





美国东波士顿与查尔斯顿地区韧性海岸规划方案 COASTAL RESILIENCE SOLUTIONS FOR EAST BOSTON AND CHARLESTOWN, THE USA

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项目背景

长期以来，波士顿市遭受着极端高温、暴雨、暴雪和洪涝的侵扰，这种状况很可能会一直持续下去。为应对这些挑战，波士顿市政府于2016年发起了一项名为“应战气候的波士顿”的行动计划，以适应气候变化。为东波士顿和查尔斯顿地区制定的韧性海岸规划方案（简称“CREBC”）是该行动计划中第一个具体到社区的实际应用项目，它直接回应了《“应战气候的波士顿”报告（2016）》中的倡议：“优先考虑并研究在地区尺度施行洪涝防护的可行性”，并“为易受灾地区制定当地气候韧性规划，以为在地区尺度适应气候变化提供支持”。之所以首选这两个地区，是由于二者目前都面临着百年一遇的沿海洪灾的威胁，当地建有众多关键性基础设施，且居民无力应对灾害影响。

根据“应战气候的波士顿”计划预测，与2000年的海平面高度相比，到2030年时，波士顿的海平面将至少升高0.23m——而最快到2050年和2070年时，海平面高度将预计升高0.53m和0.91m——0.23m的升幅尽管看起来并不起眼，却能使东波士顿与

1. 该方案创建了一个宏大的地区级防洪愿景，不仅明确了短期和长期的设计契机，也描绘出了切实的实施路径，继而为波士顿进一步提升未来城市韧性奠定了基础。
1. It creates a strong vision for district-level flood protection including clearly identified design opportunities in the short- and long-term and robust roadmaps for implementation, and in doing so, sets the stage for additional future efforts to be undertaken by the City of Boston.

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摘要

东波士顿与查尔斯顿地区韧性海岸规划方案为波士顿这两个防灾条件最为不利的地区制定了近期和远期保护战略，使当地社区免遭洪涝侵袭。这一韧性战略通过分层洪水控制和整合绿色基础设施等措施，力求减轻气候变化的影响，并为两地居民和所有依赖城市与海港生存的人们创造社会、环境与经济裨益。该方案创建了一个宏大的地区级防洪愿景，不仅明确了短期和长期的设计契机，也描绘出了切实的实施路径，继而为波士顿进一步提升未来城市韧性奠定了基础。

关键词

海岸韧性；波士顿；洪涝；气候变化；社区参与

ABSTRACT

Coastal Resilience Solutions for East Boston and Charlestown outlines near- and long-term strategies to protect vulnerable neighborhoods from flooding in two of Boston's most disadvantaged areas. The resilience strategy embraces layered flood control and integrated green infrastructure measures that mitigate the effects of climate change, and create social, environmental and economic benefits to the people of East Boston and Charlestown and to all who share in the health of the city and the harbor. It creates a strong vision for district-level flood protection including clearly identified design opportunities in the short- and long-term and robust roadmaps for implementation, and in doing so, sets the stage for additional future efforts to be undertaken by the City of Boston.

KEY WORDS

Coastal Resilience; Boston; Flooding; Climate Change; Community Engagement

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TRANSLATED BY Tina TIAN WANG Yinyu

项目地址：

美国马萨诸塞州波士顿市

项目面积：200hm²以上**项目委托：**

波士顿市政府

项目团队：

Stoss景观设计事务所、Kleinfelder建筑工程咨询公司、One Architecture & Urbanism建筑设计与城市规划公司、Woods Hole海洋分析研究所

设计时间：

2017年1-9月

LOCATION:

Boston, Massachusetts, USA

AREA (SIZE) :

Over 500 acres

CLIENT:

City of Boston

PROJECT TEAM:

Stoss, Kleinfelder, One Architecture & Urbanism, Woods Hole Group

DESIGN PERIOD:

January - September 2017

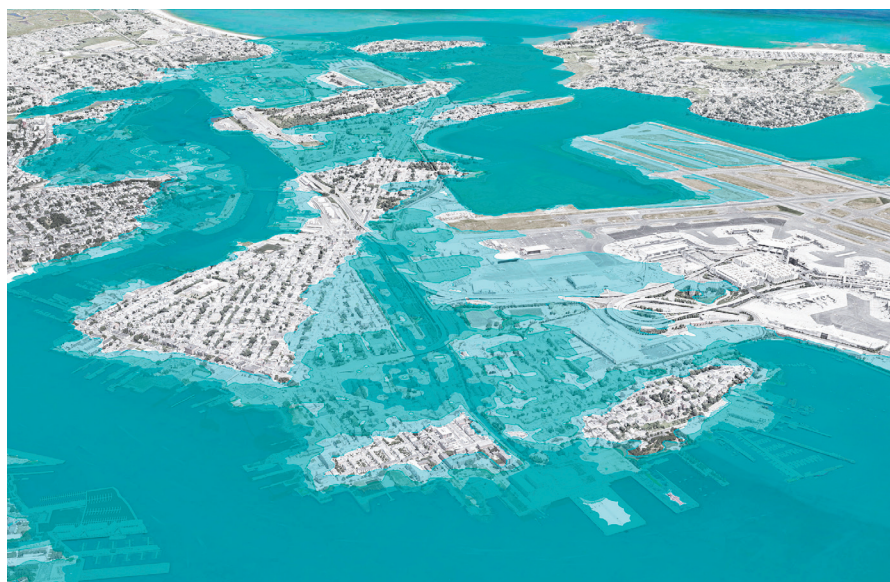
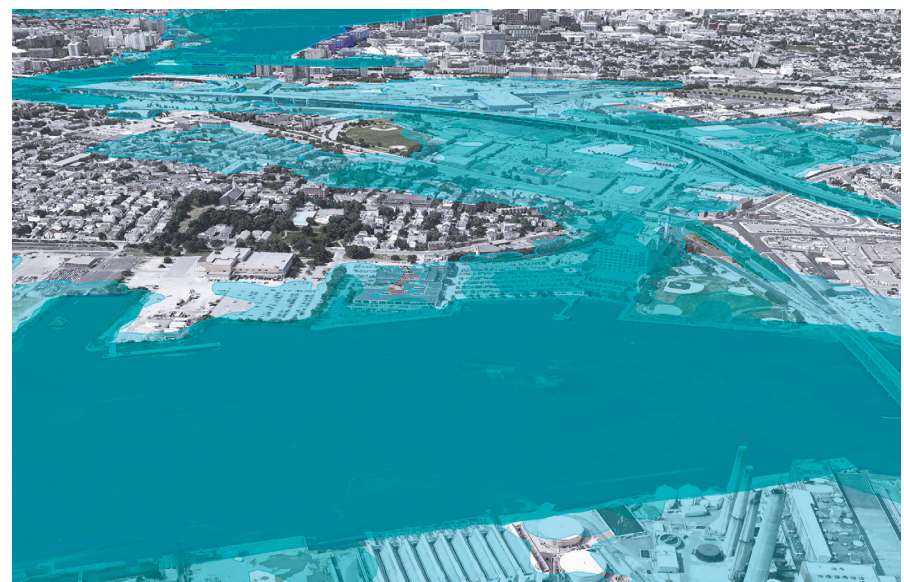
查尔斯顿地区百年一遇的沿海洪灾发生概率提高4或5倍；当海平面高度升幅达0.91m时（即2070年预测值），现在百年一遇的洪水届时将可能“一月一遇”。此外，这两个研究区域都面临着洪水通过海滨的低洼道路倒灌入城市之中的风险。马萨诸塞州交通局研发的波士顿港洪水风险模型（其亦为“应战气候的波士顿”计划提供了分析基础）确定出了洪水倒灌路径，继而以更高的精度对沿途的物业和街道层面进行了分析。虽然洪水的流量和范围会随着时间的推移而增加，但这些洪水路径的范围始终相对狭窄且界限清晰，这意味着针对这些位置的韧性提升设计方案可以防止项目研究区域内大部分沿海洪灾的发生。

设计策略

设计团队通过与各级政府部门、当地居民和私营机构展开积极合作，制定出了一套包括一系列评价标准、近期及远期行动建议、数量级成本估算体系，以及具体实施措施在内的韧性战略，其将指导波士顿地区将保护社区的韧性规划逐一落地。

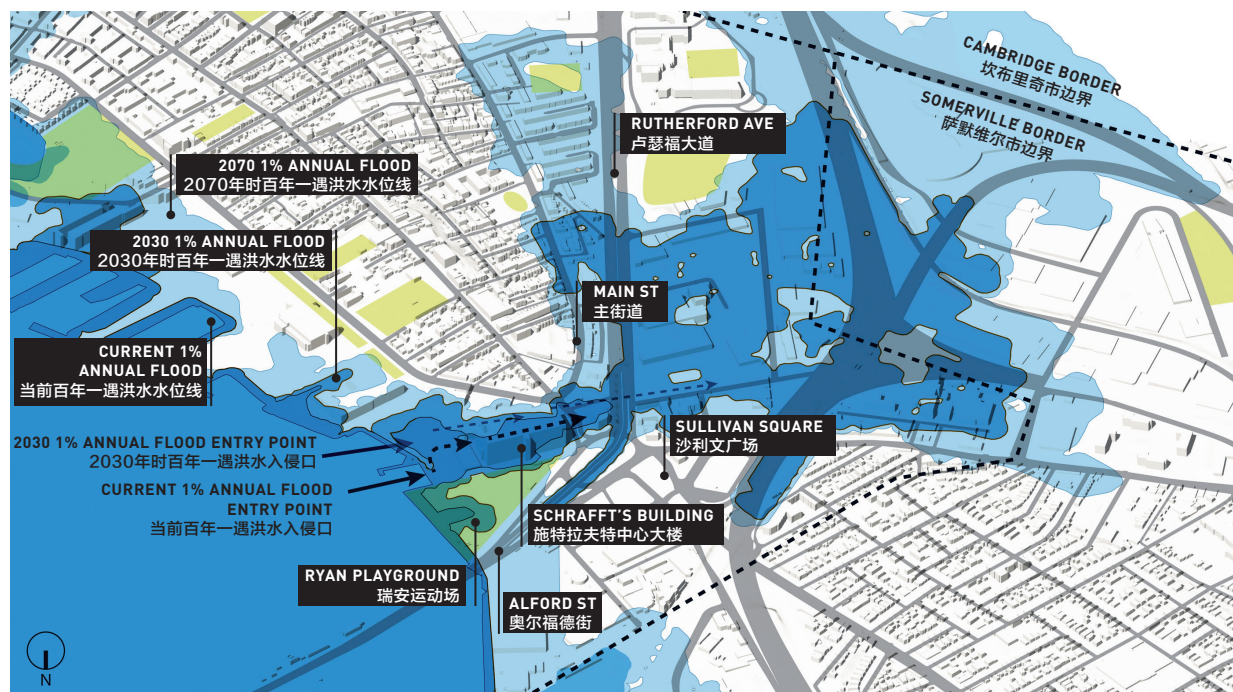
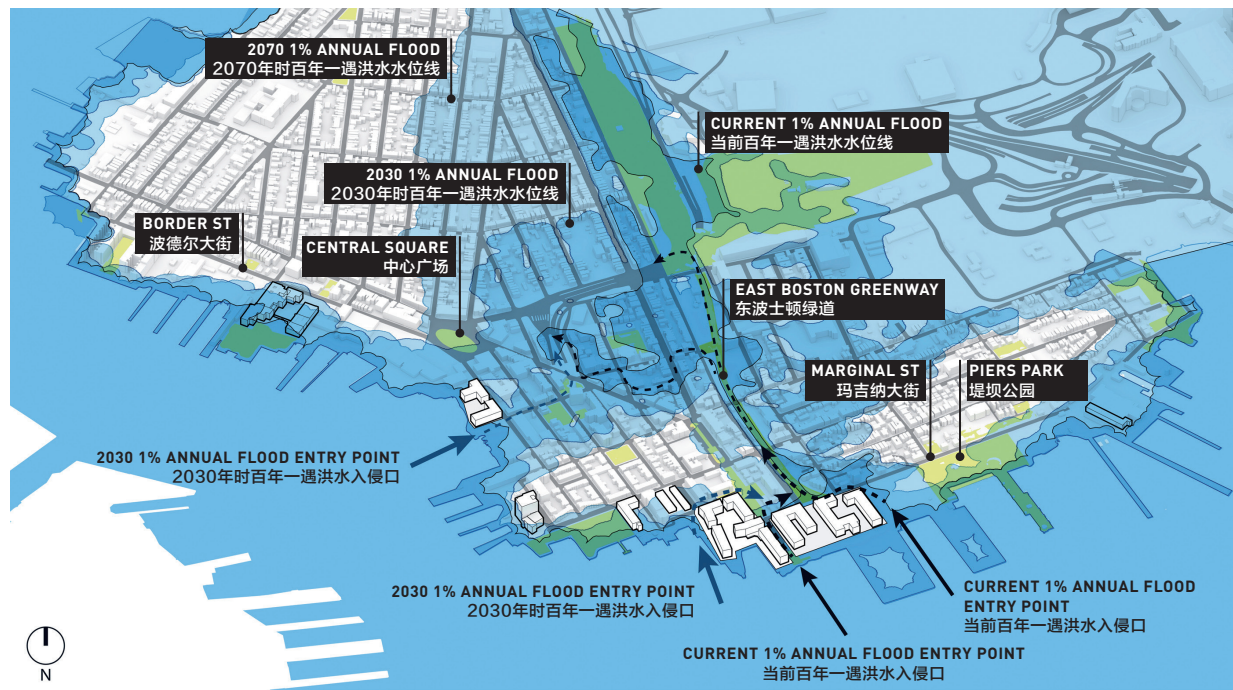
这一韧性战略包括一个地区尺度的滨海开放空间网络的开发计划，该网络既包含了当前的可用空间维度，还为那些可能在将来被重新开发或设计为网络中关键部分的用地预留出调整空间。其中，滨水开放空间的设计与洪水入侵路径（如东波士顿绿道、毗邻查尔斯顿施拉夫特中心的主街道）上的关键

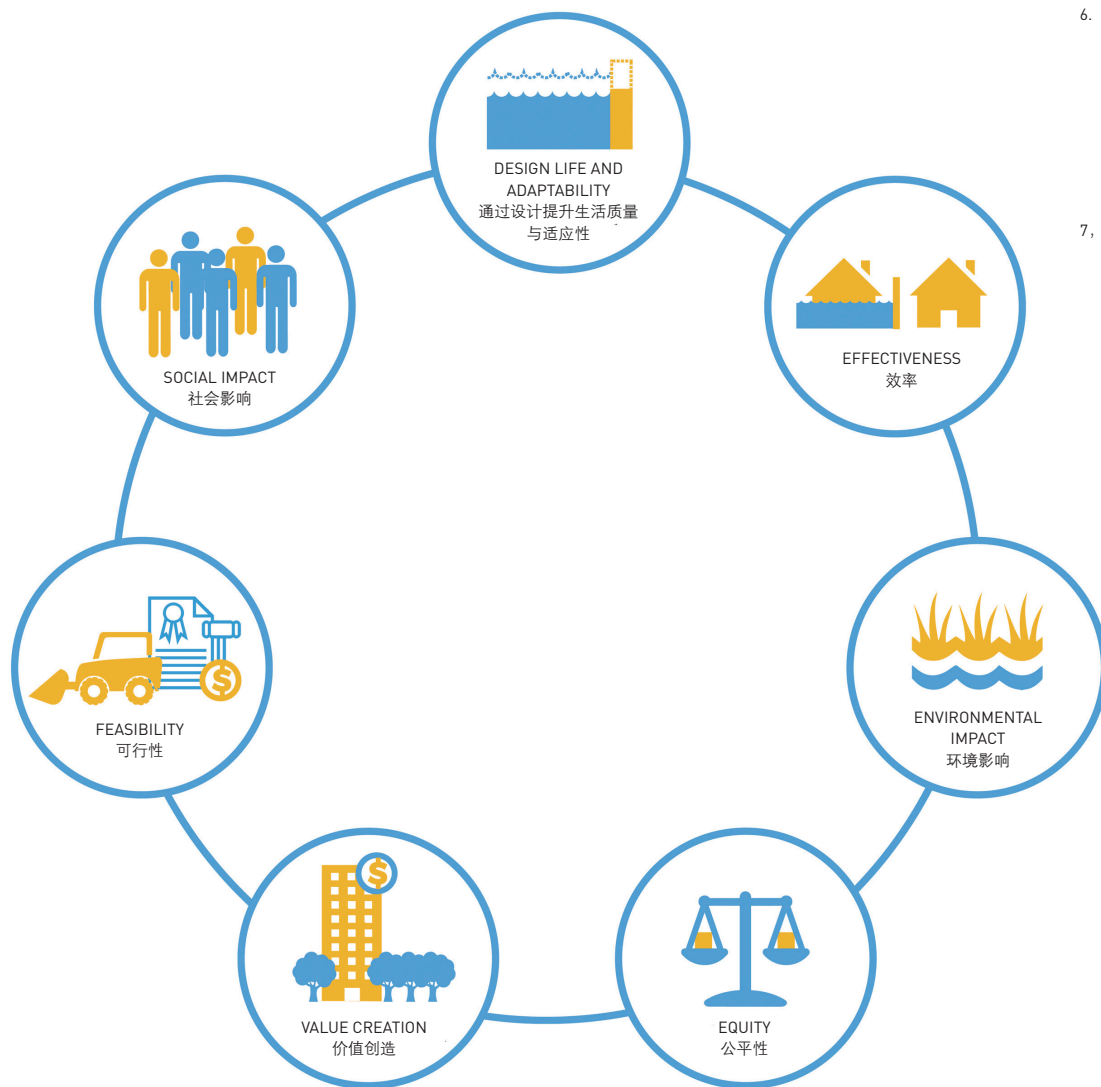
- 根据预测，到2030年左右时，海平面将上升约0.23m，而到2070年左右时将上升约0.91m，届时东波士顿将有大面积地区面临沿海洪涝风险。方案提出的短期计划为通过对东波士顿绿道进行改善设计的方式保护城市；长期韧性提升计划还有赖于制定出一套全面性的沿海战略。
 - 查尔斯顿地区与东波士顿相似，不论是当前还是将来，都有大面积地区面临洪水威胁。通过建立一个新的滨海开放空间，长期韧性提升战略现阶段对关键的洪水入口点进行了保护，今后还会将保护范围扩展至邻近的萨默维尔和坎布里奇地区。
 - 地图中不同的蓝色区域表示随着海平面上升，东波士顿地区百年一遇洪水影响范围的变化。箭头显示目前、2030年左右（海平面预计上升0.23m后），以及2070年左右（海平面预计上升0.91m后）的洪水入侵点与倒灌通道。
 - 地图中不同的蓝色区域表示随着海平面上升，查尔斯顿地区百年一遇洪水影响范围的变化。箭头显示目前、2030年左右（海平面预计上升0.23m后），以及2070年左右（海平面预计上升0.91m后）的洪水入侵点与倒灌通道。
- East Boston has extensive areas at risk of coastal flooding with current plus 9 inches (2030s) and plus 36 inches (2070s) sea level rise. The resilience strategy seeks to protect the city in the short-term through measures at the Greenway and in the long-term through a comprehensive coastal strategy.
 - Charlestown, similar to East Boston, has extensive areas subject to flood risks now and into the future. Through creation of a new waterfront open space, the long-term resilience strategy protects key flood entry points now and adjacent Somerville and Cambridge into the future.
 - The gradations of blue in the map show how the 1% annual chance flood extent changes as sea levels rise in East Boston. Arrows show the flood entry points and pathways for current sea level, 9 inches of sea level rise (2030s) and 36 inches of sea level rise (2070s).
 - The gradations of blue in the map show how the 1% annual chance flood extent changes as sea levels rise in Charlestown. Arrows show the flood entry points and pathways for current sea level, 9 inches of sea level rise (2030s) and 36 inches of sea level rise (2070s).

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性抬升区相协调。在规划愿景中，这些开放空间包括更具韧性的海港步道、可达性更好的滨水空间、天然湿地缓冲带和“有生命的海岸线”、阶梯式硬质景观、临时性防洪缓冲带，以及为缓解高温而补植的遮荫树木。在目前重要的可用公共空间和未来潜在的可用区域中将建设拥有滨水良田和湿地等可淹没景观的大型公园。与此同时，通过塑造缓慢抬升的地形来满足高于基准水位线4.3m的规划要求，并向内陆逐渐升高，既可满足居民平日的亲水需求，亦能够使社区免受洪水侵袭。在空间条件更为有限的地段，可建造具有公共通道功用的简单护堤，既可供行人享受海滨美景，又能起到关键性的保护作用。该计划中最具挑战性的部分是东波士顿绿道区域，由于近期的开发项目仅仅抬升了所在地本身的高程，致使道路成为了城市开发中的洼地，更易受洪水侵袭。针对这一问题，规划采用了一个由临时性防洪墙与斜坡草坪组成的系统，草坪不仅具有防洪堤的功用，还为在东波士顿绿道入口处的洪泛区外围设置食品贩卖车、自行车租赁点或其他便利设施提供了空间。这些措施将为11 000多名当地居民，300余家企业，以及重点公路和交通基础设施、医疗设施和其他重要服务设施提供保障；此外，其还将提升东波士顿和查尔斯顿地区在洪水防护、海滨可达性、娱乐和交通等方面的韧性，并大大扩展了滨水区的开放空间，使公众能够更好地享用此处波士顿地区最好的自然资源之一。

在该项目的愿景和实施建议中，可行且有趣的公共参与战略是极为重要的一环。有400余位来自东波士顿和查尔斯顿地区的居民参与了项目会议、公开问询和问卷调查等活动，分享了他们对CREBC的期望及重点考虑因素。除了保障生命、财产和生计免受洪水侵袭的基本目标外，许多人还表达了提升当地交通、经济性、公共空间和滨海可达性的诉求，尤其希望制定出能够长期保持空间亲水性的有效方案。规划最终提出的防洪设施的有效期在50年以上，在保证公众亲水需求的同时，抬升的高度也足以应对预计将于2070年左右发生的百年一遇的洪水事件





6. 项目建立了一套评估标准，以对方案提出的气候适应性战略进行指导和评估。该评估标准涉及许多迫在眉睫的实际问题（例如方案的有效性和可行性），以及方案的社会和环境影响等更广泛的问题。
- 7, 8. 东波士顿地区长期韧性提升战略根据现有开放空间分区要求而制定。
6. A set of evaluation criterion were established to help guide and rank proposed climate resilience strategies. Criteria included both immediate, practical concerns such as effectiveness and feasibility as well as broader issues such as social and environmental impact of solutions.
- 7, 8. The long-term resilience strategy was developed in concert with existing open-space zoning requirements of East Boston.

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（海平面将升高约0.91m），以及0.3m的风暴潮。

规划愿景的实现需要对直接的公共投资和对个人行为进行规范指导，例如出台区划调整方案及后续的港口规划方案。项目团队制定的实施计划对这些行动以及部分令人振奋的潜在先行项目提供了指导性建议，以助力未来行动的推进。

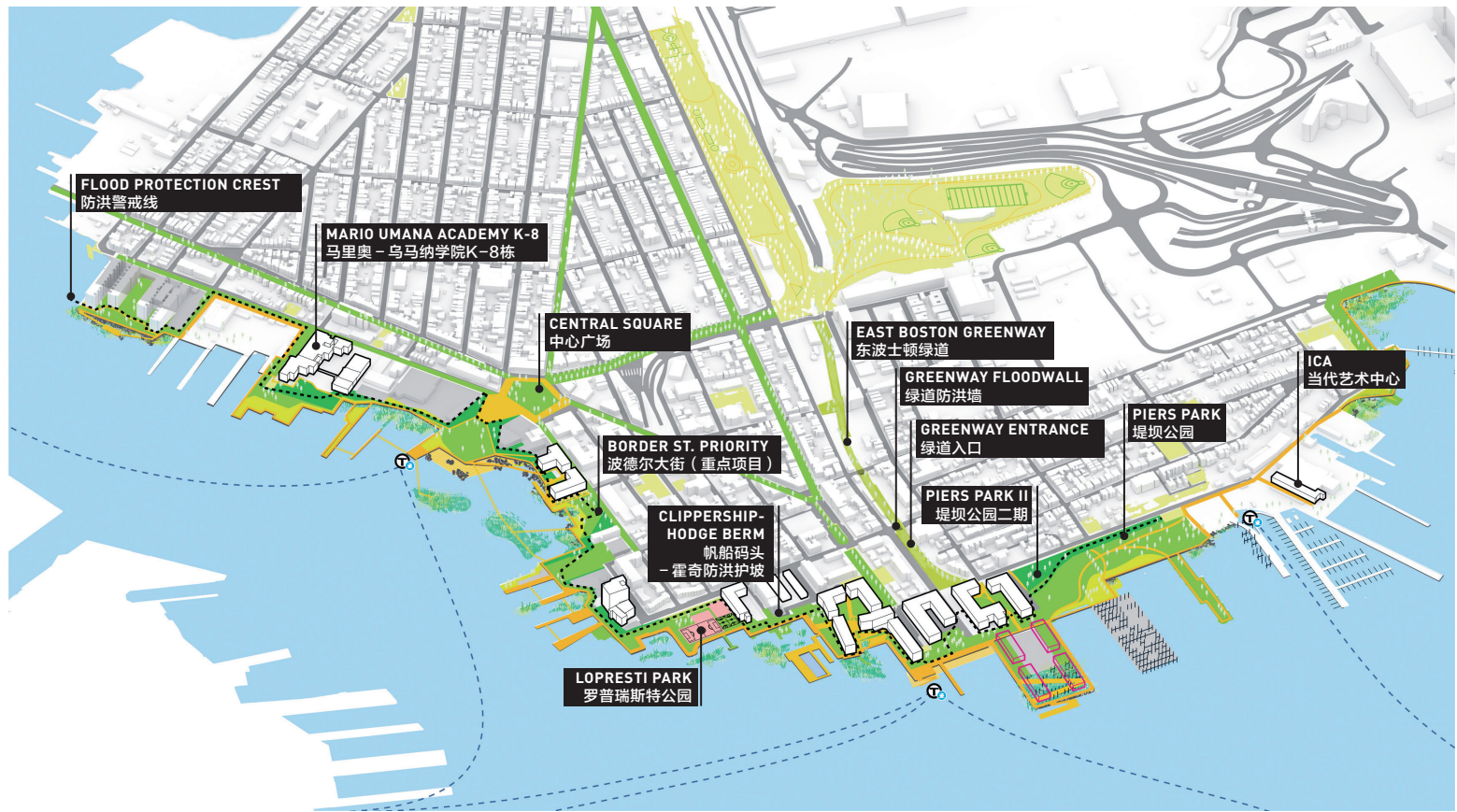
CREBC为项目涉及区域从现在起到2030年的近期建设实施、2030~2050年的远期计划，以及2050年之后的计划提供了详尽的实施指导建议，包括细化的阶段性计划、成本估算和效益—成本分析。近期计划

针对设计、政策、合作机制、资金筹募等方面提出了具体建议。实施指导建议亦将可预测的新开发和再开发周期、完成不同行动所需的时间纳入考量。成本则根据典型的海滨公园、护堤和满足最高防洪需求的海岸线保护设施的工程量和造价来估算。待CREBC全面落地后，除了实现防洪功能外，还会带来社会、生态和经济等方面的裨益，尽管其中许多效益是难以量化的。利用“应战气候的波士顿”模型框架和数据可对防洪措施的效益或“避免的损失”进行直接量化，这里所说的“损失”包括建筑物及其内里损坏、搬迁成本、生产延误、精神压力等。成本和

阶段性计划仅作为估算和建议参考，不可直接用于指导详细规划。

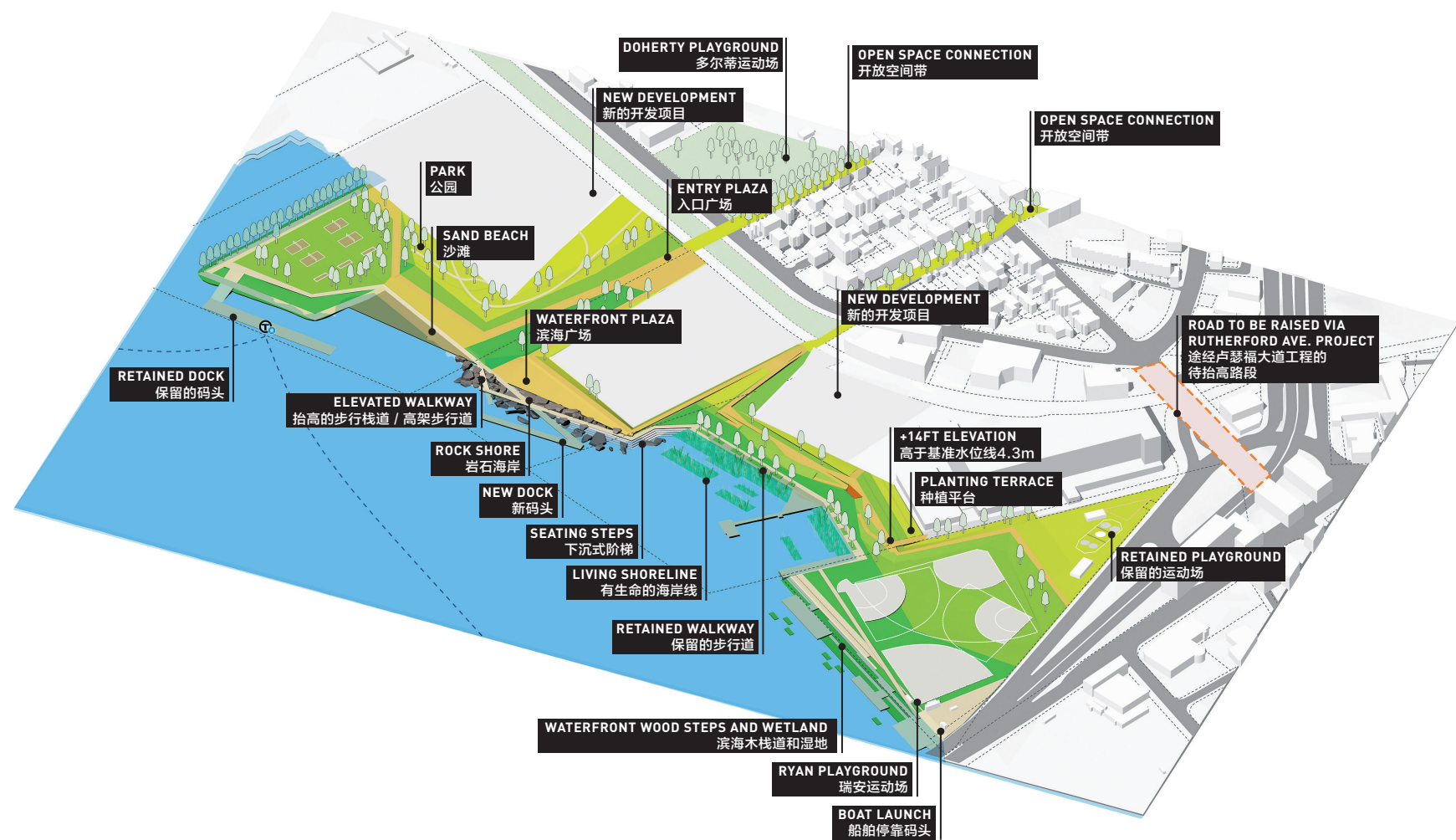
结语

波士顿是为数不多的在遭受风暴侵袭前就未雨绸缪，为应对海平面上升和气候影响制定规划的城市之一。作为波士顿韧性规划重要的第一步，CREBC通过明确短期和长期的设计契机，以及制定有效的实施路径，为地区尺度的洪水防护描绘了一幅切实可行的美好愿景，为波士顿进一步提升未来城市韧性奠定基础。**LAF**



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Project Background

The City of Boston has been suffering from extreme heat, rain, snow, and flood, which will likely continue. In response to these challenges, the government launched Climate Ready Boston, an ongoing initiative to adapt to climate change in 2016. Coastal Resilience Solutions for East Boston and Charlestown (CREBC) is the first neighborhood-specific application of this initiative. It directly responds to recommendations in the Climate Ready Boston report (2016) that the Boston

“prioritize and study the feasibility of district-scale flood protection” and “develop local climate resilience plans in vulnerable areas to support district-scale climate adaptation.” Boston chose to address these study areas first because they are currently at risk from the 1% annual chance coastal flooding and have high concentrations of vulnerable residents and critical infrastructure.

Climate Ready Boston projections indicate that Boston’s sea level could rise (from 2000 levels) by at least 0.23 meters by 2030, 0.53 meters by as soon as 2050, and

0.91 meters by as soon as 2070. Although 0.23 meters may seem small, it will make the current 1% annual chance flood in the East Boston and Charlestown study areas four to five times more likely than it is today. With 36 inches of sea level rise, floods that are now “1% annual chance” may occur monthly at the highest tides. Both study areas are at risk of flooding through low-lying pathways that originate at the waterfront. Flood pathways in East Boston and Charlestown were identified using the Boston Harbor Flood Risk Model developed by the Massachusetts Department of

9, 10. 查尔斯顿地区长期韧性提升战略根据现有开放空间分区要求而制定。

9, 10. The long-term resilience strategy was developed in concert with existing open-space zoning requirements of Charlestown.

Transportation (the basis of the Climate Ready Boston analysis), and then analyzed at a higher resolution down to the property and street level. While the depth and extent of flooding increasing over time, the flood pathways remain relatively narrow and well-defined. This means that targeted solutions at these locations can prevent coastal flooding in large portions of the study areas.

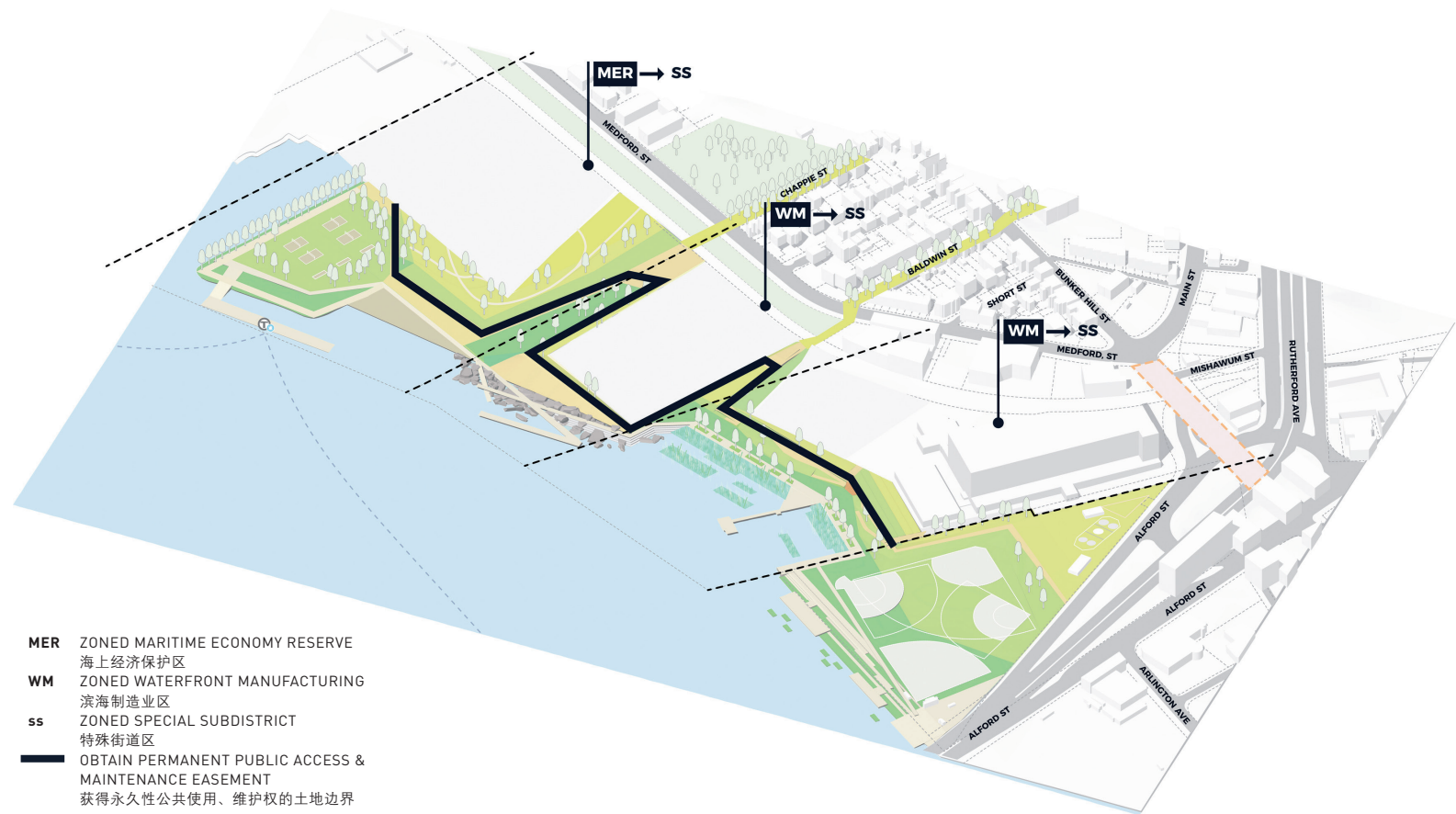
Design Strategies

The design team, in coordination with partners at all levels of government, community members, and the private sector, developed a resilience strategy that included a set of evaluation criteria, recommendations for near-term and long-term actions, order-of-magnitude

costs and an implementation roadmap to guide Boston as it begins to move from planning to physical actions to protect the community.

The resilience strategy includes the development of a district-wide coastal open space network that is tuned to the dimensions of currently available space as well as properties which may be redeveloped and designed as key components of the proposed network. These waterfront open spaces are coordinated with strategic elevated areas at key points of entry for coastal flooding such as the Greenway in East Boston and Main Street adjacent to Schrafft's Center in Charlestown. The envisioned open spaces include enhanced Harborwalks, improved connections to the waterfront, natural wetland buffers and

“living shorelines,” stepped hardscapes, temporary flood barriers, and increased planting of shade trees to combat higher temperatures. In areas of significant available open space, or potential future available area, large parks with floodable landscapes such as fields and wetlands at the waterfront are envisioned. These are combined with a slowly rising topography which meets the required +14 NAVD88 elevation and does so further inland, allowing for a closer relationship to the water daily while protecting the neighborhood during flood events. Where space is more limited, simple berms with public access are envisioned, allowing for pedestrian enjoyment of the waterfront while providing critical protection. The most challenging area at the base of the East Boston Greenway, where recent





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11, 12. 为了实现与现有公共开放空间的最佳连接并提升海滨空间的可达性，东波士顿地区计划修建一个大型海滨公园，作为沿海洪涝防御系统的关键一环。通过在公园中塑造缓慢抬升的地形来满足所需的高于基准水位线4.3m的规划要求，来防御洪水对城市关键资产的破坏。

13, 14. 在查尔斯顿地区，滨水区的防洪工程主要包括建立一个新的海滨开放空间系统，可以连接滨海公园，并对其功能进行提升。公园内的地形达到了高于基准水位线4.3m的设计高度，可以对周边地区以及萨默维尔和坎布里奇地区形成防洪保护。

11, 12. In East Boston, a large waterfront park, located in order to best connect to existing public open spaces and provide extensive waterfront access, acts as a key element of protection against coastal flooding. Topography in the park gradually rises to the +14 NVAD88 design elevation and prevents floodwater from damaging critical assets in the city.

13, 14. In Charlestown, flood protection along the waterfront is developed through creation of a new waterfront open space that both connects to and enhances an existing waterfront park. Topography in the park gradually rises to the +14 NVAD88 design elevation and prevents floodwater from entering the adjacent property, protecting it and Somerville and Cambridge just beyond.

developments have raised their own properties but left roadways in between vulnerable to flooding, a combined system of temporary floodwalls and a sloped lawn that doubles as a berm and adds programmable space for food trucks, bike rentals, or other amenities at the entry to the East Boston Greenway where flood waters are at risk of entering a low area and flooding inland portions of Boston. Together the measures will protect over 11,000 residents and at least 300 businesses, as well as critical highway and transit infrastructure, healthcare facilities, and other important services, and provide flood protection, waterfront access, recreation, and mobility, and dramatically increase waterfront open space and public access to one of Boston's greatest natural

resources.

A robust and fun community engagement strategy was central to the development of the project vision and recommendations. Over 400 East Boston and Charlestown residents participated in meetings, open houses, and surveys to share their visions and priorities on coastal resilience solutions. In addition to the base goal of protecting their safety, property, and livelihoods from coastal flooding, many shared a strong desire for improvements in mobility, affordability, open space, and waterfront access. Residents placed particular importance on ensuring access to the water and that solutions are effective over the long term. As a result, the flood protection measures proposed are designed to be



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effective for over 50 years and would provide public access while also being raised to elevations sufficient to protect against the 1% annual chance flood level with 0.91 meters of sea level rise and a foot of storm surge, a condition currently estimated to be a potential reality in approximately 2070.

Achieving the vision laid out by the project will require both direct public investments and private action guided by regulatory tools such as modified zoning and continued harbor front planning. The implementation plan developed by the project team outlines these actions as well as a number of exciting potential first steps to help catalyze future action.

Roadmaps were developed to guide the implementation of near-term actions in the East Boston and Charlestown study areas between now and 2030, and long-term actions through 2050 and beyond. They include high-level phasing plans, cost estimates, and benefit-cost analyses. Near-term actions are described in more detail, with recommendations on design, policies, partnerships, and funding. The roadmaps also take into account foreseeable cycles of development and redevelopment and the time necessary for completing different actions. Costs are based on construction estimates per acre for typical waterfront parks, berms, and shoreline protection features with the height necessary to achieve a desired flood protection level. The benefits of fully implementing the identified coastal resilience solutions extend well beyond flood protection to include social, ecological, and economic factors, although many of these benefits cannot be easily quantified. The directly quantifiable benefits of flood protection, or "avoided loss," are calculated using the Climate Ready Boston framework and data. Losses include damages to buildings and their contents, displacement costs,



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impacts to productivity, and mental stress. Both costs and phasing plans are estimates and recommendations only, and should not be used for detailed planning.

Conclusion

Boston is one of the few cities planning for sea level rise and climate impacts in advance of major storm-related damages. As an important first step in Boston's resilience planning, CREBC creates a strong vision for district-level flood protection including clearly identified design opportunities in the short- and long-term and robust roadmaps for implementation, and in doing so, setting the stage for additional future efforts to be undertaken by the city. **LAF**



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