BEFORE ENVIRONMENT SOUTHLAND AND SOUTHLAND DISTRICT COUNCIL

UNDER	the Resource Management Act 1991
IN THE MATTER	of a Resource Consent Application and Designation by Southland District Council to discharge treated wastewater to land and odour to air from the Te Anau Wastewater Treatment Plant

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STATEMENT OF EVIDENCE OF KEVYN JAMES LOCKYER FOR SOUTHLAND DISTRICT COUNCIL

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QUALIFICATIONS AND EXPERIENCE

1. My name is Kevyn James Lockyer.

2. I am a Principal Process Engineer and I work for MWH.

3. I have over 25 years of experience in odour control, process engineering, environmental management and air pollution control. I am recognised as a global leader for MWH specialising in septicity, corrosion and odour control.

4. I have experience of a wide range of applications and was the odour specialist for the United Utilities / MWH Integrated Alliance before joining the team in Sydney.

5. I have worked for a number of specialist air pollution control contracting and consultancy companies and have experience with the conceptual and detailed design as well as the installation and commissioning of a wide range of abatement equipment and technologies. As well as experience in Australia and the UK, I have also undertaken projects in Lebanon, Abu Dhabi, America and Europe.

SPECIALISATIONS

- Process Design
- Odour Control
- Septicity, corrosion and odour in sewer networks
- Air Pollution Control
- Air Quality Modelling
- Process Plant Commissioning
- Environmental and Energy Impact Assessment

CAREER SUMMARY

- Area discipline manager for process, mechanical and electrical teams, MWH (Australia), 2011 to present
- Principal Process Engineer, MWH (Australia), 2010 to present
- Principal Process Engineer, MWH/UU Alliance (UK), 2009 to 2010
- Technical Sales Manager, Operational UK Ltd, 2006 - 2009
- Operations Manager, Alderley Environmental Ltd, 2001 – 2006
- Senior Process Engineer, Alderley Process Technologies Ltd, 1998 - 2001

QUALIFICATIONS AND MEMBERSHIPS

- BEng (Hons), Chemical Engineering (University of Wales College Swansea)
- Institution of Chemical Engineers (AIChemE)

6. I have read the Code of Conduct for Expert Witnesses in the Environment Court Practice Note. This evidence has been prepared in accordance with it and I agree to comply with it. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

SCOPE OF EVIDENCE

7. I have been asked to prepare evidence in relation to odour production and mitigation for the Te Anau wastewater treatment plant scheme. This includes:

    a. What is odour?

    b. What is the issue for the Te Anau scheme?

    c. Available treatment options

    d. Selected option

    e. Basis for flow and load

    f. Predicted Trickling Filter and soil filter performance

    g. Chemical dosing

    h. Conclusion

EXECUTIVE SUMMARY

8. One of the key design considerations for the Te Anau scheme is to prevent the release of fugitive odours from the system with the discharge to land at the Kepler Block. The following section highlights the steps taken and the depth of knowledge available to identify the formation of odour in the system and the mitigation measures required to minimise the risk of odours from the facility.

9. Overall it is proposed that the treated wastewater is further processed through a trickling filter, soil bed biofilter and chemically dosed before irrigation to land. This is to occur at the Kepler Farm prior to discharge. This process in my opinion will minimise any risk of fugitive odour releases from the facility. This is my recommended treatment process to best manage potential odour from this proposal.

10. With the mitigation measures in place the risk that odours will be detected at or beyond the site boundary will be minimised. The level of odour at the point of irrigation will be low. With the effect of dispersion over the distance from the point of irrigation to the site boundary will minimise any impact beyond that point.

What is odour?

11. Odour is caused by the presence of one or more compounds in the air at concentrations that can be detected by the human olfactory system.

12. The olfactometry nerve is connected to the limbic system. The limbic system is a set of brain structures which support a number of functions including emotion, behaviour, motivation, long term memory and olfaction. Therefore, it can be shown that odour can be closely linked to emotion and can trigger an emotional response.

13. Odours rarely cause physical sickness, but can cause emotional distress. This is one of the reasons why odour can be a problematic issue and why effort is employed to mitigate odours.

What is the issue for the Te Anau scheme?

14. Almost all wastewater systems face the potential for the wastewater to turn septic (anaerobic). Under these conditions “sewer gases” can form in the headspaces of the wastewater system which can lead to corrosion of wastewater structures and release odours into the environment.

15. The Pomeroy / Boon suite of equations predict the concentration of sulphide in wastewater using a range of input criteria including predicted oxygen demand, pipe diameters, temperature, residence time, and sulphate concentrations.

16. Based on the design data presented, and the assumptions made, the calculated soluble sulphide generation is conservatively judged to be 1 mg/l in the liquid phase.

17. 1 mg/l in the liquid phase can, under the relevant conditions of temperature, pH and turbulence, correspond to 2 ppm – 19 ppm H_2S if untreated in the gas phase. This level of H_2S will represent a risk, under certain conditions, of an unacceptable level of odour at the site boundary or nearest receptor.

18. Consequently, mitigation measures for odour have been designed to minimise the risk of odours released from the system to prevent effects on people and potential odour complaints.

Available treatment options

19. A number of options are available to mitigate the risk of release of hydrogen sulphide gas including chemical dosing, biological treatment and the method of irrigation.

20. The options for liquid phase mitigation include chemical dosing in the transfer main from the Te Anau ponds, oxygen dosing in the transfer main and biological treatment of the effluent at the point of discharge.

21. Removal of the odour compounds from the gas phase can be achieved with bio filters, wet chemical scrubbing and dry adsorption systems.

22. Minimisation of odour release from the point of irrigation will include the design of the spraying system, nozzle selection and flow rates.

Selected option

23. Following analysis of the various options and considering efficacy, cost and operational complexity, a train of treatment steps has been identified:

    a. Biological treatment of the liquid stream in a Trickling Filter (TF);

    b. Chemical addition to the effluent prior to discharge to land;

    c. Effluent discharge to land; and

    d. The air stream from the TF is treated in a soil-bed biofilter prior to discharge to atmosphere.

Basis for flow and load

24. The basis of design has been developed in two stages. Firstly the air flow for the biofilter has been determined as a result of the trickling filter requirements.

25. The contaminant load has been determined based on the Pomeroy / Boon suite of equations, detailing the development of sulphide

generation in the system, the removal of sulphides in the trickling filter, and the liquid / gas equilibrium defined by Henry's Law.

26. The abatement characteristics of the biofilter will allow for, up to, 95% removal of the odours from the air stream.

Predicted TF and soil filter performance

27. Modelling of the TF has shown greater than 90% removal of hydrogen sulphide, from the wastewater stream, for the scenarios examined.

Chemical (oxidation) dosing

28. Predicted sodium hypochlorite solution dosing requirements to oxidise the load remaining after the TF were typically low for the scenarios examined. The proposed storage volume of chemical would provide sufficient capacity.

29. Therefore, it can be shown that the risk of odorous compounds remaining in the wastewater at the point of irrigation will be very low.

WHAT IS ODOUR?

30. The development of the flows, loads and design of the mitigation measures has been achieved utilising my knowledge and experience as well as published literature including the Pomeroy / Boon suite of equations.

31. In addition, the MWH Global Emissions Database, a database of over 8,000 measurements of odorous contaminants from wastewater treatment facilities in Australia, New Zealand and Europe, has been consulted to ensure the output from the model is "realistic".

32. Odour is caused by the presence of one or more compounds in the air at concentrations that can be detected by the human olfactory system. The human nose is highly variable and the detection and classification of odour as objectionable is highly dependent on the sensitivity and perception of the individual and is hence measured by a panel of selected individuals and the results examined statistically. In the context of wastewater, the most common source of odour that is considered objectionable is the presence of hydrogen sulphide gas. Untreated wastewater has a somewhat distasteful odour. However,

where wastewater has become oxygen depleted, microbial activity can generate sulphide by the reduction of sulphate (which is not associated with objectionable odour) present in the wastewater. This sulphide can be released from the liquid into the atmosphere and create an objectionable odour.

33. Other than the Pomeroy / Boon suite of equations, and published supporting papers, to calculate the sulphide generation within the transfer main all other support material has been in house experience and understanding.

34. The method followed in the development of the expected sulphide generation and mitigation measures has utilised, in addition to myself, the input from other process engineers at MWH. They are all experienced process engineers with degrees in a range of engineering disciplines including chemical engineering and experience with wastewater treatment and odour control abatement projects.

35. The system has not been built. Therefore there will always be a requirement to assume certain design figures. However, based on the information put forward and my experience of similar systems, the conclusions here are firm and complete.

WHAT IS THE ISSUE FOR THE TE ANAU SCHEME?

36. A similar example of the design and calculations associated with this application is a recent project at Ti Tree Bend in Tasmania where I was the principal process engineer responsible for the delivery of:

    a. Odour and contaminant emission rate sampling;

    b. Emission rate estimation;

    c. Odour impact and mitigation assessments via dispersion modelling (CALPUFF);

    d. Odour control design and options MCA assessment;

    e. Client support with EPA submissions; and

    f. Development of odour management plan.

37. The information and data presented in the design of the Te Anau scheme allowed me, with my technical knowledge and project experience, to develop the conclusions stated herein.

38. The Te Anau wastewater treatment plant scheme will pump the treated wastewater from the existing oxidation ponds to the irrigation block via a 19km rising main. The retention time of the treated wastewater in the pipeline will likely deplete the dissolved oxygen present. In the absence of oxygen, microbial activity from the biofilm in and on the surface of the pipeline will reduce sulphate to sulphide. The amount of sulphide produced is dependent on a number of factors including pH, temperature, effluent characteristics and retention time. As such, there is the risk of sulphide present in the treated wastewater when it arrives at the irrigation block. Dissolved hydrogen sulphide, if present may be released into the atmosphere by the irrigators. Hence treatment is required to mitigate the risk.

AVAILABLE TREATMENT OPTIONS

39. The treatment options for odour control have been based on my technical knowledge and project experience. A good example of this is the recent project completed for Melbourne Water, Eastern Drop Structure (EDS), where, as principal process engineer I was responsible for:

    a. Review of corrosion and odour management at the EDS;

    b. Development of air flow model;

    c. Triple bottom line assessment of the preferred ATF solution;

    d. Odour impact and mitigation assessment via AUSPLUME dispersion modelling;

    e. Concept design of the preferred air treatment facility solution; and

    f. Client support with EPA submissions.

40. A number of options are available to mitigate the risk of release of hydrogen sulphide gas from the treated wastewater, if present. These include nitrate dosing to prevent sulphide formation in the pipeline

(other chemicals such as coagulants were not considered due to solids production), pH adjustment to keep hydrogen sulphide in solution, oxidation (both biological and chemical) and air stripping.

41. Nitrate dosing (which provides another source of oxygen) was examined and discarded on the basis of high cost and uncertain performance. PH adjustment using hydroxides was examined but discarded due to the likely residual risk of odour if the pH was kept within a limit acceptable for pasture production. Biological treatment, air stripping and chemical oxidation were selected as the best options to mitigate the risk of fugitive odour emissions from the discharge location.

SELECTED OPTION

42. The design of the selected option for the odour mitigation has been based on my technical knowledge and project experience. A good example of this is the recent project completed for Queensland Urban Utilities, Luggage Point WwTW, where, as principal process engineer I was responsible for:

    a. Odour contaminant emission rate sampling;

    b. Emission rate estimation for future process units via MWH Global odour database;

    c. Odour impact and mitigation assessment via CALPUFF dispersion modelling;

    d. Odour control options assessment via Multi Criteria, cost and non-cost Analysis (MCA);

    e. Development of short, medium and long term odour control strategy and staging; and

    f. Provision of selected option Odour Control Specification.

43. The selected option to mitigate the odour risk comprises a trickling filter (TF), soil biofilter and chemical oxidation stage before discharge to the irrigation field.

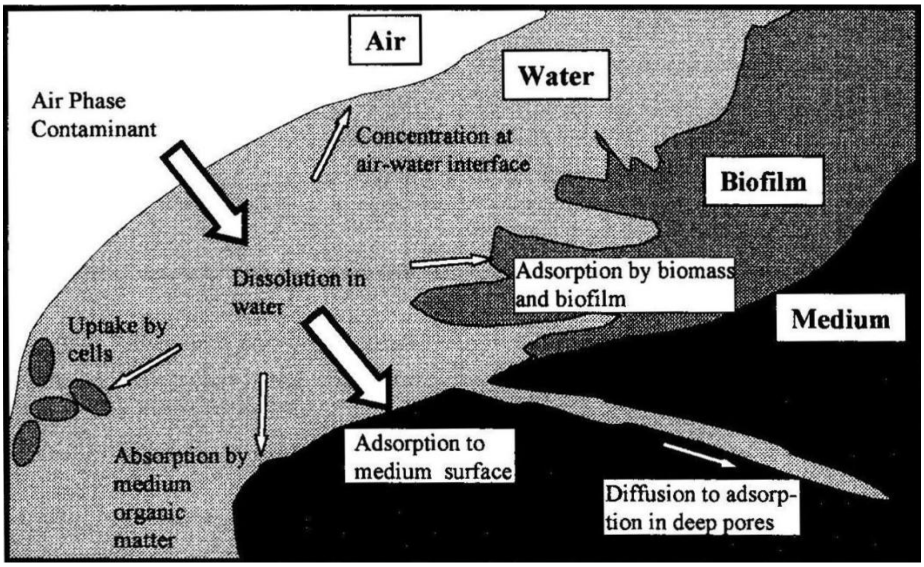
44. The treated effluent arriving at the irrigation block will be delivered into a recirculating pumping station. The pump station will deliver the

treated effluent to the TF mixed with recirculated TF flow. The pumping station will pass forward final treated effluent to the chemical oxidation stage before discharge to the irrigation field. The irrigation flow will be controlled to reduce the risk of dissolved odorous compounds being released into the atmosphere as a result of the irrigation process. Air flow from the pumpstation will be vented through the soil biofilter (discussed below) to manage odour from this source.

45. The TF will comprise a covered 13m diameter tank containing approximately 500m^3 of plastic media, approximately, 4 m deep. The treated effluent will be distributed over the media by a rotating distributor arm and will trickle by gravity through the media. A thin biofilm containing a population of micro-organisms will become established on the surface of the media. These micro-organisms will provide biological treatment of sulphide present in the treated wastewater, converting it to sulphate. Treated wastewater from the base of the TF will be returned to the recirculating pumping station where part of the flow will be mixed with the incoming treated wastewater and recirculated to the TF. A fraction of the flow equal to the incoming flow will pass forward to the chemical oxidation stage for further treatment before discharge to the irrigation field.

46. Air will be drawn upwards through the covered TF by extraction fans. A portion of the sulphide present in the treated wastewater pumped into the TF will pass into the air extracted from the TF. This is known as air stripping. The extracted air from the TF will be passed to a soil biofilter to treat the sulphide present before being discharged to the atmosphere. Soil biofilter treatment of odorous gases is a common approach to odour control. Micro-organisms will become established on the surface of the soil media. These micro-organisms will provide biological treatment of sulphide and other contaminants present in the extracted air from the TF. The soil biofilter will be irrigated to maintain the desired moisture content to maintain microbial activity.

Figure showing mechanism for contaminant removal in a biofilter



47. Treated wastewater from the TF will receive chemical oxidation before discharge to the irrigation field. Sodium hypochlorite solution will be stored in containers housed inside a building. Dosing pumps located inside the building will deliver the solution into the treated effluent from the TF which will oxidise the sulphide to sulphate. The final treated effluent will be discharged to the irrigation field.

48. Optimisation of the irrigation method to control odour risk is discussed in Dr Tony Davoren's evidence

BASIS FOR FLOW AND LOAD

49. The flow has been determined by the requirements of the air flow for the TF. The contaminant loading has been based on the design calculations for the development of septic conditions within wastewater systems as well as utilising the information contained in the MWH Global Emissions Database.

50. While hydrogen sulphide will be the prominent wastewater odour, the odours from wastewater systems will comprise of a range of compounds.

Table highlighting odours associated with wastewater

Compound	**Description**
Hydrogen Sulphide	Rotten eggs
Methyl Mercaptan	Decayed cabbage, garlic
Ethyl Mercaptan	Decayed cabbage
Dimethyl sulphide	Decayed vegetables
Dimethyl disulphide	Putrefaction
Ammonia	Sharp, pungent
VOCs	Varies between compounds – solvent type / putrid / sickly sweet

51. The development for the flow and load for the odour mitigation has been based on my technical knowledge and project experience. A good example of this is the recent project completed for Melbourne Water, Dandenong Valley assessment, where, as principal process engineer I was responsible for:

    a. Septicity modelling to establish H_2S and corrosion risks

    b. Odour control design and options assessment.

    c. Odour control design and options MCA assessment

    d. Development of corrosion & odour management plan

52. A sensitivity analysis has been carried out on the concept design. During the detailed design the flows, loads and sizes of key equipment may increase or decrease.

PREDICTED TF AND SOIL FILTER PERFORMANCE

53. Toxchem™. Toxchem™ is tool that can be used to estimate the fate of hydrogen sulphide in wastewater treatment including biological oxidation and air stripping.

54. The performance of the TF was predicted using Toxchem™ for a number of scenarios covering current and future summer and winter periods. The model output comprises the proportions of the incoming hydrogen sulphide that are biologically oxidised within the TF, air stripped from the TF and the fraction remaining in the TF treated effluent. The predicted performance is summarised below.

55. Approximately 65 to 85% of the influent hydrogen sulphide is oxidised within the TF. Approximately 13 to 28% of the influent hydrogen sulphide is stripped from the liquid to the gas phase and hence is passed to the soil biofilter for treatment. Approximately 2.5 to 6% of the influent hydrogen sulphide remains in the TF treated wastewater discharge and hence is passed to the chemical oxidation stage for further treatment before discharge to the irrigation field.

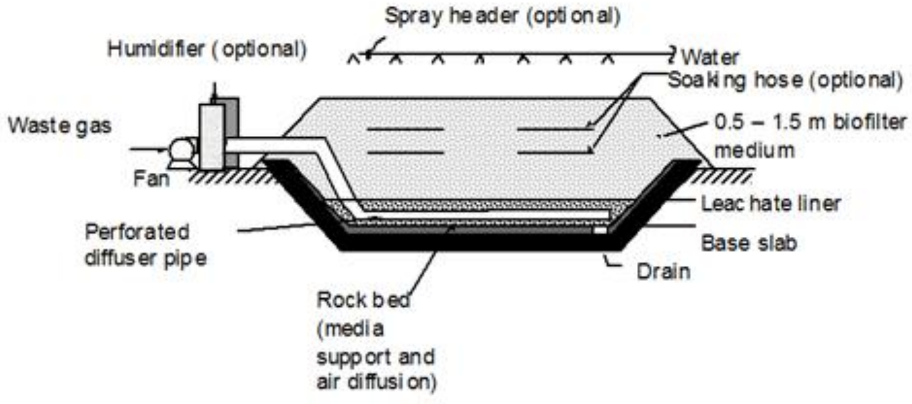
56. Within a soil bed biofilter, the gases are extracted from the odorous areas and pass through a bio-filter for abatement. Typically the air will enter the bio-filter at the bottom into a plenum, or void, chamber. The air will then pass through the bio-filter media located on a support structure above the plenum. Within the bio-filter microorganisms will capture the odorous components and digest them, thus removing them from the air and thus effecting odour abatement. The treated gases then pass onto atmosphere.

57. The microorganisms are typically naturally occurring “bugs” but enhancements can be made by inoculating with specific species known to target specific odour components.

58. The main issue with all bio-filters is moisture and “food” for the “bugs”. The bio-filter must not be allowed to dry out or the microorganisms will die and no odour removal will be possible. Also, if the bed was to become flooded then there would be no movement of air through the unit. If the odour levels are variable then there is the risk of damage to the microorganism colonies as a lack of odour (food) will cause the colonies to die off and spikes of odours will overload the system resulting in poor odour abatement.

59. For the design of the Te Anau biofilter an irrigation system will be installed to prevent drying out and the biofilter will be constructed above ground to prevent flooding.

Typical layout of a biofilter



60. A well maintained soil-bed biofilter will achieve a performance in excess of 95% odour removal.

CHEMICAL (OXIDATION) DOSING

61. The fraction of hydrogen sulphide remaining in the TF treated effluent will be treated by dosing sodium hypochlorite solution. Sodium hypochlorite is an oxidising agent and reacts with sulphide present in the treated effluent converting it to sulphate.

62. Dosing rates and hence chemical storage requirements were estimated using industry recommended dosing rates. The sodium hypochlorite solution 30 day demand is typically 60 to 70 litres for the current scenarios and up to approximately 150 litres for the future scenario requirements (i.e. 2–5 litres per day). The proposed 1000 litre storage capacity renders a suitable degree of robustness and contingency in the event of higher hydrogen sulphide concentrations and/or lower TF removal efficiency at the future consented flow.

CONCLUSION

63. Overall I consider that the construction and use of a trickling filter, soil, biofilter and chemical oxidation is the most suitable technology to ensure that odour does not become a problem at the Kepler Farm where is it discharged to land. This technology is well understood and I consider it will work well as part of this discharge at Kepler Farm.

DATED this 27th day of June 2014

Kevyn Lockyer