IN THE MATTER of the Fast-Track Approvals Act 2024

AND

IN THE MATTER of the Application for the Waitaha Hydro Scheme

STATEMENT OF EVIDENCE OF JON FRANCIS TUNNICLIFFE ON RIVER GEOMORPHOLOGY

Dated: 23 January 2026

QUALIFICATIONS AND SCOPE

1. My full name is **Jon Francis Tunnicliffe**.
2. I am an independent researcher and associate professor in fluvial geomorphology and physical geography at the University of Auckland's School of Environment. I have worked there since 2013.
3. I obtained my PhD in Physical Geography from the University of British Columbia, Vancouver (2008). I was a post-doctoral research fellow in the Sediment Processes Group in NIWA's Christchurch Office (2006-2008) and held a research/teaching position at Carleton University (Ottawa, 2008-2013).
4. I have over 25 years of experience in professional geomorphology research, teaching, and management. I have over 56 peer-reviewed publications in international scientific journals and books. I have given over 50 conference presentations and have been the principal supervisor of 17 MSc and PhD students. My area of expertise is gravel-bed river morphodynamics, sediment budgets, and the effects of sedimentary disturbance on river systems.
5. I am the Vice-President of the Australian and New Zealand Geomorphology Group (2023-present) and have served as an academic liaison to Engineering NZ's Rivers Group (2013-2018). I have delivered professional short courses and training workshops for regional councils, consultants, and practitioners working in river management, flood mitigation, and environmental assessment.
6. I have been engaged by the EPA to provide an independent technical review of the "Waitaha Hydro Scheme: Assessment of Environmental Effects – Sediment" (the Sediment Report).
7. My evidence relies on the hydrological and sediment yield data provided in the Applicant's documentation. I do not have access to the private NIWA client reports upon which some of the Applicant's supporting evidence is based. I have also reviewed additional materials from the Fast-Track website, including DOC section 51 reports and subsequent correspondence.

CODE OF CONDUCT

8. I confirm that I have read the code of conduct for expert witnesses contained in the Environment Court Practice Note 2023. I have complied with the code in preparing my written statement of evidence and I will also comply if I am required to participate in conferencing or ptovide oral evidence to the Panel.

9. Unless I state that I am relying on the evidence of another witness, my evidence is within my knowledge and expertise. The data, information, facts, and assumptions I have considered in forming my opinions are set out in my evidence below, along with the reasons for the opinions expressed. Where relevant, I have stated why alternative interpretations of data are not supported. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

10. Where I consider that my evidence may be incomplete or inaccurate without some qualification, I have included such qualifications. I have identified any knowledge gaps I am aware of and their potential implications.

EXECUTIVE SUMMARY

11. My review identifies several points in the Applicant's sediment assessment methodology that undermine the conclusion that effects will be "less than minor." These deficiencies relate to: (a) the characterisation of bedload transport and its partitioning relative to suspended load; (b) the system-scale implications of locating the intake at a critical sediment connectivity node; (c) the treatment of sediment transport dynamics in the abstraction reach; and (d) the inadequacy of proposed adaptive management as a substitute for robust baseline assessment.

12. **Bedload Proportion and Composition:** The Applicant estimates bedload at approximately 5-6% of total sediment load, derived from an empirical relationship with the nearby Whataroa River. I consider this estimate likely to be biased low for the intake area of the Waitaha. The Whataroa transfer function is mathematically constrained such that it cannot produce bedload fractions exceeding a few percent, regardless of discharge—this is a methodological artefact, not a physical constraint. Bed load proportions are highly uncertain and vary from event to event, and no measurements have been taken. Given the Waitaha's modest glacier cover (6.6%), proximity to mass-wasting runout processes, steep gradient ($S \approx 0.015$), and flood-dominant transport regime, higher proportions (10-15%+) should be considered, leading to important implications for intake operability and downstream sediment continuity.

13. **Sediment Connectivity at Morgan Gorge:** The proposed intake is located at the governing node of the Waitaha's sediment system, where Kiwi Flat—a laterally unconfined, low-gradient alluvial reach—transitions abruptly into the narrow bedrock constriction of Morgan Gorge. Under natural conditions, sediment supplied from steep headwaters is stored transiently across Kiwi Flat and episodically exported through Morgan Gorge during favourable flow conditions, generally on the rising limb of flood hydrographs. The introduction of a weir at this location would modify this critical control point by reducing the effective longitudinal slope and extending backwater effects, shifting sediment delivery from a semi-continuous, event-driven process to a more pulsed, intervention-dependent regime.

14. **Maintenance Dependency:** The principal consequence of locating the intake at this sediment connectivity node is an elevated and ongoing requirement for mechanical in-river maintenance. These effects arise from system-scale

geomorphic controls rather than local design detail. The Applicant's documentation does not provide: (a) quantitative grain-size distributions across Kiwi Flat and at the gorge entrance; (b) calibrated morphodynamic modelling under rising and falling hydrograph limbs; (c) a clearly articulated coarse sediment and debris management strategy; or (d) an operational maintenance plan describing contingencies for floods of varying magnitude. Without this information, the Panel cannot assess whether the Scheme can maintain sediment continuity without frequent mechanical excavation.

15. **Potential Ecological Implications:** The Waitaha River supports populations of whio (blue duck), classified as Nationally Vulnerable. According to the Applicant’s report, whio are found in areas of clean, fast-flowing water with low fine or suspended sediment loadings and diverse invertebrate communities. The Scheme's operational regime—characterised by reduced and stabilised flows, increased fine sediment residence time, periodic artificial turbidity pulses, ongoing instream works, and potential disruption to substrate composition from interrupted bedload supply—appears inconsistent with these habitat requirements. The Applicant has identified that mechanical excavation will be required, and indicated a likely frequency 5-15 times annually, but it is unclearwhat this is based on.

16. **Conclusion:** I assess the overall effects profile as **moderate to more than minor**. The Applicant's conclusion of "less than minor" effects rests on optimistic assumptions about sediment dispersal, a likely underestimate of bedload proportions, reliance on spatial averaging that obscures localised impacts, and faith in adaptive management despite well-documented limitations.

EVIDENCE

Issue 1: Bedload Proportion and Estimation Methodology

17. The Applicant estimates bedload at approximately 50,000 t/yr, which is approximately 5% of the mean annual suspended load (1,050,000 t/yr). This estimate is derived not from direct measurement in the Waitaha at the upper end of Kiwi Flat, but from a transfer function developed for the much larger nearby Whataroa River, which relates the bedload-to-suspended-load ratio to normalised discharge.

18. The Whataroa relationship used in the Sediment Report is: bedload/suspended-load = 0.0172 ln(Q/Qmean) + 0.0094. This equation is constrained so that it cannot produce high bedload fractions at any discharge. For example, achieving a bedload fraction of 20% would require Q/Qmean ≈ 3 × 10^6—a physically impossible value. The method is formulated such that bedload will always be a few percent of suspended load.

19. This methodological constraint does not reflect a physical law governing sediment partitioning in steep alpine catchments. Published literature from instrumented basins demonstrates that bedload fractions are highly variable and strongly dependent on catchment characteristics, mass-wasting regime, sediment supply regime, and flood sequencing. In smaller, steep, and dynamic mountain basins with a mixed sediment supply, long-term bedload

fractions are highly variable but commonly range from 10 to 30% (Turowski et al. 2010; Rickenmann 2001).

20. Cosmogenic ^{10}Be denudation measurements from the neighbouring Whataroa catchment (Larsen et al., 2014) offer an alternative, long-term estimate of landscape-scale sediment production (6.6 ± 1.7 mm yr^{-1}), integrating processes over millennial timescales. Contemporary suspended-sediment models (Hicks et al., 2011, 2019), which reflect modern hydrological and sediment monitoring, capture only 70–75% of this magnitude. Although these datasets are not directly commensurate and may reflect fundamentally different temporal regimes, the contrast nonetheless raises a plausible risk that coarse sediment delivery is being under-represented, warranting careful consideration in project assumptions.

21. The implications of underestimating bedload are significant for both intake operability and downstream effects. If bedload constitutes 15-20% rather than 5% of annual sediment yield, the coarse sediment flux through the intake zone is 3-4 times greater than assessed. This has direct implications for: (a) the frequency of gravel accumulation requiring mechanical removal; (b) the volume of material that must transit the residual-flow reach at 3.5 m^3/s; and (c) the sediment budget of the downstream reach, below the powerhouse.

Issue 2: Sediment Connectivity and the Morgan Gorge Control Point

22. The proposed intake and weir are located at what I consider the most geomorphically sensitive linkage in the Waitaha catchment: the transition between Kiwi Flat and Morgan Gorge. This transition represents the governing node of the river's longitudinal sediment connectivity.

23. Kiwi Flat is an approximately 1.5 km long alluvial reach, up to ~400 m wide, characterised by relatively low channel gradients and active floodplain storage. Immediately downstream, the river contracts into a 15-20 m wide bedrock canyon with substantially steeper slope. Analysis of the longitudinal profile confirms that peak stream power (ρgQS) occurs within Morgan Gorge itself, while a pronounced reduction in transport capacity is evident upstream, across Kiwi Flat (Figure 1).

24. Under current conditions, the system maintains dynamic equilibrium: sediment supplied from steep headwaters is temporarily stored on bars and floodplains across Kiwi Flat and is periodically exported downstream during favourable flow conditions.

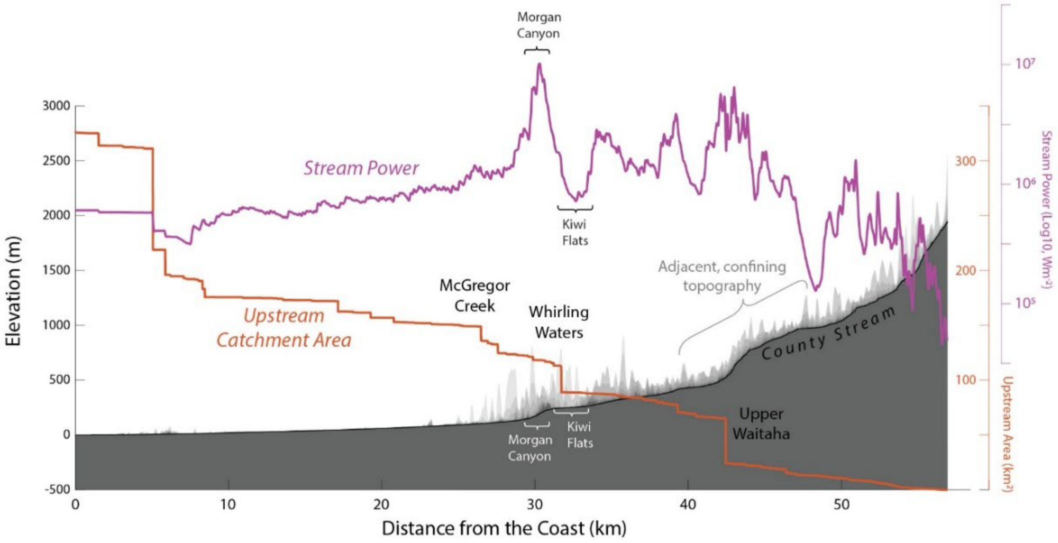

Figure 1 - Longitudinal profile of the Waitaha River from the upper end of County Stream to the coast. The bed elevation, upstream catchment area, and stream power have been assessed using LINZ regional LiDAR (2020-2025). The stream power (scaled logarithmically) emphasizes that the peak of transporting capacity is found within Morgan Gorge (note that capacity is seldom fully satisfied).

25. Hydraulic modelling indicates that during large floods, backwater effects induced by the gorge constriction dominate flow behaviour across Kiwi Flat. As discharge increases beyond moderate levels, upstream transport capacity exceeds downstream conveyance, resulting in net deposition. Extensive slackwater conditions characterise peak and waning flood stages. The flows most effective at evacuating accumulated material will depend on antecedent conditions in the reach, but are likely to occur within a short window on the rising limb of flood events (Figure 2).

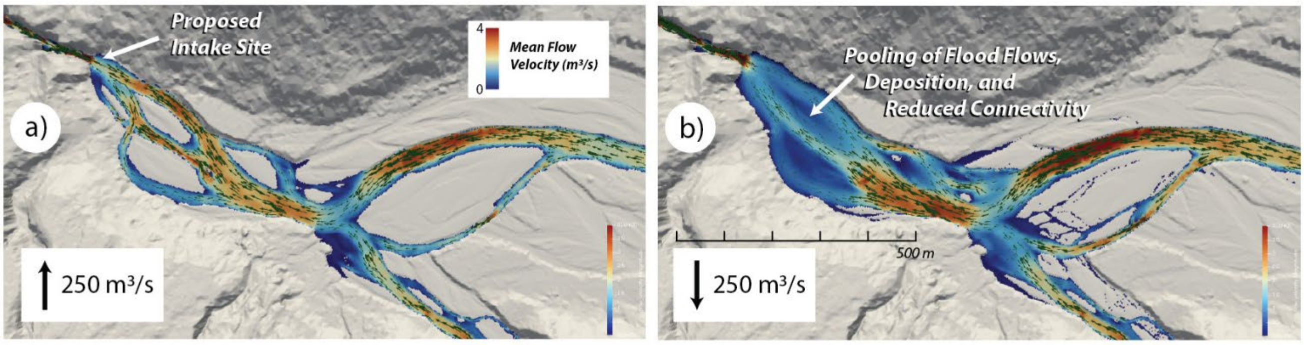

Figure 2 - The BASEMENT 2D flow solver was used to simulate flows across Kiwi Flat (current conditions), upstream of the proposed intake site. In this simulation, flow was gradually ramped from 50 to 800 m³/s, then back to 50, to observe the evolving distribution of flow velocity in the channel (Appendix A). The figure shows a snapshot of the model at 250 m³/s on the rising limb (a), then the same discharge on the falling limb (b). Note the more even distribution of channel velocities in the lower channel during the rising limb, implying a focused and better-connected sediment transfer pathway. Conversely, during the falling limb, an extensive slackwater zone has formed. High velocities upstream and low velocities downstream imply that deposition is likely to take place, much as sediment flux from a delta settles in the slower waters of a distal basin. A more complete picture of the model run is provided in Appendix A.

26. The introduction of a weir at the gorge head would alter this delicate balance by: (a) reducing effective longitudinal slope across Kiwi Flat; (b) extending backwater effects further upstream; (c) reducing bed shear stresses during the critical rising-limb transport window; and (d) promoting additional sediment deposition upstream of the weir. Even a relatively low structure would shift the reach from transient sediment storage toward persistent accumulation. While this effect was anticipated for the initial weir emplacement, there does not appear to be a plan to manage potential ongoing aggradation and channel dynamics.

27. The consequence of this shift is that sediment delivery downstream would become increasingly intermittent and reliant on mechanical removal rather than natural transport. This represents a fundamental shift from a self-regulating, event-driven system to one that requires ongoing intervention to remain operational. The proposal to verify changes using LiDAR surveys "on a 5–10 yearly basis" represents post-hoc monitoring rather than precautionary management, where morphological changes will be documented but not proactively mitigated.

Issue 3: Altered Flow Regime and Geomorphic Effectiveness

28. The Applicant's framing of flow regime effects emphasises that 73% of suspended sediment is transported during floods exceeding 250 m^3/s when the intake is closed. While this may be accurate (again noting wide variation in annual deliveries), this framing conflates total sediment mass flux with geomorphic effectiveness. It therefore mischaracterises the ecological and geomorphic significance of the altered flow regime.

29. In fluvial geomorphology, the "effective discharge"—the flow responsible for transporting the most sediment over the long term and maintaining channel form—is typically a moderate flood event rather than an extreme, catastrophic flood (Wolman & Miller 1960; Andrews 1980). By focusing on the 73% of mass transported during large floods, the Applicant appears to overlook the geomorphic significance of the remaining 27%.

30. This 27% fraction—approximately 270,000 tonnes annually—corresponds to flows below 250 m^3/s: the moderate freshes and median flows that occur frequently. These are the "maintenance flows" that winnow fine sediment from substrate, cycle nutrients, maintain open interstitial spaces required for benthic life, and sustain the hydraulic diversity that supports invertebrate communities and species like whio.

31. The Scheme proposes to divert up to 23 m^3/s from this flow range. Consider a common fresh of 50 m^3/s: under natural conditions, this flow transports a specific load of sand and fine gravel. Under the Scheme, the residual flow is reduced to 27 m^3/s. This reduction leads to a non-linear reduction in shear stress and stream power. The river's capacity to transport the sediment load supplied from upstream is severely curtailed. The "lost" energy means that sediment is more likely to settle.

32. Furthermore, the "bypass" argument ignores the temporal decoupling of water and sediment. The intake structure diverts water but passes bedload and a portion of suspended load into a reduced-flow reach. Maintenance of the intake reach results in bedload being pushed into the reach during low-flow conditions. Conversely, downstream of the tailrace, the river receives water depleted of its coarse sediment fraction, creating localised "hungry water" effects that can promote bed degradation and armouring.

Issue 4: Fine Sediment Deposition and Subsurface Infiltration

33. The Applicant's assessment of fine sediment effects employs a spatial averaging approach that is inappropriate for evaluating ecological impacts. The calculated deposition depths of 2-14 mm represent averages across the entire abstraction reach channel margin. This approach fails to account for the spatial heterogeneity of sediment deposition.

34. In coarse-grained reaches downstream from Morgan Gorge, flow dynamics create zones of reduced velocity in the lee of large clasts, in pools, and in backwater areas. These sheltered zones are typically where fine sediment preferentially accumulates. Research demonstrates that fine sediment deposition in sheltered zones can be 3-10 times greater than reach-averaged values (Lisle 1989; Wohl & Thompson 2000).

35. More concerning than surface deposition is subsurface infiltration. Fine sediment infiltrates into the interstitial spaces of the coarse substrate through gravitational settling and advective transport. This infiltration substantially reduces porosity, with cascading effects on hyporheic exchange, dissolved oxygen concentrations, and the viability of substrate-dependent biota (Descloux et al. 2013; Jones et al. 2012).

36. The Applicant's assertion that fine sediment deposits will be "flushed" by subsequent floods requires scrutiny. While moderate flows may remove surface drapes, infiltrated fine sediment within the gravel matrix is substantially more difficult to mobilise. Once deposited, fine sediments develop cohesive properties that increase resistance to erosion (Grabowski et al. 2011). Effective flushing of subsurface fines requires sufficient flow depth and velocity to fluidise the entire active layer - conditions that may not occur in the more sheltered zones of the abstraction reach.

Issue 5: Desander Flushing and Artificial Sediment Pulses

37. The Applicant proposes to flush approximately 375 tonnes (250 m³) of sand from the desander over 30-60 minutes, approximately 8 times per year. The assessment characterises these flushes as negligible relative to natural flood loads. This is highly dependent on hydrological conditions at the time.

38. The relevant comparison is not total mass but the nature and timing of the sediment pulse. Natural flood loads consist of mixed sediments delivered over extended rising and falling hydrographs as part of coherent geomorphic events. Desander flushes deliver a concentrated pulse of sorted sand (>0.3 mm) as a point-source discharge. The "unnaturalness" of this sediment signal—its timing, duration, concentration, and size-selective composition—distinguishes it from natural transport events.

39. The Applicant's assertion that flushing during "natural runoff events" will mitigate effects requires examination. The proposed trigger is river flows exceeding approximately 75 m^3/s. However, the co-occurrence of desander capacity being reached and suitable river flows is not guaranteed. If operational requirements necessitate flushing during lower flows, the receiving environment will have substantially reduced capacity to disperse the sand pulse.

40. Research on reservoir flushing demonstrates that ecological recovery from artificial sediment pulses is highly variable. Some studies report recovery within weeks; others document persistent effects lasting months (Crosa et al. 2010; Doretto et al., 2021; Espa et al., 2013, 2016, 2019). The Applicant provides no site-specific evidence regarding Waitaha's capacity to recover from repeated flushing events.

Issue 6: Limitations of Visual Monitoring

41. The Applicant proposes adaptive management with visual monitoring as the primary mechanism for detecting and responding to adverse effects. This approach has well-documented limitations.

42. Visual assessment is inherently insensitive to subsurface effects. Fine sediment infiltration causes ecological harm—reduced oxygen levels, impaired hyporheic exchange, degraded invertebrate habitat—at stages when surface accumulation may be minimal or imperceptible. A visual trigger cannot detect these subsurface effects until they manifest as surface deposition, by which time ecological damage may already be substantial.

43. The proposed trigger threshold—action when fine sediment cover increases by more than 20%—lacks scientific justification. Research indicates that invertebrate community composition begins changing at levels well below those commonly proposed for such management thresholds. (Burdon et al., 2013; Kaller & Hartman, 2004; McKenzie et al., 2023).

Issue 7: Fundamental Limitations of Adaptive Management

44. The Applicant's reliance on adaptive management as the primary safeguard against adverse effects is concerning for several reasons.

45. Adaptive management is designed to manage uncertainty through iterative learning—it is not a substitute for adequate baseline assessment. The Applicant’s assessment contains fundamental uncertainties about bedload proportions, sediment transport dynamics, deposition patterns, and ecological thresholds that should have been resolved through site-specific investigation rather than deferred to post-consent monitoring.

46. Adaptive management cannot reverse effects that have already occurred. If fine sediment accumulation degrades whio habitat, or if interruption of bedload supply causes downstream bed armouring, the proposed monitoring framework can only detect these effects after the fact.

Issue 8: Long-Term Maintenance Dependency

47. The geomorphic setting of the proposed intake presents a fundamental challenge to long-term operability. Kiwi Flat is both a sediment reservoir and a high-value floodplain habitat within an otherwise steep mountain environment. Repeated mechanical intervention to manage sediment and debris and construct berms would result in ongoing disturbance of substrate, channel form, and ecological values.

48. The Applicant's documentation does not provide an operational maintenance plan that describes a detailed methodology and anticipated effects of this disturbance. In a tectonically active, high-sediment catchment subject to episodic mass-wasting events, maintaining intake functionality will likely necessitate repeated gravel excavation, debris clearance, berm building, and channel reshaping following flood events and sediment pulses.

49. This maintenance dependency arises from first-order geomorphic controls inherent to the intake location—it cannot be fully mitigated through detailed engineering design or consent conditions. The primary environmental effect of the Scheme may not be the initial construction, but the commitment to repeated in-channel disturbance over the operational lifetime.

50. Advancing the project without fully addressing these constraints risks locking the Scheme into a maintenance-intensive operational regime.

CONCLUSIONS AND RECOMMENDATIONS

51. There is a good likelihood that the proposed Scheme will impact the Waitaha River's sediment system. The Applicant's assessment relies on assumptions that do not fully account for the uncertainty and variability inherent in the conditions of the West Coast mountain sedimentary environment. Factors such as natural disturbance regime, bedload supply, and high spatial heterogeneity in deposition dynamics need to be considered.

52. I assess the overall effects profile as moderate to more than minor. The key drivers of this assessment are: (a) the likely underestimate of bedload proportions and its implications for intake operability; (b) the location of the intake at the critical sediment connectivity node between Kiwi Flat and Morgan Gorge; (c) the elimination of intermediate-flow geomorphic work for extended periods; (d) the preferential accumulation of fine sediment in ecologically sensitive locations; and (e) the inadequacy of visual monitoring and adaptive management as safeguards.

53. To address these concerns, I recommend the Panel consider the following conditions:

54. **Bedload Characterisation:** The proportion of sand, gravel and coarser fractions at Kiwi flat should be characterised to understand the modal composition of materials being delivered to the intake over the long term. Monitoring of topographic change at Kiwi Flat should be carried out during a range of flow conditions *prior* to construction. An investigation of historical channel evolution here would help to constrain the trajectory of the system.

55. **Sediment Management Plan:** A comprehensive sediment and debris management strategy is required, that addresses coarse material and large wood, including explicit protocols for maintaining sediment continuity through the intake zone without reliance on frequent mechanical excavation.

56. **Water and Sediment Modelling:** Appropriately parameterised and calibrated modelling approaches should be used to assess:

    - rising limb vs falling limb dynamics upstream of the intake at Kiwi Flat, and the likely associated deposition patterns.

    - the effect of large, pulsed deliveries of varying grain size composition, with sensitivity analysis of scheme operations using rates of bedload yield that reflect 10%, 15%, and 20% of the annual load.

    - The downstream fate of the various fractions that are diverted (during floods) or bulldozed (at low flow) into Morgan Gorge.

57. **Quantitative Substrate Monitoring:** Replace visual protocols with quantitative methods that detect subsurface fine sediment infiltration, such as bulk surface samples, freeze-core sampling, infiltration bags, or regular McNeil core sampling.

58. **Ecologically-Based Thresholds:** Establish trigger thresholds based on demonstrated ecological relationships rather than arbitrary percentage increases, including invertebrate community monitoring using standardised protocols.

59. **Maintenance Audit:** Require annual reporting on the frequency, duration, and spatial extent of in-channel maintenance works, with provisions for consent review if maintenance frequency exceeds predicted levels.

60. **Effectiveness Review:** Require independent review of monitoring results and mitigation effectiveness after two years of operation, with explicit provision for consent modification if effects exceed predictions.

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Appendix A: BASEMENT 2D Model Results

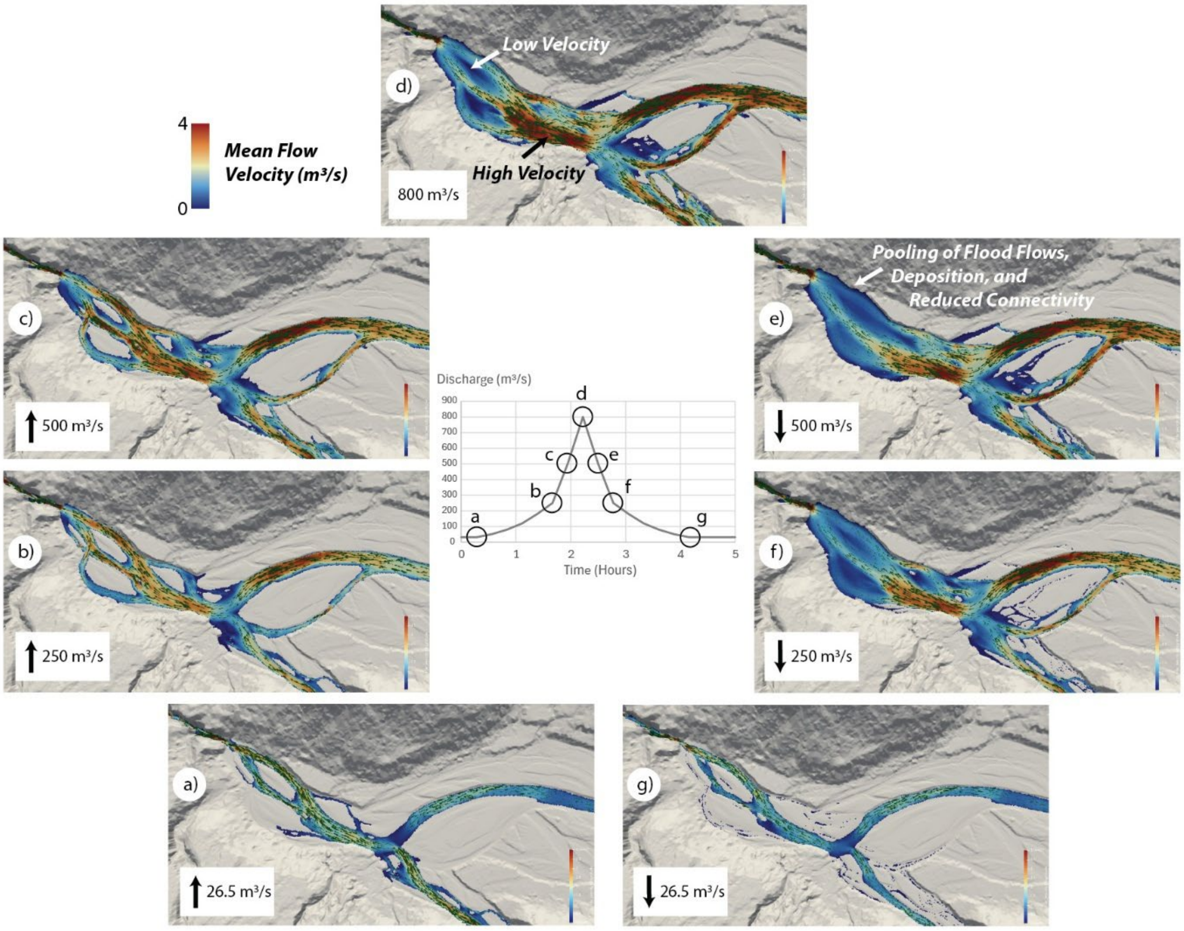

Figure A1 - The BASEMENT 2D flow solver was used to simulate flows across Kiwi Flat (current conditions), upstream of the proposed intake site. The sequence reveals the changing connectivity of the reach: as rising flows (a,b) surpass 500 m^3/s (c) high velocities upstream suggest transporting capacity here is much greater than downstream, leading to deposition. This culminates in the development of an extensive slackwater zone at the peak (d) and in subsequent waning flows (e,f). More balanced upstream-to-downstream transfer dynamics re-emerge in the final stages of the flood.