Appendix E: Illustrative Green Infrastructure Examples

May 2016 Version - Updates and errata will be published as necessary

The illustrations included here are meant to inspire designers on how green infrastructure can be incorporated into San Francisco landscapes.

Integrating LID into San Francisco's Urban Landscape

The illustrations on the following pages show how LID and GI can be integrated into San Francisco's diverse land uses to both protect water quality and contribute to the character of a given location. The figures are not meant to provide a comprehensive list of the stormwater design solutions that are possible in San Francisco. Rather, they offer ideas and examples of stormwater management strategies appropriate for the land uses listed below:

- High-density Residential
- Low-density Residential
- Mixed Use
- Industrial
- Open Space and Natural Areas
- Piers over Water
- Redevelopment and Multi-Parcel Projects

Appendix A: BMP Fact Sheets and *Appendix B: Green Infrastructure Typical Details and Specification* (both available on the SFPUC website at www.sfwater.org/smr) provide more detailed guidance about BMP design and placement.


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Figure E1. High-density Residential

In San Francisco, high-density residential development is defined as 40 or more living units per acre. High-density residential development is characterized by zero lot line development and high levels of imperviousness. In this context, the greatest opportunities for stormwater management reside in replacing impervious surfaces with BMPs. Ample roof space with relatively low pollutant loads provides opportunities for vegetated roofs (also known as green roofs or living roofs) and rainwater harvesting. Interior courtyards can accommodate landscape-based BMPs, permeable paving, and subsurface treatment or capture systems. Sidewalks and streets adjacent to high-density residential development are often the nearest public open spaces available to residents. Stormwater management BMPs in these locations, such as bioretention, also can improve streetscape aesthetics and provide wildlife habitat.

1. Vegetated roof
2. Downspout discharges to dry well
3. Permeable paving in pedestrian areas
4. Rain garden
5. Bio-retention planter with curb cuts
6. Large-scale rainwater harvesting cistern
7. Downspout discharges to flow-through planter

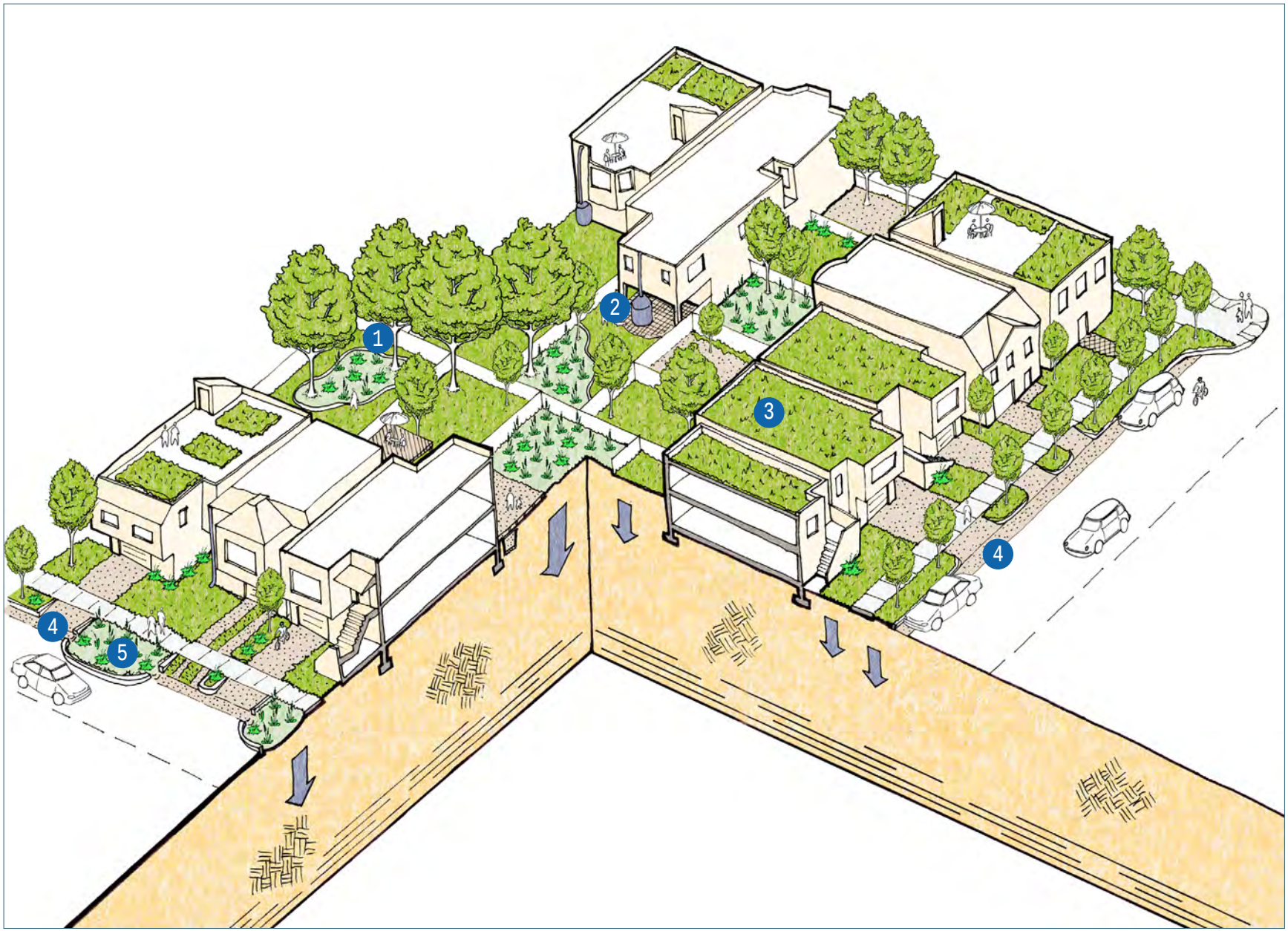
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Figure E2. Low-density Residential

In San Francisco, low-density residential development is defined as 24 or fewer living units per acre. Low-density residential parcels typically include open space in the form of yards and setbacks, sidewalks with more landscaping than those found in high-density residential areas, and rooftops that are more likely to be under the control of a single owner. Low-density residential parcels therefore tend to both generate less stormwater and have more space in which to manage stormwater than high-density areas. Diverse parcel sizes and shapes, along with variability in building footprints, provide opportunities for site-specific stormwater management designs.

1. Rain garden
2. Cistern to store rainwater for irrigation
3. Vegetated roof
4. Permeable paving
5. Bio-retention planter with curb cuts

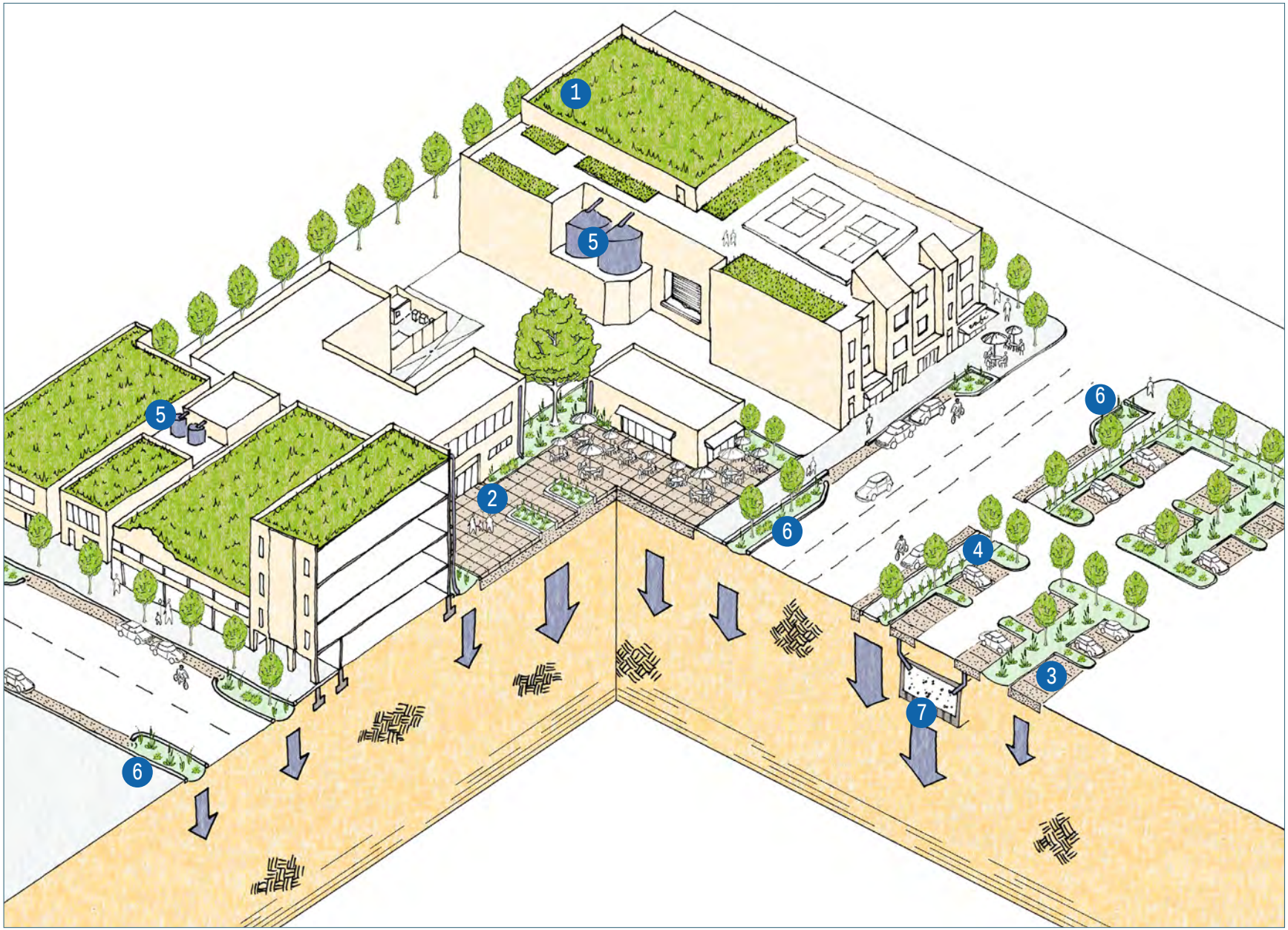
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Figure E3. Mixed Use

Many new, redevelopment, and infill projects in San Francisco include mixed-use areas. Mixed use development fosters a high level of activity throughout the day, resulting in an active public realm. Roofs, public plazas, setbacks, parking lots, and the public right-of-way are all spaces that can double as stormwater controls that improve the quality of public areas and achieve stormwater management goals. Of these spaces, roofs generally have the lowest pollutant loads, while streets have the highest. The commercial elements of mixed use development sometimes require special attention. For example, restaurants and light industrial activities might need to implement source controls targeting grease, litter, and other food wastes.

1. Vegetated roofs
2. Permeable paving in pedestrian areas
3. Permeable paving in parking areas
4. Swales in parking lots
5. Cistern to store rainwater for toilet flushing
6. Bio-retention planter with curb cuts
7. Infiltration gallery or dry well

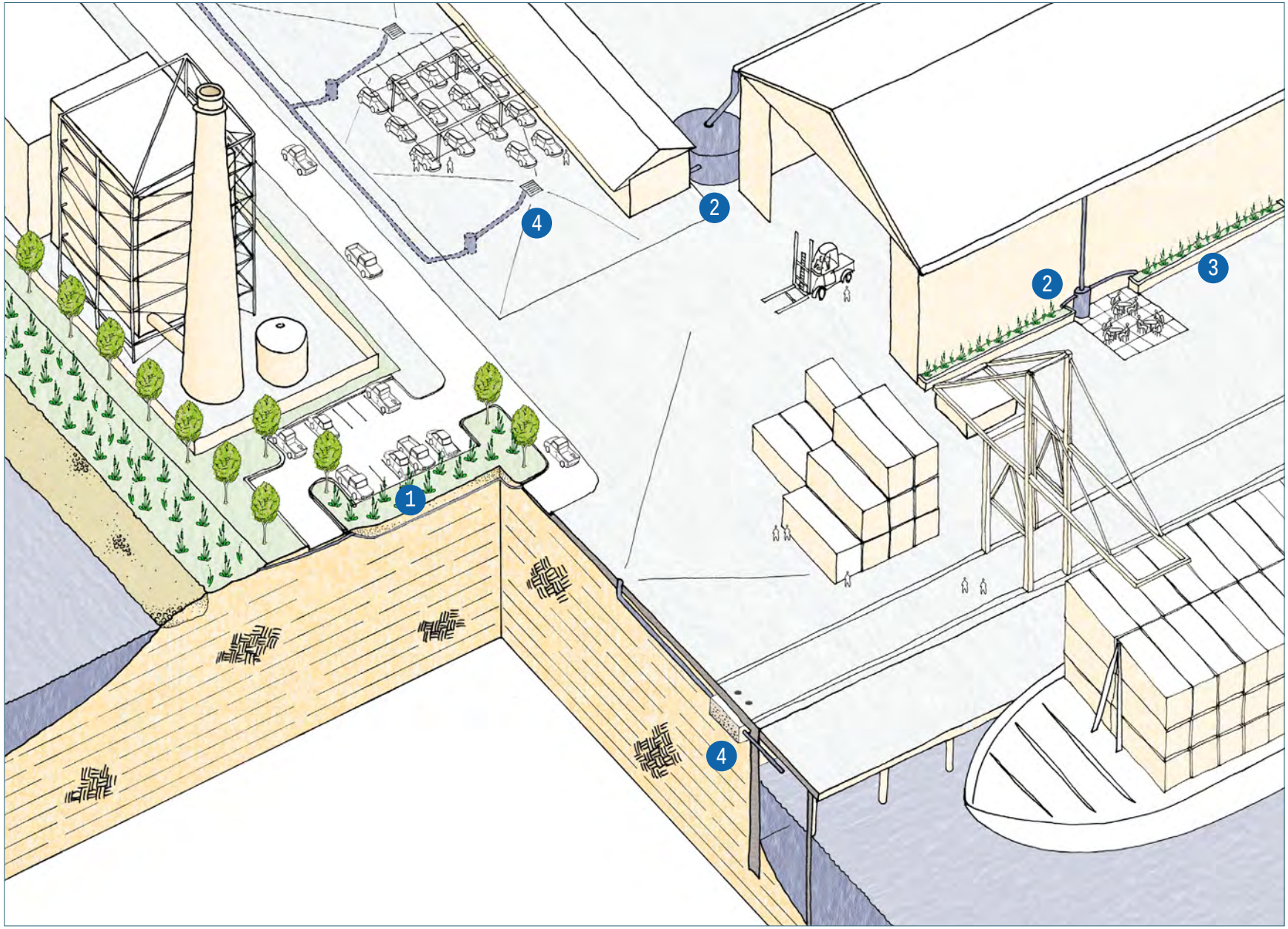
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Figure E4. Industrial

Industrial land uses in San Francisco are concentrated in the Bayside watersheds. Because industrial areas often have potentially polluting activities coupled with large impervious areas, treating and managing stormwater on site in these areas is essential. Industrial land use is generally characterized by large, low-density structures that provide ample space for GI. Stormwater management strategies in industrial areas can serve not only to protect water quality but also to act as a buffer against adjacent land uses, provide high-quality rest areas for workers, and maintain public access to waterfront open space where appropriate. Pollutants associated with industrial activities – chemical waste storage, for example – require special source control strategies such as hydraulic isolation and treatment in areas where polluting activities occur.

1. Swales in parking lots
2. Cisterns to store and reuse rainwater for vehicle washing
3. Flow-through planters
4. Media filter

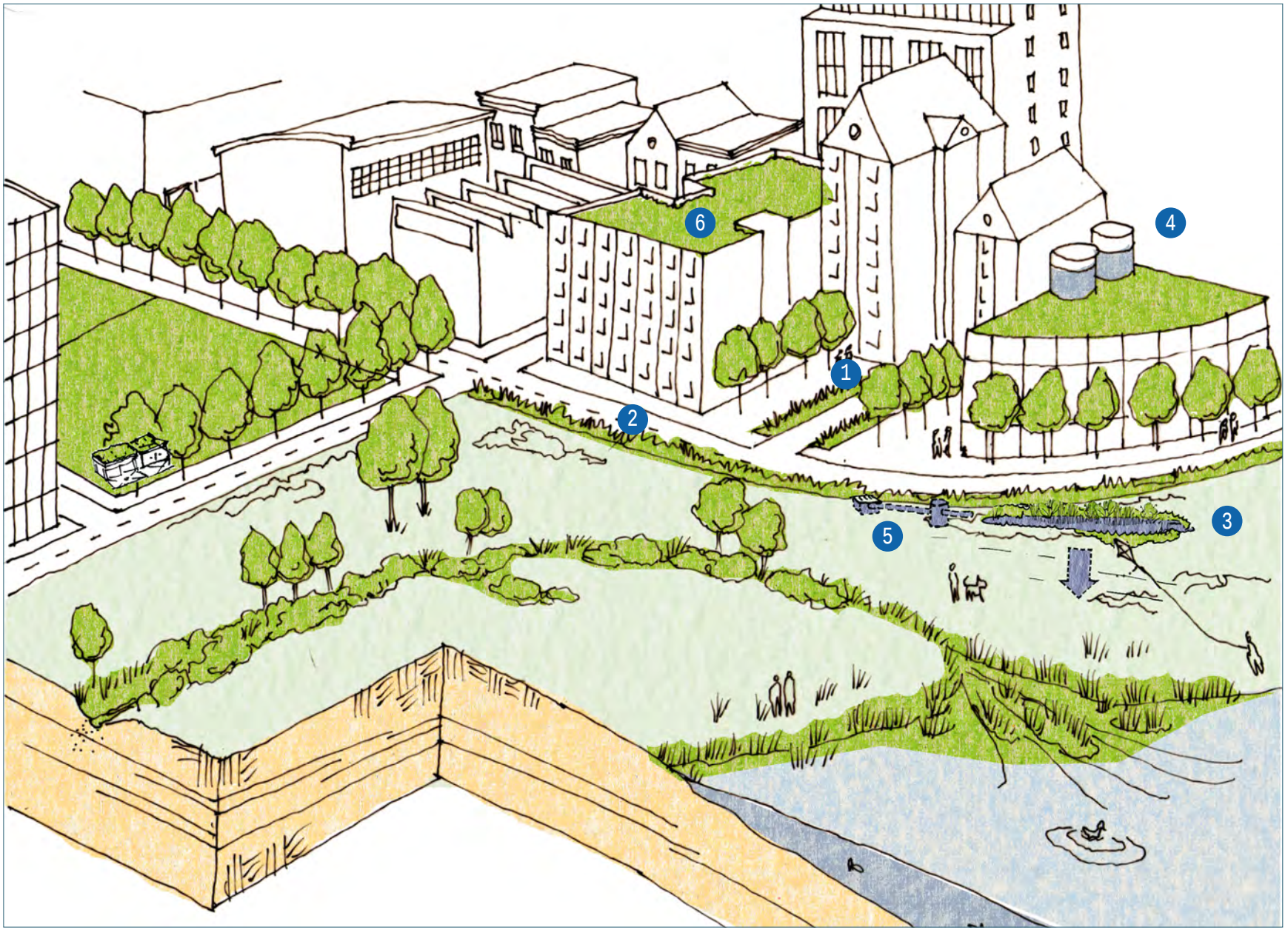
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Figure E5. Open Space

San Francisco's open spaces provide areas for passive and active recreation, wildlife habitat, and environmental education. Open space areas can also protect air and water quality. Some open space areas, most notably Lake Merced, include water bodies whose health and function depend upon protection from adjacent polluting activities. To that end, stormwater BMPs can be sited on less sensitive open spaces to protect more sensitive core areas. Open spaces can often accommodate larger stormwater controls and controls placed in series (known as "treatment trains") that integrate stormwater management with other ecological functions. Because of this, stormwater management in open spaces can make significant contributions toward restoring natural hydrology and ecosystem health. Open spaces that are opportunity sites for GI include parks, recreational areas, school playfields, and natural areas.

1. Swales in parking lots and roadways
2. Swales along roadways
3. Constructed wetlands to treat runoff
4. Cistern to store rainwater for irrigation
5. Treatment train: swale to swirl separator to wetland
6. Vegetated roof

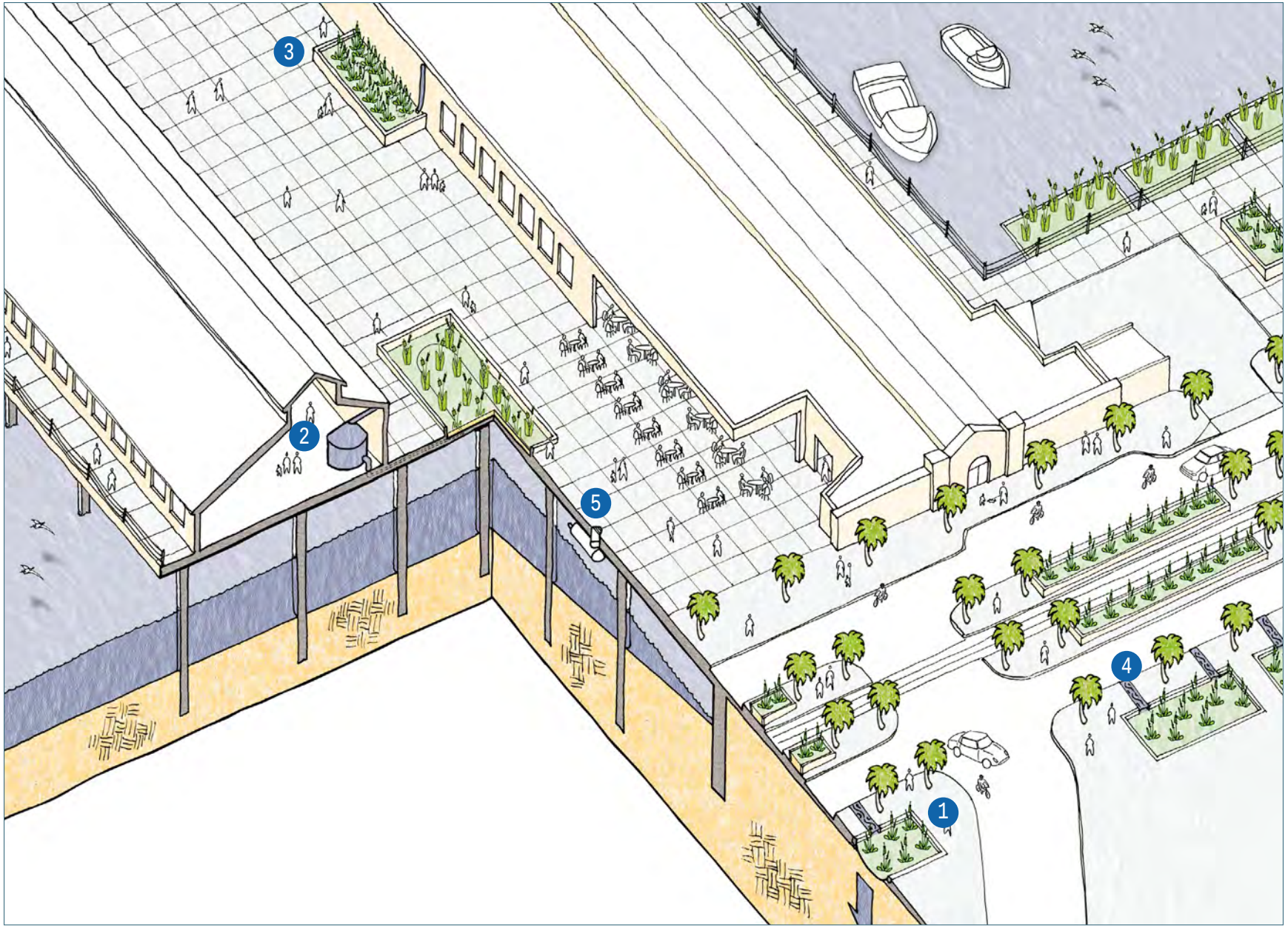
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Figure E6. Piers Over Water

Piers over water are common along San Francisco's waterfront. They are frequently the site of redevelopment projects seeking to adaptively reuse attractive and unique historic properties. Development on piers over water encompasses a wide variety of land uses, including commercial, recreational, industrial, and maritime uses. Because runoff from these developments often flows directly to the Bay without the benefit of dedicated conveyance structures, stormwater management on piers over water requires creative infrastructure solutions. Limited space, structural constraints, cultural and historic preservation requirements, and the threat of sea level rise all impose additional design constraints. The transition between piers and streetscape can provide opportunities for landscape-based stormwater management strategies that might not be feasible on the piers themselves. In some cases, media filtration devices may be the only feasible option for certain aspects of pier redevelopment. The design and sizing of media filtration devices for piers over water should be consistent with the California Stormwater Quality Association (CASQA) *Stormwater BMP Handbook for New Development and Redevelopment* (CASQA, 2003).

1. Bioretention planter in the streetscape
2. Cistern to store rainwater for irrigation
3. Flow-through planter
4. Trench drains for conveyance
5. Media filter

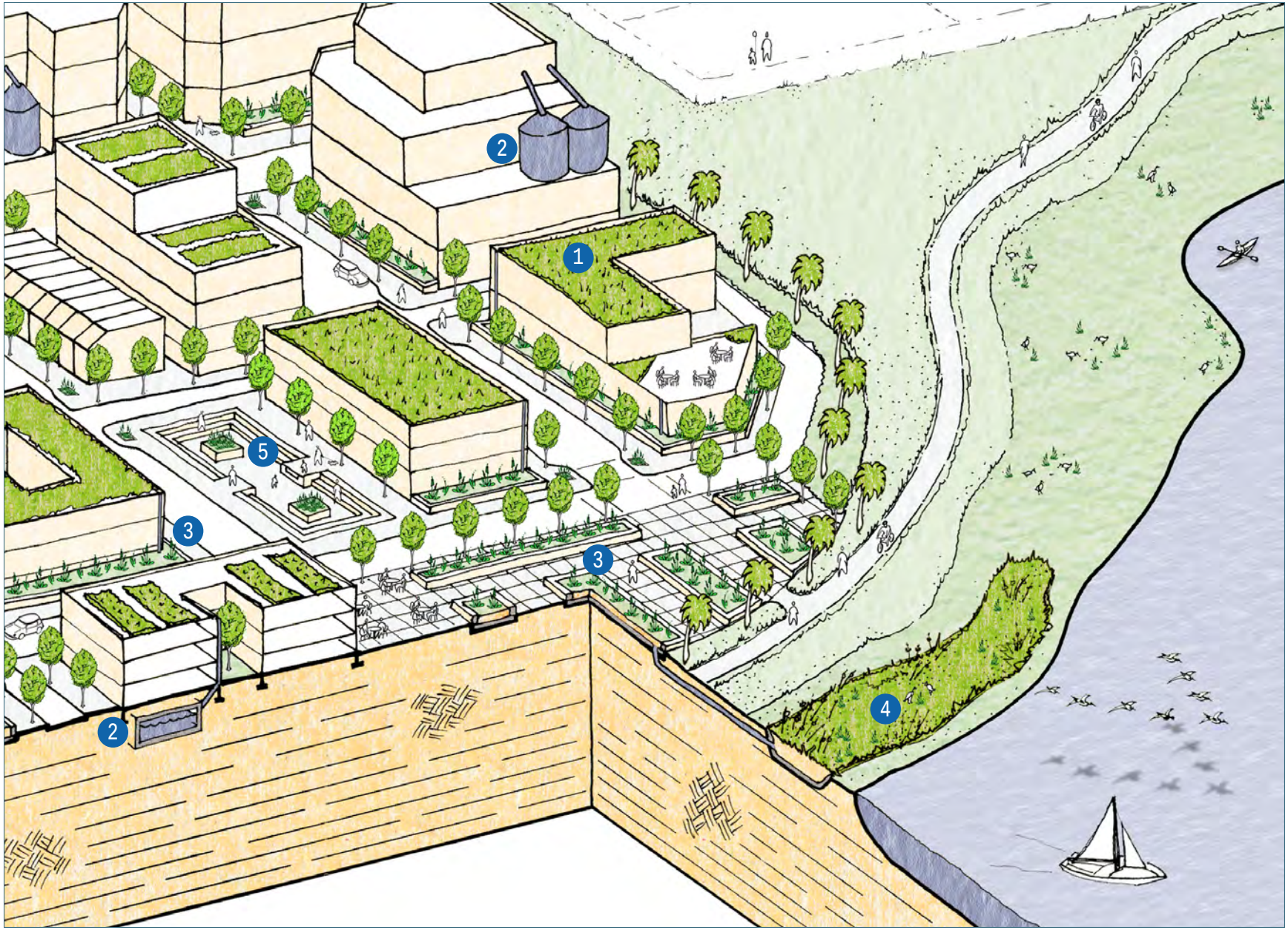
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Figure E7. Redevelopment and Multi-Parcel Projects

Many future projects in San Francisco will be located in large redevelopment areas and will include construction of significant horizontal infrastructure (roads, sewers, water mains, utilities) and open space, in addition to subdivided parcels and individual buildings. Redevelopment projects, such as Treasure Island, Hunters Point Shipyard, and the Port's Sea Wall Lot 337, can make use of centralized GI that can provide superior treatment, wildlife habitat, recreational amenities, and other benefits that may not be possible with smaller projects. Constructed wetlands and large-scale rainwater harvesting are just a few examples of LID strategies presented in these SMR that are suited to large projects.

1. Vegetated roofs
2. Cisterns to store rainwater for heating and cooling
3. Bioretention planter
4. Constructed wetland for centralized stormwater treatment
5. Urban stormwater plaza/detention pond