O'Reilly (1999) gave a detailed description of the system.

Agronomic issues

CSIRO, CSR, the Bureau of Sugar Experiment Stations (BSES) and WA Department of Agriculture (WADA) have all contributed to sugarcane research since the 1960s. The research conducted by BSES and WADA in the late 1970s and early 1980s provided the basis for the foundation of the industry in the 1990s. Current research efforts are supported through grower levies and State Government. Once the industry had been established in the 1990s, a new research and development programme was initiated. Areas of focus included the accessing and screening of new varieties, irrigation and nutritional requirements. With the notable exception of red stripe/top rot, pests and diseases were not considered to be a serious problem in the early stages of development.

In 1998 sugarcane smut was first detected in the ORIA. Smut spread rapidly through the highly susceptible varieties NCo310 and Q117, which comprised 30% of the area planted to cane. As described in Engelke et al. (2001), swift industry action resulted in protocols being established for the removal of these two varieties. The last commercial plantings of NCo310 and Q117 were removed at the end of 2001. Research and development programmes had to be equally swift in establishing smut screening trials and re-evaluating the plant material being introduced into the ORIA. Smut screening trials are now an intrinsic component of the research and development programme.

The commercial varieties that remain available to the industry include Q95, Q96 and Q99. The varieties Q95 and Q99 are highly resistant to smut, with Q96 displaying intermediate resistance. NCo310 and Q117 were the superior performing varieties at the time smut was detected. In some respects it was fortunate that smut entered the ORIA early, otherwise it would have been likely that a far larger percentage of the area would have been planted to Q117. Varieties are being accessed through a project jointly funded by CSIRO, WA Department of Agriculture and Sugar Research & Development Corporation. Initially the focus was on BSES bred 'Q' canes; however, this focus has now shifted to accessing smut resistant canes of which a large proportion originate from overseas breeding programmes.

The commercial performance of the industry to date has been very promising. Average cane yields of 128 tons/ha and pol percent of 14.0 were achieved over the period 1996-2001. Performance data on an annual basis are presented in table 4.

Table 4. Summary of Ord sugar industry cane performance for the years 1996-2001.

Year	Area harvested (ha)	TCH	Pol% cane	Tons pol/ha
1996	2239	171.0	13.5	23.09
1997	3274	125.7	13.9	17.47
1998	3509	135.9	13.2	17.94
1999	3705	128.0	14.2	18.18
2000	3632	126.8	14.6	18.51
2001	3143	92.5	14.8	13.69

The hectares harvested increased steadily from 1996 to 1999. The discovery of smut in 1998 and subsequent removal of NCo310 and Q117 then resulted in a temporary decline in the area harvested. Average tons cane per hectare has also varied substantially, yields ranging from 93 to 171. The 1996 yield figure of 171t/ha is largely a result of the high percentage of plant cane harvested.

Productivity in 2001 was disappointing with an average of 93 t/ha. Reasons for this dramatic decrease in yield are not entirely clear: possibilities include climatic influences in the form of lower radiation; late application and reduced rates of nitrogen and other inputs applied by some growers due to uncertainty regarding sale of the mill; early heavy rains at the beginning of the wet season suspected of causing nitrogen loss through volatilisation of urea; and the increasing age of ratoons. Interestingly the local banana industry reported yield reductions of 10-15% for the same period, suggesting that a more generic effect, such as climate, may have been the major factor responsible for the reduction in sugarcane yields.

With the exception of 1998, pol % cane has steadily increased since industry inception and current pol values are exceptionally good. The low pol in earlier years could be related to the preponderance of plant crop and early ratoons on soils with high level of cations and possibly nitrogen. The high level of scale build up in the factory evaporators during the early years lends support to the elevated levels of cations present in juice.

Sale of factory to Cheil Jedang
In late 1999 CSR made the decision to sell the sugar mill, which created considerable anxiety for many of those directly and indirectly involved in the sugar industry in the ORIA. In September 2000, the mill was sold to the Korean firm, Cheil Jedang, who have been the major purchaser of Ord raw sugar since industry inception.

Proposals for Ord 2 and the future

Selection of Wesfarmers
In 1997, the Governments of Western Australia and Northern Territory invited proposals for the position of "preferred proponent" for the development of portions of the Ord River Irrigation Area (ORIA) Stage 2. From the bids received, the consortium of Wesfarmers Limited and Marubeni Corporation was granted a mandate in April 1998 to carry out the development of the M2 area for sugar production. Water Corporation of Western Australia was appointed by the two Governments to build, own and manage the irrigation infrastructure for Ord 2 M2 area and, as such, became a co-proponent for the development.

Wesfarmers proposed to own and operate a 400000 tons p.a. sugar factory. It also intended to develop and manage an estate of some 29000 ha, later on selling some or all of the land to individual farmers. An additional 3000 ha was to be made available at the beginning of the project for independent farmers. The public and farmers in the Ord were enthusiastic about the proposed expansion.

Wesfarmers carried out the feasibility study in three main streams:

1. Technical & Economic Investigations in which the sugarcane agriculture and factory aspects were contracted to Booker Tate, the infrastructure design to Kinhill Pty Ltd. (now Brown and Root) and the economic assessment was done in house.
2. Kinhill carried out a comprehensive Environmental Review and Management Programme, which *inter alia* resulted in a reduction of the proposed development area by 3000 ha.
3. Land acquisition investigation was done in house with assistance from Anthropos Australis Ltd.

Development of the project would be dependent on the successful completion of all three aspects. The importance given to accommodating environmental problems and also of native land title issues was impressive.

Termination of Ord 2

The Ord is arguably the best place in the world to grow sugarcane and it has been said that, if there is anywhere that a greenfields project selling sugar at world prices can be viable, it is the Ord. Well, it did not happen! Wesfarmers carried out a model feasibility study over three and a half years costing AUD$3.8 million, and on 11 December 2001 were forced to announce that they would not proceed with the project, estimated to cost AUD$ 500 million. The major reason stated was the continuing price volatility of sugar on the world market, with the potential for major expansion in Brazil. Ord Project Manager Andrew Hopkins said "Fluctuations in the world sugar price were particularly severe in the last three years… and there is little evidence to suggest that price volatility will not be significant in the medium term".

Further reasons cited for the decision not to proceed included the significant reduction in terms of both allocation volume and the level of reliability of irrigation water and the fact that issues relating to environmental approval and land tenure remained unresolved.

The future

The governments of Western Australia and the Northern Territory continue to be committed to the development of irrigated agriculture in the Ord Stage 2 areas. Both governments are currently working with the relevant aboriginal representative bodies to resolve land access and aboriginal heritage issues prior to seeking new tenders for the development of the M2 area.

The intentions of the existing mill owners, Cheil Jedang, are to pursue plans to double the crushing capacity of the mill which was originally designed for this; a further 4000-5000 hectares of land is required to grow the necessary cane. The three major avenues for obtaining the land required to grow the sugarcane include:

- continuing to increase the area of sugarcane within the existing Ord Stage 1 development, (this option however is restricted by the presence of other crops competing for the same land)
- development of Green Swamp, an area of land approximately 1200 ha to the north of Ord 1
- development of land within the Ord Stage 2 M2 Weaber Plain area.

All of these avenues are currently being explored and would need to be the subject of a comprehensive development proposal.

Cheil Jedang will require assurance of the required cane production before capital expenditure required to double mill capacity is committed.

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