Achievements of the Virginia Pipeline Scheme: *Horticultural production with reclaimed water.*

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INTRODUCTION

The township of Virginia, South Australia, is the focal point of the Northern Adelaide Plains. This area is regarded as a high value horticultural region with the ideal climate, soil types, hydrology and groundwater resources for intensive horticultural production (Matheson 1975). As such, it is often described as South Australia's "Vegie Bowl" and has a reputation for delivering high quality horticultural produce to markets in Adelaide, interstate and overseas. The major intense horticultural activities, on the 20,000 ha of land in the region, include fresh vegetables, nuts and wine grapes.

Although the extensive groundwater in the region has traditionally irrigated these horticultural crops, Class C reclaimed water (as defined in Anon 1999a) was used in the region for up to 28 years, prior to the commencement of the Virginia Pipeline Scheme (1999). The Class C reclaimed water was pumped from the Bolivar wastewater treatment plant out-fall channel through private reticulation pipelines installed by several growers. Growers recognised the value of this new water resource having the potential to provide a secure water resource and underpin horticultural development in the region.

The Northern Adelaide Plains Water Reclamation Scheme (Virginia Pipeline Scheme) has supplied approximately 230 licensees with highly treated (Class A) reclaimed water over the last three years. It has the potential to deliver 23,000ML/year of Class A reclaimed water which is suitable for 'unrestricted' agricultural irrigation (Anon 1999a). To our knowledge, this is the largest, high-quality, reclaimed water scheme in the world, which provides solely reclaimed water. Much of the science that underpins the safety of the scheme was developed as part of the Monterey Reclaimed Water scheme and the Californian Title 22 Regulations, which are viewed by many to have set the benchmark for development of reclaimed water schemes for the irrigation of raw eaten vegetables (Anon. 1998).

After 3.5 years of full-scale operation, it is timely to reflect on the achievements of the Virginia Pipeline Scheme and the benefits it has brought to the district, the immediate environment and the Australian water and horticultural industries. In some cases comparisons between pre and post reclaimed water were difficult obtain. However, we have attempted to source the best available information through our experience, the literature and reputable industry sources, to outline some of the achievements of a reclamation and reuse scheme that was first suggested in the late 1960's and has, to some extent, been in the "pipeline" for more than 30 years (Hodgson 1966).

ECONOMIC DEVELOPMENT IN THE REGION

The availability of good quality water has been identified as the major limiting factor for the growth of horticultural enterprises in the Virginia region. Conclusive data is difficult to obtain at this juvenile stage of the Virginia Pipeline Scheme, however, some economic benefit to the region can be assessed through production volumes, land values and investment in the region.

In 2000/2001, farm-gate production values for horticulture were $72M. Through value adding and processing this was increased to a value of $160M. If the value adding of produce from outside region is also included the total horticulture value sold from the region has been estimated to be $203M (Anon 2001). Figures for 2001/2002 and 2002/2003 are not available, however, relative resource use for the years could be used to assess the potential economic benefits for the region in these years.

For example, in the year 1999/2000, 4,500 ML of reclaimed water and 19,077ML Anon 2003 of groundwater were used for irrigation of horticultural production on the Northern Adelaide Plains (23,577ML in total). The scheme managers have identified that the reclaimed water use for 2002/2003 will be 10,000ML. The Department of Water, Land and Biodiversity Conservation stated that water use for 2002/2003 was 19,377ML (preliminary data, DWLBC) for the full year. Thus a total of 29,377ML of water will be used for irrigation on the Northern Adelaide Plains.

When comparing the data from the 1999/2000 and 2002/2003 there has been an increase in the delivery of water to the region (5800ML). This water has been used for further irrigation and has delivered an economic benefit to the region. No matter what crop values or seasonal conditions affect net production values, the increase in water availability and usage should be reflected in an increase in relative production.

Recently, land sales in the region have included reclaimed water allocations to add value to the land. Interviews with local growers and businessmen have indicated that land with water has twice the market value of undeveloped land without water. There are wide ranging values for land in the region with “good” land for horticulture without water and improvements fetching $15,000/ha, when a water allocation is supplied with the land it is worth $30,000/ha. Growers also stated that the increase in land value, due to water allocation, was not dependant on water source. Thus, reclaimed water has the same influence on land values as groundwater.

The scheme manager has identified that much of the reclaimed water sold in the past 2 years has been used for the development of new irrigation properties. This reflects not only the expansion of production in the region, but also the confidence of growers to expand their operation with this new water resource. One such grower has recently purchased 200ha of virgin country and has contracted a further 1,000ML of reclaimed water to be used for irrigation.

Clearly, increased water use, land use and investment by growers reflects the economic benefit to the region, not only through production, but also capital gains through the allocation of water and the associated development of land. The Corporate Strategy and Policy unit of Primary Industry and Resources South Australia (PIRSA) will be undertaking an economic assessment of the region for 2002/2003 in the later half of this year, which will provide the quantitative assessment of the region and enable further assessment of the value of reclaimed water to the region.

VISITORS AND TOURISM

The potential for tourism within the region was initially highlighted by the Centre for Economic Studies (Anon 1995). Tourism opportunities have been linked to the development of boutique wineries and cellar door sales. International horticultural regions also have significant tourism opportunities due to the attractiveness of production and speciality food opportunities. The relative proximity of the Northern Adelaide Plains to Adelaide positions the region for easy access by visitors.

Currently the region has formed a wine association and has a geographically defined wine region, the Northern Adelaide Plains Wine Region. The wine association is exceptionally proactive and is looking to exploit, in terms of tourism, its proximity to Adelaide and build on the development of other foods produced in the region, including nuts and olive oil (*pers. com.* Dr Joe Ceravolo, Chair of the Northern Adelaide Plains Wine Association). The region now boasts 40 growers and is producing 8 wine labels, there is only one winery offering cellar door sales. Another winery will be operating in the region for the 2003-04 vintage.

Recently the Virginia nursery has undergone redevelopment and has included a full commercial garden nursery and associated lines, in addition to their more tradition market of seedlings to horticulture. The nursery currently has 3000-4000 customers/week in winter and 7000-8000/week in spring and summer. More than 80% of the customers come from the Adelaide metropolitan area.

It is difficult to link the Virginia Pipeline Scheme directly with increase tourism or visitors in the region. However, the scheme seems to have provided the foundations and security for the region to begin to explore the potential for the development of tourism in the region.

MORE JOBS FOR THE REGION

The Centre for Economic Studies identified the potential benefits of the Virginia Pipeline Scheme to the job market in the region (Anon 1995). They projected a further 1,150–3,100 jobs would be created within the region as a result of increased horticultural activity. Further to this, an additional 1,600-2,700 jobs would be created as downstream opportunities in the packing, processing and marketing industries (Anon 1995). There is undoubtedly a strong link between increased horticultural production and job opportunities.

Horticulture is a labour intensive industry and there has generally been little change in the practices of the region that would have the potential to reduce relative labour demands significantly in the last 5 years. However, as farms grow in size there may be some economies of scale achieved. This is a national trend in agriculture, but on the Northern Adelaide Plains expansion, due to the Virginia Pipeline Scheme, has seen sizeable economic growth that would ensure flow on effects for employment. The Northern Adelaide Development Board has recognised a gradual increase in the labour force in the past 5 years, this is supported by ABS Census data from 1996 and 2001 showing a +7.5% increase in the labour force for the agricultural sector in the Northern Adelaide Region.

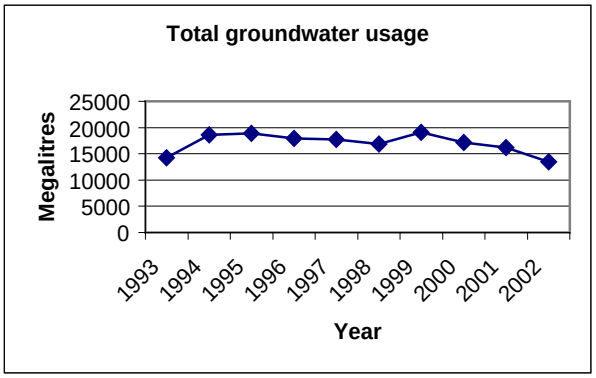
These statistics appear to be supported by an unprecedented shortage of labourers within the region in 2003. Several growers have been forced to plough crops into the ground, as they have not been able to find the labour required for harvesting and processing. However, several factors could influence this shortage. For example, increased staff demands from increases in productivity, low wages offered in horticulture and competition from other industries, could also have a significant bearing on labour availability (*pers. com.* Rocco Musolino, Chair of the Virginia Horticulture Centre).

To date, there is limited data to assess the economic, business development and employment trends in the region. This deficiency limits investment within the region from both government and private sectors. Good statistical data is required to enable targeted development opportunities and enable planning to meet the regions social and economic needs.

MINING OF GROUNDWATER RESOURCES

Until the development of the Virginia Pipeline scheme the predominant water resource has been groundwater, from two aquifers beneath the region (Tertiary 1(T1) and Tertiary 2 (T2)). Some domestic (potable) water from Adelaide's water mains has also been used, predominantly for domestic uses, processing and glasshouse irrigation. Historically, there has been significant overuse of groundwater in the region, resulting in mining of these aquifers and a decrease of water levels in these aquifers (T1 aquifer by 10-20m and T2 aquifer by 50-70m (Anon 1998)). In 1995, 26,000ML/annum of groundwater was licensed to the Northern Adelaide Plains, with 18,000ML/annum being used (Anon 1995; Marks et al 1998). The replenishment rate was estimated to be in the order of 6,000-10,000ML/annum (Anon 1995; Marks et al 1998).

Recent data suggests that there has been a reduction in the use of groundwater on the Northern Adelaide Plains (Figure 1; Anon 2003). However, in 2002/2003 19,377ML of groundwater was used, contrary to the recent downward trend (*pers. com.* Phil Murray, DWLBC). This anomaly is probably due to a combination of increased production in the region and an unseasonably dry irrigation season. Additional supportive evidence of reduce extract of groundwater is the reported increase in water levels of the T1 and T2 aquifers (*pers. com.* Nabil Gerges). The reduction in use of groundwater in the area has been achieved through the supply of reclaimed water in the area, and the trading of groundwater allocations outside of the Virginia region (*pers. com.* Phil Murray, DWLBC). If these changes in water use patterns in the area continue, groundwater could potential reach a sustainable equilibrium.



Source: DWLBC, and published by Anon 2003.

Figure 1 Total groundwater usage on the NAP

PROTECTION OF SEA GRASS

By reclaiming and reusing water and nutrients from the Bolivar Wastewater Treatment Plant (WWTP) the Virginia Pipeline Scheme has decreased the volume of nutrient rich treated effluent entering St Vincent Gulf. As one of the key factors in the degradation of seagrass in St Vincent Gulf was the discharge of nutrients through the effluent outflow it would be reasonable to assume that the scheme has helped improved the marine environment (Marks et al 1998).

Approximately 48,000ML of treated effluent water was discharge to the ocean from Bolivar WWTP prior to the commencement of the Virginia Pipeline Scheme (Anon 1996). Based on this figure the Virginia Pipeline (10,000ML) has reduced outfall by approximately 20% and at scheme capacity (23,000ML) would reduce outfall by approximately 50%.

These reductions in water volumes would equate to similar reductions in nutrients. In addition to these benefits from reuse, in 2001 SA Water built and began operating an Activated Sludge Plant to further remove nutrients from outfall water (Table 1). The Virginia Pipeline Scheme, in conjunction with improvement in water treatment has achieved significant reduction in nutrient discharge to the Gulf, with approximately a 75% decrease in nitrogen and 40% decrease in phosphorus

Table 1. Typical nutrient loadings of effluent discharge to ocean from the Bolivar WWTP

	Pre Activated Sludge	Post Activated Sludge
Nitrogen	40 mg/l	12 mg/l
Phosphorus	7 mg/l	5 mg/l

Source: United Water.

loadings from 1996 to 2003. Theoretically, this should also lessen the impact of these nutrients on the gulf's seagrass, but only future monitoring will confirm this.

MARKET FOR RECLAIMED WATER

Pre-Scheme Marketing

For the Virginia Scheme to be viable 16,000 ML of reclaimed water needed to be contracted (Wright 2000). Negotiations between the reclaimed water supplier (Water Reticulation Services Virginia - WRSV) and the Virginia Irrigation Association (representing growers) in 1997, set the price for water at 9.5 cents/kL, with shoulder season rate of 7.5 cents/kL and winter season rate of 5.5 cents/kL (WRSV 1997). Individual growers and WRSV entered into contracts that included agreed customer rules and a 2.5% increase per annum fixed until 2007. After 2007 water pricing will be linked with CPI.

Prior to commencement of the scheme the target of 6,000ML was exceeded and 17,500ML of reclaimed water was already contracted on a use or pay basis. A significant factor in achieve this target was the contracting of 25% of the required water to a single customer. Initial contracts were pivotal in the design phase of the project as the contracted water affected the spatial design of the scheme.

Following the commissioning of the scheme in 1999, in the first year 4,500ML of water was used, many of the scheme customers were not "set up" for irrigation. In 2003 the scheme will reach 10,000ML/year.

Collapse of a Major Customer

The single purchaser of 25% of the initial allocation, collapsed before using any reclaimed water. However, this water has since been contracted to the purchasers of the land and other existing reclaimed water customers. New sales of water and redistribution of initial allocations have demonstrated the acceptance and robust nature of the scheme, good scheme management and the increasing demand for this water resource. Significant amounts of reclaimed water have also been allocated to land that has not previously been used for irrigation purposes.

Current Market Trends

Since the commencement of the scheme the driving force behind water purchases has been the demand for water for irrigation and crop requirements. However, as the total water contracted approaches scheme capacity, there is another clear driving force emerging, investors and growers are purchasing water to add value to land and provide future security. For example, there are some customers who have contracted 1,200ML of water and have not used any of their annual allocation.

Proposed Expansion

A proposed expansion of the scheme has been planed for the Angle Vale region to supply a further 3,000-4,000ML of water to 30 growers. Feasibility and costing are currently been undertaken. An opportunity to deliver water to local government in the surrounding areas, for the irrigation of open space, has also emerged as part of the potential development.

As a consequence of this proposed expansion the total contracted water supply between SA Water and Water Reticulation Systems Virginia will be reached. This will see reclaimed water enter into a new era, one of water trading, or increasing winter storage through aquifer storage and recovery to meet this demand (Dillon et al 1999). A significant achievement of the Virginia Pipeline Scheme is that growers, investors and municipal managers now "see" Class A Reclaimed Water as a valuable water resource.

TRAINING AND EDUCATION

A significant driver for training and education has been the strong commitment to success by the users of reclaimed water for horticulture. This has resulted in the implementation of a range of training strategies and programs in the region, linked not only to the use of reclaimed water but to other aspects of business and production.

Horticulture Australia Limited has funded a range of projects on the Northern Adelaide Plains prior to and after the inception of the scheme. These projects include, 'Sustainable Use of Reclaimed Water for Horticultural Irrigation on the Northern Adelaide Plains' (VG 97081; Adelaide University and CSIRO Land and Water) and two 'Industry Development Officers (IDO)' (HG 97022 – One for Marketing and Business Development, and one for Production; Virginia Horticulture Centre). Further to this, Rural Solutions SA undertook an NHT funded project, 'Sustainable Use of Reclaimed Water on the Northern Adelaide Plains'. A key component of this project was to examine the relationship between the use of reclaimed water and production systems on the Northern Adelaide Plains, to form grower focus groups and provide training in sustainable farm management systems including soil and irrigation management (Hollow 2000).

The Adelaide University, CSIRO Land and Water, and Rural Solutions SA projects developed and delivered a number of training packages related to the use of reclaimed water for horticultural production. The identification of a need and the delivery of a reclaimed water information package was the first step in reclaimed water training program for growers and was delivered person-person with 90% of contracted reclaimed water uses (Stevens 2000). In 2001, a reclaimed water user manual was distributed to 100 % of the contracted reclaimed water users, and this manual is now provided with all new contracts (Kelly et al 2001).

The Virginia Horticulture Centre IDO project recognised the disjointed approach to training from several traditional agricultural services. They also highlighted the need for training in business and product development. Consequently, a three-stage program of training and education, which recognised prior learning (skills obtained through business and life experience) and complied with the National Accredited Horticulture Certificate (www.ntis.gov.au) was developed, called the Better Business Program. More than 140 growers have received Certificates of Horticulture through the program and the program has lifted both the production and business skill of all growers within the region.

Training deficiencies had previously been identified as a major weakness for the development of the Northern Adelaide Plains as there was no pre existing "training culture" in the region (Anon 1995).
The training and education programs instigated or developed specifically as part of the Virginia Pipeline Scheme, for growers and associated industries in the region, have contributed significantly to the development of improved agricultural management in the region.

The knowledge and information gained from the commission and use of the Virginia Pipeline Scheme is a valuable resource for the growth of reclaimed water use nationally. Many of the lessons learnt, especially regarding public perceptions and communication, will be beneficial in the development of reclaimed water schemes across Australia.

MARKETS FOR PRODUCE

Acceptance of Reclaimed Water Use

At the commissioning of the scheme, a media response task force was nominated to ensure correct information was communicated to all public and media enquiries. The task

force consisted of experts in the fields of agronomy, environmental sciences, hydrology and human health, and was lead through the Virginia Horticultural Centre. To ensure untruths were corrected with facts the task force responded to negative press or hearsay immediately. The public needed to be correctly informed of the enormous amounts of research undertaken to ensure the safety of the reclaimed water scheme. A communication program targeted all wholesalers and kept them informed of the development of the scheme and reassured them, with scientific facts and industry experience from across the world, that product quality would not (i.e extremely low risk) be compromised.

An assessment of communication and risk analysis, associated with the use of reclaimed water on the NAP, identified three key stakeholders: Industry, Retailers, and Public (including the media). Three different levels of communication were suggested. For industry, a low key campaign with simple factual information to reassure of the quality and safety of the scheme. For retailers, information was disseminated to ensure the awareness of the integrity of the produce. For the public, proactive communication was not favoured, as it would provoke more questions and concerns than benefits (Anon 1999b).

In addition to the extensive training and education programs discussed above, industries (including growers) associated with reclaimed water all received a series of fact sheets on water quality, food quality and the environment. Retailers and wholesalers were provided with an information package, outlining the facts with respect to reclaimed water and produce quality. The wider community of the region, and general public, have also been exposed to the Virginia Pipeline Scheme through an ongoing series of news articles, electronic media, and person-to-person dialogue (bush telegraph). The scheme was also endorsed by the SA Department of Human Services and EPA (Anon 1999a).

The success of this communication campaign has been demonstrated through, the adoption of reclaimed water by growers and the acceptance of produce grown with reclaimed water by all levels of the retail chain. One of the most stringent quality assurance programs in the world, EUREPGAP, accepts produce grown with reclaimed water that is fit for purpose, but not untreated effluent (Eurepgap 2001).

Development of Export Opportunities

With the Australian domestic market being well supplied with fresh vegetables, if increased water supplies leads to increased production, the development of export markets must underpin future develops in this area (Anon 1995; Playford 2000).

In recognition of the importance of the development of export markets for the region, the Virginia Horticulture Centre managed a Horticulture Australia Limited project (IDOs discussed above) to assist in the development of export opportunities (Anon 2002). In 1998, 4% of production on the Northern Adelaide Plains was focused on export markets. Limited continuous export of broccoli, potatoes, carrots and onions occurs at present and there has been little expansion in the area for the last few years. Poor markets, and the increased cost of packing/shipping for export markets have not attracted many growers, processors or packers to attempt to export. Too often growers prefer spot marketing on the domestic market and forego export markets if the domestic price is good. Growers often comment that many export destinations are too hard to grow for and the returns are only slightly better, if at all, than those of the domestic market (*pers com* Craig Feutrill, SA IDO for Vegetables). This coupled with a strengthening Australian dollar during the past twelve months has created further barriers to the development of export markets.

The two main ingredients for successful export marketing are quality produce and continuity of supply. Often, even with large producers, they cannot produce enough to satisfy overseas demand and are unwilling to work with their neighbours to fill the shortfall. The historical competitive nature of growers and the diversity of nationalities in the region were barriers to the formation of large production groups necessary for the development of export opportunities. However, as identified above, there is a continued shift to larger production identities, which may assist in the development of export markets in the future.

There are always exceptions to the rule. For example, we know one grower in the region, irrigating solely with reclaimed water, who exports 100% of his produce to S.E. Asia. This grower has been exporting to the same customers for more than three years and has a reputation for quality and quantity.

Another example is a large grower/packer in the region who recognises that future development of his business must be linked to export opportunities. In the past three years export has grown from zero to 10% of the gross income of his business. Some of the major issues were they identified were: providing appropriate quantity and quality of produce; logistical problems when sourcing produce from across Australia; and developing trust and respect with international customers. They also believe there is possibly an opportunity to form supply relationships with international competitors, whereby they supply product during their peak period (northern hemisphere) and we supply product during our peak period (southern hemisphere).

These examples demonstrate state, national and international acceptance of produce grown with reclaimed water in the region. Due credit must be apportioned to growers who have had the vision and commitment to invest the time, effort and dollars into ensuring quantity and quality of produce grown with reclaimed water. Without their vision and willingness to take the risk, these achievements may have been unreachable.

WATER DELIVERY

Water Treatment - Dissolved Air Flotation and Filtration

The Dissolved Air Filtration Floatation (DAFF) Plant was funded by SA Water (approximately $30 Million cost) and constructed to reduce wastewater discharge to the marine environment and provide water of a suitable quality for irrigation through the Virginia Pipeline Scheme. United Water operates the DAFF plant, which was constructed during 1998 and 1999.

A DAFF treatment process was selected as the most economic solution to achieve the required treated water quality and quantity following a review of options and a pilot plant trial.

The treated product water must meet a range of quality criteria set by the SA Department of Human Services, SA EPA and SA Water, including:

- Turbidity < 10 Nephelometric turbidity units (NTU) for a 24-hour average;
- Salinity < 1500mg/l over 12-hour average;
- E. coli < 40 / 100ML with monthly median < 10 / 100ML ;
- pH between 6.5 and 8.5;
- No cryptosporidium detected in treated water; and
- Various chemical parameter limits such as soluble BOD, heavy metals and pesticides.

Other approval conditions include maintaining supply of treated water and continuous disinfection through chlorination.

The DAFF plant has now been operational since 1999, achieving high standards in water treatment with turbidity typically less than 2NTU and consistently complying with all approval conditions. Water demand has seen the plant operate over a range of conditions and water volumes up to design capacity, with the plant meeting all operational requirements of the regulators, Virginia Pipeline Scheme Managers and growers.

Pump Station and Pipeline

The Virginia pipeline was designed to meet the actual demands of the contracted irrigators, approximately 20,000ML of reclaimed water to be delivered over a period of 187 days to 230 properties in volumes from 5ML to a 1000ML/year, through 120 km of pipe covering an area of approximately 120 km^2.

The pumping station is located at Bolivar and receives water from the DAFF Plant via a balance storage dam. The pump station contains 5 variable speed pumps which automatically switch on and off in response to changes in demand for reclaimed water by the growers. The pumps deliver water into the pipelines at a head of approximately 55m, which is sufficient for the water to be delivered at low pressure to all grower storages. The pipelines are generally constructed from an engineering thermoplastic known as ABS and are laid within public roadways. Pipe diameters vary from 826 mm to 100 mm. The pipeline was designed to have a life in excess of 50 years.

The pumping and pipeline system's maximum demand to date has peaked at 100% of capacity (Wright 2000). The pipeline design model has shown to be in line with actual flow rates and pressures achieved throughout the system and operation costs have also been inline with the design model. Most importantly the pipeline has demonstrated it's ability to exceed the supply parameters as set out in the Virginia Pipeline Scheme Customer Rules and the guaranteed daily delivery of 0.54% of customers annual allocation (WRSV 1997).

CONCLUSIONS

The major achievement of the VPS scheme and resulting benefits to the region have been: economic development providing more jobs in the region; decreased mining of groundwater resource in the region; decreased environmental impacts on Gulf St Vincent's marine life; development of markets for reclaimed water; improved understanding of reclaimed water and best management practices; acceptance of produce grown with reclaimed water; and verification of reticulation technologies.

Many of these achievements have benefited the region directly, but have also contributed to the acceptance of reclaimed water in horticulture across Australia and SE Asia. Providing many state government and regional councils the confidence to develop reclamation and reuse schemes in Australia.

With the limited data available, which in some cases is some-what anecdotal, we have attempted to demonstrate the increased opportunities and developments that a guaranteed supply of reclaimed water has brought to the region. The deficiencies in this data also highlight that better regional data of this nature is required, in the future. This will allow for more informed planning decisions to be made and development of long-term strategies for the region. Such information will also allow more critical assessment of the benefits of the Virginia Pipeline Scheme in the future.

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