Before the Environment Court
At Auckland

In the matter of	the Local Government (Auckland Transitional Provisions Act 2010 (**LGATPA**) and the Resource Management Act 1991 (**RMA**)
And	
In the matter of	appeals under section 156(1) of the LGATPA
Between	Weli Yang, Zhi Lu & Jing Ni
	(ENV-2016-AKL-000196)
	Okura Holdings Limited
	(ENV-2016-AKL-000211)
	Appellants
And	Auckland Council
	Respondent
And	Weiti Development Limited Partnership
	Section 274 Party

(continued on next page)

STATEMENT OF EVIDENCE OF ANDRES ROA
(STORMWATER AND EROSION AND SEDIMENT CONTROL) ON BEHALF OF THE ROYAL FOREST AND BIRD SOCIETY AND THE LONG BAY - OKURA GREAT PARK SOCIETY INCORPORATED

28 JULY 2017

And Long Bay-Okura Great Park Protection Society

Section 274 Party

And Royal Forest and Bird Protection Society Incorporated

Section 274 Party

1. INTRODUCTION

1.1. My full name is Andrés Roa. I am a civil engineer with particular expertise in stormwater and a director of AR & Associates Limited.

2. QUALIFICATIONS AND EXPERIENCE

2.1 I hold a Bachelor of Engineering degree from the Javeriana University in Bogotá, Colombia, and a post graduate diploma in geothermal energy technology from the University of Auckland.

2.2 I am an Engineering Consultant. I hold membership of the Institute of Professional Engineers New Zealand (IPENZ) and Chartered Professional Engineer (CPEng) and International Professional Engineer (IntPE) status.

2.3 I have approximately twenty years' experience in the field of Civil Engineering. I am currently a director of AR & Associates Ltd, a civil engineering consulting firm based in Takapuna, Auckland.

2.4 I have acted as a civil engineering consultant to a wide range of clients in both the public and private sectors throughout New Zealand. I have considerable experience in the stormwater and erosion and sediment control fields, in addition to land development civil infrastructure in general, having been responsible for the design and supervision of many civil engineering projects.

2.5 For the last ten years I have acted as a stormwater management consultant for the Auckland Council (and the legacy councils), where I have been responsible for undertaking technical review of numerous stormwater related consents throughout the Auckland Region, and more recently the technical review of Special Housing Area applications on behalf of the Stormwater Unit (for the Housing Project Office) and Development Engineering.

2.6 More recently I have also been responsible for the technical review of erosion and sediment control applications on behalf of Auckland Council and Bay of Plenty Regional Council.

2.7 In addition, since 2008 I have been responsible for the feasibility planning and design of a considerable number of stormwater projects for Auckland Council, involving stormwater quality, quantity and additions to flood management works. My work has also included the design and delivery of stormwater modelling training courses to industry and tertiary institution entities on behalf of Council.

2.8 I have also been responsible for the engineering design and supervision of a number of land development and residential subdivision proposals such as the Okura Holdings Limited (OHL) development discussed in this statement of evidence, including stormwater, erosion and sediment control, wastewater, water supply and roading elements.

2.9 I participated in expert conferencing and was involved in preparing rebuttal evidence as part of the Okura Unitary Plan hearings held in 2015 and 2016, and am familiar with evidence prepared at the time by representatives of OHL, Bin Chen et al (Okura Rural Land Owners Group) and Auckland Council.

2.10 I also attended the stormwater expert conference held on 6 June 2017 at the Auckland Council offices between representatives of Auckland Council, OHL and Long Bay-Okura Great Park Protection Society and Royal Forest and Bird Protection Society Incorporated (refer Infrastructure and Stormwater Management Joint Witness Statement (**JWS**) dated 6 June).

2.11 I was unable to attend the erosion and sediment control expert conference held on 2 June 2017, and this conference was attended by Sam Morgan on my behalf. I have reviewed the joint statement from this conference (Erosion and Sediment Control JWS dated 2 June) and provided comments under a separate statement dated 14 July 2017.

2.12 I have visited the OHL project site and familiarised myself with the wider area.

3. CODE OF CONDUCT

3.1 I have read and understand the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2014 and agree to comply with it. This evidence is within my area of expertise, except where I state otherwise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed in this statement of evidence.

4. BACKGROUND AND SCOPE

4.1 The focus of my evidence is on the stormwater design and sediment control measures proposed by OHL, as they relate to potential effects from urban development and intensification in the Okura Estuary catchment.

4.2 This statement does not cover modelling aspects of the proposal directly. Instead, it provides high level comment on some of the assumptions made for the definition of modelling inputs, and the interpretation of modelling outputs.

4.3 This statement re-captures a number of key points raised during the 2015 and 2016 Okura Unitary Plan hearing process, along with matters discussed in recent stormwater and erosion and sediment control expert conferences.

4.4 In preparing this statement I have read the evidence prepared in relation to Okura through the Unitary Plan hearing process, expert conferencing statements and associated technical reports, and evidence presented by Auckland Council, Long Bay-Okura Great Park Protection Society and the Royal Forest and Bird Protection Society Incorporated for this appeal. The specific documents are listed below:

- Coffey Geotechnics (NZ) Ltd (February 2014). Desktop Study for Proposed Rezoning of Okura Ling Bay Development, Okura.

- Green, M. (Sept 2015). Assessment of potential effects of land development on Okura Estuary. Estuary Sediment Transport Modelling - Whole Catchment Sediment Runoff. (NIWA report reference Ham2015-115).

- Green, M. (Sept 2015). Assessment of potential effects of land development on Okura Estuary. Estimates of Metal Accumulation in the Estuary. (NIWA report reference 2015-114).

- Moores, J., Green, M. (November 2014). Assessment of potential effects of land development on Okura Estuary. Urban Contaminant Load Modelling. (NIWA report reference Ham 2014-103).

- Reeve, G., Green, M. (April 2015). Assessment of potential effects of land development on Okura Estuary. Estuary Sediment Transport Modelling - Additional Scenarios. (NIWA report reference Ham 2015-043).

- Reeve, G., Green, M. (May 2015 2nd Amendment). Assessment of potential effects of land development on Okura Estuary. Estuary Sediment Transport Modelling. (NIWA report reference Ham 2014-113).

- Yalden, S., Moores, J. (Oct 2014). Assessment of potential effects of land development on Okura Estuary. Estimates of Construction Sediment Loads. (NIWA report reference Ham 2014-106).

- Green, M.O. and Reeve, G. (2017) Assessment of Potential Effects of Land Development on Okura Estuary. Connectivity between Okura Estuary and Weiti Estuary. Report TOD1601–3, Streamlined Environmental, Hamilton.

- Ridley, Graeme (April 2017), Report for Event Number Forty-Eight, Ridley Dunphy Environmental Limited Adaptive Environmental Monitoring and Management Response Plan for Long Bay Communities Limited, Long Bay Auckland Regional Council Consent Number 40585 (EW2), 40587 (EW3), 41664 (EW4) and 44628 (EW5) and Auckland Transport Glenvar Ridge Road Earthworks (43847) Event Monitoring Report Event of 13th April 2017, prepared for Long Bay Communities Ltd.

- Ridley, Graeme (May 2017), Report for Event Number Forty-Nine, Ridley Dunphy Environmental Limited Adaptive Environmental Monitoring and Management Response Plan for Long Bay Communities Limited, Long Bay Auckland Regional Council Consent Number 40585 (EW2), 40587 (EW3), 41664 (EW4) and 44628 (EW5) and Auckland Transport Glenvar Ridge Road Earthworks (43847) Event Monitoring Report Event of 13th April 2017, prepared for Long Bay Communities Ltd.

- Flood, Brian (November 2015), Infrastructure Assessment Report for the Okura Development, by Woods Ltd prepared for Todd Property Ltd,

- Statement of Evidence of Michael Parsonson for Auckland Council dated 19 July 2017.

- Statement of Evidence of Nicholas Vigar for Auckland Council dated 19 July 2017.

- Statement of Evidence of Samuel Morgan (draft) for Long Bay-Okura Great Park Protection Society and the Royal Forest and Bird Protection Society Incorporated dated 20 July 2017.

5. KEY CONSIDERATIONS - STORMWATER

5.1. Intensive urbanisation such as is proposed by OHL has the potential to result in adverse effects associated with stormwater quantity and quality including contaminant discharges into receiving freshwater and coastal environments and effects on stream health and erosion.

5.2. Stormwater quantity effects are caused by the modification of the land form and the construction of impervious surfaces. These changes increase discharge flows and volumes, affect the timing of flows (generating a “flashier” hydrograph as referred to by Mr Vigar), reduce the ability of rainwater to infiltrate to ground (through compaction) and generally modify a catchment’s natural response to storm events. This can lead to erosion within receiving stream environments, increased flood risks, channelization and concentration of discharges and scour at discharge points.

5.3. Stormwater quality effects can arise from the generation of sediment as a result of construction processes and the erosion experienced within urbanised catchments, in addition to other pollutants such as heavy metals which are commonly associated with urbanisation. The discharge of sediment, heavy metals and other pollutants can in turn lead to adverse effects on freshwater and their accumulation in coastal receiving environments over the longer term.

5.4. Auckland Council has provided guidelines around the design of stormwater treatment practices and low impact design. These guidelines, TP10 (2003) and the more recently GD004, intend to provide an industry standard and best practice for the design and installation of these measures. It is recognised that the measures will continue to evolve as innovation in their application arises.

5.5. Initiatives to promote infiltration and groundwater recharge are also encouraged through the implementation of stormwater biofiltration/ bioretention practices with retention and detention functions (similar to the Stormwater Management Area Flow (SMAF) approach promoted under the Unitary Plan). These practices also help maintain natural baseflow patterns and prevent channelized stream erosion, in turn resulting in overall benefits to stream health.

5.6. When first considering the planning of any project, regard should be given to the context of the project site itself and the sensitivity of the receiving environments. These considerations are an important part of the planning phase, and should set the essential parameters or objectives for the design. Hence, they help establish the standards required to provide the level of protection appropriate to maintain and enhance the inherent natural values of the project's surroundings.

5.7. The Okura Estuary is part of the Long Bay-Okura Marine Reserve, and has been assigned a SEA Marine 1 classification under the Auckland Unitary Plan (AUP), which reflects the sensitivity of the receiving environment and the level of protection required for these environments from adverse effects of stormwater, sediment and other impacts that may result from urbanisation.

5.8. The use of a Water Sensitive Design (WSD) approach (also referred to as Integrated Stormwater Management Approach) is promoted through the AUP (including Policies E1.3.8, E1.3.9 and E1.3.10) and is a widely accepted practice, nationally and internationally, for the management of stormwater and related effects.

5.9. WSD is the integration of the water-cycle into urban planning and design, using or mimicking natural processes at source. From a stormwater management point of view, the purpose of WSD is to preserve the hydrological characteristics of an area by maintaining, wherever possible, existing topography (through the minimisation of earthworks), hydrology and flow patterns and behaviours.

5.10. This is achieved through the use of existing natural features such as streams and wetlands to avoid or reduce changes in runoff, and the management of stormwater discharges at source and on the surface, through the interaction of stormwater with a naturalized urban environment. This approach also helps provide a stormwater quality treatment function and promotes infiltration thereby replenishing groundwater systems.

5.11. A key premise of WSD is the adoption of a multidisciplinary approach where stormwater is embedded into other design elements of a project such as urban design, landscape design, roading and earthworks, during their planning, design, construction and operation and maintenance processes. It requires stormwater to be considered upfront and as a central part of the design planning, rather than being dealt with in isolation or as an afterthought.

5.12. Given the sensitive nature of the receiving environments and the context of the OHL development, it is my view that the implementation of WSD philosophies should be a paramount consideration that forms a key and integral part of the design process at Okura. Consideration of WSD elements should therefore form part of the overall master planning and urban design process, so as to achieve a coherent, integrated design solution that results in the best possible outcome for the project and the environment.

5.13. This means that the overall form, density and layout of the development should be achieved by integrating WSD with urban, landscape, traffic and other design elements together, and not the other way around, where a commercially driven layout seeks to retrospectively 'retrofit' WSD or stormwater management needs.

6. STORMWATER DISCUSSION – OHL PROPOSAL

Water Sensitive Design

6.1. The nature, intensity and scale of the OHL development require large-scale earthworks which will result in comprehensive changes to the topography, and hydrology, the filling of natural gullies and the modification of stream systems. This is evident from the Infrastructure Assessment Report for the Okura Development prepared by Woods (November 2015) which describes and illustrates the spatial extent and volume of earthworks prosed by OHL, which involves 1.8 million cubic meters of cut to fill over 103 hectares of the 130 hectares of OHL land being rezoned.

6.2. As a site undergoes this level of modification, any opportunities to implement true WSD, which seeks to safeguard, through an integrated design cognitive of site conditions, natural landform and hydrological patterns, are effectively removed.

6.3. The comprehensive large scale earthworks at Okura would therefore appear to respond in the first instance to developer's density objectives, with little apparent thought given to WSD at master planning stage.

6.4. In order to reduce earthworks to a point where it more closely responds to the natural topography and hydrology, a reduction in density may be required. This was agreed in expert conferencing in relation to this catchment specifically (paragraph 6.4 of the Infrastructure and Stormwater Management JWS). In my experience I have seen several cases where through clever design (consistent with WSD being applied for the outset) , the natural features of a site are able to be successfully safeguarded and in fact showcased as a feature of the project, while maintaining minimum yields that meet positive commercial outcomes.

6.5. By contrast, OHL propose to introduce WSD 'practices' into the design more in a retrospective sense than an integrated sense, in other words, as and where opportunities dictate, which is an approach that I do not support.

6.6. For example based on the advice from Mr Williams and Mr Wadan during the 6 June 2017 stormwater expert conference, I understand that OHL propose to introduce raingardens for the treatment of stormwater runoff at source within the roading network. While the use of 'at-source' bioretention (e.g. raingardens) is in principle supported, this is counteracted by the fact that the configuration of roads and earthworks at Okura is such that (from the outset) there was little or no allowance for WSD to be implemented due to the need for large scale earthworks.

6.7. The non-implementation of WSD at master planning stage has in turn reduced the ability to preserve natural features, protect streams or manage stormwater in a manner that recognises the natural environment.

6.8. In my opinion, the retrospective and reactive implementation of WSD at Okura is a poor application of the founding principles of WSD and will ultimately fall short of achieving desirable stormwater management outcomes. It contradicts sustainable design practices and does not adequately respond to the context of both the OHL site and the receiving environment at Okura.

OHL Stormwater Management Approach

6.9. As noted earlier, OHL proposes to introduce raingardens for the treatment of stormwater runoff at source, for all impervious areas in the development. I support this from a water quality management perspective.

6.10. It was agreed in expert conferencing (paragraph 2.1 of the Infrastructure and Stormwater Management JWS) that the soils within OHL land are not amenable to infiltration practices due to geotechnical constraints. A broader retention approach through infiltration to maintain pre-development hydrology is therefore not specifically proposed, and instead non-potable water re-use is proposed, along with the provision of extended detention for all impervious surfaces for the control of stormwater volumes and to protect against channelized stream erosion (paragraph 2.1 of the Infrastructure and Stormwater JWS).

6.11. While I acknowledge the geotechnical constraints on infiltration, I also note that the non-implementation of infiltration practices, along with the compaction of earth-worked areas will severely compromise the ability to maintain pre-development hydrology, potentially significantly reducing stream baseflows and removing opportunities for groundwater recharge. I consider that the further consideration of these potential effects at the master planning stage of the project would have resulted in a different scale of development being proposed.

6.12. The experts support the use of inert building and roof materials, and consider that the use of galvanised copper and unpainted zinc-aluminium roofing, cladding and spouting products should be avoided (paragraph 3.1 of the Infrastructure and Stormwater JWS).

6.13. OHL propose to size stormwater treatment practices in accordance with Auckland Council TP10 (2003) guidelines, which call for 75% total suspended solids (TSS) removal on a long term average basis (paragraph 4.4 of the Infrastructure and Stormwater JWS).

6.14. While these guidelines currently constitute Council's minimum accepted water quality standard, I don't agree that this is sufficient and in my opinion the nature of the receiving environments is such that opportunities to achieve water quality outcomes that exceed TP10 (e.g. adopting a "TP10+" approach) are warranted and should be considered wherever practicable (paragraph 4.6 of the Infrastructure and Stormwater JWS).

Cumulative Effects

6.15. Modelling work undertaken by NIWA has predicted progressive contaminant accumulation in the Okura estuary, based on heavy metal (zinc and copper) contaminant yields arising from the OHL development.

6.16. For catchment areas outside OHL land, the NIWA Urban Contaminant Load Modelling report (NIWA report reference Ham 2014-103) in Section 4 indicated that present day land cover of the catchments as they exist today was used in the model, in other words there is no allowance for further development outside OHL (this is further acknowledged in Streamlined Environmental 2017 report TOD1601-3, pg. 5).

6.17. During the expert conference held on 15 October 2015 the experts also agreed that no modelling had been done to predict the level of sediment and metals that may accumulate from further development in the catchment (Paragraph 3.1 third bullet point), and that in order to assess potential sediment and metal accumulation from proposed development other than OHL, further modelling would likely be required (Paragraph 3.1 fifth bullet point).

6.18. Mr Vigar in his evidence (paragraph 4.4) further notes that the NIWA modelling only accounted for about 50% of the density potentially allowed by the proposed Mixed Housing Suburban Zoning for the Okura catchments and that this could potentially lead to an under-estimation of sediment and metal concentrations in the estuary.

6.19. Although the extent to which these contaminants will impact the receiving marine environments is outside my area of expertise, in my opinion the fact that the NIWA models do not make allowance for development outside the OHL footprint brings the meaningfulness of the model into question as the results present only a partial picture. I therefore question whether these results can be relied on when assessing the proposal in the context of the wider catchment and associated cumulative effects.

6.20. In my opinion, in order to understand the true cumulative impacts of these contaminants, a catchment-wide Maximum Probable Development Scenario (MPD) approach is required, which accounts for timing, extent, nature and intensity of urbanisation likely to take place within the catchment as a whole. Only when such an analysis is done will the true cumulative effects of development at Okura be understood.

7. KEY CONSIDERATIONS - EROSION AND SEDIMENT CONTROL

7.1. Soil erosion is a natural process when the action of water, gravity and wind wear away the soil surface. This process can be accelerated during construction and earthworks activities as open earth becomes exposed. For this reason erosion and sediment control measures are typically incorporated into the earthworks operation as a whole in order to minimise the amount of sediment entering the receiving environment.

7.2. Auckland Council has provided guidelines around the various types of erosion and sediment control measures and their application. These guidelines, TP90 and the more recent GD005, intend to provide an industry standard and best practice for the design and installation of these measures. It is recognised that the measures will continue to evolve as innovation in their application arises.

7.3. GD005 highlights that the overall reduction in sediment yields is dependent upon a three stage holistic approach, which in the first instance should consider the site in terms of factors such as topography, soil, hydrology, climate and the receiving environment.

7.4. Consistent with WSD, consideration of the construction methodology in the context of the development and the site's environmental characteristics should then be undertaken and include the lot yield, stormwater management, geotechnical constraints, minimisation of earthworks through design and staging of works.

7.5. Once these matters have been considered, an erosion and sediment control plan can be developed in more detail. As also discussed by Mr Parsonson (at his paragraph 7.28), this should include consideration of non-structural measures in the first instance, such as the retention of vegetation, staging of works, slope protection, minimising disturbance and protection of waterways. Structural controls in turn relate to measures needed to manage active earthworks areas and include practices such as sediment retention ponds, stabilised entranceways, cleanwater diversions, decanting earth bunds, silt fences and super silt fences.

7.6. All of these measures contribute to the overall effectiveness of a site in the minimisation of sediment lost to the receiving environment. It should be noted that a high level of structural treatment efficiency and/or effectiveness does not necessarily translate to avoidance of adverse effects on the receiving environments. As I discuss further below, even with relatively high structural treatment efficiencies, large sediment volumes can still be discharged in absolute terms.

7.7. I would also like to clarify that while the focus of my evidence relates to efficiency and effectiveness of erosion and sediment control systems at Okura, it does not seek to assess the effects on freshwater and marine environments as this matter is outside my area of expertise.

7.8. Research has been undertaken to suggest a well-designed and maintained sediment retention pond (SRP) utilising chemical flocculation techniques can achieve a 95% of sediment retention efficiency, for a 2 year rain event (Parsonson, at paragraph 7.48) .

7.9. However, despite the efficiency that may be achieved in a particular device, the overall effectiveness of erosion and sediment control measures extends beyond the efficiency of individual devices and therefore plays an important part in ensuring that optimum results are achieved.

7.10. A key factor that affects the effectiveness of erosion and sediment control systems is the sequencing and magnitude of storm events. For example, if a storm takes place which is followed closely by a second storm, there is a risk that erosion and sediment controls may partially silt up in the first storm, compromising the ability for them to effectively deal with the second storm. Or in some cases where a storm is large enough to cause the primary spillway to become activated, turbulence generated within the SRP may re-suspend sediment particles and cause a sediment plume discharge downstream. Often these factors are controlled by nature and despite a team's efforts, abilities or best intentions, such events can and do happen in reality.

7.11. I see this as a key risk because it means that despite having a competent team on site and a well-designed system that operates satisfactorily most of the time, under certain weather conditions there is still a risk of 'sediment plume' discharges being generated which have the potential to release many times the amount of sediment normally discharged from the system.

7.12. An option to reduce this risk is to have additional capacity built into the design of the practices, as this will increase the resilience of the system and reduce the frequency of overflows that may take place.

7.13. Other factors affecting effectiveness include the ability to carry out proactive monitoring and maintenance of the devices (including pre and post storm checks and periodic cleaning or mucking out of forebays, silt fences etc), and to adapt to variable site conditions, for example by adjusting the runoff diversion controls to changes in the earthworks areas or catchments as the work progresses.

7.14. Again, while these factors can be effectively controlled by a well-trained and dedicated team on site, in my opinion it is risky to assume that the practices will perform to 100% of their ability at all times and in particular during periods of persistent adverse weather. Instead I consider it is prudent to allow in the design for remnant risks that may arise from specific site conditions or should things not go to plan, and this does not appear to have been taken into account in the modelling assumptions or input parameters.

7.15. An example of such a risk includes the heavy reliance placed by the NIWA sediment transport modelling on chemically treated SRP's capturing all of the runoff generated from a particular site (refer Erosion and Sediment Control JWS, point 8) . While there may be opportunities for these devices to capture most of the runoff, inevitably there will often be marginal areas that cannot be drained to the devices, particularly given the ever-changing nature of active and evolving earthworks sites.

8. EROSION AND SEDIMENT CONTROL DISCUSSION - OHL

OHL Erosion & Sediment Control Approach

8.1. Mr. Ridley provided evidence through the Unitary Plan process on behalf of OHL detailing the broad erosion and sediment control principles that will be potentially employed throughout the construction phase, indicating that in some respects these will be similar to the controls and monitoring protocols that were used in the nearby Long Bay development.

8.2. No specific details around the potential erosion and sediment control measures have yet been provided. But I accept that under normal operating conditions, the erosion and sediment control measures employed at Long Bay would typically exceed the Auckland Council standards.

8.3. Mr. Ridley discussed a number of additional measures in relation to SRP's that are over and above minimum TP90 requirements. These include the introduction of baffles which aim to increase flow paths and residence times and aid sediment deposition, double manholes to mitigate against the risk of turbulence and resuspension during large storm events, and double floc sheds to provide a treatment for a greater range of storm events and flexibility and resilience to the chemical dosing process.

8.4. While I consider that these measures may well assist with improving the performance and resilience of erosion and sediment control systems at Okura, I understand that their performance has not yet been tested and as such I would caution against relying on the use of these measures to claim overall higher treatment efficiency or effectiveness. In that regard, I agree with Mr Parsonson's position as recorded at point 6 of the Erosion and Sediment Control JWS, and note his discussion of the issue in section 7 of his evidence.

8.5. Mr. Ridley also in the expert conferencing discussed that a last line of defence approach could be employed to capture sediment lost in case of an issue with the erosion and sediment control devices. Such measures include the installation of devices such as silt fences or super silt fences below the primary treatment measures. These types of devices will have some degree of benefit but overall (and as also expressed by Mr Parsonson) I do not think they will substantially reduce the amount of sediment entering the receiving environment.

8.6. Overall, despite the innovative initiatives and proactive approach offered by OHL, which I support, I don't agree that the evidence presented thus far provides sufficient information to conclude that the receiving environment will be able to be preserved or adverse effects avoided.

Water Sensitive Design

8.7. As already mentioned, the OHL development proposes large scale earthworks to realise the intended landforms and yields, and there is little or no opportunity left to consider rationalisation of earthworks or land modification. The use of non-structural elements discussed in 7.5 above by OHL, which include features such as the retention of natural features, minimisation of disturbance and protection of waterways, in my opinion has therefore not gone far enough, and the use of WSD in the context of the need to minimise earthworks has not been fully realised.

8.8. I would add that the extent of exposed earthworks and associated sediment risks can be more easily controlled through the development of larger lots, or through a different design approach such as cluster housing for example, where smaller lots are developed with larger communal open spaces in return which can be used for passive recreational purposes. I am not aware of initiatives such as these being considered or included within the OHL design.

Sediment Modelling Inputs

8.9. NIWA produced a series of construction sediment load estimates based upon the results of the GLEAMS numerical modelling programme. Results from this model were then used to inform models on the sedimentation in the coastal environment.

8.10. The GLEAMS model assumes that sediment control measures during the construction period achieve an overall efficiency of between 90-95%, and this is used as an input parameter into the model. This is based upon a theoretical efficiency of 95% for a 2yr rain event, 85% for a 5yr rain event and 65% for 10yr rain event.

8.11. As noted earlier, these efficiencies are built upon the assumption that all sediment laden runoff will pass through a chemically treated SRP (i.e., a system that is 100% effective at capturing sediment laden runoff), and that all ponds will achieve the theoretical optimum efficiency at all times.

8.12. While I acknowledge that good results can be obtained from a well-designed, constructed and maintained system, in my opinion the assumption that all earthworks areas will be treated to an optimal degree of efficiency at all times, assuming the practices are 100% effective at doing so, is simply not realistic nor does it represent a safe design assumption in this case.

8.13. I believe that a factor of safety should be built into the design and parameters to account for natural, physical and operational circumstances that can happen and which lead to sub optimal efficiencies or effectiveness in a particular system.

8.14. Two potential examples of this type of occurrence relate to two monitoring events provided by Mr. Ridley for the Long Bay site where excessive sediment was discharged into Vaughan Stream as a result of two 2-5 year ARI events, which took place between 4 & 6 April and 12 & 13 April 2017 ("Events 48 and 49" respectively).

8.15. Automated sample readings from SRP's "Q" and "T" estimated that the amount of sediment that was lost to the environment during Events 48 and 49 was in the order of 27 and 52 tonne respectively, with Total Suspended Sediment readings being as high as 19,600gr/m3. I understand that the total contributing earthworks catchment for these readings is about 13 hectares and that both events took place over a period of 36 hours approximately.

8.16. The causes of these discharges were attributed to a flocculation system requiring maintenance, sediment resuspension as a result of high flows and high sediment loads present in the SRP's. Further, the malfunctioning of a decant arm compounded the problems in Event 48. In the case of Event 49, there was also an issue with the timeframes and wet conditions between rain events not allowing the SRPs to be cleaned out.

8.17. Event 49 was of particular interest as it was the largest event over the Long Bay construction period and thought to be somewhere between a 2 and 5 year event, thus providing a useful means of comparison with the GLEAMS modelling parameters.

8.18. I have estimated through Universal Soil Loss Equation (USLE) calculations that the sediment yield from SRP's "Q" and "T" would be approximately 70-75 tonnes per year if an efficiency of 95% were to be achieved at all times. In comparison, the total sediment yield obtained from the automated sample readings during the specific events 48 and 49 at these ponds was about 68 tonnes i.e. over 90% of the theoretical <u>yearly</u> sediment yield for these ponds (with the 95% treatment efficiency assumption that was adopted in the GLEAMS model applied in the NIWA sediment transport model) .

8.19. In my opinion the above examples therefore show that during certain conditions or circumstances, including significant rainfall events, erosion and sediment control devices will not always achieve the target efficiency, no matter how well designed, implemented or monitored these systems might be.

8.20. In addition, and as illustrated through the data referenced by Mr Parsonson (at his paragraphs 7.52 to 7.58), even assuming the treatment efficiencies adopted in the modelling are achieved at all times, comparatively greater absolute volumes of sediment would be generated under the OHL development, than for the existing land use.

9. CONCLUSION

Stormwater

9.1. The comprehensive large scale earthworks at Okura, which will result in modifications to the landform, hydrology and stream systems at Okura, would appear to respond in the first instance to the objective of the appellant to meet development density requirements, with little apparent thought given to WSD at the development's planning stage.

9.2. While there are elements in the OHL stormwater management design which I am in favour of, such as the use of raingardens, inert building materials and extended detention, in my opinion the retrospective and reactive implementation of WSD falls short of achieving a desirable stormwater outcome in the context of both the OHL site and the receiving environment at Okura.

9.3. The modelling results presented by NIWA on behalf of OHL present only a partial picture, as the models do not account for development outside the OHL footprint or cumulative effects. In order to understand the true cumulative impacts of these contaminants, a catchment-wide approach is required assuming MPD conditions.

Erosion & Sediment Control

9.4. Despite the innovative initiatives and proactive approach offered by OHL, which I support, I don't agree that the evidence presented to date provides sufficient information to conclude that the receiving environment will be able to be preserved or adverse effects avoided, from an erosion and sediment control perspective.

9.5. The use of non-structural elements by OHL such as the retention of natural features, minimisation of disturbance and protection of waterways, in my opinion has not gone far enough, and the use of WSD in the context of the need to minimise earthworks has not been fully realised.

9.6. While I acknowledge that good results can be obtained from a well-designed, constructed and maintained system, in my opinion the assumption that all earthworks areas will be treated to an optimal degree of efficiency at all times and assuming the practices are 100% effective at doing so is not realistic. Therefore I would caution against using this approach to formulate modelling input parameters.

9.7. As shown in the examples given for Events 48 and 49, it is evident that during certain conditions or circumstances, things sometimes don't go to plan despite best efforts to prevent this, and erosion and sediment control devices do not always achieve target efficiencies, no matter how well designed, implemented or monitored these systems might be.

Andrés Roa
Civil Engineer

28 July 2017