OPTIMISING WASTEWATER TREATMENT AND REUSE – MOUNT ISA – A CASE STUDY

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ABSTRACT

This paper promotes a holistic approach to wastewater infrastructure upgrading, and shows by the use of an example project that aspects of a project can be linked to each other.

To deal with one aspect purely in isolation is to risk achieving a sub-optimal outcome, or at worst, an outcome where resources may have been spent on infrastructure that does not completely achieve important key outcomes.

This paper features a case study of the upgrade to the wastewater network, treatment plant and land disposal/reuse systems at Mount Isa to provide optimal financial value and reuse of treated effluent in a region short of water.

The overall project has provided value for the city by;

- Determining the most economical way to upgrade the city's trunk wastewater network, while reducing overflow risk in existing overloaded trunk sewers.
- Optimising the use of existing infrastructure at the WWTP while upgrading to provide increased capacity and enhanced quality to meet the terms of the existing Environmental Authority (EA) and new recycled water legislation enacted since.
- Re-negotiating the terms of the EA with increased nutrient limits to better suit the end use (reuse by irrigation on city parks and grazing paddocks, or reuse by the Glencore mine).
- Considering optimal beneficial reuse of the effluent in an area that is critically water short.

KEYWORDS

Wastewater, infrastructure, reticulation, treatment, reuse, disposal, holistic, value, optimise.

1 INTRODUCTION

This paper promotes how a holistic approach to wastewater infrastructure upgrading, and shows by the use of an example project that all aspects of the project may be linked to each other in some way.

To deal with one aspect purely in isolation is to risk achieving a sub-optimal outcome, or at worst, an outcome where resources may have been spent on infrastructure that does not completely achieve important key outcomes.

2 THE MOUNT ISA SEWERAGE AUGMENTATION PROJECT

2.1 BACKGROUND

The city of Mount Isa, in north-western Queensland is different from many cities – Mount Isa Mines, owned by Glencore is the main employer and industry, and generates much of the wealth of the area. The main minerals mined are copper, zinc lead and a small amount of silver.

The area is classified as having a hot semi-arid *climate* (Köppen *climate classification* BSh), Wikipedia (2015). Monthly evapotranspiration exceeds annual monthly rainfall for every month of the year. Summers are hot, with high rainfall, winters are usually mild and dry.

From a holistic approach, water supply, wastewater collection, treatment, disposal and reuse are all interconnected at Mount Isa.

Figure 1: Location of Mount Isa

The collection system is a conventional gravity system with traditional pipe materials, mainly AC, Concrete, CI, PVC and earthenware. Most of the rising mains are AC, although some of the more recent pipelines are PVC and mPVC.

The system suffers from a high degree of infiltration and inflow during heavy rain, and frequent overflows to watercourses due to inadequate pipe and pumping capacity.

The existing wastewater reclamation plant (WWRP) was first built in the 1960s, followed by a series of upgrades. The current plant configuration consists of an elevated coarse inlet screen, primary clarifiers, balance tanks, trickling filters, secondary clarifiers and a chlorine contact tank. The secondary treated effluent is then discharged into a series of four polishing ponds prior to the effluent pump station. Chlorination has not been practiced since 1980s.

Effluent is irrigated onto horse paddocks, sports fields, parks and a cemetery generally northeast of the town near to the WWRP. The effluent reuse results in a significant physical, social, cultural benefit to the city and reduces water demand. While the reuse is beneficial, operation has been driven by the need to dispose of the effluent, particularly in wet years.

2.2 THE SEWERAGE AUGMENTATION PROJECT

The sewerage augmentation project comprised three main portions, the collection network, the wastewater reclamation plant (WWRP) and the effluent reuse system.

The first part of the project consisted of upgrading the wastewater network to convey flows from proposed developments to the south of Mount Isa, through the city to the WWRP to the north-east of the city, and reduce wet weather overflows. The WWRP needed to be upgraded to cater for the increased flows, and also to increase the quality of the effluent to comply with the EA and Class A water reuse standard. Thirdly, the effluent reuse capacity needs to be expanded.

The existing system was not meeting the current Environmental Authority standards (EA, the Australian equivalent to a resource consent), and the city wanted the effluent to comply with current Australian public health water reuse regulations to Class A standard for recycled water.

Table 1: Existing WWRP effluent quality and the requirements for the EA and Class A

TABLE 1: Final Effluent Existing Quality (2010 To 2013) and Regulatory Requirements

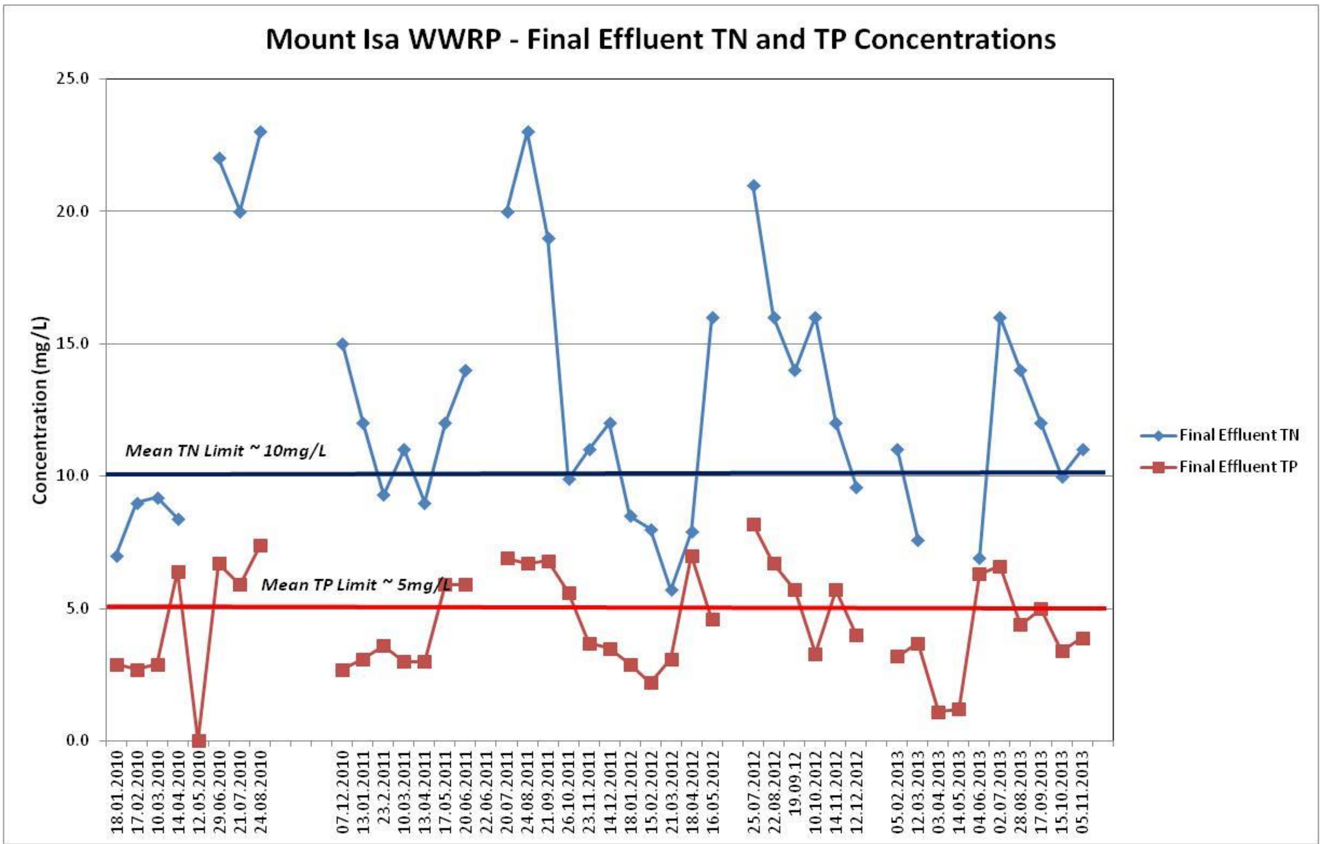
Parameters	WWRP Performance	Regulatory Requirements		
	Effluent Analysis Range	EA Release Limits		Class A [1,2]
		Median	Max	
pH	7.4-9.8	Range 6.5 to 8.5		6.5-8.5
BOD_5 (mg/L)	12-66	<10	<20	<20(median)
Total Suspended Solids (mg/L)	5-160	<15	<30	<5(Median)
Turbidity	No data	-	-	<5 (Max)
Total Nitrogen (mg/L)	5.7-23	<10	<30	-
Total Phosphorus (mg/L)	1-8	<5	<15	-
E Coli (cfu/100mL)	15-9300	-	-	<10
Faecal Coliform (cfu/100mL)	No data	-	<1000	-

Notes:

1. *Class A quality as defined by Water Supply (Safety and Reliability) Act 2008.*
2. *Extracted from Workplace Health & Safety Queensland "Guide to workplace use of non-potable water including Recycled Water" Table 2, and the concentration limits were based on the superseded Queensland Water Recycling Water Guidelines 2005. Thus the limits are considered to be non-mandatory.*

Figure 2 below shows the current WWRP performance for nutrients (nitrogen and phosphorus).

Figure 2: Existing TN and TP Effluent Concentration



The above data shows that the current WWRP does not meet the EA requirements, or Class A requirements. This highlighted the need for a nutrient removal upgrade (unless the EA limit could be revised).

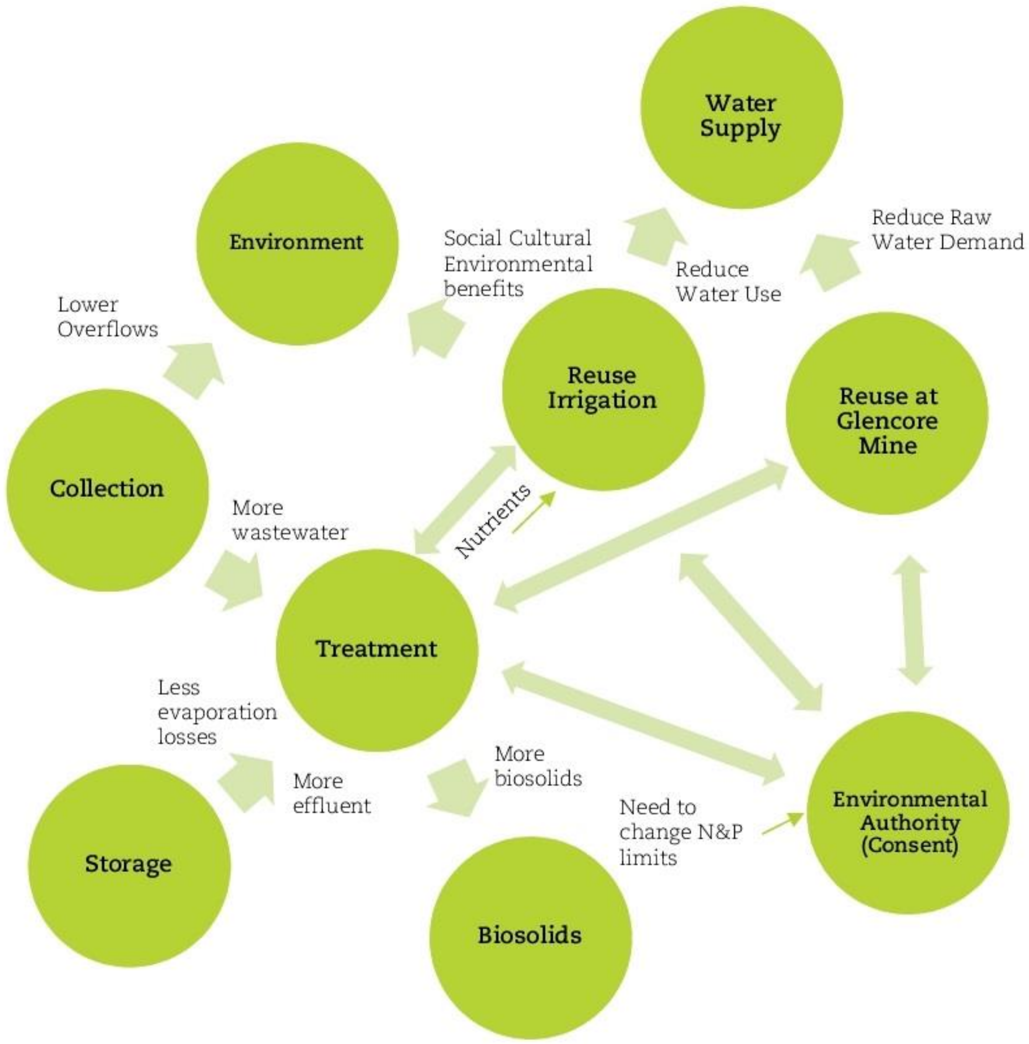
2.3 INTERACTIONS OF ASPECTS OF THE PROJECT

In brief, the collection system, treatment plant and effluent disposal/reuse upgrading all interact with each other, and also have an impact on the water supply system. While this is dealt with later in the paper, in summary the main interactions are:

- Collection system upgrading reduces overflows and increases peak flows to the WWRP.
- The effluent irrigation system benefits from the nutrients remaining in the effluent to promote plant growth. If most of the nutrients are removed, as the existing EA (consent) would require, the effluent would have insufficient nutrients to support ideal plant growth, and fertilizer may need to be added.
- If nutrient removal is not required at the WWRP, considerable capital and operating cost savings could be made. This required a change to the EA.
- The effluent reuse system has positive environmental, social and cultural benefits for the city.
- Effluent reuse also reduces overall water use by the city.
- The existing effluent storage lagoons would degrade the quality of effluent produced. If lagoon effluent is filtered and disinfected, algae would be a problem.
- If the existing effluent storage lagoons are retained for wet season storage only, overall evaporation losses will reduce, thus making more effluent available for reuse.

These interactions are represented in the figure below.

Figure 3: Wastewater System Interaction Diagram



Some of the interactions were not identified until later stages of the project. If they had been identified earlier, further savings may have been possible.

3 WASTEWATER COLLECTION SYSTEM

The existing wastewater network was mostly at capacity with very high infiltration and significant overflows during heavy rainfall. Although the climate at Mount Isa is usually hot and dry, the area can be subject to intense tropical rain, particularly during the summer months, and this results in very high wastewater flows and consequent overflows. The two main trunk sewers, the East Street Trunk and the West Street Trunk (both DN450) were already overloaded during heavy rain. In addition the main terminal pumping station, PS01, was at capacity and could not cope with peak wet weather flows.

This project involved upgrading the city's wastewater network to convey flows from proposed developments at Gliderport and Healy Heights to the south of the city to the WWRP, located to the north-east of the city. All flows from the new developments would need to be conveyed through the existing city. A solution had to be devised to not only convey flows from the new developments, but also to reduce overloading of the city's existing network.

Several options were considered, including replacement of the existing East Street Trunk gravity sewer with a larger diameter pipe. However this option was considerably more expensive than building an additional rising main through the city. Several other options were also considered, including pumping the southern flows directly to PS04, PS01 or to the WWRP.

The chosen option was to build a new pumping station, PS18 to serve the new southern developments and relieve overloading in the East Street and West Street trunk sewers by

- Pumping flows from PS18 directly to the main pumping station, PS01 (3.2km).
- Diverting PS04 directly into the PS18 rising main, thus reducing the flow in the East Street Trunk.
- Diverting PS11 to PS18, thus reducing the flow in the West Street Trunk.
- Diverting part of the gravity catchment of PS04 by gravity directly to PS18, thus reducing the flow at PS04. This avoided the need for a costly capacity increase upgrade at PS04.

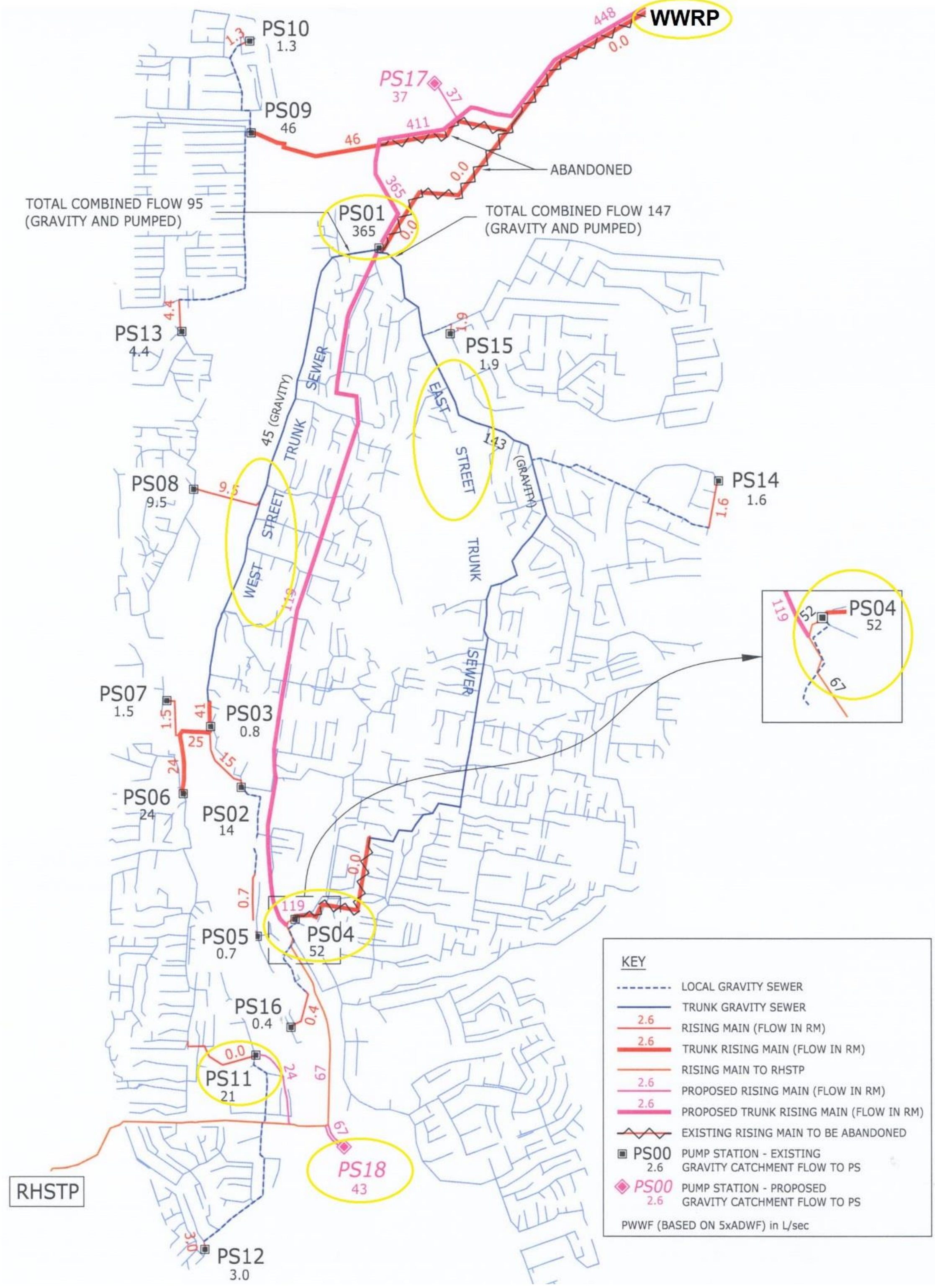
Figure 4: Location of Main Features of Mount Isa Wastewater System

The advantages of this option are:

- The diversion of flows from PS11 to PS18 will reduce flows in the overloaded gravity sewer to PS06 and the West St Trunk sewer, avoiding the need for major upgrading.
- The diversion of flows from PS04 to the new rising main will reduce flows in the overloaded East St Trunk sewer, avoiding major upgrading.
- PS18 will be a built in a greenfield site, thus making construction relatively easy.

A plan of the city, and the new works, is shown below.

Figure 5: City Plan and Proposed works



In the above diagram, PS18 is shown in the lower centre of the city. Diversion of PS11 to PS18 is accomplished by constructing a new DN150 rising main from PS11 to a spare DN250 pipe, into which the rising main was threaded, saving trenching costs. This reduces flows to PS06, PS03, and to the West Street Trunk sewer.

Most of the initial length of the rising main for PS18 uses an existing rising DN250 rising main to PS04. PS04 is diverted a short distance to the new rising main from PS18, which is adjacent to PS04.

The remainder of the rising main form PS04 to PS01 is DN300 DI to cater for the combined flow from PS04 and PS18. PS01 is also upgraded, and a new DN525/600 GRP rising main built to the WWRP.

Photograph 1: The Upgraded PS01 at Mount Isa

The upgrades to the reticulation system result in fewer overflows throughout the city, and greater conveyance of wastewater to the treatment plant. This increase in environmental outcomes requires upgrades at the sewage treatment plant to cater for increased peak flows, and slightly increases the volume of effluent available for disposal and reuse.

4 WASTEWATER TREATMENT

The existing WWRP consists of coarse screens, three primary clarifiers, two balance tanks, three trickling filters and two secondary clarifiers. The secondary treated effluent is then discharged into a series of four polishing ponds prior to the effluent pump station. Chlorination is currently not practiced.

While the existing WWRP works well and produces a good quality effluent, it needs upgrading to meet the terms of the existing Environmental Authority (an EA is the Queensland equivalent of a resource consent) in terms of BOD, SS, TN, TP and E-coli. Upgrading is also required to increase capacity, and to remove some inefficiencies and shortcomings with the existing plant. Moreover, the Council intends to upgrade their treated effluent to achieve Class A recycled water standard, as water is a precious commodity in the region.

4.1 UPGRADING TO MEET THE ENVIRONMENTAL AUTHORITY

With the terms of the existing EA, the following upgrading would be required:

a) The inlet screen is to be replaced with a new fine screen and grit removal system.
b) The trickling filters have adequate capacity, but further BOD removal is required.
c) Additional biological reactor will be required to achieve nutrient removal.
d) Chemical dosing (carbon and alum) would be required to achieve the nutrient limits.
e) The secondary clarifiers have sufficient capacity.
f) New effluent tertiary filtration is required to achieve solids removal, and facilitate effective disinfection.
g) A new UV disinfection facility will be provided achieve Class A disinfection.
h) A new chlorine dosing facility will be provided to ensure a chlorine residual remains in the final effluent for the protection of end users.
i) The effluent storage ponds will be configured to provide off-line storage, rather than on-line. This is to prevent deterioration of the bacteriological quality of the effluent in the lagoons due to contamination by wildlife.

To advance the effluent reuse options, irrigation modelling using the MEDLI model (Model of Effluent disposal by Land Irrigation) was carried out.

MEDLI modelling identified that the reduced nitrogen and phosphorus content of the effluent (based on the existing EA conditions) would provide insufficient nutrient to promote plant growth, and that plants would benefit from the addition of artificial fertilizer.

We realized it makes little sense to remove nutrients to low levels by the energy consuming biological nutrient reduction process (nitrification and denitrification, enhanced by carbon dosing) and to reduce phosphorus by chemical precipitation (with alum) and then to add artificial fertilisers to the soil to enable plants to make use of the irrigated water. A more sensible approach would be to remove less nutrient at the WWRP and not apply any artificial fertilizer to the soil.

It was realized that if the nutrient limits in the EA could be renegotiated, significant additional upgrades (c & d above) could be delayed or avoided altogether.

For this reason, early on in the design phase, it was decided that dialogue with DEHP (the Queensland Department of Environmental and Heritage Planning) should commence to explore the possibility of a relaxation of the Total nitrogen limit from an average of 10mg/L to 30mg/L. Similarly, a relaxation of the phosphorus limit from an average of 5mg/L to 8mg/L was sought.

4.2 REVISION TO THE ENVIRONMENTAL AUTHORITY

The application for a new EA with higher total nitrogen and phosphorus limits avoids the need for a significant upgrade of the sewage treatment plant, and ongoing power and chemical costs for carbon dosing and alum dosing.

By involving DEHP early in the process, first through initial discussion, and then a formal pre-lodgement meeting, appropriate information was provided to enable the application to change the conditions to be processed and approved in a straightforward manner.

After the initial discussion, further MEDLI modelling was carried out to determine the effect of irrigation with higher levels of nutrient in the effluent on soil drainage. The result of this modelling showed that very low levels of deep drainage of nitrogen and phosphorus to the groundwater, and the effect would be minimal and acceptable from an environmental viewpoint.

After a total of around 10 months, DEHP agreed to amend the discharge standards specified in the EA. The design of the WWRP is currently being amended, which will result in substantial savings in capital and operating cost.

The revised EA effluent release limits are:

Table 2: Final Effluent Quality Release Limits

Table 3: Final Effluent Quality Release Limits

Parameters	OLD EA Release Limits		REVISED EA Release Limits	
	Median	Max	Median	Max
pH	Range 6.5 to 8.5		Range 6.5 to 8.5	
BOD_5 (mg/L)	<10	<20	<10	<20
Total Suspended Solids (mg/L)	<15	<30	<15	<30
Turbidity	-	-	-	-
Total Nitrogen (mg/L)	<10	<30	<30	<50
Total Phosphorus (mg/L)	<5	<15	<8	<15
Faecal Coliform (cfu/100mL)	-	<1000	-	<1000

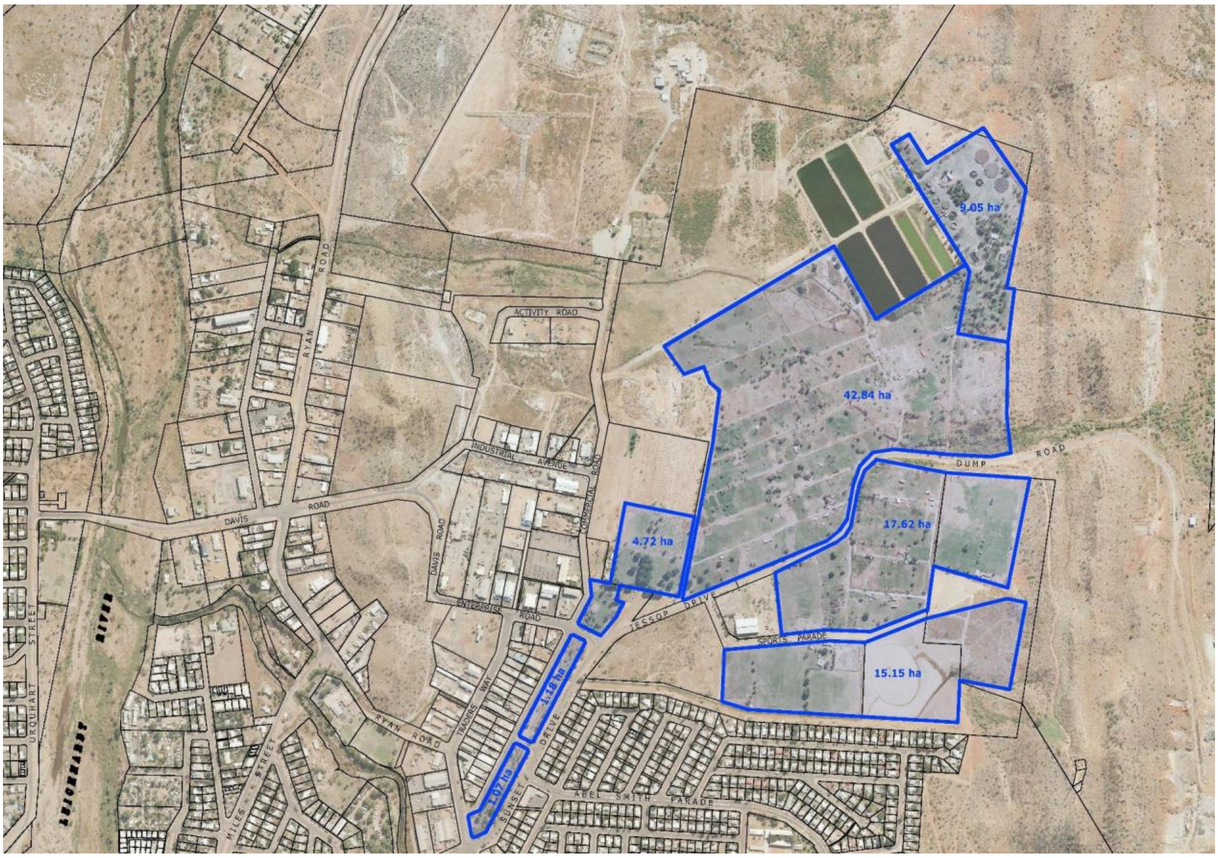
It can be seen that the Total Nitrogen limits have been raised to a median of 30 and a maximum of 50 mg/L, which removes the need for additional works to enhance nitrogen removal, while providing nutrients to support plant growth. This represents a win-win solution for the Council in that the capital and operating costs of treatment plant upgrades can be reduced.

5 EFFLUENT REUSE

For many years, treated effluent has been irrigated onto horse paddocks, sports fields, parks and a cemetery on land generally to the northeast of the town near to the STP. The use of water in this way benefits the town by keeping public areas green that would otherwise be dry and unproductive for most of the year, and reduces the city potable water demand as these areas do not require irrigation from the town supply. In all likelihood, some of these areas may not be irrigated much or at all if the effluent were not available.

In the case of the horse paddocks, there is benefit to many horse owners. Mount Isa has been known as the "Rodeo Capital of Australia" and the events contribute socially and economically to the region.

Figure 6: Location of Existing Effluent Reuse Areas



The average annual evapotranspiration is 3042mm p.a, which exceeds annual average rainfall at 327mm p.a. King, (2012). In addition, the average monthly evapotranspiration exceeds the annual monthly rainfall for every month of the year.

During dry years, the irrigation areas are obvious from aerial photos.

In the past irrigation occurs in a somewhat 'ad-hoc' way, to regulate the water level in the storage lagoon, rather than in response to soil moisture deficit. Some areas receive more irrigation water than others. During winter and wet periods, over-irrigation occurs, while at dry times there may be insufficient irrigation in some areas.

During the preliminary design, two options were considered.

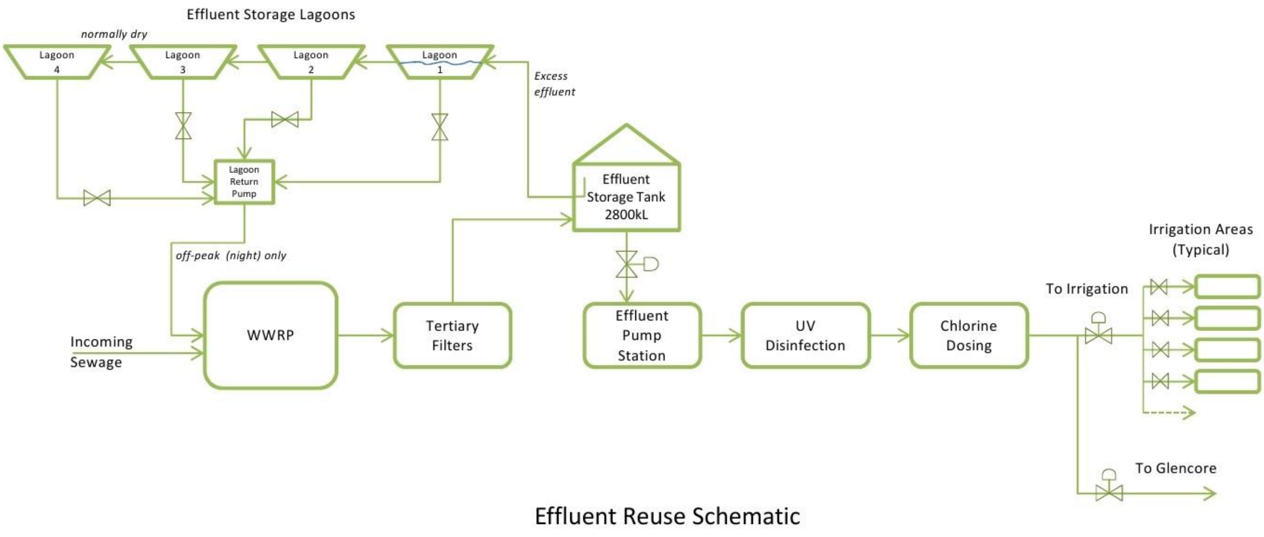
1. Maximize irrigation to existing and new irrigation areas, by deficit irrigation to close to field capacity, but avoiding runoff. The purpose of this is to reduce the amount of additional area required, and hence minimize costs. Frequent irrigation would be carried out to maximize evaporation. Essentially, the irrigation would be relatively "inefficient".
2. Irrigation to satisfy irrigation demand (deficit irrigation), thus maximizing the amount of effluent available for reuse by the Mount Isa Mines. Essentially, the irrigation would be relatively "efficient".

The second option was selected for a number of reasons:

- Additional irrigation area would cost significantly more, primarily in relation to the addition pipelines required to transfer effluent to other potential beneficial reuse areas of the city. Much of Mount Isa has rock at a shallow depth below the surface, increasing the cost of pipelines.
- Glencore Mount Isa Mines is keen to take the effluent, and can use as much as is available. All the effluent used will result in a corresponding reduction in the volume of water abstracted from the storage reservoirs.
- Irrigating at reduced rate (deficit irrigation, generally to satisfy plant water demand) results in more efficient irrigation, and more recycled water available for reuse by Glencore.

Figure 7 below shows the schematic of the prosed effluent reuse system, with day to day storage in a covered tank to preserve effluent quality. Any excess effluent flows to the open effluent storage lagoons, and is later returned to the WWRP for re-processing.

Figure 7 Schematic of Effluent Reuse



The significant advantage of this option is to maximize beneficial reuse, both on the existing irrigation areas, and also for the mine, and ultimately reducing the volume of water required by the mine from lake storage. While only a small portion of overall water use, the reused water may reduce the proportion of time that higher level water restrictions would need to be imposed at Mount Isa.

6 SUMMARY

While satisfactory upgrades can be achieved by considering each aspect (collection, treatment and disposal) in isolation, an enhanced overall solution can be achieved by taking a holistic approach to design, consenting and operation philosophy.

From this case study of Mount Isa, it can be construed that there are many areas where one aspect of the scheme has a significant effect on other aspects. To allow all of these to be taken into account requires flexibility during the design and investigation phase of a project, as not all interactions may be evident at the conception phase of the project.

In particular, the effluent standard should as much as possible be tailored to the means of ultimate disposal or reuse. In some cases, lower levels of contaminants are not necessarily better, as in the case of beneficial reuse by irrigation.

Other aspects interact with each other, using the effluent lagoons for wet season storage results in less evaporation losses, freeing up more water for reuse.

Reuse can also make a small but valuable reduction in raw water demand in the region, which is significant for Mount Isa, where droughts lasting for a year or more have occurred repeatedly.

The purpose of this paper is to encourage the reader to look for aspects of interaction in the project they are considering, and to look at their projects holistically.

ACKNOWLEDGEMENTS

Mount Isa City Council

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