Applicability of International Stormwater Manufactured Treatment Device Evaluation Protocols in New Zealand: A Comparison of Three Field Trial Protocols

June 2023

Background

Stormwater is highly variable; hence the performance of stormwater management systems and Manufactured Treatment Devices (MTDs) are highly variable. The performance of stormwater treatment systems can be affected by multiple factors including influent concentration, particle size distribution (PSD), contaminant speciation, topography, geology, and rainfall events. Sampling methodologies can also affect performance results of stormwater management systems.

Various countries have developed their own protocols to locally approve MTDs in recent years. For example, in the USA the Washington Department of Ecology (ECOLOGY) developed the Technology Assessment Protocol – Ecology (TAPE), and the New Jersey Department of Environmental Protection (NJDEP) developed the New Jersey Corporation for Advances Technology (NJCAT) protocol. Canada have developed the Environmental Testing Verification (ETV), Australia have developed the Stormwater Quality Improvement Device Evaluation Protocol (SQIDEP), the United Kingdom have developed the British Water Testing Protocol and Germany have also developed their own protocol. Some jurisdictions require field testing only, some require lab testing only, and some require both laboratory and field testing.

Field testing is important for monitoring the effects of all variables that exist in real-world conditions. Real-world conditions include a wide range of sediment types and water chemistries which can affect an MTDs ability to remove dissolved and micro pollutants. These types of variabilities in field conditions are difficult to replicate in a laboratory, hence field testing should always be a requirement. Auckland Council only require field testing, therefore for the purposes of this review we will look at field testing requirements of three separate protocols.

Washington TAPE prescribes procedures for field testing with prescribed influent concentrations and performance requirements. The extensive process allows for applicants to have different levels of approval throughout the stages of field testing. Depending on the data supplied, an initial Pilot Use Level Delegation (PULD) or Conditional Use Level Delegation (CULD) is granted to allow installation and operation of MTDs to gather the field data required for the final General Use Level Delegation (GULD).

NJDEP NJCAT originally prescribed the Technology Acceptance Reciprocity Partnership (TARP) protocol as a field-testing protocol. TARP field testing was eventually dropped from the NDJEP NJCAT protocol, which now relies on laboratory data and only accepts MTDs as pretreatment to green infrastructure. The TARP field testing protocol is no longer in use but provides a good example of a field protocol and field protocol evolution.

The original TARP protocol did not prescribe procedures or concentrations instead it recommended appropriate pathways and best practice procedures for verification of MTDs in field conditions for states in the partnership. The protocol gave quite broad parameters that could be tested, such as nitrates and heavy metals, to allow for each jurisdiction to choose the parameters most applicable to their region. In 2009 the

TARP protocol was updated with a document entitled "Protocol for Total Suspended Solids Removal Based on Field Testing, Amendments to TARP Protocol". The amendment provided more robust requirements in terms of TSS influent concentrations, TSS removal requirements, PSD requirements and hydraulic performance reporting requirements. Influent and effluent concentrations remained unprescribed for any other parameter.

The Stormwater Quality Improvement Device Evaluation Protocol (SQIDEP) is similar to the original TARP protocol where it provides best practice procedures and a pathway for verification of MTDs in field conditions. Influent bands are prescribed for parameters such as TSS, phosphorous and nitrogen, however performance requirements are not prescribed. The SQIDEP for field testing does not intend to address hydraulic performance characteristics or laboratory testing practices.

New Zealand councils have accepted MTDs field certified under NJDEP (TARP) and TAPE historically, and more recently have started to accept MTDs certified or approved under SQIDEP. This document looks at key differences between the three field testing protocols, ECOLOGY TAPE, the TARP protocol and SQIDEP, and discusses key factors in approving MTDs for use in New Zealand.

Key Differences

There are five key differences in field testing requirements between SQIDEP, TARP and TAPE. This section outlines the differences and denotes issues and risks associated with each.

Particle Size Distribution Requirements

- SQIDEP does not require PSD test on the sediment, rather calls for discussion on any factors affecting the performance including scaling effects and PSD of both the influent and effluent. Performance metrics required to be reported are the average Concentration Removal Efficiency (AvCRE) and Efficiency Ratio (ER).
- TARP originally assumed that sufficient data would be provided to demonstrate that TSS and Suspended Sediment Concentration (SSC) of untreated/inflow samples were consistent with the total load and particle size distribution of typical urban runoff. However, the 2009 amendment states:
    - The arithmetic average particle size of the weighted median particle size for each sampled storm must not exceed 100 microns. In addition, the weighted median particle size for an individual storm event included in the arithmetic average must not exceed 200 microns.
- TAPE requires the particle size distribution to be reported as a screening parameter for each of the following performance goals (required performance parameters in brackets): basic and pretreatment (TSS), phosphorus removal (TSS, TO, orthophosphate), and dissolved metals (TSS, hardness, total and dissolved Cu and Zn). The PSD screening parameter is to check that the influent primarily consists of silt sized particles (i.e., 3.9 to 62.5 microns) and is representative of the Pacific Northwest.

Optional PSD testing potentially allows misinformation or manipulation of datasets where claimants may, unintentionally or otherwise, set up the testing site somewhere with a coarse sediment. Coarse sediments can be easy to remove, which may result in an overestimate of the performance of any given device. It is important to ensure MTDs capture finer particles as part of the measured efficiency. When assessing performance data for catchments in New Zealand, it is necessary to consider the PSD of the verified study versus the PSD of the jurisdiction that is to accept the verification such as the check done in the TAPE.

Allowable TSS influent concentration bands and performance goals

- SQIDEP states:
    - recommended mean TSS influent concentration 151mg/L
    - maximum average TSS influent concentration for all qualifying storms 371mg/L

- maximum TSS influent concentration for any individual event 591mg/L
  - Effluent goals not defined.
- TARP originally did not provide recommended concentrations for any parameter, however the 2009 TSS amendment states:
  - The arithmetic average TSS concentration of the weighted average TSS concentration for each sampled storm must not exceed 100 mg/l.
  - In addition, the weighted average TSS concentration for an individual storm event included in the arithmetic average must not exceed 300 mg/l.
    - Effluent goals not defined.
- TAPE states:
  - TSS Influent range 20 - 100mg/L
    - Effluent TSS less than 20mg/L
  - TSS Influent concentration range 100mg/L – 200mg/L
    - Effluent to demonstrate 80% TSS removal

It is widely recognised that influent concentration can affect the performance of a treatment system and that a higher concentration will lead to a higher performance but not necessarily provide a better outcome for the environment. The range of allowable influent concentration for TSS under the SQIDEP is quite wide and could lead to an overestimate in performance of a device tested at a site with the maximum average of 371mg/L when compared to other devices tested at a site with the recommended mean of 151mg/L. There is no defined performance goal under SQIDEP or TARP, however influent and effluent concentrations do need to be reported and should be consistent across storm events.

In New Zealand, a database such as URQIS from NIWA could be used as a guide to determine the most appropriate TSS influent concentrations for each jurisdiction (Figure 1). Alternatively, a more robust approach such as that prescribed in the TAPE could be appropriate to help ensure consistency in the performance of MTDs.

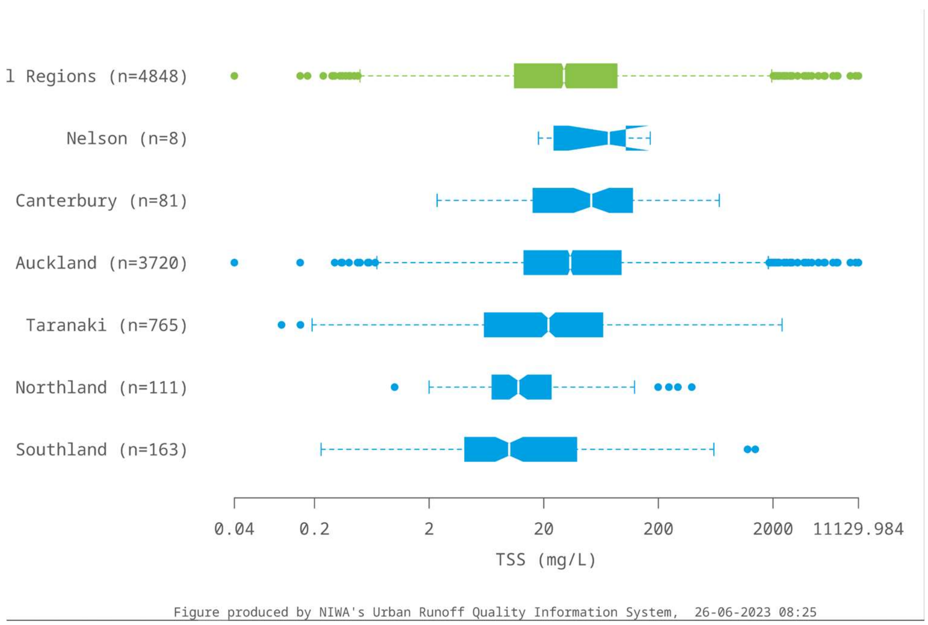

Figure 1: TSS Concentration by Region (Source: URQIS)

Heavy metal contaminant influent concentration and performance goals

- SQIDEP does not address heavy metals.
- TARP suggests additional testing parameters such as heavy metals is likely to result in broader acceptance (across the reciprocity), however this is not a requirement and concentrations are not prescribed.
- TAPE maximum dissolved metal influent concentrations:
    - Dissolved copper (Cu) maximum 0.2mg mg/L
        - Must meet basic treatment goal (80% TSS removal) and 30% Cu removal
    - Dissolved zinc (Zn) maximum 0.3 mg/L
        - Must meet basic treatment goal (80% TSS removal) and 60% Zn removal
    - The device must meet the criteria for both copper and zinc to be approved for dissolved metal treatment.

SQIDEP does not address heavy metals and recommends maximum influent limits of concentration for TSS, Phosphorus and Nitrogen. TARP does not prescribe any concentrations for metals and only lists parameters that can be selected. Washington TAPE provides the most robust approach for assessment of heavy metals treatment and considers both total and dissolved to measure the MTDs performance.

Heavy metals, in particular zinc, are an issue throughout New Zealand. The RMA requires an assessment of all effects. When assessing the performance of MTDs in New Zealand it is necessary to consider all effects as per the RMA, however some emphasis should be given to the contaminants of concern for each jurisdiction. Regulation of TSS removal alone, such as in Auckland, or a lack of emphasis on the contaminants of concern, such as phosphorus in the Waikato, is unlikely to result in the best outcomes for the receiving environment.

Hydraulic requirements

- SQIDEP is not intended to address hydraulic performance characteristics such as head loss. Claimed maximum treatment flow rate (MTFR) and head loss curves are not required to be reported.
- TARP originally required a discussion of technology hydraulics and system sizing to meet performance standards and goals. However, Section 2.3 Addition 1 of the 2009 update states:
    - The Maximum Conveyance Flow Rate (MCFR) and MTFR of a device must be determined through laboratory testing in accordance with the NJDEP's Protocols for Manufactured Hydrodynamic and Filtration Devices for TSS Removal Based on Laboratory Analysis. The MCFR is the highest flow rate that can be conveyed through all components of the MTD without surcharge, bypass, or overflow.
- TAPE requires claimed MTFR and media head loss curves to be reported.

Demonstrating the performance of a device at the design treatable flow rate is critical for meeting regulatory requirements. Auckland Council, Christchurch City Council, Wellington Water and Waikato Regional Council all have requirements for treating 80-90% of the annual rainfall. To evaluate the requirement for annual runoff treatment, the flow rate of the device must be verified. In addition, because the driving head affects the flow rate, head loss is also essential to verifying the hydraulic requirements.

Operation and Maintenance requirements

- SQIDEP does not require details around Operation and Maintenance.
- TARP requires a full range of operating conditions for the technology, including minimal, maximal, and optimal conditions to achieve the performance goals and standards, and for reliability of the technology in addition to details on the minimum maintenance requirements to sustain performance.

- TAPE requires details around operation and maintenance, including but not limited to:
  - Any data on operation and maintenance performed on the MTD being tested
  - An evaluation of pollutant removal and bypass frequency over time (graphical representation highlighting when maintenance was performed)
  - An evaluation of the average bypass frequency to demonstrate 91% of the average run off volume is being treated
  - The results of the required screening parameter tested (e.g., TSS, Cu, Zn)
  - Measurements of sediment depth to help demonstrate facility performance and design an Operation and Maintenance Plan

Understanding the maintenance requirements is critical to understanding how much sediment load an MTD can handle and how much the asset will cost over time. A useful feature of the GULD certificate provided by TAPE is that it reports the operation and maintenance information provided by the applicant, including any maintenance activities that were required during field testing, and the information is publicly available for all users. Measuring and recording this data during testing, and prior to approval, helps inform the long-term life cycle cost that will become the ongoing cost for the asset owner. This information is critical to all stakeholders. If long term maintenance cost is not considered, the system can become an unmaintained burden to the asset owner. The burden can be in financial terms and potentially in terms of an inability to meet stormwater discharge consent requirements given that unmaintained devices will not meet the desired level of treatment.

Discussion

Particle size distribution testing and reporting is important. As discussed, coarser particles are easier to remove and an MTD could be tested at a site with a coarser PSD resulting in an overestimate of performance. Without a PSD reporting requirement there is potential that an MTD superior to another may not be recognised as such and there is the further risk of too many fine sediments entering the receiving environment. Finer particles have a higher concentration of heavy metals and tend to remain suspended in the water column making toxic heavy metals highly bioavailable for aquatic life. The PSD at any MTD testing site should be required to be reported to enable regulators and design consultants can use the site data to check that the results are transferable and applicable within their catchment. Data availability can help ensure that they are choosing the best MTD for their site.

Performance goals such as percentage removal or effluent quality need to be defined by an influent band to remove the bias of high concentrations and subsequent overestimates in performance. The assessment of the performance of MTDs for meeting local requirements, such as 75% TSS removal, needs to be based on an understanding of the local catchment and concentrations that the device was tested to. By limiting the concentrations and prescribing effluent boundaries the TAPE provides a more conservative approach and provides transferrable MTDs performance results. Of equal importance to the percentage removal is the treatable flow rate for the sizing of the device to meet annual load reduction requirements. A device may get 90% removal but only treat 50% of the annual runoff therefore only achieving a 45% reduction on an annual basis. While another device may achieve 75% removal but treat 90% of the annual runoff achieving a 67.5% annual reduction. Auckland council requires 90% of the annual runoff to be treated while Christchurch city requires 75% removal of TSS on an annual basis. Flow rates are an important factor in evaluating long term performance and treatment outcomes.

Water bodies are impaired with different contaminants across the country. Regulators need to place emphasis on local contaminants and their characteristics. For example, contaminants of concern in Christchurch are dissolved metals, and in some parts of the Waikato total phosphorus is the principal contaminant of concern. The removal of each of these contaminants requires different processes and components within an MTD.

Therefore, it is important that the testing and verification of an MTD is specific to the contaminants of concern within a catchment. Regulators should complete a comprehensive catchment management plan as the first step and MTDs suitable for that catchment should then be specified based on the specific findings. International protocols cannot be deemed appropriate for generalised use in New Zealand. SQIDEP, for example, could be appropriate for some parts of the Waikato but is unlikely to be appropriate for Christchurch given heavy metals are not addressed within that protocol.

The National Code of Practice for the Three Waters Reform is currently under development. The development of these national standards is an opportunity to include the development of a national standard for evaluating innovative stormwater technologies. We need innovative solutions to protect Te Mana o te Wai and counteract the effects of ever-increasing pressures on our freshwater from activities such as urban development, agriculture, and farming. With such a body of work already been undertaken it makes sense to adopt an existing international protocol adding additional guidance on how to apply this protocol to New Zealand's Regions.

Conclusions and Recommendations

It is important to note that performance testing is just a demonstration useful for benchmarking performance. Benchmarking is the evaluation of MTDs by comparison against a standard. It is not a guarantee that a device will achieve equivalent performance when in use.

The demonstration protocol needs to be robust and provide sufficient information around all factors that will affect performance to ensure that the regulator or consulting engineer can assess that the results are transferable to their location. The assessment protocol should provide a methodology and set of requirements that is legally and scientifically defensible to align with the RMA and other regulatory requirements in New Zealand.

This review demonstrates that of the three protocols reviewed, the Washington TAPE is the most thorough and robust. As a general rule, the TAPE comprises a finer PSD that that typically encountered in New Zealand. Therefore, the adoption of the TAPE would be a conservative approach for New Zealand. Using the TAPE with a PSD representative of local soils for specific regions will most likely see MTDs perform better and give a more realistic indication for an MTDs performance in areas of New Zealand.

It is recommended that New Zealand regulatory bodies carry out an analysis on the merit and appropriateness of different MTD testing protocols to draw on the most applicable components for use in their catchments to ensure the best outcomes for the local receiving environments and Te Mana o te Wai.

References

Auckland Council. (2023, 06 22). *GD01 Stormwater Management Devices In the Auckland Region.* Retrieved from Auckland Design Manual: https://content.aucklanddesignmanual.co.nz/regulations/technical-guidance/Documents/GD01%20SWMD%20(Amendment%202).pdf

Stormwater Australia. (2023, 06 14). *Stormwater Quality Improvement Device Evaluation Protocol (SQIDEP): Field Monitoring.* Retrieved from Stormwater Australia: https://stormwater.asn.au/images/SQIDEP/SQIDEP_report_v1.3.pdf

TARP 2009 Update. (2023, 06 16). *Protocol for Total Suspended Solids Removal Based on Field Testing Amendments to TARP Protocol Dated August 5, 2009, Revised December 15, 2009.* Retrieved from New Jersey.gov: https://dep.nj.gov/wp-content/uploads/stormwater/field-protocol-for-mtds.pdf

TARP. (2023, 06 16). *The Technology Acceptance Reciprocity Paternership Protocol for Stormwater BMPs.* Retrieved from mass.govt: https://www.mass.gov/doc/stormwater-best-management-practice-demonstration-tier-ii-protocol-for-interstate-reciprocity/download

Waikato Regional Council. (2023, 06 22). *Waikato stormwater management guideline TR20/07.* Retrieved from Waikato Regoinal Council: https://www.waikatoregion.govt.nz/assets/WRC/WRC-2019/TR20-07.pdf

Washington TAPE. (2023, 06 13). *Technology Assessment Protocol – Ecology (TAPE): Process Overview.* Retrieved from WA.gov: https://apps.ecology.wa.gov/publications/documents/1810039.pdf

Wellington Water. (2023, 06 22). *Water Sensitive Design for Stormwater: Treatment Device Design Guidelines.* Retrieved from Wellington Water: https://www.wellingtonwater.co.nz/assets/Blocks/Building-Development-/WSD-for-Stormwater-Treatment-Device-Design-Guideline-December-2019.pdf