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新西兰流域综合管理规划概况及对中国实践的启示

THE INTEGRATED CATCHMENT MANAGEMENT PLAN IN NEW ZEALAND AND THE ENLIGHTENMENT TO CHINA'S PRACTICE

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摘要

中国当前编制的流域规划多从水利角度出发，针对流域防洪、水资源优化配置等提出总体战略要求，尺度较大，编制范围广。而针对城市尺度，对城市内涝、水体污染等城市水系统问题的细化分析、技术策略、实施方案等尚未充分纳入现有流域规划体系，未建立针对城市水体中小流域的综合管理方法。本文通过研究新西兰汉密尔顿市等城市流域综合管理规划案例，对新西兰流域综合管理规划的理念、定位、目标、编制要点及执行手段等进行梳理，包括其跨行政区域的流域综合管理机制、流域规划综合目标与技术体系、与城市长期发展规划协同编制和纳入资源许可管控要求等从筹划到落实的一系列核心工作；并结合中国城市水系统综合治理的现状和重点问题，以及流域规划亟待补充的重要内容，尤其是与城市关系密切的中小尺度流域综合规划方法，提出了针对中国实践的建议与启示。

关键词

新西兰；流域；流域综合管理规划；城市水系统问题

ABSTRACT

China's current catchment planning often focuses on formulating overall strategies for flood control and water resource distribution from a perspective of water conservancy. Usually, such plans are developed at large scales, covering a huge territory. However, city-scaled analyses, technical strategies, or roadmaps responding to issues of urban flooding, water pollution, etc. are less integrated into the current catchment planning; there is also an absence of comprehensive management methods for medium- or small-scaled urban water bodies. Combing with a case study on integrated catchment management plans (ICMP) for the Hamilton City, New Zealand, this paper reviews and summarizes the idea, role, objectives, key sections, and implementation of ICMPs in New Zealand, including a series of core tasks ranging from the trans-administrative catchment management mechanism, comprehensive and operational objectives and the technical system to the integration with long-term urban planning and Resource Consent requirements. In view of the status quo and major problems in China's comprehensive management of urban water systems, as well as the gaps in the existing formulation and implementation of catchment planning, especially the absence of integrated planning methods for medium- or small-scaled catchments that have a more direct and stronger relation with urban development, New Zealand's experience in ICMP preparation and implementation reflects a paradigm significance.

KEYWORDS

New Zealand; Catchment; Integrated Catchment Management Plan; Issues of Urban Water System

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EDITED AND TRANSLATED BY　Tina TIAN

1 研究背景

1.1 中国典型流域规划概述

中国自20世纪50年代开始，对黄河、长江、珠江、海河、淮河等河流先后开展了流域规划的编制和多轮修编工作。一般而言，中国当前的流域规划尺度较大，涉及区域范围广，规划重点针对水资源优化配置、流域防洪防潮、水系生态环境整治和保护、水利设施配套建设等方面提出总体战略部署，以明确江河水系功能定位、流域空间开发时序、城市开发建设范围、城市与江河水系的关系、河道流量与防洪要求、水质与水土流失防治要求等。部分流域规划主要针对江河本身的治理和开发，偏重于干—支流梯级和水库群的布局，以及防洪、发电、航运等功能的开发；还有的以流域水利开发为目标，重点包括水资源的调度利用、水土资源的平衡，及水土保持等[1]；此外，为落实《水污染防治行动计划》等要求，提高流域水环境质量，中国多个流域也在持续开展水污染防治规划，以确定相关目标及重点工作。

以黄河流域为例，中国水利部于2013年发布了《黄河流域综合规划（2012–2030年）》，明确规定了黄河的防洪（防凌）标准、设防流量、防凌库容、平滩流量、地表水用水量、地表水耗水量、地下水开采量、万元工业增加值用水量、大中型灌区灌溉水利用系数、水质目标、COD入河量、氨氮入河量、河道内生态环境用水量和断面下泄水量共计14项控制指标。规划构建了完善的水沙调控、防洪减淤、水土流失综合防治、水资源合理配置和高效利用、水资源和水生态保护，以及流域综合管理等“六大体系”[2]，但由于黄河流域范围极广，对沿线城市仍然缺少系统且深入的问题评估和具体的方案策略。

1 Research Background

1.1 Overview of Typical Catchment Planning in China

Since the 1950s, China has worked out catchment planning or planning revisions for major rivers including the Yellow River, Yangtze River, Pearl River, Haihe River, and Huaihe River. Basically, China’s current catchment planning focuses on large-scaled rivers that cover extremely wide territories, with main goals of improving the distribution of water resources, preventing floods, protecting catchment ecosystems, and building supporting water infrastructure, so as to enhance or redefine catchment services, spatial construction priorities, urban development territory, interactions between cities and rivers, river flow and flooding control requirements, and water quality and erosion control requirements. A number of such planning efforts are developed to respond to the issues of ecological remediation and development in catchments, particularly on the layout of main stream-tributary system and reservoirs and service enhancement in flooding control, waterpower, shipping, etc. Meanwhile, some catchment plannings are formulated for water conservancy and development through management and utilization of water resources, as well as water-soil conservation[1]. Furthermore, to improve water quality of catchments as required by the Act of Water Pollution Prevention and Control, China has launched a series of water pollution control and remediation plans in different regions across the country, to formulate relevant objectives and key tasks.

In the case of the Yellow River Basin, for example, the Ministry of Water Resources of China issued the Yellow River Catchment Comprehensive Planning (2012-2030) in 2013, which clearly stipulates the requirements of 14 indicators, namely flood (and ice-jam flood) prevention, security volume, ice-prevention storage capacity, volume in alluvial plains, surface water consumption, surface water loss, groundwater consumption, and the water consumption of industrial value increase per RMB 10,000, irrigation utilization coefficients of large- and medium-sized irrigation areas, water quality improvement objectives, COD inflows, ammooinacal nitrogen inflows, water consumption of river ecosystem, and section discharge volume. The planning also established six systems: water and sediment regulation, flood control and siltation reduction, comprehensive prevention and control of erosion, distribution and utilization of water resources, protection of water resources and ecosystems, and integrated catchment management[2]. However, due to the majestic scale of the entire basin, there is still an absence of systematic assessment and specific resolutions to each city or town along the Yellow River.

1.2 中国城市水系统面临的挑战

由于传统的开发建设模式在土地开发前对城市洪涝风险、水质污染情况、生态评估干扰情况等方面的分析深度和系统性不足，中国大量城市在快速城镇化过程中未能有效协调城市发展与流域水系统保护之间的关系，导致新、老城区都出现了不同程度的水问题（如水环境污染加剧、水资源过度消耗、内涝风险增加、生态环境恶化等），严重影响了城市的可持续发展。

近年来，各级政府和社会公众对城市水系统的综合整治越发关注，海绵城市建设、黑臭水体治理等专项工作快速推进。《关于推进海绵城市建设的指导意见》《城市黑臭水体治理攻坚战实施方案》《城镇污水处理提质增效三年行动方案（2019–2021年）》等相关国家政策文件的出台，体现出国家层面对城市及周边范围内水体综合整治的重视和决心；同时，大量城市在城市雨水系统、污水系统、合流制系统建设，以及河道治理等方面也取得了初步成效。

另一方面，很多城市水体由于跨越不同行政管辖区域，其管理责任和边界仍需进一步明确。在技术层面，城市水体系统整治涉及城镇雨水系统、污水系统与合流制系统的完善与改造提升、城市洪涝综合防治、不同水体水质标准体系的构建、城市内生物栖息地和湿地的保护等重点内容，这些工作都需要基于流域尺度进行综合目标统筹、规划协同并制定综合方案。

然而，虽然目前中国水利部门编制的流域规划已逐步纳入城市生态修复、城市内涝防治、海绵城市建设等城市水环境相关内容，但并未涉及从城市建成区的汇水分区和流域关系上详细分析评估不同区域水体的水质、水量标准，城市雨水地表径流通道和洪涝淹没风险区域，排水系统改造策略和水资源分配等核心问题，难以形成切实可行、清晰明确的实施方案与计划。当前，中国住房与城乡建设部要求各城市针对水系统问题编制排水防涝专项规划、海绵城市专项规划、水系规划等各专项规划，但由于编制时序、管理主体不同等原因，各

1.2 Challenges in China's Urban Water Systems

Because traditional development and construction modes often do not include important preparations such as assessments of flood risk, water pollution, and disturbance on catchment ecosystems, many Chinese cities fail to coordinate urban development and ecological protection in catchments during rapid urbanization, resulting in a series of water problems in both new urban development and downtown areas, such as increased water pollution, water over-consumption, increased risk of flooding, and ecosystem deterioration, largely impeding these cities' agenda of sustainability.

In recent years, governments at all levels, as well as Chinese citizens, have paid attention to the comprehensive remediation and improvement of urban water systems and introduced initiatives and projects such as sponge city construction and treatment of malodorous water bodies. China's central government has issued a series of policies, including the Sponge City Construction Technology Guidelines, Roadmaps for Treatment of Malodorous Water Bodies in Urban Areas, Action Plan for Improving the Quality and Efficiency of Urban Sewage Treatment (2019-2021), to promote the comprehensive remediation and improvement of water bodies in urbanized areas and environs. Such projects in many cities have begun to take effects in the improvement of urban rainwater systems, sewage systems, combined sewer systems, and river management.

Meanwhile, in China, the stewardships and administrative jurisdictions of urban water bodies still need to be clarified or redefined. At the technical level, the remediation of urban water system should often give priorities to the improvement of urban rainwater, sewerage, and combined sewer systems; comprehensive control of urban flooding; formulation of water quality standards for varied water bodies; protection of urban habitats and wetlands, all of which require comprehensive, integrated, and synergic planning efforts at catchment scales.

Currently, urban water initiatives (such as urban ecological restoration, urban waterlogging prevention, and sponge city construction) have been increasingly integrated into the current catchment planning formulated by China's government agencies in water conservancy. However, the planning has less reflected specific assessments on varied standards of water quality and quantity in different regions by examining the relationship of catchment and subcatchments in urban built-up areas; urban runoff paths and the areas prone to flooding; drainage system improvement strategies and water resources distribution. It is therefore difficult to develop practicable detailed plans or roadmaps. Furthermore,

专项规划又普遍缺乏目标及方案的综合衔接，部分内容甚至出现矛盾冲突，难以系统指导工程实施。因此，建立基于城市尺度的流域综合管理方法对城市水系统问题的统筹应对极为重要。

1.3 城市流域规划需重点解决的问题

基于上述分析，城市尺度的流域规划需要重点解决的问题主要涵盖以下几点：

1）在很多情况下，城市内涝会受到山洪暴发、流域洪水、海潮及河道水位顶托或满溢等多方面因素的影响，即每个城市的排水系统与流域水系之间均存在着复杂的相互影响关系，无法在城市内部分割洪与涝的联系并分而治之[3]，而应基于整个流域的视角构建针对城市洪水与城市内涝的综合防治策略。

2）城市水质与上游水质情况密切相关，例如，浙江省嘉兴市地处杭嘉湖东部平原的下游，拥有丰富的过境水资源，外来客水量是本地水资源量的三倍以上[4]，其城市地表水环境质量与境外客水状况密切相关。如果忽略流域上下游关系，一味对城市内部水体提出高水质要求，很有可能造成过度投资且收效甚微。需要根据流域内不同区域的水体条件和功能需求提出针对性的水质要求，综合分析城市雨水径流污染、合流制溢流污染、污水直排等不同污染源的占比，根据具体城市条件提出针对性污染综合控制策略。

3）在相关部门的协调层面上，城市水系统问题涉及与城市规划、水务、水利、城建、环保等多部门的衔接协作，不同部门间的信息传达、综合管理决策与执行体系的构建也更为复杂。

the Ministry of Housing and Urban-Rural Construction of China now requires city governments to draw up subject plans for drainage and flooding prevention, sponge city construction, and urban water system construction. However, due to the uncoordinated planning sequence and the variety of stewardship subjects, there is a general lack of combination between planning objectives and specific schemes — conflicts or discrepancies are even found in some plans — making it difficult to guide the planning implementation. Therefore, city-scaled integrated catchment management methods are significant to address urban water system problems synergically.

1.3 Major Issues to Be Addressed in Urban Catchment Planning

To sum up, the major issues to be addressed in catchment planning at a city scale include as follows:

1) Quite often urban flooding are impacted by mountain torrents, floods in upper streams, tides, water levels of rivers, etc. In other words, a city's drainage system and its catchment(s) complicatedly relate and interact with each other, and therefore either of them cannot be managed or remediated separately[3]. It is necessary to establish an integrated prevention and control strategy against urban flooding at catchment scales.

2) The water quality of urban water bodies is closely impacted by that of upper reaches. For example, Jiaxing City, Zhejiang Province is located in the lower reaches of the eastern plain of Hangjia Lake, and has abundant passing-by water resource that is at least as three times large as local water resources in amount[4], which means that the quality of urban surface water is greatly defined by passing-by water resource. The neglect of the upstream-downstream interaction in a catchment would lead to difficulties in water quality improvement and a poor investment-return. It is necessary to formulate different water quality requirements for specific water conditions and various service demands. It is equally important to well understand the proportion of different pollution sources such as urban rainwater runoff pollution, combined sewer overflow pollution, and un-treated sewage discharge, in order to develop integrated pollution control strategies for varied urban scenarios.

3) Urban water system problems should be addressed through effective coordination among various government agencies, ranging from urban planning, water affairs, water conservancy to urban development and environmental protection, where information exchange, as well as the establishment of a comprehensive management decision-making and action system, is complicatedly multi-related.

1.4 案例研究

部分中国学者已对美国、欧洲等地区的流域综合管理与规划案例开展了较多研究，例如欧洲莱茵河和多瑙河的跨国界河流综合管理，美国田纳西河流域的“多层次、多部门”综合管理等，其研究重点多集中于流域规划的综合目标协调、立法与管理制度建设、监测与评估方法、公众参与机制等方面[5][6]，而对于城市内部与城市建设发展关系密切的跨行政区域的中小尺度流域综合管理案例的研究相对较少。本文将通过介绍新西兰流域综合管理规划（ICMP）并分析城市开发建设与流域综合管理的关系，为中国基于流域规划对城市水系统问题进行综合统筹的相关实践提供借鉴。

2 ICMP提出的背景、定位及综合目标体系

2.1 ICMP提出的背景

新西兰自然资源丰富，以山地丘陵地貌为主，水系发达，其城市开发建设与流域水系的关系极为密切。20世纪三四十年代，新西兰开始逐渐认识到城市开发对环境污染、洪涝等问题的影响，在新西兰环境部于1941年颁布的《水土保持和河道控制法》中首次提出了应以自然流域边界对水系统进行综合管理，并于1943年在马纳瓦图成立了第一个流域管理委员会[7]。1991年，新西兰国会通过了《自然资源管理法》，为江河、海洋等自然资源的利用及环境管理制定了法律框架，详细规定了各级政府在保护自然环境资源方面的职责与任务[8]。鉴于统筹考虑水系统上下游的水质、水量的必要性，各级政府逐渐提高了对流域综合管理的理念的重视程度，并提出按照自然流域边界制定ICMP的要求。

ICMP是一套水系统综合规划与管理方法，其以自然流域为单元，分析城市发展引起的土地利用变化对水系统的潜在影响，将流域水文学、工程学、生态学等不同学科相结合，以解决雨水系统问题为核心，并衔接雨水、污水、供水等相关水系统。各级政府以ICMP为依据制定城市规划方案，保障城市的可持续发展。以新西兰汉密尔顿市ICMP为例，其编制范围即汉密尔顿市涉及的主要河道的自然流域边界，超出了汉密尔顿市的行政管理边界（图1）。

值得注意的是，ICMP不仅针对水系统问题，还涉及生态、娱乐、景观、遗产和文化保护等其他相关问题[9]。

1.4 Case Study

Chinese scholars have carried out research on the comprehensive catchment management and planning in advanced regions such as the United States and European countries — for example, the River Rhine and Danube in Europe have been managed within a trans-national framework; the Tennessee Valley in the United States has been managed in a multi-level and multi-sectoral method. Such research focuses more on the coordination of management objectives; the establishment of legislative and management systems; monitoring and evaluation methods; and public participation mechanisms[5][6]. However, medium- or small-scaled, cross-administrative management cases where catchment management is closely related to urban development are less studied. This paper introduces the integrated catchment management plan (ICMP) in New Zealand and analyze the relationship between urban development and integrated catchment management, so as to offer reference for China's practice in comprehensively addressing urban water system issues through approaches of catchment planning.

1. 新西兰汉密尔顿市城市行政管理边界与ICMP边界示意

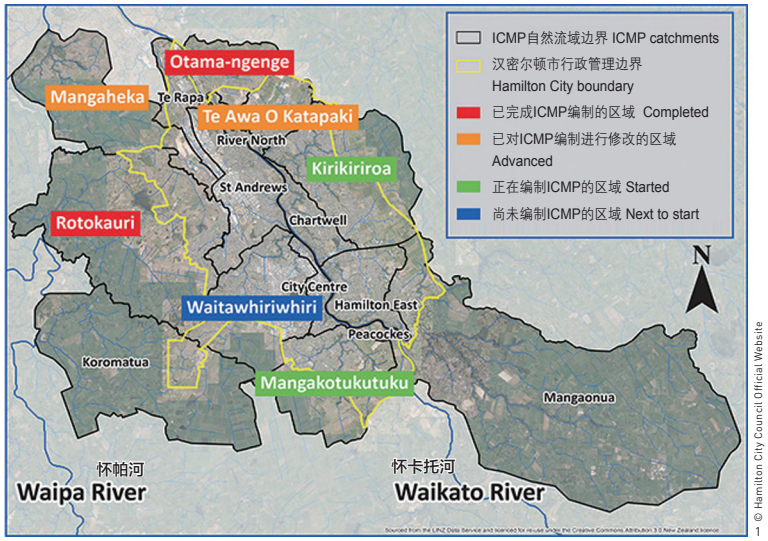
1. The administrative boundary of the Hamilton City and the ICMP catchments

2 The Background, Role, and Comprehensive Objective System of ICMP

2.1 The Background of ICMP

New Zealand enjoys rich natural resources and is known for its hilly topography and interconnected water systems, where urban construction is hand-in-hand with catchment development. In the 1930s and 1940s, New Zealand began to realize the pollution, flooding, and other problems resulted from urban development. In the Soil Conservation and Rivers Control Act issued in 1941 by the Ministry for the Environment, New Zealand, the idea of comprehensive water system management at a scale of natural catchment was proposed; the first national catchment management committee was founded in Manawatu in 1943[7]. In 1991, the New Zealand Parliament approved the Resource Management Act which serves as a legal framework for the utilization and management of natural resources such as rivers and oceans by stipulating the responsibilities and targets of governments at all levels in protecting natural resources[8]. In view of the fact that the water quality and quantity in upper or lower reaches of a catchment should be coordinated as a whole, the idea of integrated catchment management has been more and more emphasized by all governments across the country, putting forward that ICMP will be developed based on natural catchment boundaries.

ICMP is a comprehensive water system planning and management method that focuses on natural catchments and analyzes potential impacts of land use changes on water systems



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2.2 ICMP的定位

新西兰针对自然资源（包括河流、土壤、海洋等）综合管理的相关法规和规划主要分为三个层面：国家法律层面、大区政府的政策与规划层面，以及地方政府指定的地区规划及其他规定层面[8]。其中，各大区政府以国家《自然资源管理法》为纲要，通过制定大区政策概要与大区规划来进行区域自然资源的管理；在大区规划的指导下，各市、区地方政府又进一步制定地区规划，落实城市对资源管理的具体要求，并根据特定区域条件制定更为详细的建设规划，并纳入地区规划之中。同时，任何具有一定规模的土地开发或工程项目，均需要申请资源许可证，以综合限制土地开发建设对自然环境的影响。在此法律与规划框架下，ICMP的作用主要体现在以下两方面：

1）支撑地区规划、建设规划及城市长期规划。城市的具体开发建设主要依托地区规划与建造规划，而城市长期规划则主要确定城市的发展方向、重要基础设施建设项目与资金安排。ICMP从流域水系统综合管理的视角，提出对城市土地开发利用与建设发展的相应要求，并将相关水系统建设项目与实施计划纳入城市长期规划中[10]。

2）支撑资源许可的申请。新西兰资源许可制度主要用于在城市建设中，对自然资源进行合理的保护、修复与利用。申请资源许可证的土地开发或工程建设项目，在递交申请时，通常需要编制相关控制方案，以保证其土地开发或施工过程达到政府对相关资源的控制要求。

during urban development by combining different disciplines such as Hydrology, Engineering, and Ecology, to improve urban rainwater system while facilitating the integration of stormwater, wastewater, and portable water systems. Each government is asked to develop urban planning with its ICMP to ensure urban sustainability. For example, the ICMP of the Hamilton City, New Zealand covers the catchment territory of its natural river network that is much beyond the administrative boundary of the city (Fig. 1).

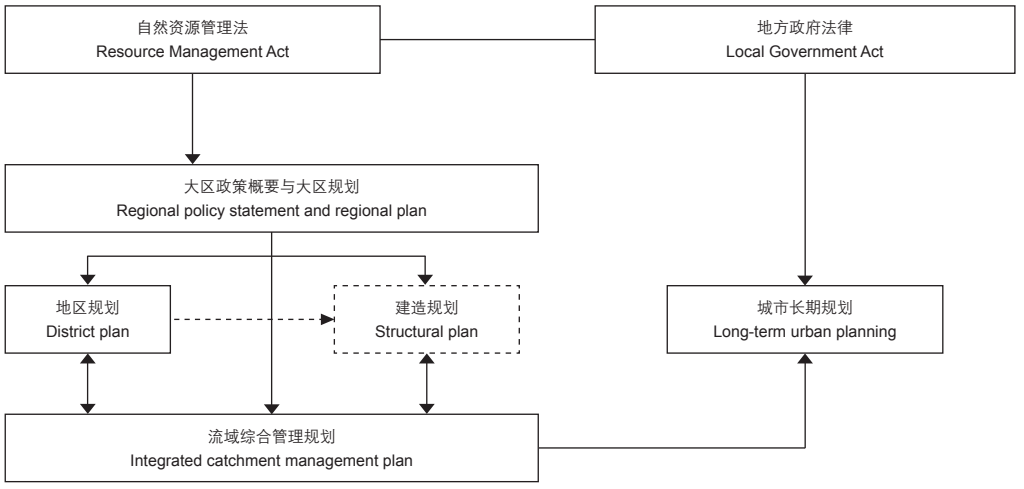
It is worth noting that ICMP not only addresses issues of water systems, but also covers ecological, recreational, and landscape management, as well as heritage and cultural protection[9].

2.2 The Role of ICMP

New Zealand's regulations and plans for the integrated management of natural resources (e.g., rivers, soil, oceans, etc.) are developed at three government levels, including national laws, regional policies and plans, and local planning and related standards[8]. Particularly, regional policy statements and plans of natural resource management are formulated according to the National Resource Management Act; and, upon the regional plans, local governments are asked to develop district plans to guide urban resource management and to conduct structural plans for specific implementation that in turn might be part of district plans. At the same time, in Zelanian cities, for an overall control of the environmental impact of land development, all land development and engineering projects of a certain scale are asked for Resource Consent application. Under such a legalization and planning framework, ICMP plays a significant role in the following two aspects:

1) Supporting district planning, structural planning, and long-term urban development planning. The former two are used to guide specific urban development and construction, while the latter is used to navigate urban development and inform important infrastructure projects and funding allocation. For the integrated water system management at a catchment scale, ICMPs stipulate the requirements for urban land use and construction and incorporate water system construction projects and implementation plans into urban long-term planning[10].

2) Supporting Resource Consent application. In New Zealand, Resource Consent is issued for a better protection, restoration, and utilization of natural resources during urban construction. Land development or engineering projects that are asked for a resource consent application require preparations of detailed management plans to guarantee the development or construction process meets corresponding requirements



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2. ICMP在新西兰规划体系中的关系示意

2. New Zealand's ICMP system

部分区域政府要求编制ICMP作为雨水排放许可申请的支撑文件；部分地区由于流域面积较大，编制ICMP需要较长的周期，可将ICMP作为许可颁发时必要的附属条件。

2.3 ICMP的综合目标体系构建

ICMP的目标体系主要可分为战略目标和实施目标两个层级。其中，战略目标主要是指结合国家及地方相关法律政策、大区规划及政策、城市发展战略等，提出ICMP的总体目标。实施目标即为具体分项指标，用于进一步指导地区规划或建设规划。

以新西兰汉密尔顿市为例，其所涉及流域的ICMP中战略目标主要包括地表水系统保护、陆地生态系统保护、雨洪管理、污水管理、供水管理、“三水”管理6个部分（表1），其中地表水系统保护、雨洪管理、“三水”管理的主要要求与城市雨水的控制利用直接相关[11]。

实施目标的制定以战略目标为指导。以汉密尔顿市下属的孟嘎赫卡子流域（流域面积为2 080hm^2）为例，其实施目标主要包括维持或提升河流水质、减少对自然水文循环的改变、水敏感性措施应用、提升河滨生态品质、提升洪涝防治能力、减少水资源的消耗和污水排放、综合水系统管理、文化保护、经济性与安全性等（表2）[11]。

表1：汉密尔顿市ICMP战略目标
Table 1: Strategic objectives for Hamilton City's ICMPs

战略目标 Strategic objectives	主要要求 Description
地表水系统保护 Protection of freshwater ecosystems	维持、保护并提升地表水生态系统和自然排水系统，保护重要的湿地等水生态敏感区域 Maintain, protect, and enhance freshwater ecosystems and natural drainage systems; protect ecologically sensitive areas of significant values such as wetlands
陆地生态系统保护 Protection of terrestrial ecosystems	维持、保护并提升本土生物多样性、陆地生态功能和生物栖息地 Maintain, protect, and enhance indigenous biodiversity, terrestrial ecosystems, and fauna habitats
雨洪管理 Stormwater management	需要结合低影响设计理念，尽可能减少不透水面积，鼓励应用雨水径流源头控制措施，减少对下游的不利影响，主要包括：1）受纳水体的水量与水质影响；2）洪涝风险的影响；3）地下水水位的影响；4）地表水体自然基流的影响 Encourage and enable low impact design, reduce impermeable surfaces where possible, utilize on-lot treatment devices to minimize adverse effects on downstream on: 1) receiving water bodies in terms of quantity and quality of stormwater discharges; 2) locations and communities subject to flood hazards; 3) groundwater levels; 4) baseflows for freshwater systems
污水管理 Wastewater management	旱季的污水溢流应消除，雨季的合流制溢流应尽可能减少 Dry weather overflows are prevented and wet weather overflows are minimized
供水管理 Portable water management	供水应满足现状及未来的生活、商业、工业需求 Water supply is planned and provided to meet existing and future domestic, commercial, and industrial water demands
“三水”管理 Three-Waters management	城市雨水、污水、供水的综合管理 Integrated management of urban stormwater, wastewater, and portable water

3 ICMP的编制要点

ICMP的主要编制内容包括流域现状分析、问题分析与规划目标、最佳措施优选、实施规划等。下文将详细阐释各部分的编制要点。

3.1 流域现状分析

3.1.1 土地利用

包括对流域范围内历史、现状及规划土地利用情况，以及主要交通情况的分析。

表2：汉密尔顿市孟嘎赫卡流域ICMP实施目标
Table 2: Operational objectives for Hamilton City Council's ICMPs for Mangaheka

实施目标 Operational objectives	主要要求 Description
维持或提升孟嘎赫卡河道水质 Maintain or enhance Mangaheka Stream water quality	1）河道水质及底泥标准应满足《澳大利亚及新西兰淡水与海水水质标准（2000）》中的相关要求 2）雨水处理设施的悬浮物去除率需达到平均75%以上，针对道路雨水径流处理设施需进一步满足烃类及重金属的去除要求 3）需避免下游水体的温度上升，净化湿地处理设施的植被覆盖率需达到80%以上 4）若单一水质控制设施无法满足要求，则应构建设施处理链，以满足污染物净化与温度处理要求 1) In-stream water quality and sediment are referred with ANZECC 2000（Australian and New Zealand Guidelines for Fresh and Marine Water Quality） 2) Stormwater treatment devices must achieve at least 75% sediment removal on average; devices serving road should be suitable for the removal of hydrocarbons and heavy metals 3) To avoid increases in temperature in downstream receiving waterways; wetland vegetation cover must exceed 80% of the device surface area 4) Where it is shown that a single device will not address receiving environmental sensitivities, a treatment train approach should be adopted and to minimize temperature effects and maximize contaminant removal
减少对自然水文循环的改变 Minimize alterations to natural flow regimes	1）通过源头雨水径流控制措施、集中调节设施等，减少雨水排放对河道侵蚀、生物栖息地的影响，控制径流水质 2）雨水排口末端排至受纳水体前，应建设延时调节设施，控制雨水径流外排的流量、流速、体积等，相关指标需达到汉密尔顿市基础设施技术标准的要求 3）雨水排口处均应设置相应的消能与侵蚀防护设施 1) Measures such as on-lot treatment / detention shall be required to mitigate bed erosion and the impact on fauna habitat and to minimize runoff pollution 2) Extended detention shall be provided at discharge locations to control flow volume, velocity, and scale, refer to the HCC ITS 3) Energy dissipation and erosion protection measures are provided at all discharge locations
水敏感性措施应用 Utilize water sensitive practices	1）在场地土壤等条件允许的情况下，需对雨水径流进行断接处理 2）水敏感性措施应用需形成完整的处理链 1) Where on-lot and soil conditions allow, stormwater shall be discharged directly to ground via soakage 2) A treatment train approach of "water sensitive practices" shall be adopted
提升河滨生态 Promote riparian ecology	需建设滨河植被缓冲区域与生态岸线 Riparian planting and eco-engineered banks shall be encouraged
提升洪涝防治能力 Improve flood protection level	1）针对积水内涝区域，要求其100年一遇的径流峰值流量削减到开发前的70% 2）识别暴雨下的地表径流路径与洪涝风险区域，并以此指导建筑布局等 1) Where existing flooding is known, peak flow management is generally required with reduction to 70% of predevelopment flow for the 100-year storm event 2) The use of property for overland flow paths and floods shall be avoided
减少水资源的消耗和污水排放 Minimize water consumption and wastewater discharge	1）增加雨水利用 2）雨污水管网的运营维护管理，减少渗漏、混接等问题 1) Increase rainwater re-use 2) Infrastructure operation and maintanence to minimize inefficiencies such as leakage and illicit discharge
综合水系统管理 Integrated water management	城市水系统的管理及规划设计均需综合考虑城市雨水、污水、供水的衔接关系 Plan and implement networks of stormwater, wastewater, and portable water in urban water system management
文化保护 Protect cultural values	保护自然本土植物与文化敏感区域 Protect native eco-sourced plant species and areas of cultural sensitivity
经济性与安全性 Economic affordability and safety	1）综合考虑控制设施的全生命周期费用 2）设施的设计需要满足相关安全性要求 1) Stormwater management systems are cost-efficient during long-term operation and maintenance 2) Stormwater management systems are designed for public safety

in resource utilization and protection. Sometimes regional governments are asked to prepare ICMPs as supplementary documents for the application of Stormwater Discharge Consent; to the regions in a large-scale catchment, when the preparation of ICMP takes a relatively longer period of time, development and construction projects can conduct ICMPs as one of the Conditions of the Consent.

2.3 The Comprehensive Objective System of ICMP

The ICMP objective system consists of strategic objectives and operational objectives. Strategic objectives (or overall goals) are often determined according to relevant national and local laws and policies, regional plans and policies, urban development strategies, etc. Operational objectives refer to specific indicators or standards that are used to guide district planning or construction planning.

Concentrating on the case of Hamilton City, New Zealand, this paper introduces six ICMP strategic objectives, namely protection of freshwater ecosystems, protection of terrestrial ecosystems, stormwater management, wastewater management, portable water management, and Three-Waters management (Table 1). In particular, the requirements in protection of freshwater ecosystem, stormwater management, and Three-Waters management are closely related to urban rainwater control and utilization[11].

Hamilton City's ICMP operational objectives are formulated upon these strategic objectives. In the Mangaheka catchment (covering an area of 2,080 hm^2), for example, its implementation objectives include maintaining / enhancing stream water quality; minimizing alterations to natural flow regimes; utilizing water sensitive practices; promoting riparian ecology; improving flood protection level; minimizing water consumption and wastewater discharge; integrated water management; cultural protection; and economy affordability and safety (Table 2)[11].

3 Key Sections of ICMP

The ICMP key sections include Catchment Description, Issues and Objectives, Best Practices Options, and Implementation Plan. Formulation details of each section are presented as below.

3.1 Catchment Description

3.1.1 Land Use

This includes reviews and analysis of the history, current status, planned land use, and traffic conditions of a certain catchment.

3.1.2 自然环境

包括地形、水系、水文地质、土壤及水土侵蚀、水质及水量等自然环境条件的分析。其中，水质分析内容主要包括：1）污染土地分析（基于历史及现状土地利用分析，对其当前的土地污染风险及对未来土地利用变化可能产生的影响进行分析）；2）主要水系的底泥污染情况分析；3）主要水系的水质情况分析；4）雨水径流污染、合流制溢流污染等水系主要污染源的污染负荷分析。上述分析将为ICMP后续水质控制目标及措施的选择提供依据。水量分析主要包括：1）洪涝风险分析（基于模型模拟，从积水深度和时间两个方面对现状及未来土地利用条件下的不同区域的洪涝风险进行分析）；2）侵蚀风险分析（对土地变化引起的排水流量、体积及流速的变化对河道产生的侵蚀风险进行分析）；3）地表径流途径分析（基于现状及未来土地利用情况，识别在100年一遇暴雨条件下的地表径流路径，以此指导土地利用规划）。

3.1.3 价值分析

包括流域范围内水生、陆生及滨河生物多样性及生态价值分析、历史及文化价值分析、娱乐及景观效益分析、经济效益分析。

3.1.4 现状水系统设施分析

结合其他相关规划，对流域范围内河道水系、雨水系统、污水系统、供水系统的现状和规划条件进行分析。

3.2 问题分析与目标设定

基于对流域现状的分析，确定流域内不同子汇水区面临的主要问题，同时结合大区规划及各地区规划的相关要求，提出ICMP的战略目标及各子汇水区的实施目标。可根据ICMP中设定的不同实施目标对战略目标能否实现的影响程度，并结合不同区域具体条件设定相应评分分值与标准，通过综合评分来判断不同子汇水区的重要性及实施优先级（表3）[12]。

3.3 最佳措施优选

ICMP中针对具体问题和目标制定相应控制措施，一般包括雨水管理、污水管理、供水管理、水系整治四大类。首先，各城市在其ICMP中制定不同类型措施适用的总体原则，并基于各区域具体控制目标，设定相应措施的设计标准、相关参数和应用条件，构建综合措施数据库，进而针对流域范围内不同区域的具体实施条件，进行最佳措施的优选，并对应用的控制措施从环境、经济、社会等方面进行综合效益评估。表4所示为汉密尔顿市孟嘎赫卡流域ICMP中针对雨水管理的相关措施应达到的技术标准要求[11]。

表3：ICMP中不同子汇水区优先级评分设置示例
Table 3: Subcatchment scoring criteria in ICMP

目标 Objectives	指标 Indicators	分值 Score	评分标准 Scoring guide
子汇水区 Subcatchment	开发程度 Developed extent	0 ~ 5	0=完全未开发 5=完全开发 0 = no development 5 = 100% development
水质 Water quality	污水溢流量 Wastewater overflows	0 ~ 5	0=无溢流 5=高溢流（溢流量大于5 000m^3/年，同时溢流频次高于4次/年） 0 = none 5 = high (5,000 m^3 per annum with 4 events per year)
	水体微生物量 Microbial level	0 ~ 3	0=低微生物量 3=高微生物量 0 = high water quality (low bug counts) 3 = low water quality (high bug counts)
	水体化学污染物含量 Chemical contaminants	0 ~ 4	0=无 4=高含量 0 = none 4 = high
	水体对游泳的适用性 Water quality for swimming	0 ~ 5	依据环保部门的指导手册 Based on beach guidelines by the Ministry for the Environment
	对海洋生态的影响 Impacts on marine ecology	0 ~ 4	0=无影响 4=显著影响 0 = no impacts 4 = significant impacts
水量 Water quantity	对洪涝的影响 Impacts on flooding	0 ~ 5	0=无影响 5=显著影响 0 = no impacts 5 = significant impacts
便利设施/娱乐/景观 Amenity / community	便利设施/娱乐/景观价值 Amenity / recreational use	0 ~ 5	0=无价值 5=高价值 0 = no recreational use 5 = high recreational use
文化 Cultural	文化价值 Cultural values	0 ~ 5	0=无价值 5=高价值 0 = no cultural value or sensitivity 5 = high cultural value or sensitivity

3.1.2 Natural Setting

It analyzes natural and environmental conditions such as topography, water system, hydrogeology, soil and erosion, and water quality and quantity. In particular, water quality analysis covers: 1) land pollution (current pollution risk assessments and possible impacts by land use changes through historical and current land use studies); 2) sediment pollution in main water systems; 3) water quality of main water systems; 4) pollution load of main pollution sources such as rainwater runoff pollution and combined sewer overflow pollution. Such analyses would inform the determination of water quality objectives and the selection of control measures. Water quantity analysis covers: 1) flooding risks assessments (of different areas

表4：汉密尔顿市孟嘎赫卡流域ICMP雨水管理技术标准示例
Table 4: An example of Hamilton City Council's ICMPs under HCC ITS

区域雨水径流控制 **Catchment stormwater runoff control**	**标准** **Requirements**
应用延时调节设施 Extended detention	调节容积为1.2倍的水质控制容积 依照汉密尔顿市基础设施技术标准，水质控制容积对应设计降雨量为24mm 1.2 × the water quality volume Water quality volume is assessed using 24 mm (24 as per HCC ITS)
雨水径流排放水质控制 **Stormwater runoff water quality control**	**标准** **Requirements**
悬浮物 SS	长期平均去除率应达到75%以上 75% removal on a long-term average basis
氨氮 Ammooinacal nitrogen	应低于0.88g/m^3 Less than 0.88 g/m^3
温度 Temperature	低于23℃，对受纳水体温度的影响不应超过3℃ ＜ 23 ℃; existing water temperature charge of no more than 3 ℃
雨水径流排放量控制 **Stormwater runoff volume control**	**标准** **Requirements**
洪涝控制 Flooding control	依据下游排水系统的排放能力，场地雨水排放系统设计标准为两年一遇和10年一遇 100年一遇暴雨条件下，开发后外排径流峰值流量应削减至开发前的70% Attenuation of 2-and 10-year events may be required on-lot depending on the design of the downstream device Peak flow management is required with reduction to 70% of predevelopment flow for the 100-year storm event
受纳水体水质 **Water quality of receiving water body**	**标准** **Requirements**
浊度 NTU	雨水排入后，受纳水体浊度不大于25NTU No greater than 25 NTU
颜色 Color	下游无显著变化 No conspicuous changes in downstream
溶解氧 COD	不低于饱和溶解氧的80% Greater than 80% of saturation concentration

in existing and future land use conditions based on modeling simulation in flooding depth and inundation hours); 2) erosion risks assessments (of the variety in discharge capacity, volume, and velocity caused by land use changes); 3) overland flow paths (that are identified through simulation of 100-year storm events upon current and future land use studies, to guide land use planning).

3.1.3 Value Analysis

It includes analysis of aquatic, terrestrial, and riparian biodiversity and ecological values, historical and cultural values, recreational and landscape benefits, and economic benefits within the entire catchment.

3.1.4 Existing Water System Facility Analysis

It analyses existing conditions and planned scenarios of river system, stormwater system, wastewater system, and portable water system through a combination with other relevant plans.

3.2 Problem Finding and Objective Determination

Upon Catchment Description, main problems of each subcatchment can be identified; then, according to the requirements in regional plans and district plans, ICMP strategic objectives, as well as operational objectives for each subcatchment, are determined. The important level and implementation priority of various subcatchments can be determined by evaluating the influence degree of each operational objectives on the realization of strategic objectives, together with the scoring criteria for varied conditions in different areas (Table 3)[12].

3.3 Best Practices Options

ICMP also needs to select control measures to address specific problems and to accomplish corresponding objectives. Basically, options of best practice include stormwater management, wastewater management, portable water management, and water system remediation. First, each city formulates ICMP general guidelines applicable to different types of measures; then, on account of specific control targets, facility design standards, parameters, and application scenarios are determined and a database of all kinds of measures is established; finally, best practices options are selected for specific implementation situations in different subcatchments and comprehensive benefit assessments (e.g., environmental, economic, social, etc.) of the selected measures are conducted. The technical standards of different stormwater management measures in the ICMP of the Mangaheka catchment in Hamilton are summarized in Table 4[11].

3.4 实施

ICMP的实施主要通过以下几种方式：

1）将相关要求纳入资源许可。ICMP本身并非新西兰法定规划，因此，大量地区采取将ICMP纳入资源许可支撑材料或附属文件的方式赋予其法律效力，进而将其相关要求落实到地区规划、建设规划、城市长期规划等法定规划中。

2）纳入地方法律。在新西兰地方政府法律的指导下，很多城市会编制地方专项法规。例如，奥克兰市制定了地方雨水法律，其将ICMP中针对城市雨洪管理的相关要求纳入考量，并以法律的形式加以落实。

3）教育与培训。需要对ICMP涉及的政府相关管理部门进行内部培训，以保证政府在资源许可审批等环节能审查其是否达到相关控制要求，并保障不同部门间的协调衔接。同时需要对开发商、民众等进行外部培训，并通过相关网站宣传及网络在线问题解答等形式，促进ICMP的推广和科学编制。

4）监测与评估。在编制ICMP后，通常还应编制相应的监测计划，对相应技术设施的控制效果（例如区域水量、水质控制效果等）进行监测、评估和反馈，及时调整并推进ICMP相关要求的落实。

4 总结与启示

4.1 ICMP重要特征总结

流域综合管理是一项复杂的系统工程，涉及到雨水、污水、供水等综合水系统问题，同时也涉及与生态、景观、文化等的衔接，以及跨区域的综合管理机制构建的问题。从新西兰ICMP的基本编制要求，以及汉密尔顿等城市的应用和执行情况看，ICMP的重要特征包括：

1）从汉密尔顿市孟嘎赫卡流域的ICMP看，通过以流域为单元，对水系统相关问题进行全面分析，是确定汉密尔顿市城市范围内的水系统整治责任边界、控制目标和核心任务的重要方法。

3.4 Implementation

Common approaches in ICMP implementation include:

1) Incorporating related requirements as part of Resource Consent. Technically, ICMP is not statutory in New Zealand. In many districts, its legal validity is obtained by being considered supporting or supplementary documents for Resource Consent application, so as to guarantee the implementation of relevant requirements into statutory plans such as regional plans, construction plans, and long-term urban plans.

2) Incorporating into local laws. Upon New Zealand's Local Government Act, many cities have developed their own regulations for local practices. For example, the City of Auckland has established its Stormwater Bylaw that integrates with the ICMP requirements on urban stormwater management and enforces the implementation.

3) Education and training. Government agencies involved in the ICMP implementation are asked for professional training to ensure officials can be proficient in Resource Consent examination and approval and to guarantee different agencies working in coordination with each other. At the same time, public education for developers and citizens is also necessary, commonly in forms of online learning, FAQ, etc., facilitating the promotion and application of ICMPs and strengthening the planning scientism and rationality.

4) Monitoring and evaluation. As part of ICMPs, monitoring plans are also required to monitor and evaluate the performance of control measures (for example, in regional water amount and quality), which also help inform, adjust, and improve the ICMP standards or requirements of such measures.

4 Summary and Enlightenment

4.1 Summary of ICMP Key Points

Integrated catchment management is systematic and complex that not only covers integrated water system management of stormwater, wastewater, portable water, etc., but also stresses the coordination with ecological, landscape, and cultural management, as well as the establishment of comprehensive management mechanism across administrative jurisdictions. Learnt from New Zealand's ICMP experience, especially the application and implementation by the City of Hamilton, ICMP key points can be summarized as followings:

1) In Hamilton City's ICMP for the catchment of Mangaheka, a comprehensive analysis of water system issues within the entire catchment plays a crucial role in the determination of the accountability, objectives, and primary tasks of water system remediation in the city of Hamilton.

2）以城市区域为核心规划管理范围。从ICMP的规划目标和编制内容可以看出，其主要以城市区域为核心，更多侧重于应对城市范围内的雨水、污水等水系统问题，制定相应的控制目标和技术策略，并进一步对城市每个相关子流域的关键指标和技术要求进行明确细化。而针对涉及的非城市区域（天然河道、湿地、林地等），主要内容即为对生态和文化敏感空间、水体水质等制定相关保护要求。

3）准确的规划定位和严格的配套执行机制。ICMP直接作用于地区规划、建设规划和城市长期规划，保障了规划的实施；同时，ICMP可直接服务于资源许可，纳入到地块开发的管理流程中，为ICMP的执行提供了法定依据。例如，2011年，惠灵顿大区政府授予惠灵顿市政府雨水排放许可，要求惠灵顿市政府在10年内编制完成并实施ICMP，需覆盖惠灵顿市雨水排放许可涵盖的所有流域[12]。

4）强调城市雨洪管理及其相关问题的综合衔接。城市雨水系统的综合管理几乎是ICMP最为重要的核心内容。一方面可能由于新西兰污水系统、河道水质和生态保护的管理水平已经较高，对城市雨水系统问题的解决已成为近年来的重要发展方向；另一方面，城市开发导致的自然水文循环破坏是引发城市洪涝、水体污染、河道侵蚀和冲刷等众多问题的本质原因。因此，从恢复自然水文循环的角度来说，城市雨水系统的综合管理也是流域综合管理的核心内容。在此基础上，还需综合衔接城市供水、污水处理、生态保护等其他相关系统，共同实现综合目标。

5）多个利益相关方的综合协调。要解决城市发展过程中面临的流域综合问题，除了雨水管理、污水处理等技术层面的发展外，首先应培养包括政府管理者、决策者、工程技术人员等专家、开发商、普通民众等利益相关方的流域综合管理理念。没有各方对流域综合管理的一致理解和配合，很难构建出完善的流域综合管理体系。

2) Urban areas are hotspots in catchment planning and management. ICMP objectives and sections target more on urban areas, concentrating on addressing water system problems by developing control aims and technical strategies on urban stormwater management and wastewater treatment and stipulating criterion of key indicators and techniques. Meanwhile, for non-urban areas (e.g., natural rivers, wetlands, forests, etc.), ICMPs focus on developing requirements for the protection of ecologically / culturally sensitive spaces, and the improvement or control of water quality and water quantity.

3) Clarifying planning purposes and establishing supporting implementation mechanism. ICMPs can greatly help the implementation of district plans, construction plans, and long-term urban plans. Also, ICMPs are used for Resource Consent approval and incorporated into the management of land development, providing a legalization and enforcing the implementation of ICMPs. For example, in 2011, the Greater Wellington Region Council consented the Wellington City Council on stormwater discharge on the premise that the Wellington City Council shall complete and implement its ICMPs in ten years for all the catchments where stromwater discharge is consented[12].

4) Emphasizing the coordination and synergy between stormwater management and other urban management realms. Integrated management of urban stormwater systems is the core of ICMPs. On one hand, since New Zealand has achieved a high level in sewage system management, water quality control, and ecological protection, stormwater system issues have attracted an increasing attention in urban development agendas in recent years. On the other hand, the impact of urban development on natural hydrological processes has aggravated urban waterlogging and flooding, water pollution, river erosion and soil loss, etc. The reasons together lead the integrated management of urban stormwater system, as a means of hydrological restoration, crucial to integrated catchment management, upon which all the objectives can only be achieved through a combination with systems in urban water supply, wastewater treatment, and ecological protection.

5) Coordination among multiple stakeholders. The stakeholders in catchment management usually include government officials, policy makers, experts (such as engineers), developers, and ordinary citizens. In addition to the technical advance in stormwater management and wastewater treatment, increasing stakeholders' awareness of integrated catchment management is also important. Without stakeholders' ideological and operational support, integrated catchment systems would collapse sooner or later.

4.2 对中国流域规划的启示

结合中国城市水系统综合治理的现状和重点问题，以及流域规划编制、实施过程中亟待补充的重要内容，尤其针对与城市关系密切的中小尺度流域综合规划方法，新西兰ICMP的编制和实施都有重要的借鉴意义。

1）在中国现有流域综合规划的基础上，应进一步针对城市区域开展城市雨水、污水、合流制相关水系统问题的专项分析，并协调城市排水防涝综合规划、海绵城市建设专项规划等，制定一致的流域综合控制目标、技术策略和措施。

2）建立统筹功能需求和适应地方实施条件的流域综合水质目标体系。目前，《地表水环境质量标准（GB3808–2002）》作为国家层面的水质控制标准，在地方执行的过程中，需要在梳理流域上下游水质关系以及生态、水文等需求的基础上，形成适用于本地条件的流域分级水质标准体系，以更经济、科学、可持续地指导后续城市水环境治理工作。

3）加强流域内洪水风险和城市内涝风险的综合分析。从近年来城市洪涝问题发生的特征来看，城市开发建设过程中对于城市竖向、重要调蓄空间和径流通道的保护与有效利用不足，是加剧洪涝问题的重要原因。建立基于流域上下游与泛洪区域系统分析的城市洪涝统筹控制方案是城市流域规划的核心工作。

4）协同城市发展要求，将相关目标纳入城市规划法定建设要求和管理流程。基于流域规划，构建水系统综合目标体系和建设实施方案，通过城市总体规划、控制性详细规划等强制性规划要求以及构建排放许可体系等相关管理要求，落实相关技术措施和建设方案。

4.2 Enlightenment to China's Practice of Catchment Planning

In view of the status quo and major problems in China's comprehensive management of urban water systems, as well as the gaps in the existing formulation and implementation of catchment planning, especially the absence of integrated planning methods for medium- or small-scaled catchments that have a more direct and stronger relation with urban development, New Zealand's experience in ICMP preparation and implementation reflects a paradigm significance.

1) Upon the existing integrated catchment planning in China, special analyses on urban stormwater, wastewater, and combined drainage systems should be introduced, coupled with the coordination with urban drainage and flood prevention planning, sponge city construction planning, etc. to determine consistent comprehensive objectives, technical strategies, and measures at catchment scales.

2) Establishing a comprehensive water quality objective system for catchments that meets various service demands and applicable to local conditions. At present, the Environmental Quality Standards for Surface Water (GB3808-2002) is adopted as a nationwide applicable standard for water quality control. For local practices, however, a gradient of water quality standards is required with an understanding of upstream-downstream relationship in water quality and other ecological and hydrological demands. The catchment water quality standard system of local conditions guides the subsequent urban water environment management work in a more realistic way — economically, scientifically, and sustainably.

3) Strengthening comprehensive risk assessments on flooding and urban flooding within a catchment. Through a systematic study on the reasons of urban flooding in recent years, it finds that topographic alterations, together with the lack of protection and underutilization of key water storage / regulation spaces and overland flow paths, resulted from urban development and construction are the culprit. Thus, integrated solutions to urban flooding based on an overall analysis on upstream-downstream interaction and flooding territory is essential to urban catchment planning.

4) Coordinating with urban development demands by integrating catchment management objectives into statutory construction requirements in urban planning and management processes. Upon catchment planning, comprehensive water system objectives and roadmaps are formulated; technical measures and construction plans can be implemented as statutory requirements of urban master planning and regulatory planning, or discharge consent requirements.

5）随着城镇建设范围的不断扩大，城市对其内部和周边水系统的需求和影响也在同时扩大。面对日益严重的城市水环境污染、上下游水文变迁影响和水资源短缺等问题，如果割裂流域与城市、生态与需求、水利与排水，无疑很难高效解决水系统问题，可能会付出高昂的代价却收效甚微。面对复杂的城市水系统问题，首先需要不同专业间打破藩篱、达成共识，形成清晰可行的城市水系统综合目标和技术策略，同时加强与景观、建筑等专业的密切协作，在解决水系统问题的同时，提升城市居民的生活品质。**LAF**

5) The continuing urbanization leads to an increasing water demand for cities and environs. In the face of the worsening urban issues including water pollution, upstream-downstream hydrological changes, and water shortage, the separation between catchment and city, ecology and demand, water utilization and drainage would lead to an inefficiency, or a complete failure, in responding to the complicated water system problems. It is expected to find a common ground for different professions, develop appropriate and consistent targets and tactics, strengthen multi-disciplinary collaboration (with Landscape Architecture, Architecture, etc.), to deal with water system problems while improving citizens' quality of life. **LAF**

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