Ecological Baseline Study of Tung Chung River Park (2nd Edition)

2023

Public Version

Published by

綠色力量 GREEN POWER

Fully Supported by

香港國際機場 HONG KONG INTERNATIONAL AIRPORT

Publisher	Green Power
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Publication Year	2023

Recommended Citation:
Green Power. 2023. *Ecological Baseline Study of Tung Chung River Park (2nd Edition)*. Green Power, HK.

Abstract

1. To assess the potential effects of the future River Park on Tung Chung River (TCR)'s biodiversity, Green Power conducted a ecological study on the areas to be covered by the River Park, as well as reference sections along the lower West Stream of TCR. Three taxa groups, namely riparian plants, freshwater fishes, and adult aquatic insects were surveyed between May 2018 and September 2022. The study recorded the ecological conditions of the surveyed sections before any construction works begin to establish baseline references for future evaluation of the conservation effectiveness of the River Park. We also summarize recommendations regarding the design and management strategies of the River Park, with the hope of informing decisions to be made by the management authority.

2. The results indicated generally degraded conditions in habitat and stream community in the currently channelised section, which would be revitalised and largely included in the River Park. High proportion of exotic plants, low diversity of adult aquatic insects and extremely low density and richness of freshwater fishes were recorded along the channelised section in the current study. High densities of invasive freshwater fishes were also observed along the relatively natural section to be included in the River Park.

3. The study revealed conservation challenges to be tackled during the establishment and operation of the River Park. We opine that any construction works should be carefully programmed and implemented, and the revitalisation of the channelised section should be carefully designed, along with preservation of the riparian woodland fringe and reprovision of diverse aquatic habitats. Invasive species control, prudent management practices, minimisation of human disturbances, water quality control, and long-term ecological monitoring should be included in the management protocols, which should, in turn, be regularly evaluated.

Contents

1. Introduction 1
1.1. Tung Chung River 1
1.2. The Tung Chung River Park 1
1.3. The Current Study 2
2. Materials and Methods 3
2.1. Plants 3
2.2. Adult Aquatic Insects 4
2.3. Freshwater Fishes 4
3. Results 7
3.1. Plants 7
3.2. Adult Aquatic Insects 7
3.3. Freshwater Fishes 7
4. Discussion 11
4.1. Current Ecological Condition 11
4.2. Recommendations 12
Acknowledgement 17
References 18
Appendices 21

1. Introduction

1.1. Tung Chung River

Often referred to as the “last remaining large-scale natural river in Hong Kong”, Tung Chung River (TCR) is one of the most vulnerable river systems within the territory. It has two major branches: the west branch, referred to as the “West Stream” in this report herein, and the east branch, referred to as the “East Stream” in the following texts, drain the catchment and join each other near the estuary. The river courses of TCR are mostly pristine from the sources to the estuary and bay, except for a section of about 600m along the lowest reach of the East Stream which was channelised for flood prevention in 1999 (Chan 2001). The East and West Streams are highly biodiverse, each having a section being designated as Ecologically Important Streams (no. 27) by the Agriculture, Fisheries and Conservation Department (AFCD). Together with the estuary, different sections of TCR are home to many important species, and TCR has been regarded as the second richest in freshwater fish diversity (the first being Tai Ho Stream) within the territory (Chong & Dudgeon 1992). Chan (2001) described the lower West Stream as “one of the most species-rich streams in Hong Kong with a very good representation of freshwater fish families in Hong Kong” and the lower East Stream harboured “rare fish species and high fish density”, and that the channelised section along the latter required urgent need of restoration to a more natural state to conserve the fish community within. The water quality of Tung Chung River has also been rated as “Excellent” between 1999 and 2019 under the grading scheme of Water Quality Index (WQI) established by the authority (EPD 2022). However, signs of deterioration in water and habitat qualities have been detected as village and new town development encroach and expand within the valley (GP 2023a, c).

1.2. The Tung Chung River Park

In 2012, the *Planning and Engineering Study on the Remaining Development in Tung Chung – Feasibility Study* was commissioned (CEDD 2015). The development proposal for Tung Chung New Town Extension (TCNTE) was subsequently announced following public engagement, environmental impact assessment (EIA) and planning processes. Part of the TCNTE scheme, namely Tung Chung West, covers the lower catchment of TCR. Large areas have been designated for village type and residential uses under statutory plans to accommodate population increase planned under TCNTE.

The ecological value of TCR was recognized during the formulation of the TCNTE scheme, which includes several conservation measures, two of which being revitalisation of the channelised section into a natural state, and the establishment of the first River Park within the territory. Planned along the lowest section of the East Stream (Figure 1.1), the River Park will be set up and managed with the aims of restoring up-and-downstream connectivity and conserving stream habitats important for wildlife, as well as promoting a “water-friendly” culture among citizens (DevB & EnB 2020). The River Park covers two major sections of the lower East Stream: 1) a lower section, which covers the majority of the section to be revitalised (415m of the 600m channelised section) immediately downstream of an illegal vehicle access (proposed as the “Revitalisation Zone”), and 2) an upper section between the illegal vehicle access and Shek Mun Kap Road, which had been disturbed by excavation activities in 2003, undergone restoration afterwards and is proposed to be named “Conservation Zone” (ACE 2020, Island DC 2020, Figure 1.1) as it is currently in a relatively natural state.

1.3. The Current Study

As the River Park is the first of its type in Hong Kong, its effectiveness in terms of restoring stream habitats for flora and fauna of lower TCR requires examination and monitoring. The current study aims at recording the ecological conditions of sections to be included in the future River Park before any construction works begin to establish baseline reference and targets for future evaluation of its conservation effectiveness. We also summarize recommendations regarding the design and management strategies of the River Park, with the hope of informing decisions to be made by the management authority.

Three other concurrent studies, namely *Ecological Baseline Study of Tung Chung River Catchment* (the "Catchment Ecological Study", GP 2023a), *Evaluation of Partial Stream Water Release Trial at Tung Chung Au Water Intake* (the "Water Release Study", GP 2023b) and *Study on Water Quality of Tung Chung River Catchment* (the "Water Quality Study", GP 2023c), provide complementary and more detailed investigation on specific issues within the TCR catchment.

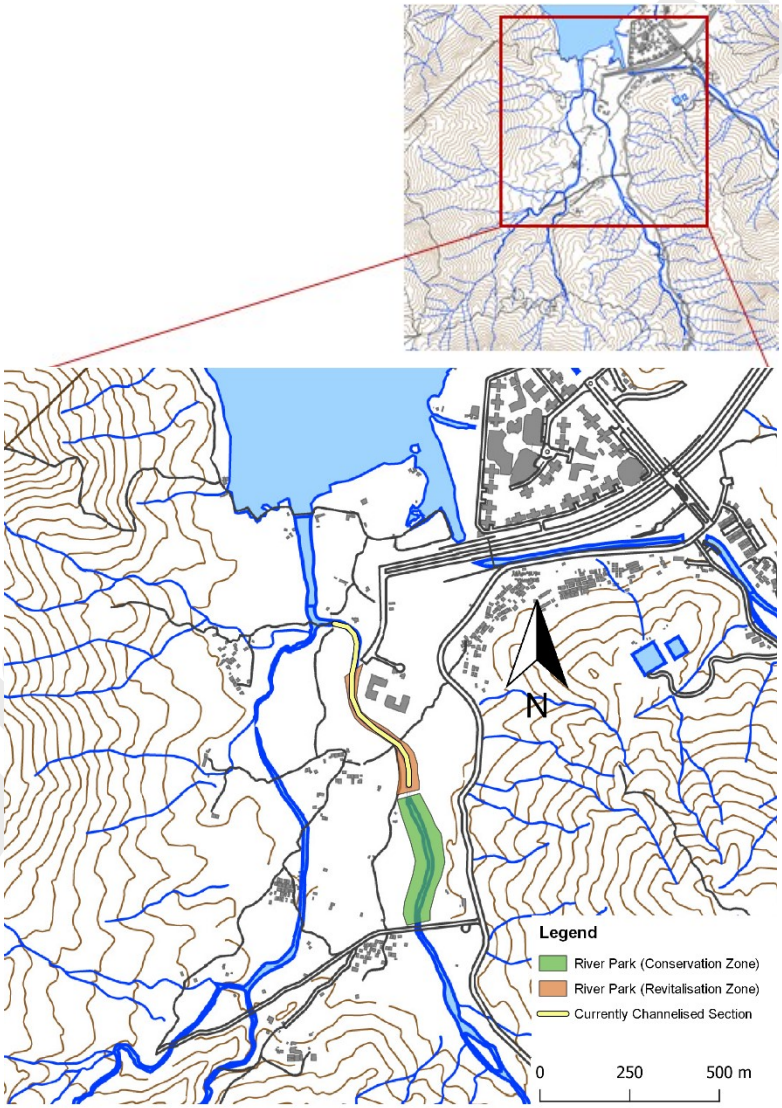

Figure 1.1. Location of the future River Park (with proposed zonings) and the channelised section along the lower East Stream of TCR planned to be revitalised. The basemap is provided by the Hong Kong GeoData Store and intellectual property rights are owned by the Government of the HKSAR.

2. Materials and Methods

We conducted surveys along three study reaches (Figure 2.1):

RP-1:
The channelised section to be revitalised, with a concrete bottom and grasscrete slopes on both sides. The section was bordered by concrete roads without tree canopy coverage, and the stream banks were mostly covered by herbs. Concrete steps of more than 20cm in height separated the section from the estuary and likely obstructed fish passage between brackish and freshwater zones. This study reach included sections within and downstream of the proposed Revitalisation Zone.

RP-2:
The proposed Conservation Zone right upstream of and separated from RP-1 by an illegal road with culverts. It was relatively natural in channel morphology and stream bed structure, and generally lined by riparian woodlands with canopies of about 5m in height.

REF:
A reference section along the lower West Stream, which was relatively natural in channel morphology and stream bed structure, and generally lined by orchards and secondary riparian woodlands with canopies of about 5m in height. The non-tidal zone along this reach was relatively unobstructed from the tidal zone, although artificial structures including culverts and weirs were present in the middle of this reach.

Riparian plants, adult aquatic insects as well as freshwater fishes were surveyed along the three reaches between April 2018 – Sep 2022 for inter-reach comparison of biotic metrics.

2.1. Plants

We established two 50-m transects along each of the above three study reaches for the plant survey (Figure 2.1), which was conducted once in each wet season (May - Sep) and each dry season (Nov - Mar) throughout the study period. Other sections of the study reaches were also surveyed in the two wet seasons and one dry season between May 2021 and Sep 2022 to provide additional data.

During each survey, two surveyors walked along the transects, identified all vascular plants observed within the stream channel and 2m-riparian region on both sides of the stream to species level whenever possible and recorded their relative abundances (using ordinals: no. of individuals of woody plants +: 1-10; ++: 11-30; +++: 31 or above; areal coverage of herbs: +: 1-10%; ++: 11-30%; +++: 31% or above). Species with conservation concern had their GPS coordinates recorded. Plants were considered of conservation importance when 1) listed under Protection of Endangered Species of Animals and Plants Ordinance (Cap.586), 2) Forestry Regulations (Cap. 96A), 3) listed as Rare and Precious Plants in Hong Kong (AFCD 2003), (4) considered rare by Xing *et al*. (2000), Wu and Lee (2000), Siu (2000), 5) listed as Category I or II protected species in mainland China, or 6) listed on the updated IUCN Red List of Threatened Species, excluding non-native or cultivated species.

Mean species richness of native plants was calculated by averaging the number of native species recorded from each wet and dry season and was compared among 50-m transects. The presence of species of conservation concern along the study reaches was also summarized.

2.2. Adult Aquatic Insects

We surveyed adult aquatic insects four times at night along each study reach during each wet (May - Sep) and dry seasons (Nov – Mar) within the study period except for dry season 2021-2022, with each survey separated by at least 14 days to ensure data independence.

During each survey, adult aquatic insects were sampled using ultraviolet light traps, each consisted of two 15cm-long 4W ultraviolet light tubes suspended over a white plastic tray (surface area = 33cm x 25cm, height = 9cm) containing 3cm stream water with two drops of detergent added. Two traps separated by at least 40m apart from each other were deployed for three hours after sunset. All three reaches were sampled on the same dates. Trapping was avoided on nights when the moon was full, as this has been reported to reduce catches of some taxa (Wolda and Flowers 1985, Young 2005).

Captured insects were sieved through 0.5mm-mesh and preserved in 75% alcohol for storage before being processed in the laboratory. Aquatic insects from orders Ephemeroptera, Plecoptera and Trichoptera (EPT), which are widely considered as major benthic taxa sensitive to degradation of water quality and habitat (Clements et al. 2000, Resh & Rosenberg 1993, Stone & Wallace 1998), were chosen as indicator taxa. Their abundance, biomass and diversity, among other metrics, were found to be indicative of stream and riparian habitat and water quality (Clements et al. 2000, Moya et al. 2007, Stone & Wallace 1998). Insects from these orders were sorted to order under 10X light-microscope and counted. We obtained dry mass of each order by oven-drying the samples at 60 °C for 48 hours. Mean abundances and dry masses of the three insect orders were calculated by pooling data of trap captures collected within each survey occasion, then by averaging data of all wet and dry seasons. One sample in wet season 2021 and all four samples from wet season 2022 were sorted down to morphospecies before drying for examination of study reach α diversity using morphospecies richness, and Shannon index (H), with $H = -\sum_{i=1}^{n} p_i \ln p_i$, where n is the number of morphospecies recorded and p_i is the proportion of abundance for morphospecies i. The metrics were averaged across samples and then compared among study reaches.

2.3. Freshwater Fishes

Freshwater fish species richness was compared among study reaches using data from a parallel study (GP 2023a) in which three of the transects overlap with those used in the current study. We conducted survey once during each wet and dry seasons between 2018-2019 and 2021-22, by actively searching (aided by snorkelling and netting) along each study reach. All fishes encountered were identified to species on site and had their relative abundances (in ordinals: +: 1; ++: 2-10; +++: 11 or above) recorded. RP-1 comprised two subsections of distinct habitat qualities: an upper section consisting of a sand trap, with lush in-stream vegetation and diverse substrates including sand and gravel, as well as deep water pools which were favourable to fishes; and a lower section (labelled as E4L in GP 2023a) beyond the sand trap with a mostly bare concrete bottom and an exceptionally thin layer of water which constituted a low-quality habitat. Data of the lower section of RP-1 was used in

the inter-reach comparison to reveal the impact of the oversimplified habitat with complete concrete-lining on the diversity of fishes, and data from each survey were taken as individual samples for inter-reach comparison of fish species richness.

Density of freshwater fishes were surveyed concurrently with adult aquatic insects, such that four night surveys along each study reach during each wet and dry seasons (except for dry season 2021-2022) were conducted within the study period. During each survey, visual counts of fishes in slow-flowing regions of each study reach (lower section of RP-1, RP-2 and REF) were conducted using five randomly thrown quadrats (0.5 x 0.5m^2 each) and a viewing chamber. Counting was started at least 10 minutes after the deployment of the quadrats to minimize the effect of surveyor disturbance on the fishes. All fishes observed were identified to species and had their abundance recorded. Mean densities of native and exotic fishes recorded from wet and dry seasons were then compared among transects.

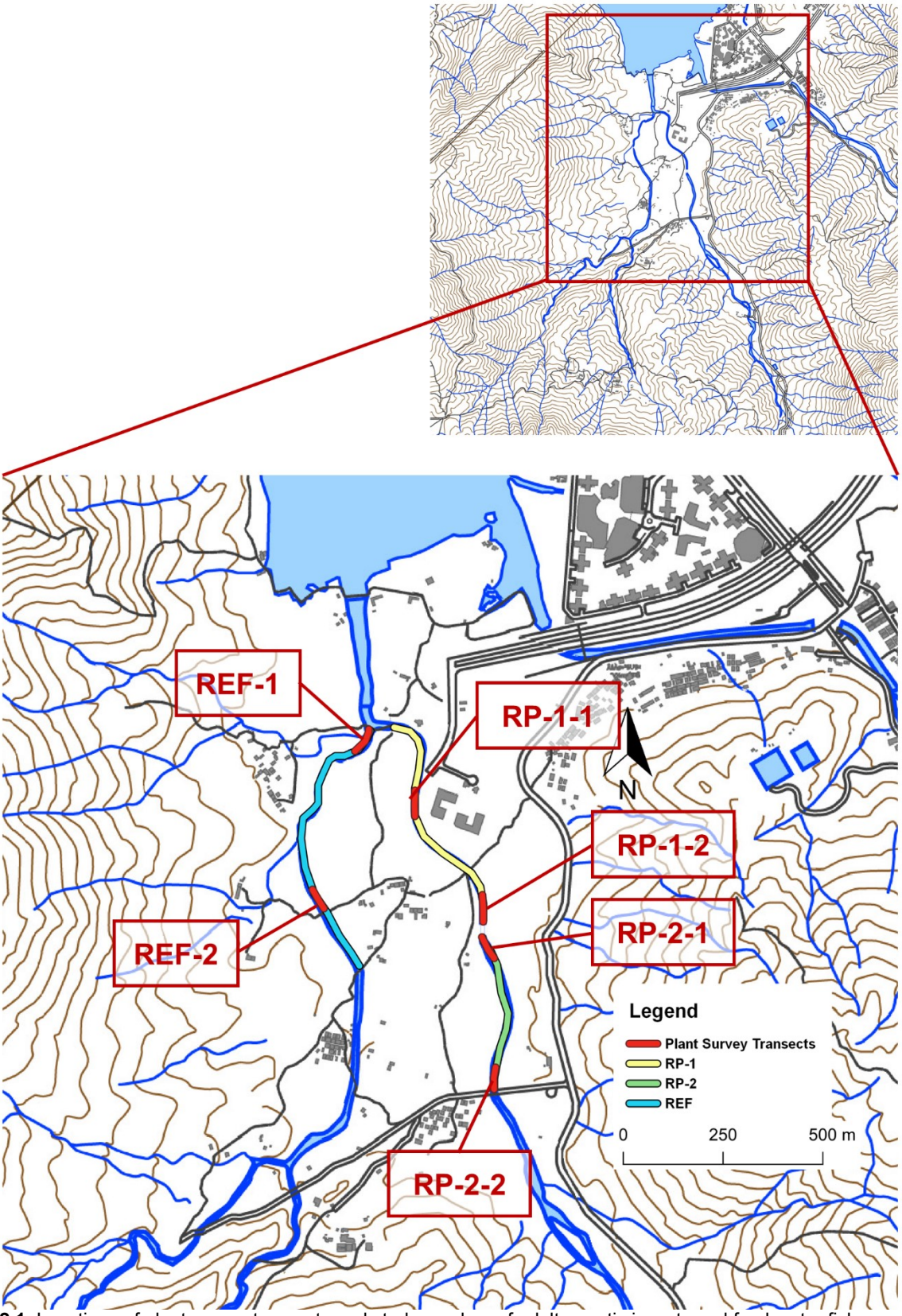

Figure 2.1. Locations of plant survey transects and study reaches of adult aquatic insects and freshwater fishes surveyed between 2018 and 2022. The basemap is provided by the Hong Kong GeoData Store and intellectual property rights are owned by the Government of the HKSAR.

3. Results

3.1. Plants

A total of 259 species of plants were recorded along the three study reaches, among which 214 were sighted along the six 50-m transects during the study period (Appendix 1). Species of conservation concern, namely Luofushan Joint-fir (*Gnetum luofuense*), Snake Acacia (*Acacia pennata*), Tall Rattlesnake-plantain (*Goodyera procera*), Incense Tree (*Aquilaria sinensis*), Ladies Treeses (*Spiranthes sinensis*) and the Water Fern (*Ceratopteris thalictroides*) were also recorded during the study (Table 3.1).

Among the 50-m transects, mean native species richness was the highest along REF-2 (41.0 spp. in wet seasons and 40.8 in dry seasons) and RP-2-2 (41.0 spp. in wet seasons and 38.5 in dry seasons) (Figure 3.1). Fifty-meter transects along the channelised section, as well as RP-2-1 and REF-1, all had no more than 30 species native plants recorded on average during both seasons (Figure 3.1).

3.2. Adult Aquatic Insects

Aquatic insect captures were mostly collected from the wet seasons, with Trichoptera being the most frequently captured target order (~65%), followed by Ephemeroptera (~35%). Plecopterans made up less than 2% of the overall captures. Wet season mean abundances of trichopteran were the highest along RP-2 and RP-1 (both ~400 indiv/survey), while that of ephemeropteran was the highest along RP-1 (345 indiv/survey), which was about 1.8 and 2.5 times of those of RP-2 and REF respectively (Figure 3.2). Mean abundances of both orders were the lowest along REF (both <160 individuals/survey) (Figure 3.2). Mean dry masses of both orders along RP-1 were higher or comparable to those of RP-2 and REF (Figure 3.3). Wet season morphospecies richness along RP-1, however, were the lowest among the study reaches (7.6 spp./survey versus 16 spp./survey along RP-2 and 18.6 spp./survey along REF). Its mean richness of trichopteran (5.6 spp./survey) was only 49% and 38 % of those along RP-2 and REF respectively (Figure 3.4). Similar pattern was observed in the comparison of Shannon diversity index H, with mean H along RP-1 being the lowest among the three study reaches (0.97 versus 1.96 along RP-2 and 1.8 along REF, Figure 3.5).

3.3. Freshwater Fishes

A total of 35 freshwater fishes were recorded along the three study reaches. Species of conservation concern such as the Beijiang Thick-lipped Barb (*Acrossocheilus beijiangensis*), Scaly Neon Goby (*Stiphodon multisquamus*), Rice Fish **(***Oryzias curvinotus***)**, Dark-margined Flagtail (*Kuhlia marginata*) and Paradise Fish (*Macropodus opercularis*), and the first sighting of the globally restricted Glass Goby (*Gobiopterus macrolepis*) on Lantau were also observed around the study area (Appendix 2). RP-2 and REF, which were relatively natural in terms of channel morphology, had on average 9 and 12 species of native freshwater fish recorded per survey respectively. Although the lower section of RP-1 was intermediate in surveyed channel length (480m vs 380m (RP-2) and 660m (REF)), it was the lowest in native species richness and had no more than four native species recorded per survey (Figure 3.6). All study reaches were found invaded by exotic species (Figure 3.6 & Appendix 2).

REF, which shares the same estuary with RP-1, had high abundance of common brackish water inhabitants, including Fork Tongue Goby (*Glossogobius giuris*), Amur Goby (*Rhinogobius similis*), Grey Mullet (*Mugil cephalus*) and Greenback Mullet (*Planiliza subviridis*), recorded in most of the surveys. These species, however, appeared absent or only recorded in low abundance (≦10 individuals) once along RP-1 throughout the study. The Rice Fish was very abundant and recorded in all surveys along REF, but was recorded along RP-1 only during the wet seasons. Other freshwater fishes commonly found along REF, including Beijiang Thick-lipped Barb, Chinese Barb (*Barbodes semifasciolatus*), Predaceous Chub (*Parazacco spilurus*) and Sharphead Sleeper (*Eleotris oxycephala*), were either virtually absent from or rarely spotted along RP-1.

Throughout the study period, only extremely low abundance of fishes was recorded in randomly thrown quadrats along the lower section of RP-1 (Figure 3.7). RP-2 had relatively high density of native species similar to that of REF. However, its exotic species (mainly the invasive *Xiphophorus* spp.) density was also high particularly during the wet season, with mean densities reaching 6.4 individual/m^2, thus being 2.6 times of the latter during the same period.

Family	Scientific Name	Common Name	Chinese Name	Conservation, Protection and Local Status[1]
Gnetaceae	*Gnetum luofuense*	Luofushan Joint-fir	羅浮買麻藤	IUCN(NT)
Mimosaceae	*Acacia pennata*	Snake Acacia	羽葉金合歡	H(R)
Orchidaceae	*Goodyera procera*	Tall Rattlesnake-plantain	高斑葉蘭	Cap. 96, Cap. 586
	Spiranthes sinensis	Ladies Treeses	綬草	Cap. 96, Cap. 586
Parkeriaceae	*Ceratopteris thalictroides*	Water Fern	水蕨	R(VU)
Thymelaeaceae	*Aquilaria sinensis*	Incense Tree	土沉香	IUCN(VU), C(VU), R(NT), Cap. 586
Total no. of Species of Conservation Concern Recorded				**6**

Information masked in the public version of the report

Table 3.1. Plant species of conservation concern recorded between 2018-2022. ^ denotes sections beyond 50-m transects.

1. Conservation, Protection and Local Status
IUCN – Conservation Status in IUCN (2023): VU = Vulnerable, NT = Near Threatened.
C – Conservation status in *China Red Data Book* (Fu & Chin 1992): VU = Vulnerable.
R - Listed in the *Rare and Precious Plants of Hong Kong* (AFCD 2003) (status in China): VU = Vulnerable; NT = Near Threatened
H – Conservation status in *Hong Kong vascular plants: Distribution and status* (Corlett et al. 2000): R = Rare.
Cap. 96 - Protected under *The Forests and Countryside Ordinance*.
Cap. 586 - Protected under *The Protection of Endangered Species of Animals and Plants Ordinance*.

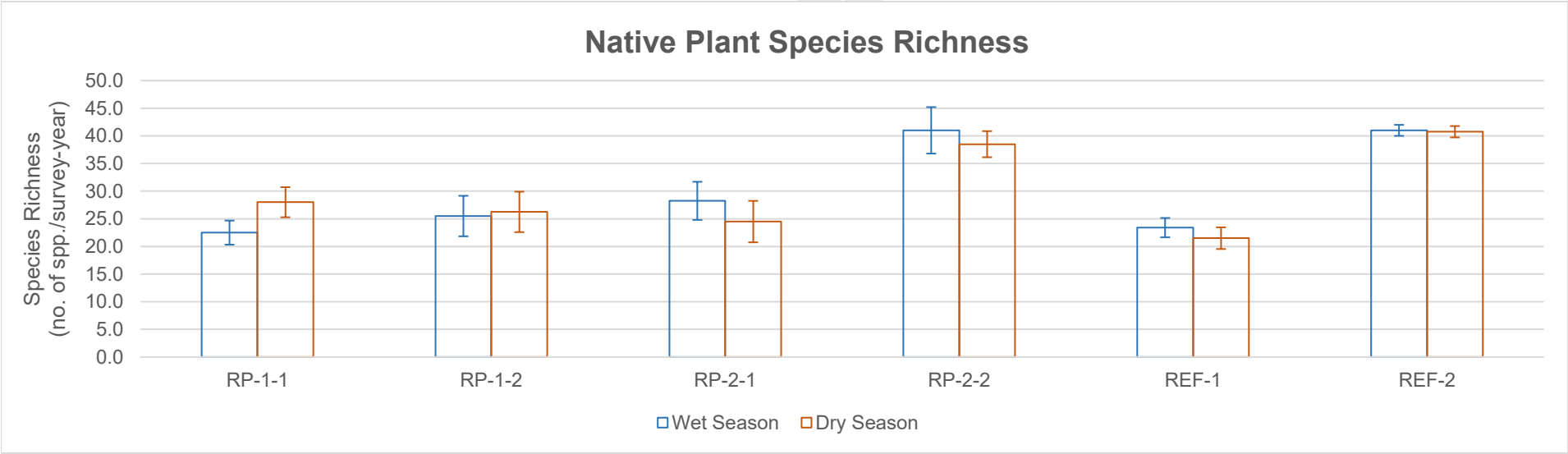

Figure 3.1 Mean (±SE) native plant species richness recorded along the six 50-m transects between 2018-2022.

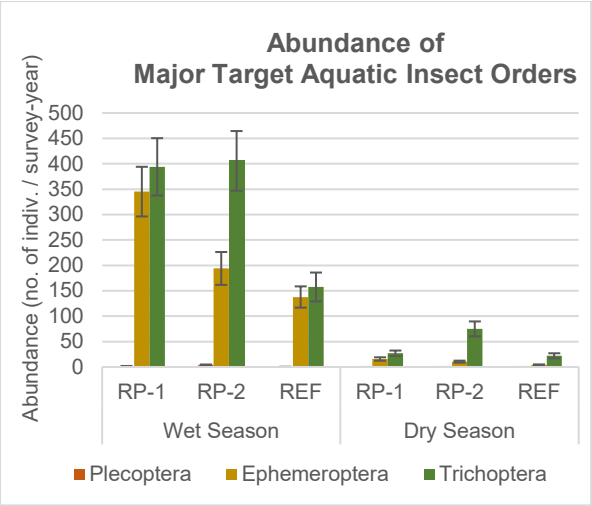

Figure 3.2 Mean (±SE) abundance of major target aquatic insect orders captured along the three study reaches during wet and dry seasons between 2018 and 2022.

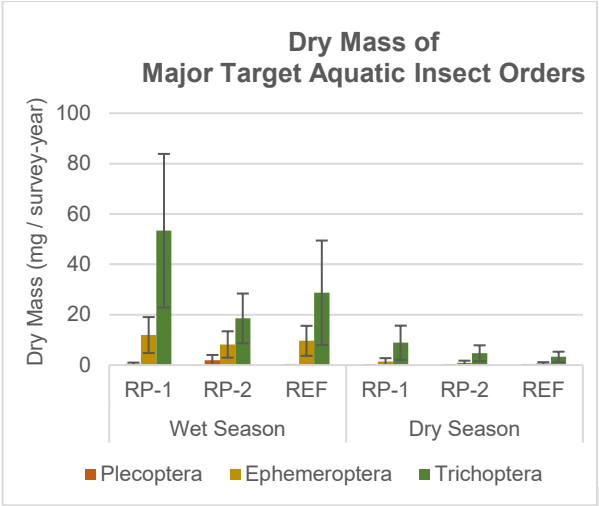

Figure 3.3. Mean (±SE) dry mass of major target aquatic insect orders captured along the three study reaches during wet and dry seasons between 2018 and 2022.

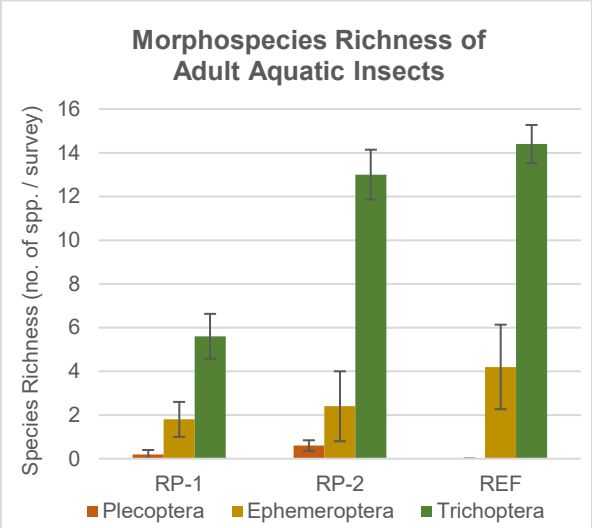

Figure 3.4. Mean (±SE) adult aquatic insect morphospecies richness recorded in five sampling occasions along the three study reaches in wet seasons of 2020 and 2021.

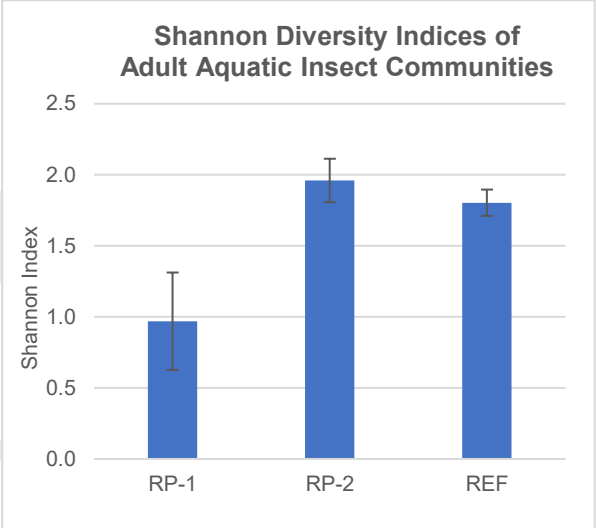

Figure 3.5. Mean (±SE) Shannon diversity indices of adult aquatic insect communities recorded in five sampling occasions along the three study reaches in wet seasons of 2020 and 2021.

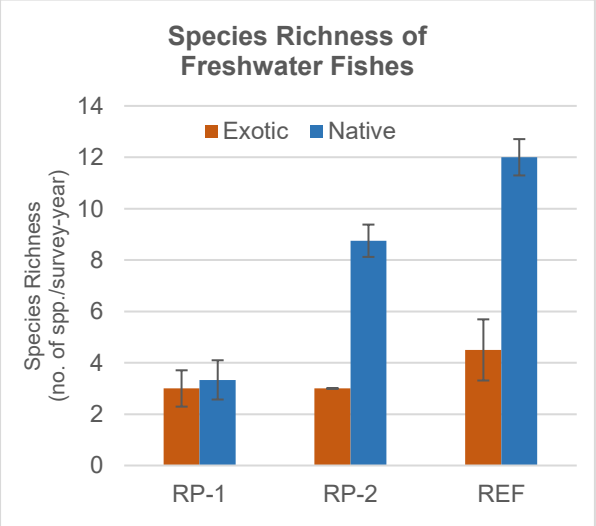

Figure 3.6. Mean (±SE) species richness of freshwater fishes recorded by active along the three study reaches in 2018-2019 and 2021-2022.

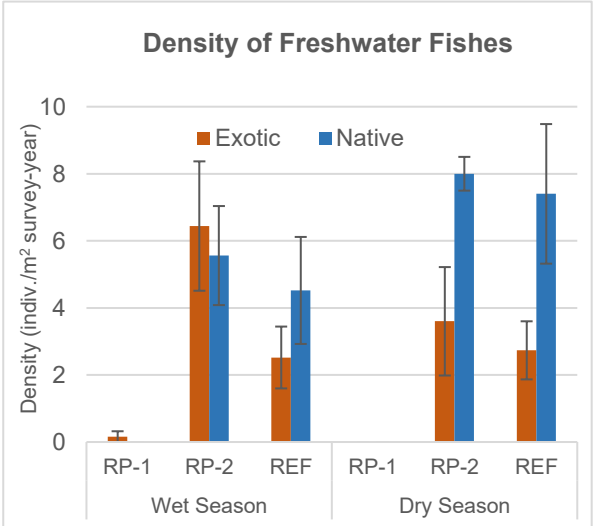

Figure 3.7. Mean (±SE) density of freshwater fishes recorded in quadrat counts along the three study reaches between 2018 and 2022.

4. Discussion

4.1. Current Ecological Condition

Plant survey transects representing the channelised section, as well as RP2-1 and REF-1, were relatively low in terms of native plant species richness compared with more natural and less-disturbed transects (RP-2-2 and REF-2). Such patterns were likely attributable to the plant management practices or other disturbance history along these sections. Indiscriminate weeding of bankside vegetation, for example, were observed along the channelised section and occasionally along REF-1 throughout the study period. Large-scale indiscriminate weeding reduces habitat structure complexity and select fast growing species, a lot of which are exotic and can easily colonize the disturbed habitat after such catastrophic disturbance. It is also noteworthy that transect RP-2-2 had higher native plant species richness than RP-2-1. During the stream excavation incident in 2003, all riparian and in-stream vegetation along RP-2-1 was removed while RP-2-2 was mostly unaffected. The observed differences in vegetation community between the two transects may be a legacy of the incident and suggests the difficulty of natural stream recovery after large-scale disturbances.

Low fish density and richness as well as adult aquatic insect diversity were recorded in the channelised study reach in the current survey, which indicated poor conditions of the aquatic community. Common native fishes which inhabit the estuary and tidal lowland rivers were apparently absent or only found in low numbers during the wet season when flow was high along the channelised section. This was likely the result of habitat discontinuity caused by artificial obstacles such as concrete steps which obstructed passage of fishes between the marine and freshwater realms. Primary freshwater fishes which were abundantly found in the neighbouring natural reference section were also rarely found along this reach. The recorded fishes were limited to small-sized and exotic species, probably washed down by spates during the wet season, and not likely to survive in the over-widened concrete channel with little refuge and extra-thin water column. The observed low aquatic insect diversity along RP-1 was also likely a result of hostile abiotic conditions, such as reduced flow potentially caused by the over-widened concrete riverbed, simplified habitat structure, relatively high stream water temperature due to the concrete channel and the lack of riparian canopy coverage (GP 2023c), and limited types of food source mainly of autochthonous origin that only selected a few adaptable species to thrive and dominate.

On the other hand, the relatively natural study reach representing the Conservation Zone of the future River Park harboured freshwater fishes and adult aquatic insects with density and/or species richness comparable to those of the reference study reach along the West Stream. However, the observed dominance of invasive fishes also indicates degradation of the aquatic biota and poses challenges for future management if the condition of the aquatic community is to be enhanced.

The results indicate relatively poor ecological conditions in the channelised section, its need for revitalisation, and effective management of the relatively natural sections.

4.2. Recommendations

4.2.1. Habitat Restoration

Stream Habitats

The channelised section should be revitalised with clear objectives of providing suitable habitats and restoring longitudinal connectivity for aquatic life.

Aquatic organisms have specific preferences towards different physical microhabitat characteristics, such as substrate types, flow conditions and water depths, which in turn affect attributes including stream water hydrochemistry and food availability which all determine the sections' inhabitability to the organisms. The provision of diverse microhabitats thus allows establishment of organisms of various niches, and is essential in restoring the diversity of aquatic biota. This could be achieved by replacement of the concrete bottom lining the entire length of the channelised section with natural substrates (including sand, pebbles, and cobbles of appropriate grain sizes), provision of varying water depths and flow conditions by artificial riffles, pools and deflectors which mimic natural stream microhabitats, as well as planting or natural establishment of native in-stream and riparian vegetation (Chan 2001). Re-provision of sand trap could also be considered for maintenance and conservation purposes as this has been found to provide refuges usable by wildlife (GP 2023a). Such elements not only enhance microhabitat heterogeneity which had significant positive effects on species richness (Miller et al. 2011), but also increase the availability of refuges for organisms to hide during spates (Negishi et al. 2002).

Currently a series of impediments in the form of concrete steps, as well as illegal roads and culverts, are present along the channelised section and obstruct the stream-to-ocean corridor needed by diadromous fishes to complete their life stages. Such impediments must be eliminated and replaced by ecologically friendly elements such as well-designed fish ladders, which must be usable by the target taxa and may need to be affixed at strategic locations so that maintenance work arising from spate disturbances could be kept minimal.

Apart from critical elements (e.g. fish ladders, flow deflectors, bank stabilizers) that need to be affixed in the stream, the revitalisation plan should allow certain flexibility of stream material (e.g. substrates) redistribution by natural flow to re-establish aquatic microhabitats and in-stream native vegetation colonies.

Ecological targets, such as reappearance of aquatic species and community structures typically found in comparable natural lowland rivers with unobstructed passage and natural stream morphology, should be set to evaluate the effectiveness of the habitat restoration work. We expect common fish species which utilize the freshwater-marine interface (e.g. gobies and mullets) and primary freshwater species abundantly found in the reference section (e.g. Beijiang Thick-lipped Barb and Predaceous Chub) to be frequently observed and increase in density along the channelised section if habitat connectivity and complexity could be restored. Increase in overall diversity of native fishes, aquatic insects and riparian plants should also indicate restoration success.

Riparian Woodland Fringe

Shading should also be provided along the riparian zones via planting of suitable native trees, with consideration of impacts on bank stability and maintenance effort. Riparian woodland fringes comprising native trees or shrubs and understory ground cover not only moderate stream microclimate (Naiman et al. 2010), but also moderate surface runoff impacts, provide habitats, stabilize the stream bank and act as ecological stepping stones and wildlife corridors linking the managed River Park areas to remnant vegetation patches and natural stream sections of lower TCR. Leaves, flowers and fruits shed by shading vegetations along the river banks also provide food and nutrients to aquatic organisms. It should be noted that under the current scheme of TCNTE, large portions of green areas would be lost to provide room for development (Arup 2015). Habitats within the River Park would become the last refuge for wildlife within the lower TCR catchment, including important species relying on woodlands, such as the endangered Romer's Tree Frog (*Liuixalus romeri*) and the near-threatened Hong Kong Newt (*Paramesotriton hongkongensis*) (GP 2023a). Native ecological communities may be more adapted to utilize resources provided by native plant species (Burghardt et al. 2009, Isaacs et al., 2009). Provision of high-quality habitats and resources, as well as good management practices (see sections below), are thus vital to the survival of wildlife within the valley.

Provision of Other Aquatic Habitats

Drastic decline of lentic habitats, including freshwater marshes and ponds originating from historical agricultural activities, is occurring within TCR. Most freshwater marshes in Tung Chung have been lost to recent urban development (KFBG 2019), and this threatens the survival of species such as the Paradise Fish (*Macropodus opercularis*) and Rice Fish (*Oryzias curvinotus*) (GP 2023a). Such loss of lentic water bodies inevitably wipes out species preferring or being able to utilise these habitats. The River Park may provide opportunities for re-establishing such habitats within its boundary or enhancing existing but degrading habitats nearby. Apart from the provision of static water bodies within the boundary of the River Park, the authority may consider restoring hydrological and thus ecological linkages between the stream and the marsh in Fong Yuen when establishing the River Park.

4.2.2. Invasive Species Control

Invasive species such as Swordtail, Guppy, Mosquito Fish, Mile-a-minute Weed and Gairo Morning Glory were found prevailing in the study area in the current and concurrent studies (GP 2023a). Invasive species could alter native habitats, compete with native species for limited resources, prey on native species (Simberloff 2010), bring pathogens and parasites to the native animals, cause hybridization and pollute the native genetic pools (Simberloff 2010, Laikre et al 2010, Sancho 2020), and thus should be strictly controlled.

Invasive species may be introduced via intentional (e.g. mercy release activities) or unintentional pathways (e.g. through trades and transport of materials) from infested regions (Pyšek & Richardson 2010). The highly invasive Green House Frog (*Eleutherodactylus planirostris*), for example, is known to disperse by eggs attached to cultivated plants and associated materials (Christy et al. 2007, Lee

et al. 2016), while Poeciliids (particularly Swordtail) are aquarium pets commonly released into natural water bodies (Gertzen et al. 2008, ISSG 2008). Both species have successfully invaded areas within and close to the future River Park (GP 2023a). The endemic and endangered Romer's Tree Frog is prone to the presence of invasive species, particularly predatory fish (Lau 1998). Invasive fishes including Mosquito Fish, Guppy and *Xiphophorus* spp. were found to be sympatric with the endangered frog in the lower TCR Catchment. In addition, the invasive Greenhouse Frog, which is suspected to share similar ecological niche with the Romer's Tree Frog due to its tiny size (Lee et al 2016), was also found in the area (GP 2023a).

The establishment of exotic species is also closely linked to the availability of resources, which in turn depends on factors such as human disturbances (Davis et al. 2020). Such species are often fast-growing and more efficient in reproduction, dispersal and resource utilization (Funk and Vitousek 2007, Pyšek and Richardson 2007, van Kleunen et al. 2010), and may colonize newly disturbed grounds more rapidly than native species (Jauni et al. 2015).

Construction of the River Park would induce high degree of disturbance which provide ample opportunity for invasion (e.g. removal of vegetation for channel maintenance or site formation), while planting of cultivated plants (even when they are native) may act as a propagation pathway for such species. The increased flow of visitors also increases the chance of mercy release activities. Proactive control of invasive species should be well-planned and implemented before construction begins.

Tracing of sources, screening and quarantine of any cultivated plants to be transplanted should be carried out. Frequent removal and continuous monitoring of invasive species from all stream sections and riparian habitats should be included in the regular management framework of the River Park. The management authority of the River Park should also actively control visitor behaviour within and beyond opening hours of the facility (see sections below).

Native riparian vegetation along both sides of the stream should be protected as much as possible, with manual selective removal of exotic vegetation instead of large-scale indiscriminate weeding to be conducted.

4.2.3. Careful Programming and Implementation of Construction Work

The restoration of the lower East Stream and establishment of the River Park, although expected to be ecologically beneficial during their operational phases, would inevitably be carried out within or immediately adjacent to the river channel and result in ecological and water quality impacts (e.g. sediments created during the demolition of the concrete bed, construction site run-off, etc.). Prudent work procedures and preventive measures, including but not limited to strict prohibition of works within the channel during wet seasons and proper redirection and treatment of sewage away from the main channel, in addition to those listed in the approved EIA report, should be strictly implemented and monitored.

The concurrent ecological study of TCR catchment suggested that the semi-natural section and the sand trap immediately upstream of the channelised section were important refuges to freshwater fishes of the section, with high abundances and species richness of fishes recorded (GP 2023a).

Some important species were also found within the sand trap and the downstream channelised section. We strongly suggest the inclusion of a walk-through survey for collection of all native aquatic wildlife and important plant species found within the semi-natural section, the sand trap and the channelised section, and translocation of the rescued organisms to suitable habitats before the revitalisation works begin.

Apart from the high diversity of riparian plants recorded in the Conservation Zone in the current study, this section and its nearby areas were found to harbour high number of odonates and herps, with important species included (GP 2023a), and deserve prudent protection. Although only limited facilities are planned within the Conservation Zone, such facilities should also be well designed so that their footprints can be minimized while the hardware is resilient enough to withstand extreme flow and weather conditions to minimize the need for replacement or reconstruction. Any materials used should be non-toxic and as inert as possible to avoid the release of contaminants into the sensitive river system.

4.2.4. Control of Human Disturbances

Although the River Park is designed to be conservation-orientated, it is undeniable that the flow of visitors to river sections with the highest biodiversity recorded would also increase, even when accessibility is limited to certain areas. Escalated human activities in the area will increase hunting and poaching pressure on native fauna, as well as chances of mercy release of exotic animals. Families with children capturing aquatic organisms using small hand nets have been seen in the River Park section, while extensive netting of fishes or other aquatic animals by presumably local people was also observed nearby the estuary. This hunting/collection pressure is particularly influential to species with low population sizes, such as those with conservation concern recorded inside the future River Park (GP 2023a).

Extensive trampling and littering by visitors, or even deliberate alteration of habitats for human use (such as the opening of sitting-out and entertainment areas and building of concrete weirs and paths across natural streams by morning hikers), are expected to intensify along stream sections within and beyond the River Park boundary. This is particularly probable as housing estates and new residential areas are planned next to the River Park. Such human disturbance and alteration not only directly damage the vulnerable river system, but also compromise the conservation benefits hoped to be achieved by the infrastructures.

Apart from setting up warning signages, fencing and restriction in opening hours for crowd control in restricted areas, sufficient 24-hour and real-time CCTVs with instant alert functions should be installed in various stream sections and access points of the River Park. 24-hour manned security posts should be set up at strategic locations (e.g. upstream boundary of the River Park between the Conservation Zone and natural sections further upstream, under Shek Mun Kap Road) while frequent patrolling should be carried out to check improper visitor behaviour. The existing legal framework should also be strengthened such that enforcement against ecologically damaging activities within the River Park could be carried out. Public education regarding the conservation of stream biodiversity should also be provided.

For natural sections beyond the River Park boundary, especially the highly accessible ones designated as Ecologically Important Streams and directly drain into the River Park, should be closely monitored and protected from human disturbance and alteration. The government has authority and responsibility over the surveillance and protection of these sections, especially when the streams and their immediate riparian margins are mostly government lands.

4.2.5. Water Quality Control

Control of the quality of water discharged into the lower East Stream is of utmost importance to the success of the future River Park, as water pollution not only undermines biodiversity, but also poses public health risks, as the authority plans to promote a “water-friendly culture” and allow citizens to enjoy stream water in the future River Park.

Connection of storm drains collecting surface runoff from high pollution risk areas (e.g. villages) to sewerage systems, rectification of land uses covered by conservation zonings, preservation of permeable land coverages as well as a closely-monitored SUDS with a comprehensive backup plan in case of failure, are all vital to the control of quality of water received by the River Park (GP 2023c).

All management practices of TCR and its riparia, including those upstream of and within the River Park, must include ecological considerations. Application of insecticides in natural streams and storm drains for mosquito control, for example, is a common practice carried out by the Food and Environmental Hygiene Department (FEHD). Effective communication and coordination among government departments are essential, and the principles of conserving the TCR ecosystem and promoting public enjoyment should be made clear among departments to avoid actions incompatible with these principles. Discussions on water quality issues of TCR is detailed in Water Quality Study (GP 2023c).

4.2.6. Long-term Monitoring and Regular Evaluation of Management Protocols

It is expected that the River Park would become a sanctuary for wildlife under the scheme of TCNTE, and its effectiveness in conserving the unique biodiversity of TCR should be monitored. It is recommended that the management authority should incorporate long term monitoring of biodiversity in the regular management protocols, and consult ecologists and environmental groups regularly to ensure such protocols continue to be effective in terms of biodiversity conservation during operation, and that any loopholes undermining its efficiency should be plugged through regular evaluation.

4.2.7. Other Habitat Management Considerations

To minimize disturbance to habitats and wildlife inhabiting the River Park, management strategies should be designed in the way that intrusive practices such as desilting could be minimally conducted. In any case that such work is needed, phasing under well-designed work programs instead of large-scale and one-off exercise should be implemented. Such works should also be monitored by qualified ecologists to avoid impacts to wildlife (e.g. bycatch) during the process.

Even for the Revitalisation Zone, which is designed to allow higher degree of public utilization and enjoyment of TCR and may require frequent grass-trimming, rotatory weeding instead of one-off removal of vegetation from large areas should be considered. Managing vegetation in phases provides refuges for wildlife and causes lower impacts to the overall riparian and stream habitats during such disturbances. Works should also be avoided during sensitive breeding seasons of wildlife and at locations inhabited by species of conservation concern.

Acknowledgement

We would like to thank Ho Ching Yuen, Xoni Ma, and Bond Shum for their assistance in the ecological surveys. We are also grateful to the Agriculture, Fisheries and Conservation Department for the issue of permits for the use of light traps.

References

Advisory Council on the Environment (ACE). 2020. Hong Kong Biodiversity Strategy and Action Plan 2016-2021 – Progress of Implementation (ACE Paper 4/2020). Available online: https://www.afcd.gov.hk/english/conservation/Con_hkbsap/bsap_implementation/files/ACE_Paper_4_2020.pdf Accessed in: Oct 2022.

Agriculture Fisheries and Conservation Department (AFCD). 2003. *Rare and Precious Plants of Hong Kong*. AFCD, Friends of the Country Parks, Cosmos Books Ltd., HK.

Burghardt K.T., Tallamy D.W. & Gregory Shriver W. 2009. Impact of native plants on bird and butterfly biodiversity in suburban landscapes. *Conservation biology* 23(1): 219-224.

Chan P.L. 2001. *Sustainability and Biodiversity: The Impact, Alternative Design and Prospects of Restoration of Channelized Lowland Streams in Hong Kong*. PhD Thesis. The University of Hong Kong, HK.

Chong D.H. & Dudgeon D. 1992. Hong Kong stream fishes: an annotated checklist with remarks on conservation status. *Memoirs of the Hong Kong Natural History Society* 19: 79-112.

Christy M.T., Savidge J.A. & Rodda G.H. 2007. Multiple pathways for invasion of anurans on a Pacific island. *Diversity and Distributions* 13(5): 598-607.

Civil Engineering and Development Department (CEDD). 2015. *Planning and Engineering Study on the Remaining Development in Tung Chung - Feasibility Study*. Agreement No. CE 32/2011 (CE).

Clements W.H., Carlisle D.M., Lazorchak J.M. & Johnson P.C. 2000. Heavy metals structure benthic communities in Colorado mountain streams. *Ecological Applications* 10(2): 626-638.

Corlett R.T., Xing F.W., Ng S.C., Chau L.K.C. & Wong L.M.Y. 2000. Hong Kong vascular plants: Distribution and status. *Memoirs of the Hong Kong Natural History Society* 23: 1-157.

Davis M.A., Grime J.P. & Thompson K. 2000. Fluctuating resources in plant communities: a general theory of invasibility. *Journal of Ecology* 88(3): 528-534.

Development Bureau (DevB) & Environmental Bureau (EnB). 2020. Item for Public Works Subcommittee of Finance Committee: 786CL – Tung Chung New Town Extension (PWSC (2020-21)24).

Environmental Protection Department (EPD). 2022. *Annual River Water Quality Report - River Water Quality in Hong Kong in 2020*. Available Online: https://www.epd.gov.hk/epd/sites/default/files/epd/english/environmentinhk/water/hkwqrc/files/waterquality/annual-report/riverreport2020.pdf. Accessed in Oct 2022

Fu K.L. & Chin C.M. 1992. *China Plant Red Data Book - Rare and Endangered Plants*. Science Press, PRC.

Funk J.L. & Vitousek P.M. 2007. Resource-use efficiency and plant invasion in low-resource systems. *Nature* 446(7139): 1079-1081.

Gertzen E., Familiar O. & Leung B. 2008. Quantifying invasion pathways: fish introductions from the aquarium trade. *Canadian Journal of Fisheries and Aquatic Sciences* 65(7): 1265-1273.

Green Power (GP). 2023a. *Ecological Baseline Study of Tung Chung River Catchment (2nd Edition).* Green Power, HK.

Green Power (GP). 2023b. *Evaluation of Partial Stream Water Release Trial at Tung Chung Au Water Intake (2nd Edition).* Green Power, HK.

Green Power (GP). 2023c. *Study on Water Quality of Tung Chung River Catchment (2nd Edition).* Green Power, HK.

Invasive Species Specialist Group (ISSG), IUCN. 2008. *Xiphophorus helleri*. *Global Invasive Species Database*. Available online: http://issg.org/database/species/ecology.asp?si=1270&fr=1&sts=&lang=EN Accessed in: Mar 2021.

Isaacs R., Tuell J., Fiedler A., Gardiner M. & Landis D. 2009. Maximizing arthropod-mediated ecosystem services in agricultural landscapes: the role of native plants. *Frontiers in Ecology and the Environment* 7(4): 196-203.

Island District Council (Island DC). 2020. Meeting Presentation Materials Attachment (19 October 2020). Available online: https://www.districtcouncils.gov.hk/island/doc/2020_2023/en/dc_meetings_doc/18043/IS_2020_120_A_EN.pdf Accessed in: Oct 2022.

IUCN. 2023. *IUCN Red List of Threatened Species.* Available online: https://www.iucnredlist.org/ Accessed in: Jan 2023.

Jauni M., Gripenberg S. & Ramula, S. 2015. Non-native plant species benefit from disturbance: a meta-analysis. *Oikos* 124(2): 122-129.

Jiang Z.G., Jiang J.P., Wang Y.Z., Zhang E., Zhang Y.Y., Li L.L., Xie F., Cai B., Cao L., Zheng G.M., Dong L., Zhang Z.W., Ding P., Luo Z.H., Ding C.Q., Ma Z.J., Tang S.H., Cao W.X., Li C.W., Hu H.J., Ma Y., Wu Y., Wang Y.X., Zhou K.Y., Liu S.Y., Chen Y.Y., Li J.T., Feng Z.J., Wang Y., Wang B., Li C., Song X.L., Cai L., Zang C.X., Zeng Y., Meng Z.B., Fang H.X. & Ping X.G. 2016. Red List of China's Vertebrates. *Biodiversity Science* 24 (5): 500-551.

Kadoorie Farm and Botanic Garden (KFBG). 2019. *Native Fish of Conservation Concern in Hong Kong (Part 2)*. Kadoorie Farm and Botanic Garden, HK.

Laikre L., Schwartz M.K., Waples R.S., Ryman N. & GeM Working Group. 2010. Compromising genetic diversity in the wild: unmonitored large-scale release of plants and animals. *Trends in Ecology & Evolution* 25(9): 520-529.

Lau W.N.M. 1998. *Habitat use by Hong Kong amphibians, with special reference to the ecology and conservation of* Philautus romeri. PhD Thesis. University of Hong Kong, HK.

Lee W.H., Lau W.N.M., Lau A., Rao D. & Sung Y. 2016. Introduction of *Eleutherodactylus planirostris* (Amphibia, Anura, Eleutherodactylidae) to Hong Kong. *Acta Herpetologica* 11(1): 85-89.

Miller S.W., Budy P. & Schmidt J.C. 2010. Quantifying macroinvertebrate responses to in-stream habitat restoration: applications of meta-analysis to river restoration. *Restoration Ecology* 18(1): 8-19.

Moya N., Tomanova S. & Oberdorff T. 2007. Initial development of a multi-metric index based on aquatic macroinvertebrates to assess streams condition in the Upper Isiboro-Sécure Basin, Bolivian Amazon. *Hydrobiologia* 589(1): 107-116.

Naiman R.J., Decamps H. & McClain M.E. 2010. *Riparia: ecology, conservation, and management of streamside communities*. Elsevier, Netherlands.

Negishi J.N., Inoue M. & Nunokawa M. 2002. Effects of channelization on stream habitat in relation to a spate and flow refugia for macroinvertebrates in northern Japan. *Freshwater Biology* 47: 1515-1529.

Ove Arup and Partners Hong Kong Limited (Arup). 2015. *Tung Chung New Town Extension – Environmental Impact Assessment Report* (EIA Register No: AEIAR-196/2016).

Pyšek P. & Richardson D.M. 2008. Traits associated with invasiveness in alien plants: where do we stand? In *Biological invasions* (pp. 97-125).

Pyšek P. & Richardson D.M. 2010. Invasive species, environmental change and management, and health. *Annual Review of Environment and Resources* 35: 25-55.

Resh V.H. & Rosenberg D.M. (Eds.). 1993. *Freshwater biomonitoring and benthic macroinvertebrates*. Chapman & Hall, USA.

Sancho V., Lacomba I., Bataller J.V., Veríssimo J. & Velo-Antón G. 2020. First report of hybridization between *Mauremys leprosa* and *Mauremys sinensis* highlights the risk of exotic Mauremys spp. pet trade. *Basic and Applied Herpetology* 34: 75-81.

Simberloff D. 2010. Invasive species. *Conservation biology for all*: 131-152.

Siu G.L. 2000. Orchidaceae of Hong Kong. *Memoirs of the Hong Kong Natural History Society* 23: 137-148.

Stone M.K. & Wallace J.B. 1998. Long-term recovery of a mountain stream from clear-cut logging: the effects of forest succession on benthic invertebrate community structure. *Freshwater Biology* 39(1): 151-169.

Van Kleunen M., Weber E. & Fischer M. 2010. A meta-analysis of trait differences between invasive and non-invasive plant species. *Ecology letters* 13(2): 235-245.

Wolda H. & Flowers R.W. 1985. Seasonality and diversity of mayfly adults (Ephemeroptera) in a “non-seasonal” tropical environment. *Biotropica* 17: 330-335.

Wu S. & Lee W.T. 2000. Pteridophytes of Hong Kong. *Memoirs of the Hong Kong Natural History Society* 23: 5-20.

Xing F., Ng S.C. & Chau L.K.C. 2000. Gymnosperms and Angiosperms of Hong Kong. *Memoirs of the Hong Kong Natural History Society* 23: 21-136.

Young M. 2005. Insects in flight. In *Insect Sampling in Forest Ecosystems*. pp. 116-145. Blackwell Publishing, UK.

Appendices

Family	Scientific Name	Common Name	Chinese Name
Acanthaceae	*Asystasia micrantha*	-	小花十萬錯
	Dicliptera chinensis	-	狗肝菜
	Hygrophila salicifolia	-	水蓑衣
Acoraceae	*Acorus gramineus*	Grass-leaved Sweet Flag	金錢蒲
Actinidiaceae	*Saurauia tristyla*	-	水東哥
Agavaceae	*Dracaena sanderiana*	Belgium Evergreen	富貴竹
Alangiaceae	*Alangium chinense*	Chinese Alangium	八角楓
Aloeaceae	*Aloe vera*	Chinese Aloe	蘆薈
Amaranthaceae	*Alternanthera paronychioides*	-	星星蝦鉗菜
	Celosia argentea	Wild Coxcomb	青葙
Anacardiaceae	*Rhus chinensis*	Sumac	鹽膚木
	Rhus hypoleuca	Sumac	白背漆
Annonaceae	*Desmos chinensis*	Desmos	假鷹爪
	Uvaria macrophylla	Uvaria	紫玉盤
Apiaceae	*Hydrocotyle sibthorpioides*	Asiatic Pennywort	天胡荽
Araceae	*Alocasia macrorrhizos*	Alocasia	海芋
	Colocasia esculenta	Taro	芋
	Pistia stratiotes	Water Lettuce	大薸
Araliaceae	*Eleutherococcus trifoliatus*	Three-leaved Eleutherococcus	白簕
	Schefflera heptaphylla	Ivy Tree	鵝掌柴
Arecaceae	*Daemonorops jenkinsiana*	Rattan Palm	黃藤
Asclepiadaceae	*Tylophora ovata*	Ovate Tylophora	娃兒藤
Asteraceae	*Acmella uliginosa*	-	沼生金鈕扣
	Ageratum conyzoides	Billygoat-weed	勝紅薊
	Bidens alba	-	白花鬼針草
	Chrysanthemum coronarium	Crown Daisy	艾菜
	Conyza sumatrensis	-	蘇門白酒草
	Eclipta prostrata	Eclipta	鱧腸
	Emilia sonchifolia	Tassel Flower	一點紅
	Mikania micrantha	Mile-a-minute Weed	薇甘菊
	Sigesbeckia orientalis	Shrimp Claw Plant	豨薟
	Sonchus arvensis	Field Sow-Thistle	苣荬菜
	Spilanthes paniculata	Gold Button	金鈕扣
	Tridax procumbens	Tridax	羽芒菊
	Wedelia biflora	-	雙頭菊
	Wedelia trilobata	-	三裂葉蟛蜞菊
	Youngia japonica	Hawk's Beard	黃鵪菜
Basellaceae	*Anredera cordifolia*	Cordate-leaved Anredera	落葵薯
Begoniaceae	*Begonia cucullata* var. *hookeri*	Perpetual Begonia	四季秋海棠
Blechnaceae	*Blechnum orientale*	Oriental Blechnum	烏毛蕨

Information masked in the public version of the report

Appendix 1. Maximum relative abundance (no. of individuals of woody plants +: 1-10; ++: 11-30; +++: 31 or above; areal coverage of herbs: +: 1-10%; ++: 11-30%; +++: 31% or above) of plant species recorded along various transects between 2018 and 2022. Highlighted rows denote exotic species.

Family	Scientific Name	Common Name	Chinese Name
Brassicaceae	*Cardamine flexuosa*	Bitter Cress	彎曲碎米薺
	Nasturtium officinale	Water Cress	西洋菜
	Rorippa indica	-	蔊菜
Cactaceae	*Hylocereus undatus*	Night-blooming Cereus	量天尺
Caesalpiniaceae	*Bauhinia championii*	Champion's Bauhinia	龍鬚藤
	Bauhinia corymbosa	Camel's Foot	首冠藤
	Bauhinia glauca	Climbing Bauhinia	羊蹄甲藤
	Bauhinia sp.	-	羊蹄甲屬
	Bauhinia variegata	Camel's Foot Tree	宮粉羊蹄甲
	Caesalpinia crista	Wood Gossip Caesalpinia	華南雲實
	Senna tora	Sickle Senna	決明
Caprifoliaceae	*Viburnum odoratissimum*	Sweet Viburnum	珊瑚樹
Caricaceae	*Carica papaya*	Papaya	番木瓜
Celastraceae	*Celastrus hindsii*	Chinese Bitter-sweet	青江藤
Chloranthaceae	*Sarcandra glabra*	Sarcandra	草珊瑚
Clusiaceae	*Garcinia oblongifolia*	Lingnan Garcinia	黃牙果
Commelinaceae	*Commelina diffusa*	Diffuse Day-flower	節節草
	Floscopa scandens	Climber Floscopa	聚花草
Convolvulaceae	*Ipomoea aquatica*	Water Spinach	蕹菜
	Ipomoea cairica	Gairo Morning Glory	五爪金龍
	Ipomoea obscura	-	小心葉薯
	Ipomoea triloba	-	三裂葉薯
	Merremia umbellata	Umbellate Merremia	山豬菜
Cucurbitaceae	*Benincasa hispida* var. *chieh-qua*	Hairy Gourd	節瓜
Cuscutaceae	*Cuscuta chinensis*	Chinese Dodder	兔絲子
Cyperaceae	*Cyperus compressus*	Compressed Galingale	扁穗莎草
	Cyperus involucratus	Umbrella Plant	風車草
	Cyperus rotundus	Nut-grass Glaingale	香附子
	Cyperus sp.	-	莎草屬
	Fimbristylis dichotoma	Dichotomous Fimbristylis	兩歧飄拂草
	Fimbristylis sieboldii	Rust-coloured Fimbristylis	鏽鱗飄拂草
	Fuirena umbellata	Umbrella Fuirena	芙蘭草
	Hypolytrum nemorum	Wooded Hypolytrum	割雞芒
	Kyllinga nemoralis	Uni-spike Kyllinga	單穗水蜈蚣
	Kyllinga polyphylla	Aromatic Kyllinga	水蜈蚣
	Pycreus flavidus	Globular Spike Pycreus	球穗扁莎
	Schoenoplectus sp.	-	水蔥屬
	Scleria ciliaris	Ciliate Razorsedge	緣毛珍珠茅
Daphniphyllaceae	*Daphniphyllum calycinum*	-	牛耳楓
Dilleniaceae	*Tetracera asiatica*	Sandpaper Vine	錫葉藤
Dioscoreaceae	*Dioscorea bulbifera*	Air Potato	黃獨
Elaeagnaceae	*Elaeagnus loureirii*	-	羅氏胡頹子
Equisetaceae	*Equisetum debile*	Frail Horsetail	纖弱木賊

Information masked in the public version of the report

Appendix 1 (con't). Maximum relative abundance (no. of individuals of woody plants +: 1-10; ++: 11-30; +++: 31 or above; areal coverage of herbs: +: 1-10%; ++: 11-30%; +++: 31% or above) of plant species recorded along various transects between 2018 and 2022. Highlighted rows denote exotic species.

Family	Scientific Name	Common Name	Chinese Name
Euphorbiaceae	*Alchornea trewioides*	Christmas Bush	紅背山麻桿
	Antidesma bunius	Chinese Laurel	五月茶
	Aporusa dioica	Aporosa	銀柴
	Bischofia javanica	Autumn Maple	秋楓
	Breynia fruticosa	Waxy Leaf	黑面神
	Bridelia tomentosa	Pop-gun Seed	土蜜樹
	Euphorbia hirta	Garden Spurge	飛揚草
	Euphorbia hypericifolia	Milk Spurge	通奶草
	Glochidion hirsutum	Thick-leaved Abacus Plant	厚葉算盤子
	Glochidion zeylanicum	Hong Kong Abacus Plant	香港算盤子
	Macaranga tanarius	Elephant's Ear	血桐
	Mallotus paniculatus	Turn-in-the-wind	白楸
	Phyllanthus reticulatus	Reticulated Leaf-flower	小果葉下珠
	Phyllanthus tenellus	-	纖梗葉下珠
	Phyllanthus urinaria	Night-closing Leaf	葉下珠
	Sapium discolor	Mountain Tallow Tree	山烏桕
	Sapium sebiferum	Chinese Tallow Tree	烏桕
	Vernicia montana	Wood-oil Tree	木油樹
Fabaceae	*Clitoria ternatea*	Butterfly Pea	蝶豆
	Crotalaria pallida var. *obovata*	Smooth Crotalaria	豬屎豆
	Dalbergia benthamii	Bentham's Rosewood	兩廣黃檀
	Dalbergia hancei	Scandent Rosewood	藤黃檀
	Desmodium heterocarpon	False Groundnut	假地豆
	Desmodium reticulatum	Distinct-nerved Tick Clover	顯脈山綠豆
	Desmodium tortuosum	Beggarweed	南美山螞蝗
	Desmodium gangeticum	Big-leaved Desmodium	大葉山螞蝗
	Macroptilium lathyroides	One-leaved Clover	大翼豆
	Pueraria phaseoloides	Wild Kudzu Vine	三裂葉野葛
	Tadehagi triquetrum	Triquetrous Tadehagi	葫蘆茶
	Pueraria montana	Montane Kudzu	葛麻姆
Flacourtiaceae	*Scolopia chinensis*	Chinese Scolopia	刺柊
Gnetaceae	*Gnetum luofuense*	Luofushan Joint-fir	羅浮買麻藤
Haloragaceae	*Myriophyllum aquaticum*	-	粉綠狐尾藻
Lauraceae	*Cassytha filiformis*	Cassytha	無根藤
	Cinnamomum camphora	Camphor Tree	樟
	Litsea glutinosa	Pond Spice	潺槁樹
	Litsea monopetala	Persimmon-leaved Litsea	假柿木薑子
	Litsea rotundifolia var. *oblongifolia*	Oblong-leaved Litsea	豺皮樟
Lemnaceae	*Lemna minor*	Lesser Duck-weed	浮萍
Liliaceae	*Asparagus cochinchinensis*	Wild Asparagus	天門冬
Lygodiaceae	*Lygodium japonicum*	Climbing Fern	海金沙
	Lygodium scandens	Scansorial Climbing Fern	小葉海金沙
Lythraceae	*Rotala rotundifolia*	Round-leaved Rotala	圓葉節節菜

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Appendix 1 (con't). Maximum relative abundance (no. of individuals of woody plants +: 1-10; ++: 11-30; +++: 31 or above; areal coverage of herbs: +: 1-10%; ++: 11-30%; +++: 31% or above) of plant species recorded along various transects between 2018 and 2022. Highlighted rows denote exotic species.

Family	Scientific Name	Common Name	Chinese Name
Malvaceae	*Hibiscus tiliaceus*	Cuban Bast	黃槿
	Urena lobata	Aramina	肖梵天花
Melastomataceae	*Melastoma malabathricum*	Common Melastoma	野牡丹
Meliaceae	*Melia azedarach*	China-berry	苦楝
Menispermaceae	*Cocculus orbiculatus*	Snail Seed	木防己
	Diploclisia glaucescens	Glaucescent Diploclisia	蒼白秤鉤風
	Hypserpa nitida	Shining Hypserpa	夜花藤
	Pericampylus glaucus	Pericampylus	細圓藤
	Stephania longa	Long Stephania	翼箕篤
Mimosaceae	*Acacia auriculiformis*	Ear-leaved Acacia	耳果相思
	Acacia pennata	Snake Acacia	羽葉金合歡
	Albizia corniculata	Corniculate Albizia	天香藤
	Archidendron clypearia	Monkey-pod	猴耳環
	Leucaena leucocephala	White Popinac	銀合歡
	Mimosa diplotricha	-	巴西含羞草
	Mimosa pudica	Sensitive Plant	含羞草
Moraceae	*Broussonetia kaempferi* var. *australis*	Climbing Broussonetia	藤構
	Ficus fistulosa	Common Yellow Steg-fig	水同木
	Ficus hirta	Hairy Fig	粗葉榕
	Ficus hispida	Opposite-leaved Fig	對葉榕
	Ficus microcarpa	Chinese Banyan	細葉榕
	Ficus pumila	Creeping Fig	薜荔
	Ficus pyriformis	Pear-fruit Fig	舶梨榕
	Ficus subpisocarpa	Japanese Superb Fig	筆管榕
	Ficus variegata	Common Red-stem Fig	青果榕
	Ficus variolosa	Varied-leaf Fig	變葉榕
	Morus alba	White Mulberry	桑
Musaceae	*Musa* x *paradisiaca*	Common Banana	蕉
Myrsinaceae	*Ardisia crenata*	Hilo Holly	朱砂根
	Ardisia quinquegona	Asiatic Ardisia	羅傘樹
	Embelia ribes	White-flowered Embelia	白花酸藤子
	Maesa perlarius	-	鯽魚膽
Myrtaceae	*Cleistocalyx nervosum*	Lidded Cleistocalyx	水翁
	Syzygium jambos	Rose Apple	蒲桃
Oleaceae	*Ligustrum sinense*	Chinese Privet	山指甲
Onagraceae	*Ludwigia erecta*	-	美洲水丁香
	Ludwigia hyssopifolia	-	草龍
	Ludwigia octovalvis	Primrose Willow	毛草龍
Orchidaceae	*Goodyera procera*	Tall Rattlesnake-plantain	高斑葉蘭
	Spiranthes sinensis	Ladies Treeses	綬草
Oxalidaceae	*Oxalis corniculata*	Sorrel	酢漿草
	Oxalis corymbosa	Lavender Sorrel	紅花酢漿草

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Family	Scientific Name	Common Name	Chinese Name	
Pandanaceae	*Pandanus austrosinensis*	-	露兜草	Information masked in the public version of the report
	Pandanus tectorius	Screw Pine	露兜樹	
Parkeriaceae	*Ceratopteris thalictroides*	Water Fern	水蕨	
Passifloraceae	*Passiflora foetida*	Passion Flower	龍珠果	
Poaceae	*Apluda mutica*	Glutene-rice Grass	水蔗草	
	Bambusa sp.	-	簕竹屬	
	Bothriochloa bladhii	Australian Bluestem	臭根子草	
	Brachiaria mutica	Blunt Signal-grass	巴拉草	
	Centotheca lappacea	Common Centotheca	假淡竹葉	
	Coix lacryma-jobi	Job's Tears	薏苡	
	Cynodon dactylon	Couch Grass	狗牙根	
	Cyrtococcum patens	-	弓果黍	
	Digitaria sp.	-	馬唐屬	
	Echinochloa sp.	-	稗屬	
	Eleusine indica	Goose Grass	牛筋草	
	Eragrostis atrovirens	Thalia Lovegrass	鼠婦草	
	Eragrostis sp.	-	畫眉草屬	
	Imperata cylindrica var. *major*	Lalang Grass	大白茅	
	Isachne globosa	Globose Zo-sasa	柳葉箬	
	Ischaemum spp.	-	鴨嘴草屬	
	Leersia hexandra	Club Head Cutgrass	李氏禾	
	Lophatherum gracile	Common Lophantherum	淡竹葉	
	Melinis repens	Redtop	紅毛草	
	Microstegium ciliatum	Ciliate Microstegium	剛莠竹	
	Miscanthus floridulus	Many-flowered Silvergrass	五節芒	
	Miscanthus sinensis	Chinese Silvergrass	芒	
	Neyraudia reynaudiana	Burma-reed	類蘆	
	Panicum brevifolium	Panic Grass	短葉黍	
	Panicum maximum	Guinea Grass	大黍	
	Panicum repens	Panic Grass	鋪地黍	
	Paspalum scrobiculatum var. *orbiculare*	Ditch Millet	圓果雀稗	
	Phragmites vallatorius	Reed	卡開蘆	
	Pogonatherum crinitum	Golden-hair Grass	金絲草	
	Setaria palmifolia	Palm-grass	棕葉狗尾草	
	Sporobolus fertilis	Australian Smut-grass	鼠尾粟	
	Thysanolaena latifolia	Tiger-grass	粽葉蘆	
Polygonaceae	*Persicaria barbata*	Hairy Knotweed	毛蓼	
	Persicaria chinensis	Smartweed	火炭母	
	Persicaria perfoliata	Spiny Knotweed	杠板歸	
	Persicaria pubescens	Pubescent Knotweed	伏毛蓼	
Polypodiaceae	*Pyrrosia adnascens*	Tongue-fern	貼生石韋	
Portulacaceae	*Talinum paniculatum*	Mock Ginseng	土人參	

Appendix 1 (con't). Maximum relative abundance (no. of individuals of woody plants +: 1-10; ++: 11-30; +++: 31 or above; areal coverage of herbs: +: 1-10%; ++: 11-30%; +++: 31% or above) of plant species recorded along various transects between 2018 and 2022. Highlighted rows denote exotic species.

Family	Scientific Name	Common Name	Chinese Name	
Pteridaceae	*Pteris biaurita*	Biauriculate Brake	狹眼鳳尾蕨	Information masked in the public version of the report
	Pteris ensiformis	Sword Brake	劍葉鳳尾蕨	
	Pteris semipinnata	Semi-pinnated Brake	半邊旗	
	Pteris vittata	Ladder Brake	蜈蚣草	
Rhamnaceae	*Ventilago leiocarpa*	Smooth-fruited Ventilago	翼核果	
Rosaceae	*Rhaphiolepis indica*	Hong Kong Hawthorn	車輪梅	
Rubiaceae	*Hedyotis corymbosa*	Corymbose Hedyotis	傘房花耳草	
	Hedyotis hedyotidea	White Ox Creeper	牛白藤	
	Mussaenda pubescens	Splash-of-white	玉葉金花	
	Paederia scandens	Chinese Fevervine	雞矢藤	
	Psychotria asiatica	Wild Coffee	九節	
	Psychotria serpens	Creeping Psychotria	蔓九節	
	Spermacoce remota	-	光葉豐花草	
	Spermacoce stricta	Narrow-leaved Borreria	豐花草	
Rutaceae	*Acronychia pedunculata*	Acronychia	山油柑	
	Clausena lansium	Wampi	黃皮	
	Tetradium glabrifolium	Melia-leaved Evodia	楝葉吳茱萸	
	Toddalia asiatica	Lopez Root	飛龍掌血	
	Zanthoxylum avicennae	Prickly Ash	簕欓花椒	
	Zanthoxylum nitidum	Shiny-leaved Prickly Ash	兩面針	
Sapindaceae	*Dimocarpus longan*	Longan	龍眼	
	Litchi chinensis	Lychee	荔枝	
Scrophulariaceae	*Lindernia crustacea*	Brittle False Pimpernel	母草	
	Lindernia pusilla	Slender-stemmed False Pimpernel	細莖母草	
	Lindernia rotundifolia	-	圓葉母草	
	Veronica undulata	Speedwell	水苦蕒	
Smilacaceae	*Heterosmilax japonica*	-	肖菝葜	
	Smilax china	Greenbrier	菝葜	
Solanaceae	*Physalis angulata*	Ground Cherry	燈籠果	
	Solanum americanum	Shining-fruit Nightshade	少花龍葵	
	Solanum torvum	Wild Tomato	水茄	
Sterculiaceae	*Byttneria grandifolia*	Spiny-fruited Vine	刺果藤	
	Sterculia lanceolata	Lance-leaved Sterculia	假蘋婆	
Theaceae	*Eurya nitida*	Shining Eurya	細齒葉柃	
Thelypteridaceae	*Cyclosorus interruptus*	Interrupted Tri-vein Fern	間斷毛蕨	
	Cyclosorus parasiticus	Wood-fern	華南毛蕨	
Thymelaeaceae	*Aquilaria sinensis*	Incense Tree	土沉香	
Tiliaceae	*Microcos nervosa*	Microcos	布渣葉	
Ulmaceae	*Celtis sinensis*	Chinese Hackberry	朴樹	
Urticaceae	*Boehmeria nivea*	Ramie	苧麻	
	Boehmeria nivea var. *tenacissima*	Virid-leaved Boehmeria	青葉苧麻	
	Pilea microphylla	Artillery Clearweed	小葉冷水花	

Appendix 1 (con't). Maximum relative abundance (no. of individuals of woody plants +: 1-10; ++: 11-30; +++: 31 or above; areal coverage of herbs: +: 1-10%; ++: 11-30%; +++: 31% or above) of plant species recorded along various transects between 2018 and 2022. Highlighted rows denote exotic species.

Family	Scientific Name	Common Name	Chinese Name
Verbenaceae	*Lantana camara*	Lantana	馬纓丹
	Vitex negundo var. *cannabifolia*	-	牡荊
Vitaceae	*Vitis balanseana*	Little-fruited Grape	小果葡萄
Zingiberaceae	*Alpinia hainanensis*	Hainan Galangal	草豆蔻
	Alpinia stachyodes	Dense Bract Galangal	密苞山薑
	Alpinia zerumbet	Shell Ginger	豔山薑
	Hedychium coronarium	Ginger Lily	薑花
Total no. of species recorded			**259**

Information masked in the public version of the report

Appendix 1 (con't). Maximum relative abundance (no. of individuals of woody plants +: 1-10; ++: 11-30; +++: 31 or above; areal coverage of herbs: +: 1-10%; ++: 11-30%; +++: 31% or above) of plant species recorded along various transects between 2018 and 2022. Highlighted rows denote exotic species. * denote sections of study reaches excluding the 50-m transects.

Order	Family	Scientific Name	English Common Name	Chinese Common Name	Information masked in the public version of the report
Anabantiformes	Osphronemidae	*Macropodus opercularis*	Paradise Fish	叉尾鬥魚	
Beloniformes	Adrianichthyidae	*Oryzias curvinotus*	Rice Fish	弓背青鱂	
Cichliformes	Cichlidae	*Coptodon zillii*	Redbelly Tilapia	齊氏非鯽	
		Hemichromis stellifer	Jewel Cichlid	點紋半麗魚	
		Oreochromis niloticus	Nile Tilapia	尼羅口孵非鯽	
Cypriniformes	Cobitidae	*Misgurnus anguillicaudatus*	Oriental Weatherfish	泥鰍	
	Cyprinidae	*Acrossocheilus beijiangensis*	Beijiang Thick-lipped Barb	北江光唇魚	
		Barbodes semifasciolatus	Chinese Barb	五線無鬚鮈	
		Carassius auratus	Goldfish	鯽	
		Cirrhinus molitorella	Mud Carp	鯪	
		Cyprinus carpio	Common Carp	鯉	
		Hypophthalmichthys nobilis	Big-head Carp	鱅	
		Parazacco spilurus	Predaceous Chub	異鱲	
	Gastromyzontidae	*Liniparhomaloptera disparis*	Broken-band Hillstream Loach	擬平鰍	
		Pseudogastromyzon myersi	Sucker-belly Loach	麥氏擬腹吸鰍	
	Nemacheilidae	*Schistura fasciolata*	Striped Loach	橫紋南鰍	
Cyprinodontiformes	Poeciliidae	*Gambusia affinis*	Mosquito Fish	食蚊魚	
		Poecilia reticulata	Guppy	孔雀花鱂	
		Xiphophorus hellerii	Swordtail	劍尾魚	
		Xiphophorus variatus	Variable Platyfish	雜色劍尾魚	
Gobiiformes	Eleotridae	*Eleotris oxycephala*	Sharphead Sleeper	尖頭塘鱧	
	Gobiidae	*Glossogobius giuris*	Fork Tongue Goby	舌鰕虎魚	
	Oxudercidae	*Gobiopterus macrolepis*	Glass Goby	大鱗鰭鰕虎魚	
		Rhinogobius duospilus	White-cheeked Goby	溪吻鰕虎魚	
		Rhinogobius similis	Amur Goby	真吻鰕虎魚	
		Stiphodon multisquamus	Scaly Neon Goby	多鱗枝牙鰕虎魚	
		Tridentiger trigonocephalus	Chameleon Goby	紋縞鰕虎魚	
Mugiliformes	Mugilidae	*Mugil cephalus*	Grey Mullet	鯔	
		Planiliza subviridis	Greenback Mullet	綠背鮻	
Perciformes	Gerreidae	*Gerres macracanthus*	Longspine Silver-biddy	大棘銀鱸	
	Kuhliidae	*Kuhlia marginata*	Dark-margined Flagtail	黑邊湯鯉	
Siluriformes	Clariidae	*Clarias fuscus*	White-spotted Walking Catfish	鬍鯰	
	Siluridae	*Pterocryptis anomala*	Nim	糙隱鱨鯰	
Spariformes	Sparidae	*Acanthopagrus schlegelii*	Blackhead Seabream	黑棘鯛	
Synbranchiformes	Synbranchidae	*Monopterus albus*	Swampy Eel	黃鱔	
Total no. of species				**35**	

Appendix 2. Maximum relative abundance (in ordinals: +: 1; ++: 2-10; +++: 11 or above) of freshwater fishes recorded along the three study reaches during wet and dry seasons in 2018-19 and 2021-22. Highlighted rows indicate exotic species. RP-1 in this table refers to the lower section downstream of the sand trap. For full list of species recorded along the study reaches between 2018-2022 in a parallel study please refer to Green Power (2023a).