Retrofit Design Considerations

Introduction

Stormwater is inherently highly variable, there are many factors that will impact types of contaminants loads, particle size distribution, and speciation. This variability extends to best management practice (BMP) performance which will be dependent on the properties of the stormwater influent. Unfortunately, it is not feasible to remove all contaminants, as such a targeted approach is essential to successful stormwater management. Retrofitting treatment devices in a catchment is complex, the treatment achievable is dependent on many factors largely influenced by topography and existing infrastructure. This document summarises retrofit design considerations and provides a suggested approach to such a project.

Treatment objectives / Target contaminants

Understanding the treatment objectives should be the first step in the design process. The treatment objectives should include target contaminants relevant to both the catchment to be treated and the downstream receiving environment. Once this is known the selection should be able to be narrowed to a specific treatment group.

- Treatment objectives
    - GD01 (best practice) or equivalent (TP10 75% TSS removal on a long-term average)
    - 100% capture of 5mm and above
    - 50% TSS removal (pre-treatment, coarse sediment removal)
    - ANZECC guidelines – bioavailable dissolved pollutants (Te Mana o te Wai)
- Target pollutants (best practicable option (BPO) or contaminants of concern for receiving environment)
- Land-use (commercial, residential, industrial, etc.) will provide an indication of expected contaminant speciation and loadings.
- Resource Consent requirement
- Regarding the general performance of certain treatment device groups refer to the BMP database:
    - https://www.waterrf.org/system/files/resource/2020-11/DRPT-4968_0.pdf

Device Performance

As mentioned above, due to the variability of stormwater, device performance is also variable and therefore difficult to definitively quantify, performance will vary from location to location, storm to storm, and within the storm. It is important to understand removal rates are higher in storms with higher concentrations. However, understanding this, the values below provide benchmark performances for the different treatment groups when considering “conventional” stormwater concentrations. Values in brackets are peak test results observed in SW360 technologies.

Screening devices

- 100% >5mm Plastic

Hydrodynamic separators

- TSS: 50% (93%)
- Total Metals (Zinc, Copper): 20 - 40% (85% TZN, 56% TCu)

Underground Filters

- TSS: 60 - 90% (98%)
- Total Metals (Zinc, Copper): 30 - 60% (99% TZN, 99% TCu)
- Total Phosphorus: 30 - 50% (92%)
- Total Nitrogen: 30 - 40% (88%)

Biofilters

- TSS: 80 - 90% (99%)
- Dissolved Metals (Zinc, Copper): 30 - 60% (99%)
- Total Phosphorus: 50% (90%)
- Total Nitrogen: 30 - 50% (85%)

Retention is another option that can provide effective load reduction, in sites located in an Auckland SMAF (Stormwater Management Areas: Flow) 5mm retention is required which is the equivalent of a 30% volume reduction, a high percentage of the dissolved contaminants will be removed by infiltrating this first 5mm. Retention also maintains baseflow in streams, reduces temperature, and reduces hydromodification.

Hydraulics

Once a treatment group has been determined from the treatment objectives the next consideration should be network and device-specific hydraulics to ascertain the feasibility of certain options. Every treatment device will have an impact on the hydraulics of the reticulation network. There will be an associated head loss through the system for a given flowrate. These head losses must be accounted for to ensure the network operates as designed and unforeseen flooding does not occur.

Head loss is defined as the difference between the immediate upstream water surface level (WSL) and immediate downstream water surface level of a given stormwater structure. The depth of flow downstream is a critical factor on upstream WSL.

When designing a treatment device there is a minimum driving head required to make the system operate at the design flow. Flow rate and the hydraulic effect are linked, all else equal, the higher the flow rate the higher the head loss, likewise, all else equal, the lower the head loss the larger the footprint required. If head loss is a concern there are design options to address this.

Surface entry devices (i.e., those that take sheet flow such as the LittaTrap or Filterra) have available driving head because of the pipe depth and associated cover. Bubble up systems for design flows can make these surface entry systems viable for some piped networks.

Typical design flow head loss on a GPT at treatment flow is between 100 – 500mm. This head loss can usually be provided in the network as it is generally approximately 10% of peak flow.

The Typical head loss on a filter at treatment flow is between 150mm – 950mm. Placing filters offline also helps with hydraulic requirements.

Further considerations:

- Tailwater
    - Water surface elevation located downstream of a hydraulic structure. It is recommended to set the outlet invert of the treatment device at or above the known permanent tailwater as a standard design.

- Headwater (backwater)
    - Water surface elevation located upstream of a hydraulic structure. Pumping treatment flows (only) can also be a cost effective solution for retrofitting.

Online/Offline

Stormwater devices can either be configured online whereby all flows must pass through the treatment bay of the device, or offline, whereby only the design treatment flow is directed to the treatment bay and peak flows are able to bypass (using diversion structures).

- In an offline design only the treatment flow rate (or “first flush”) will be directed to the treatment device, flows exceeding the treatment flow rate will bypass the system (this is typically done upstream with a diversion weir).
- Best practice is to configure a treatment device offline to minimise the risk of scour and resuspension of removed sediment and potential loss of floatables/oil & grease.
- Head losses can be minimised using an upstream diversion weir (in an offline configuration). The longer the weir the less the head loss incurred to discharge a given flow rate over said weir.

Footprint

Space is valuable whether the device is above or below ground. Footprint can vary drastically between devices despite having equivalent treatment objectives and design flow rates.

- Footprint constraints exist due to natural features/surrounding infrastructure/nearby services, etc.
- There is a relationship between footprint vs performance. vs flow, lower performance devices (such as gross pollutant traps) have a smaller footprint per flow rate.
- There is also a relationship between footprint and head loss, a lower head loss for a given device will require a larger footprint.
- Biofilters 0.4% (Filterra) to >2% (conventional raingardens) of impervious catchment.

Levels

Device levels are dictated by the hydraulics, network design, internal components, and maintenance accessibility.

- Depth to invert is the depth from outlet invert to the lid level of the treatment device. For a retrofit this is usually constrained by head loss, pipe diameter, and pipe cover.
- Depth below invert is the depth from outlet invert to the invert of the sump, this has a significant effect on the cost of installation.
- Upstream Water Surface level provides the boundary condition for hydraulic design (i.e., the freeboard).

Flow rates:

Flow rates are typically the driving factor for device sizing (i.e., the manhole/vault footprint or filter media area of a device to be used).

- Water quality flow rate
    - Typically calculated using the rational method and a rainfall intensity of 10mm/hr (within Auckland). Should account for different surfaces (e.g., impervious/pervious).

- Peak flow rate
    - Typically, a flow rate corresponding with the one in ten or one in twenty year storm event.
- Both the water quality and peak flow rates are critical when sizing a device. A device is typically sized such that its design treatment flow rate exceeds the water quality flow rate while having capacity for the peak flows (if not configured offline).

Costs

Stormwater treatment comes at a cost, ultimately a budget may dictate what level of treatment is implemented. Once feasible options have been determined, analysis should be done to determine which provides the best treatment for the cost, ongoing operational costs must be considered.

- Lifecycle cost analysis
- Cost-benefit analysis
- Do-nothing cost

Cost Factors

- Level of performance. How clean do we want the water? (Te Mana o te Wai)
- Location
- Catchment area and topography (the larger the catchment area the lower cost per m^2 of the treatment device to catchment area – the same relationship exists for maintenance)
- Size (footprint/depth)
- Land acquisition – may be cheaper to buy land and use a larger device
- Maintenance
    - Access
    - Equipment/labour
    - Confined space
    - Treatment trains (e.g., pre-treatment (GPT) upstream of a filtration device) reduce operational costs
    - Sediment and storage capacity of device and mass load design. Devices with low capacity will need more frequent maintenance
- Installation
    - Equipment/labour

Other considerations

- Future growth – increasing contaminant loads due to an increasing population.
- Climate change – increasing flow rates due to higher intensity storm events.
- Regulatory bodies
    - Auckland Transport, Healthy Waters/Auckland Council – will your design get approval from all necessary parties? Have they been engaged?
- Compliance

Suggested approach for retrofitting treatment devices in existing catchments

1. Determine treatment objective. With a best practicable option approach initial objective should be dissolved contaminants then a hierarchy of objectives should apply, moving down from dissolved,

total contaminants, sediment, and gross pollutants. Alternatively, the objective should be based on the needs of the receiving environment. Consider applying retention in addition to treatment.

2. Hydraulic Investigation of existing stormwater network. Prepare long section with hydraulic grade line for design and peak flows. Use this investigation to determine possible treatment locations.
3. Review location of the sites for possible locations to install a device (considering access, services, cost of land).
4. Review treatment objective. If the treatment objective is not feasible choose a lower treatment objective.
5. Once treatment objectives, hydraulics, and location have been established, this information (along with catchment areas (for mass load calculations) and water quality/peak flow rates) can be supplied to Stormwater360 to provide device and sizing options.
6. Costs vs. budget of feasible options must be analysed before making a final decision on BMP.

Conclusion

The purpose of this document is to summarise the key considerations required when undertaking a retrofit project. We understand there is a considerable amount of information to digest here however this is a symptom of the complexity of retrofit design. Stormwater360 can provide a free consultation to discuss your retrofit project and review the above in finer detail. The earlier Stormwater360 is engaged the better we can advise.