Impact Analysis: On-Site Sodium Hypochlorite Generation for Potable Water Chlorination.

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Abstract

Current chlorination practices in potable water disinfection face opposition to the growing financial strain of operational costs, safety risks from chemical handling, and potential environmental consequences caused by system failures and human error. Further investigation is required to explore and implement new and updated technologies to address these issues, and by doing so aim to increase cost efficiency, strengthen safety protocols, and minimize the environmental footprint of the disinfection processes.

This technical paper presents an impact analysis of transitioning from traditional bulk delivery and storage of 12% sodium hypochlorite to on-site generation for chlorination of potable water. This paper evaluates key performance criteria, including operational safety, chemical stability, cost efficiency, and environmental footprint via technology trials in conjunction with Yarra Valley Water and Coliban Water. On-site chemical generation demonstrates measurable benefits, namely, decreased operational costs, mitigated transportation and storage risks associated with hazardous chemicals, eliminates degradation losses, and enhances dosing accuracy. Through comparative and operational data, this paper evaluates how on-site chemical generation can strengthen safety protocols, optimize operational expenditure, and contribute to sustainability goals at water treatment facilities.

Introduction

Secondary chlorination is an increasingly common practice used by Victorian water authorities to safeguard customers' water supply from bacteria and other forms of organic growth. This traditionally relies on 12.5% sodium hypochlorite to accomplish this. However, reliance on traditional bulk hazardous chemicals introduces several significant costs such as insurance, incident management plans, procedure and transport to make conventional delivery both financially and operationally costly.

By eliminating the hazardous chemical classification through use of on-site generation, organisations eliminate the costs of hazardous chemical insurances, chemical transport and its associated risks, bulk hazardous chemical storage facilities, specialized transport vehicles delivery infrastructure and overheads required to comply with strict chemical safety regulations. Whilst the chemical compound difference lies only in concentration – typically 0.6% versus 12.5%, the financial benefits are far reaching.

Beyond the financial benefits and time reductions, the change is seen to benefit both reputational and safety, through its improved operator safety from elimination of hazardous chemical risks, demonstrating a desire of improved operational and environmental responsibility and reduced risk to customers and building trust with regulatory bodies. In short, Sodium hypochlorite generators offer financial, safety and reputational benefits to users, making them both a technical upgrade to secondary chlorination, but also a great option to reduce running, safety and environmental costs.

Discussion

This analysis compares the two methods used for secondary chlorination by structuring the evaluation across six key categories: operational safety, infrastructure requirements, environmental risk, reputational exposure, resourcing implications, and customer safety. Whilst on-site generation eliminates hazardous chemical handling, transport, and storage, it introduces new considerations, such as hydrogen management and softener regeneration waste. This analysis draws on operational data and recent Victorian water authority trials to provide an evidence-based comparison of the two models and how they could impact the burden of secondary chlorination.

Figure 1 - Yarra Valley Trial System

Operational Safety

Operational Hazard	Traditional Bulk Delivery	On-Site Generation
Transport of hazardous chemical	**High-consequence hazard introduced** (transport of hazardous chemical; spill potential; road exposure)	**Risk eliminated** (no hazardous chemical transport)
Delivery of hazardous chemical	**High-consequence hazard introduced** (spray, leaks, operator exposure during transfer)	**Risk eliminated**
Storage of hazardous chemical	**High-consequence hazard introduced** (bunding, corrosion, fumes, hazardous inventory)	**Risk eliminated**
Storage of brine tank	**Not applicable**	**Low-severity hazard introduced** (non-hazardous material; minimal consequence)
Hydrogen gas	**Not applicable**	**Low-severity hazard introduced, reduced to very low** through engineered controls

		(ventilation, sensors, shutdown at ¼ LEL)
System longevity	**Risk increased** (corrosion reduces equipment lifespan)	**Risk reduced** (no corrosive chemical exposure)
Chemical leak	**High-consequence hazard introduced** (hazardous chemical exposure; eye splash risk)	**Risk reduced to negligible** (low-strength, non-hazardous solution)
Manual handling	**Risk introduced** if manual carboy handling is required; **risk reduced** if automated filling is used	**Low-severity hazard introduced** (manual handling of salt bags; severity depends on bag size)

The operational safety comparison shows that on-site hypo generators eliminate high consequence hazards associated with bulk chemical transport, storage and handling, whilst introducing low-severity hazards with sufficient control systems managing the added risks. Latest reported data from Safe Work Australia indicates that between July 2023 and June 2024, a total of 1200 Serious Chemical and other substances were claimed through Work Safe Australia [1]. This reinforces the elevated safety burden placed on operators when hazardous chemicals are transported and handled, highlighting the benefit of removing these tasks entirely. The trial data revealed the hydrogen levels stayed well below explosive limits under normal operation with additional safety measures present as safeguards. Coliban Water's Trial showed the softener regeneration waste was small and easily managed through use of correct disposal services [2]. While on-site generation introduces new risks that are well controlled, it clearly eliminates substantial high-level risks which are significantly outweighed by the elimination of transport-related incidents, delivery-stage exposure, and high-strength chemical handling.

Infrastructure

Infrastructure Element	Traditional Bulk Delivery	On-Site Generation
Delivery vehicle	**Risk introduced** (delivery vehicle access required).	**Risk eliminated**.
Concrete delivery apron	**Risk introduced** (concrete apron required for safe delivery).	**Risk eliminated**.
Safety shower and eye wash	**Risk introduced** (safety shower and eye wash required).	**Risk eliminated**.
Hazardous chemical handling procedures	**Risk introduced** (hazardous chemical handling procedures required).	**Risk eliminated**.
On-site delivery control system	**Risk introduced** (cam-locked fill point; PLC-controlled delivery).	**Risk eliminated**.

Space for system and equipment	**Risk eliminated**.	**Risk introduced** (space required for generator cabinet or container).
Chemical tank bund	**Risk introduced** (bunded chemical tank required).	**Risk reduced** (not required but recommended; bund and sensor add protection).
Insurances	**Risk increased** (higher insurance cost due to hazardous chemical storage).	**Risk reduced** (lower insurance cost).

A significant portion of traditional chlorination infrastructure is not required for on-site chemical generation. Preliminary data from Yarra Valley Water suggests the chemical storage and delivery infrastructure required to meet Australian Standards for hazardous chemical storage and delivery, accounts for roughly 60% of the total cost of a secondary chlorinator, suggesting capital savings could be as high as 50% when building new secondary chlorination infrastructure [3]. Traditional systems require delivery bunds, wash-down hoses, hazardous chemical delivery infrastructure and vehicle access, all of which increase the site footprint. At locations where space is at a premium, on-site generation offers a markedly smaller spatial requirement. Expensive overheads such as chemical handling procedures and site insurances are substantially reduced, resulting in improved cost efficiency.

Environmental Safety

Environmental Risk	Traditional Bulk Delivery	On-Site Generation
Hazardous chemical spill during transport	**Risk introduced** (transport of hazardous chemical creates potential for environmental contamination).	**Risk eliminated**.
Hazardous chemical spill during filling	**Risk introduced** (hose or coupling failure may release chemical to environment and stormwater).	**Risk eliminated**.
Hazardous chemical spill during system failure	**Risk introduced** (fitting or hose failure may release chemical to environment and stormwater).	**Risk eliminated**.
Tank failure	**Risk introduced** (bund required to prevent soil and waterway contamination).	**Risk reduced** (low-strength solution; smaller volumes; significantly lower impact if released).
Chlorate formation and chemical degradation	**Risk introduced** (bulk hypochlorite degrades over time, increasing chlorate levels).	**Risk eliminated** (freshly generated solution; minimal degradation).

Brine storage and handling	Not applicable.	**Low-severity hazard introduced** (low-risk material; minimal environmental impact; bunding recommended).
Impact severity of chemical leak	**Risk increased** (high-strength hazardous chemical; regulated substance).	**Risk reduced** (low-strength, non-hazardous solution).
Brine regeneration waste	Not applicable.	**Risk eliminated** when using replaceable softener cartridges; **risk introduced** only if using self-regenerating softeners.

Latest reported data from The CFA Incident Data between July 2021 -June 2022 shows that a total of 15 Chemical Spill or leak incidents required CFA intervention [4]. This highlights the ongoing environmental risk associated with transporting and storing hazardous chemicals. The environmental risk is substantially reduced when hazardous-chemical transport, delivery, and bulk storage are eliminated from the site. Trial observations from Yarra Valley Water noted that eliminating 12% sodium hypochlorite reduces the environmental risk such as elimination of hazardous chemical spills from delivery, on-site storage or chemical transport [3]. At Coliban Water's trial, the expected softener regeneration waste stream was captured and disposed of at an appropriate waste-recycling facility [5]. This introduced a small additional management requirement, typically two collections per year which was risk assessed and classified as low severity. Since the Coliban Water trial, replaceable softener cartridges have been incorporated as a system design option, removing brine waste entirely and adding a routine maintenance task of replacing the cartridge resin. The evidence from both trials suggests that on-site generation significantly eliminates or reduces environmental risks while introducing only minor risks that can be controlled through new procedures or maintenance regimes.

Reputational Cost

Reputational Risk	Traditional Bulk Delivery	On-Site Generation
Public perception following an environmental chemical spill	**Risk increased** (transport-related spills are public-facing and attract community, media, and regulatory scrutiny).	**Risk reduced** (fewer spill pathways; any incident is contained on-site with low-strength product).
Brand and community trust	**Risk increased** (a single transport incident can reduce confidence in the organisation's chemical-handling practices).	**Risk reduced** (lower hazardous inventory and elimination of transport-related risks strengthen confidence).

Visibility of incident	**Risk increased** (transport spills are highly visible, may affect roads or infrastructure, and often require emergency response).	**Risk reduced** (any spill is isolated to site and involves a non-hazardous solution).

No negative reputational impacts were noted by either Coliban Water or Yarra Valley Water during their trial or ongoing trial periods. Coliban Water reported no customer complaints after notifying customers of the change in chemical concentration. While neither organisation commented directly on broader reputational effects, the move toward improved operator safety and reduced environmental risk is likely to be viewed favourably by regulatory bodies and local communities.

Resourcing

Resourcing Element	Traditional Bulk Delivery	On-Site Generation
Staff involvement during delivery	**Risk introduced** (staff required to facilitate or perform chemical deliveries).	**Risk eliminated** (no deliveries required).
Skills and training	**Risk introduced** (staff require hazardous chemical handling training; procedures must be created and maintained).	**Low-severity hazard introduced** (operators require basic generator knowledge; salt top-ups as needed).
Time commitment	**Risk introduced** (time required for chemical delivery and testing of safety shower and eye wash).	**Risk reduced** (no delivery; safety shower and eye wash not applicable; periodic salt top-ups only).
Maintenance increase	Not applicable.	**Low-severity hazard introduced** (additional annual maintenance ~30 minutes).
Emergency preparedness	**Risk introduced** (staff must prepare for delivery-related emergencies and catastrophic tank/bund failure; high consequence if it occurs).	**Risk reduced** (no delivery-related emergencies; catastrophic tank/bund failure remains possible but with greatly reduced consequence).
Inventory management	**Risk introduced** (staff must monitor tank levels and organise chemical deliveries).	**Risk eliminated** (self-topping system; no inventory management required).

Neither organisation noted an increase in resourcing requirements by the conclusion of the trial, and Yarra Valley Water (whose trial is still underway) has observed a reduction in

resourcing demand due to the removal of chemical deliveries to site. At the commencement of the trial, Coliban Water recorded an increase in SCADA monitoring and operator attendance at Tooborac. This was associated with heat-related issues that had been predicted during the HAZOP process, as the trial period occurred during the hotter months. By the conclusion of the trial, no ongoing additional resourcing requirements were noted by Coliban Water. Both trials, however, reported a 100% reduction in chemical deliveries, replaced with the simple requirement of checking and topping up the salt in the brine tank. Salt can be easily stored on-site and does not spoil or degrade in the way sodium hypochlorite does further increasing the reliability of the system [6].

Customer Safety

Customer Risk	Traditional Bulk Delivery	On-Site Generation
Exposure to delivery incidents	**Risk introduced** (public may be exposed to hazardous chemicals during transport or on-site filling if catastrophic failure occurs).	**Risk eliminated**.
Supply chain dependency	**Risk introduced** (dependency on chemical supplier; some authorities maintain surplus stock which can degrade over time).	**Risk reduced** (dependency shifts to salt supply; can be mitigated by storing a pallet of salt which does not deteriorate).
Operational disruption	**Risk introduced** (operations affected if chlorine supplier experiences issues).	**Risk reduced** (operations only affected if generator fails; failure unlikely due to no rotating parts and full availability of spare parts in Australia).
Chlorate formation	**Risk introduced** (aged hypochlorite increases chlorate levels due to degradation during transport, storage, and heat exposure).	**Risk reduced** (on-site generation produces fresh hypochlorite with significantly lower chlorate levels, minimising chlorate formation).

Coliban Water observed a significant improvement in residual stability at the commencement of the trial, likely due to the reduced chemical strength, which resulted in less pronounced fluctuations in chlorine concentration. However, because the PID controller was adjusted during the installation phase, it cannot be definitively attributed to the Hyprolyser alone. Regular ALS monitoring indicated no significant changes in bromoforms, chloroforms, or total trihalomethanes (THMs) following the commencement of the trial. The removal of hazardous chemicals from the local area also provides an inherent customer-safety benefit, eliminating the risk of catastrophic chemical leaks and reducing the potential for transport-related chemical incidents. It is also reasonable to expect that producing hypochlorite at a lower strength and using it while fresh will reduce chlorate formation within

the chemical tank, further improving water quality for human consumption and meeting the World Health Organisation suggested chlorate limits.

Conclusion

The evidence from both Victorian water authority trials demonstrates that on-site hypochlorite generation provides a fundamentally safer and more sustainable approach to secondary chlorination. High-consequence hazards associated with chemical transport, delivery, and bulk storage are eliminated entirely, whilst the new risks introduced by on-site generation are low in severity and effectively controlled through engineered safeguards. Through the removal of on-site chemical, we eliminate the potential customer, operator and environmental exposure risks that hazardous chemicals pose, and reduce the chlorate formations in drinking water.

The trials also show that these safety and environmental gains are achieved alongside meaningful financial benefits. Traditional systems require extensive hazardous-chemical infrastructure such as delivery aprons, bunded tanks, safety showers and delivery control systems, which represent a substantial proportion of capital cost. On-site generation removes much of this requirement, offering the potential for significant capital savings in new installations. Operationally, both utilities reported equal or reduced resourcing demands, including the complete elimination of chemical-delivery tasks and early indications of notable operating-cost reductions.

Customer safety was maintained or improved, with no increase in disinfection by-products and reduced exposure to hazardous chemicals for both operators and the local community. The findings indicate that on-site generation delivers a safer, lower risk, and more cost-effective solution for secondary chlorination, with benefits that extend across operational safety, environmental protection, organisational reputation, and long-term financial performance.

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