APPENDIX D

Assessing the Feasibility of Stormwater Credit Trading in San Mateo County, CA

Assessing the Feasibility of Stormwater Credit Trading in San Mateo County, CA

An analysis and recommendations for increasing green stormwater infrastructure implementation and operations on public and private property.

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Introduction

This memorandum grows out of a year-long partnership between staff from the Stormwater Program within the San Mateo County City and County Association of Governments (C/CAG) and a team of water policy and economic professionals from American Rivers, WaterNow Alliance, and Corona Environmental Consulting (project team). This partnership began in 2020 with the invitation to C/CAG staff to participate in a series of trainings hosted by project team members. These trainings focused on incentive programs to encourage the implementation of green stormwater infrastructure (GSI) on privately owned property and approaches to financing these incentives. The trainings provided a foundation for a more detailed follow up project in which the project team collaborated with C/CAG staff to analyze the potential for establishing a stormwater volume credit trading program within C/CAG's member communities.

The intention of this effort is to provide a very high-level assessment of the factors that could promote, or obstruct, the design and administration of a credit trading program. This analysis also includes an evaluation of whether and how such a program could be integrated into the Regional Collaboration Framework currently being considered by C/CAG and its member agencies for addressing stormwater challenges and complying with the San Francisco Bay Municipal Regional Permit (MRP).

This memorandum summarizes the project team's high-level assessment. It is intended to be informative and exploratory only and does not represent an expression of C/CAG's intention to develop a stormwater credit trading program. This memorandum is organized as follows:

- Section 1 provides a basic introduction to the concept of stormwater credit trading, its application, and potential benefits.
- Section 2 provides an assessment of the feasibility of a credit trading program among C/CAG member communities under existing (and likely future) regulatory conditions and offers some suggestions about how possible alternative regulatory drivers could influence trading program feasibility.
- Section 3 describes the project team's assessment of the potential demand for a stormwater credit trading program in San Mateo County relative to potential supply.
- Section 4 contains an analysis of potential costs for credits compared to costs for on-site compliance and within the context of the Regional Collaboration Framework.
- Section 5 relates the team's conclusions regarding credit trading feasibility and provides recommendations on program structure. The section also identifies additional research and analysis that could be pursued with additional resources to further characterize feasibility in greater detail.

1. Overview of Stormwater Credit Trading

For the purposes of this memo, post-construction stormwater credit trading is a voluntary, alternative compliance strategy that allows developers and property owners who are subject to post construction stormwater management requirements to meet those requirements (or a portion of those

requirements) by purchasing volume-based stormwater credits generated by the installation of GSI projects located off-site.

The credit trading approach may succeed when property owners and developers find that purchasing credits from an off-site provider reduces technical or economic obstacles to a real estate development project. In some cases, buying credits can allow property owners or developers to take advantage of additional buildable area on-site, including surface, rooftop, or underground areas. In other cases, on-site controls may not be feasible due to technical or land use constraints and/or may be very expensive. Purchasing credits can provide a less expensive option for meeting stormwater management obligations compared to on-site compliance or paying an in-lieu payment to the permitting authority (where this option exists.)

In addition to benefits for developers, the goal of a stormwater credit trading program is to provide greater overall water quality/stormwater control benefits relative to an approach that requires all developers to strictly manage stormwater on-site. For example, allowing some portion of retention to be met off-site (while still requiring that some percentage be met onsite when feasible) can result in a greater number of smaller GSI installations which, in comparison to a smaller number of larger stormwater management practices, capture more stormwater per event and can help distribute the environmental, social, and human health co-benefits of GSI throughout a city or watershed.[1] Municipalities can design programs in a way that encourages or incentivizes credit generation in areas where it will result in the greatest overall benefit, rather than simply gaining additional stormwater control where new development and redevelopment happens to be occurring.

Any trading program in San Mateo County would be tied to the minimum post construction stormwater standards reflected in section C.3 of the MRP and the requirements/guidelines for meeting these standards, as expressed in San Mateo County's C.3 Regulated Projects Guide. Some municipalities in the County have stricter standards/higher requirements than outlined in the MRP; these could also be incorporated into a volume-based trading program. While the demand for post-construction stormwater credits would come from property owners/developers seeking to comply with MRP/municipal standards, credits could potentially be generated/supplied from several sources:

- Property owners not subject to post construction stormwater management requirements who voluntarily implement GSI retrofit projects on their property.

- Developers and property owners subject to post construction stormwater management requirements who build GSI projects that provide additional storage capacity and/or manage additional (i.e., non-regulated) impervious area. These developers and property owners can either bank the extra storage capacity they create for use at future development sites or sell them.

- In San Mateo County, the project team is also evaluating the potential for public projects to serve as a source of supply of credits. These projects could include those identified in the

[1] Dougherty, S., R. Hammer, and A. Valderrama. 2016. How to: Stormwater Credit Trading Programs. NRDC Issue Brief 16-01-A. New York: NRDC, Available at https://www.nrdc.org/sites/default/files/stormwater-credit-trading-programs-ib.pdf.

County's Sustainable Streets Master Plan, current and future regional stormwater projects (including those identified in the Regional Collaboration Framework), and other public agency constructed stormwater management features.

Stormwater credit trading was pioneered by the District of Columbia's Department of Energy and Environment (DOEE). DOEE's Stormwater Retention Credit Trading program allows property developers to meet a portion (or in some cases all) of their stormwater retention requirements by purchasing an equivalent volume of stormwater BMP capacity from credit generators (i.e., private property owners or project developers) who build stormwater retention projects located elsewhere in the District. Developers are also allowed to build additional storage capacity (i.e., go above and beyond requirements) and use the associated credits at future development sites. Developers can purchase credits "by-right," meaning they do not have to demonstrate technical constraints/site conditions that prevent them from implementing stormwater controls on-site.

DOEE has carefully designed its program to incentivize stormwater management projects within its MS4 permit area, where distributed GSI projects result in greater water quality benefits compared to projects located in the downtown/combined sewer area.[2] The program provides economically valuable flexibility to developers, particularly in the downtown urban core where buildable area is relatively scarce and valuable. In addition, the distribution of credit generating GSI projects results in improvements in neighborhoods that are not otherwise seeing direct investments from real estate development projects. Other volume-based credit trading programs are being evaluated or are under development in several other jurisdictions, including Grand Rapids, MI, and Cook County, IL.

A key aspect of DOEE's program is that credits are purchased on an annual basis (though multi-year purchases/contracts between buyers and sellers are encouraged). One credit is equal to one gallon of retention capacity per year. Credits are certified by DOEE for three years at a time, which helps to ensure that credit generating projects are continuously maintained. This approach creates flexibility for sellers who may wish to redevelop their property and/or stop selling credits at some point. However, the frequency of credit purchases can increase overall compliance costs (because credits are purchased annually) and creates some uncertainty for credit purchasers. For many developers however, the cost for recurring annual credit purchases is offset by the high opportunity cost of land in D.C., especially in the downtown core.

Stormwater credit trading programs may be structured in different ways; for example, the City of Grand Rapids is contemplating a one-time (upfront) purchase of credits. This provides more certainty for buyers and reduces long-term compliance costs, but also limits flexibility for market participants (i.e., sellers that may want to exit the market).

In both Grand Rapids and DC, an in-lieu fee (ILF) serves as the ceiling price for credits on the market. This works because the cost to the public agency for constructing GSI is typically higher than the cost that private credit generators incur to build the same installations on private property. To sell credits, credit providers must charge less than the ILF charged by the city, otherwise developers would opt to pay the

[2] Special rules also apply to credit demand sites located in the Anacostia Waterfront Development Zone, with the goal of reducing any adverse effects associated with dislocating the development site from the location of the stormwater management project.

ILF. In DC, DOEE has also implemented a purchase guarantee program as a way to encourage credit suppliers to enter the market. Under this program, credit generators can enter into an agreement with DOEE that stipulates DOEE will purchase their credits (at a price slightly below market price) if they can't sell them on the market. Once purchased, DOEE retires those credits. The program serves as a price floor on the market and provides certainty to sellers.

2. Feasibility Considerations for Credit Trading in San Mateo County

As noted earlier, the objective of our analysis is to perform a high-level assessment to evaluate the potential feasibility for post construction stormwater credit trading in San Mateo County. This section provides an overview of general feasibility conditions for credit trading and describes the potential for credit trading under alternative regulatory compliance frameworks.

2.1 General Feasibility Conditions

A key tenant of stormwater credit trading is that it requires regulatory standards for post construction stormwater management that create sufficient demand for off-site compliance. A program may be feasible when development projects are subject to stormwater management standards that are challenging to meet within the footprint of project site. "Challenging" implies that compliance with the management standard may create additional technical costs or difficulties. Examples include on-site retention requirements that necessitate dedication of substantial site area or that may be difficult to achieve with local soil, slope, or land use conditions. Where these conditions impact cost or difficulty of on-site compliance, off-site alternatives become attractive options. The central importance of a stringent management requirement makes it the threshold pre-condition for the feasibility of a credit trading program.

Another necessary pre-condition is that the relevant permit (in this case the MRP) allows for off-site compliance. This condition is met in San Mateo County, as the MRP allows for alternative compliance by-right (although stricter regulations may exist within individual municipalities). However, the draft alternative compliance language in MRP 3.0 requires the use of GSI or low impact development techniques on-site "to the Maximum Extent Practicable" (MEP). This could interpreted as a requirement for developers to conduct a feasibilitiy assessment to demonstrate the need for offsite compliance or as an avenue for implementing alternative "non-LID controls" or flow-through treatment devices. Although this is not necessarily the case; it could also be interprted quite differently, depending on how MEP is defined.

Site-level economic factors also influence the likelihood of trading program success, as well as how it is structured. When the dedication of space within the project footprint for stormwater management needs exceeds the alternative economic value of the area, off-site options become more economically attractive, further increasing the number of potential demand sites and the ability to pay for off-site compliance (i.e., purchase credits).

At the same time, trading requires the possibility that lower cost compliance is possible within a trading geography. Where costs of on-site compliance equal or nearly equal the costs of off-site alternatives, trading becomes less viable. From a municipality's perspective, there must also be enough locations where voluntary stormwater projects can be installed to create credits in a way that optimizes

stormwater management benefits (supply sites), as well as associated co-benefits of GSI projects. This distribution will be governed by, geologic, topographic, and demographic factors.

Finally, the implementation and administration of a credit trading program requires sufficient capacity/resources within the implementing agency (or from a third party). Once established, the program can be integrated into ongoing administration of a post construction stormwater management/MS4 compliance program. However, administrative needs include developing the relevant resources and technology to track credit purchases, certify credit generating projects, incentivize supply (e.g., though a purchase guarantee or other programs, as applicable/needed), and more. This assessment does not include an analysis of program administration needs (or the feasibility of contracting some aspects of program administration to a third-party); however, the project team recommends this as a next step towards implementation.

2.2 Feasibility of Credit Trading under Current Stormwater Management Standards

The primary driver for project-level post construction stormwater management in San Mateo County is MRP provision C.3 (as well as additional, more stringent standards required by some municipalities). This provision affects new real estate development and redevelopment projects that create or replace 10,000 square feet or more of impervious area (although some land use categories trigger the threshold at 5,000 square feet). These projects must "treat the stormwater runoff equal to the volume of annual runoff required to achieve 80 percent or more capture" based on local rainfall data (80 percent capture method).[3] This is approximately equivalent to managing for the 85th percentile storm event, which ranges from 0.29 to 1.20 inches (24-hour rainfall event), depending on location in the County.

Based on the MRP, C/CAG's post-construction stormwater control standards emphasize that new real estate development projects, and certain redevelopment projects, must use one of two approved approaches for managing the stormwater generated within the project site. As mentioned above, one approach is to manage 80% of the volume associated with the annual mean precipitation depth ("the volume-based approach"). Alternatively, developers may opt to use the "flow-based sizing criteria" requiring control of runoff resulting from a precipitation rate of 0.2" per hour. The Countywide Water Pollution Prevention Program has translated this into guidance that the surface area of a biotreatment measure be sized to 4% of the impervious area that drains to it and prefers this approach for sizing GSI projects.[4]

Information available to this project team indicates that, generally, project developers have not had difficulty in meeting either of these standards within their project footprints. This seems to be because the infiltration or other measures required to meet the standard can be effectively incorporated into the project design and footprint with relative ease and at a low cost (or at least relative to off-site compliance options). Were this not to be the case, developers have had the option of using the Alternative Compliance options outlined in MRP Provision C.3.e. Based on information available to the team, this option has rarely been utilized in San Mateo County, likely because (a) the MRP standards are reasonably easy to meet on-site and there is flexibility in achieving standards that go beyond the MRP

[3] Alternative approaches are allowed, however, are less preferred by the Countywide Program. See C.3 Regulated Project Guide at 5.1.2.

[4] C.3 Regulated Projects Guide at 5-7.

requirements (e.g., drainage requirements); and (b) the available off-site alternative compliance options are not economically attractive.[5] In the absence of technical or economic incentives to look for off-site compliance options, developers would see little benefit in a credit trading program.

However, some property owners in the county are able to take advantage of special allowances for Special Projects and "non-LID treatment credits," which reduce on-site management requirements (making it easier to comply onsite). For example, roadway projects and some infill development projects are either exempt from or have reduced LID requirements .These provisions may be removed or altered in the forthcoming updated MRP, which could have the effect of increasing demand for off-site/alternative compliance.

While an updated MRP has yet to be finalized, a Tentative Order has been released that provides insights into future requirements. - While the C.3 treatment measure design standard in the Tentative Order remains unchanged, it proposes to lower the application threshold to projects that create 5,000 square feet of impervious area for all land use categories. The project team's analysis suggests that this will create challenges for some future projects, but probably not in sufficient numbers to support a credit trading program, at least one that emphasizes transactions between private developers (i.e., the model developed in DC).

2.3 Feasibility of Credit Trading under a Regional Collaboration Framework

While a credit trading market based solely on private (mostly) parcel-based GSI as the source of supply may not currently be feasible, the possibility of utilizing the capacity of regional stormwater projects (including those identified in the Regional Collaboration Framework) and potentially, other public projects, as sources of credits for multiple buyers (including developers seeking to meet post construction management standards and other seeking to meet MRP-related standards) creates a potential opportunity for a different type of market or program. Functioning more like a mitigation bank than a credit exchange marketplace, a program of this nature in San Mateo County could incorporate the purchase of private parcel-based GSI projects by the public implementing agency. The credits associated with these private parcel-based projects would be added to an overall pool that would also include credits generated from regional and other public projects. As described in the memo outlining the Regional Collaboration Framework (Geosyntec 2021), the pool of credits would be available for purchase to a range of potential buyers. This could include developers seeking to meet post construction stormwater standards, particularly if the stringency of local/MRP regulatory drivers were to be increased to a level that motivated uptake of the off-site alternative compliance option.

As described in the following sections, the project team's analysis focused on the potential functionality of a credit bank for developers seeking to comply with meeting post construction stormwater management standards. Specifically, the project team analyzed the potential demand for credits from new and redevelopment sites based on the regulatory, economic, and technical factors that influence the need or desire for off-site compliance. For demonstration purposes, the project team assumed a hypothetical stormwater management standard that required on-site retention of the 85th percentile storm. This standard was chosen because it is similar to the current standard except it requires retention (i.e., use of infiltration practices) and prioritizes off-site compliance over the use of flow through treatment when infiltration is not possible on-site. Further, as reflected in the San Mateo County

[5] Personal communications with Matt Fabry and Reid Bogert.

Stormwater Resource Plan, the average rainfall depth associated with the 85th percentile storm (0.57 inches across the County)[6] reflects the expected marginal increase in the 10-year (6-hour) storm event under climate change.[7] Infiltrating this volume will help to protect the existing storm sewer system, which is designed to manage the 10-year storm.

We also examined the potential supply to a credit bank/exchange that could be generated from private parcel-based GSI projects. To examine the economic drivers for a credit exchange program, our analysis factored in the presence of credits created by both private suppliers (i.e., private parcel-based GSI projects located in high priority areas for stormwater management) and public agencies (i.e., credits generated by current and future regional and green street projects) and the resulting influence on credit price and supply volume.

As described in more detail below, the result of this analysis support the conclusion that there is likely enough supply and demand to support a credit bank/exchange program for post construction stormwater management if it is incorporated into a broader regional program. The presence of large amounts of credits created by the regional projects skews the price of credits downward, because those projects are considerably less expensive to install and maintain on a cost/greened acre basis (compared to private parcel based GSI projects). As a result, off-site compliance becomes more cost-effective for developers. This type of model would incentivize more private parcel-based projects in areas of high priority for stormwater management (including those areas that will not be managed by proposed regional projects) because developers of such projects would have a guaranteed buyer (i.e. the associated credits would be purchased and added to the overall pool of credits). This is a key tenant and priority for C/CAG's approach to stormwater management throughout the County. In addition, participation in alternative compliance for numeric retrofit targets or C.3 regulated projects could also help municipalities address the need for funding and resources to ensure ongoing O&M for regional or distributed GSI.

3. Potential Site-Level Supply and Demand for Post Construction Stormwater Credit Trading in San Mateo County

A post construction credit trading/exchange program must have sufficient supply and demand to support robust market activity. The project team's feasibility assessment focused largely on identifying potential demand for credits from future new development and redevelopment sites, as well as the potential supply from private parcel-based GSI projects in high priority areas for stormwater management. The following sections describe the project team's methodology for assessing supply and demand and presents our high-level results.

3.1 Overall Methodology

Using data provided by C/CAG and Craftwater, we first identified opportunity parcels that would serve as high priority for parcel-based GSI credit supply sites. We then estimated the potential demand for credits based on parcel level data and projections for new development and redevelopment by County

[6] See San Mateo Countywide Water Pollution Prevention Program, Stormwater Resource Plan for San Mateo County, February 2017, at Table 2-5.

[7] Personal communication with Matt Fabry, 9/2/21.

Traffic Analysis Zone (TAZ, as developed by CD+A 2017). To assess total supply for a credit "bank," we also included supply from regional projects identified for the Regional Collaboration Framework and planned Green/Sustainable Streets projects. We did not include other public GSI projects (e.g., parcel-based projects) because these were constructed for regulatory compliance purposes. We then estimated the cost of a credit on the market and compared the value of a credit to the cost of on-site compliance.

Geographic data provided by C/CAG served as the basis for this analysis. This data included parcel-level land use, impervious area, projected new/redevelopment by TAZ, as well as sewer-shed and groundwater basin boundary information. Additionally, Craftwater shared GIS data on areas that are flood prone and/or have a high potential for stormwater recharge, and soil infiltration rates. Craftwater also provided information on identified opportunities for regional projects and their associated drainage areas. These data provided criteria to help prioritize supply and demand sites. We focused our analysis on the eastern side (or Bay side) of San Mateo County, as this is the portion of the county that is the focus of certain MRP requirements (e.g., PCB load reductions) and where the majority of existing and proposed development is occurring or is expected to occur.

The first step in our process was to build a database of relevant parcels. We excluded single-family residential parcels, as well as other land uses that are not well suited for GSI installations (see Appendix A for a full list of land use types that were excluded). We identified the impervious area associated with each parcel, as well as the TAZ within which most of the parcel lays. We overlayed parcel data with the criteria data that helped to determine locational attributes of each parcel, including drainage area for the top regional project opportunities, high potential for stormwater recharge, flood zone area, soil drainage type, and areas classified as "old industrial" (which are high priority for stormwater management retrofits/reducing PCBs and other water quality contaminants). This database of parcel level information enabled us to look at parcels that could potentially provide supply of stormwater credits to a market, as well as aggregate parcels that might have a more difficult time meeting stormwater compliance on site and would therefore generate demand for those credits. The parcel-level database is included as an attachment to this memo.

3.2 Identifying High Priority Supply Sites

For a property to be considered a candidate for on-site stormwater management (i.e., serve as a credit generating retrofit site), it must have enough uncontrolled impervious area[8] to generate a sufficiently sized credit generating project. For our analysis, we also assumed that it would be more cost-effective to construct GSI projects on sites with some level of existing pervious area. To identify potential supply sites, we therefore included properties with at least 2,500 square feet of impervious area and that have a ratio of impervious area to total parcel area of 90% or less (i.e., at least 10% of the property would be more readily available for retrofitting stormwater management practices).

Next, we used criteria provided by Craftwater to rank each potential supply parcel's locational attributes that contribute to increased benefit of managing stormwater at that site. Parcels were ranked from 0 – 5

[8] We chose to use impervious area rather than building footprint to identify potential supply sites. This provided a simple and consistent approach across all parcel types. However, it's possible there are sites that are more than 90% impervious that could generate additional supply that we have not captured in this analysis, for example small buildings with large parking lots that could be retrofitted with permeable pavement.

based on the proportion of land in a flood zone, in a high potential for recharge area, in an opportunity drainage area or on poorly draining soil, as well as whether the parcel is classified by C/CAG as old industrial (based on 2019 land use data). All attributes were weighted equally.

If a parcel has poor soil infiltration capabilities or is located in a drainage area of an identified opportunity for a regional public project (including four projects in the planning phases and the top 14 opportunity projects identified by Craftwater), it was discounted based on the proportion of area with those qualities. Poor soil quality makes infiltration of stormwater difficult. The top opportunities for regional public projects are large projects that will manage a significant portion of stormwater in the associated drainage areas, so private commercial retrofits in these areas will not contribute as great a benefit compared to projects located outside of the drainage areas. Parcels with land in an area with high potential of stormwater recharge or in an area prone to flooding were assigned a higher ranking based on the proportion of the property that have those attributes. The old industrial land use classification also improved a parcel's ranking as these sites might be at high risk for PCB loading (or other water quality contaminants) and could therefore benefit from onsite GSI controls.

Our analysis identified close to 9,500 impervious acres that could be managed; of these 3,520 impervious acres are on parcels designated as high priority supply sites. If these parcels were to install GSI-based stormwater management practices, they would offer additional benefits of increased recharge, local flood management, and potentially other benefits. If these sites were to provide stormwater credits to a market or credit bank, they would increase the efficiency of stormwater management across the region due to the accrual of these additional benefits.

3.3 Identifying Potential Demand in Priority Development Areas

To identify total regulated impervious acres that might benefit from off-site compliance, we started with the regulatory requirements outlined in the current MRP. The threshold for on-site management is 5,000 square feet or more of impervious surface for uncovered parking areas, restaurants, auto service facilities and retail gasoline outlets. We note that the Tentative Order proposes to reduce the threshold for C.3 compliance to 5,000 square feet for all new or redevelopment projects. With these two factors in mind, we began our analysis by identifying properties greater than 5,000 square feet in size. This represents the universe of parcels that could potentially trigger stormwater management standards if they were developed/redeveloped.

The demand analysis is complicated by the fact that we do not know how parcels will be redeveloped in the future. For the purposes of this analysis, we assume that redevelopment sites will follow the general pattern of existing land uses by TAZ. Thus, we relied on existing site conditions (e.g., % of sites with lot line to lot line development) to predict future demand from new/redevelopment sites.

For parcels with greater than 90% impervious area, we assume there is little room to effectively implement stormwater management practices that could retain required runoff from all impervious surfaces. We anticipate these sites would have more difficulty implementing on-site retention due to the limited land capacity and the opportunity cost of using land to manage stormwater in high density development zones. Additionally, parcels with more than 50% of their land located on poorly drained soil areas would likely not be able to infiltrate runoff on-site. We estimate at least 3,219 impervious acres of parcels meet these criteria. These parcels constitute potential demand sites (if they were to be redeveloped).

Since MRP requirements only apply to new and redevelopment projects, we needed to filter our results based on whether land was expected to be redeveloped. C/CAG shared data on acres of projected growth of single-family housing, multifamily housing and commercial/industrial by TAZ through 2040. In total, these estimates project that a total of 1,170 acres of commercial and/or multifamily housing will be redeveloped. Since we are concerned with commercial retrofits, we calculated the proportion of multifamily housing and commercial/industrial acres of projected growth relative to total area of each TAZ that is not classified as single family (or any of the other land uses excluded from our analysis). We applied this proportion to the area of identified potential demand parcels based on the TAZ in which the majority of the parcel is located. This generated an approximation of acres of new or redevelopment aggregated by TAZ that might have difficulty meeting stormwater regulations on site. Results of this analysis indicate that approximately 338 acres of development meet the criteria outlined above and might benefit from off-site compliance (approximately 30% of projected redevelopment acres).[9] The location of the projected acres of demand in new and redevelopment is visualized in Figure 1.

3.4 Supply and Demand Analysis

In this high-level analysis, we identified nearly 340 acres that would potentially serve as a source of demand for credits. As shown in Figure 1, that demand is driven by the areas C/CAG has identified as high priority for new and redevelopment over the next 20 years. We also identified over 3,500 acres of high priority supply sites. If GSI were implemented at these supply sites, C/CAG member agencies would see an increase in efficiency in stormwater management through dispersed GSI. This is particularly true if areas being redeveloped are already highly impervious and were not previously subject to stormwater management standards (i.e., there is no net harm from moving stormwater compliance off-site).

Stormwater credit trading can increase efficiency both by allowing flexibility for developers subject to stormwater regulations without sacrificing valuable land assets, and by distributing stormwater infrastructure geographically to areas that offer greater benefits of on-site management. To demonstrate these benefits, Figure 2 shows a high demand TAZ around Redwood City, and high priority supply parcels within the TAZ and the surrounding region. While overlap of potential supply and demand exist in the area just southeast of Redwood City towards North Fair Oaks, there is a high concentration of projected new and redevelopment parcels that might seek compliance off-site in Redwood City center. There is also a pocket of high priority supply parcels just south in Menlo Park.

Potentially, a credit exchange program could encourage developers in Redwood City to pursue off-site compliance, while facilitating their purchase of credits created by distributed GSI in Menlo Park. Figure 3 demonstrates the additional benefits of allowing for off-site compliance. Figure 3(a) shows that the areas of high development that would generate demand are located outside of a flood zone, while the concentration of priority supply sites in Menlo Park could potentially be designed to reduce localized flooding in that area. Additionally, Figure 3(b) shows some sites in Menlo Park as well as a few supply sites to the northwest of Redwood City that are located in areas that have high potential for groundwater recharge if stormwater were to be infiltrated intentionally in these locations.

[9] This estimate may be reduced if there are redevelopment projects that qualify as Special Projects and could more easily achieve compliance on-site with non-LID treament measures, which is allowed in the current MRP.

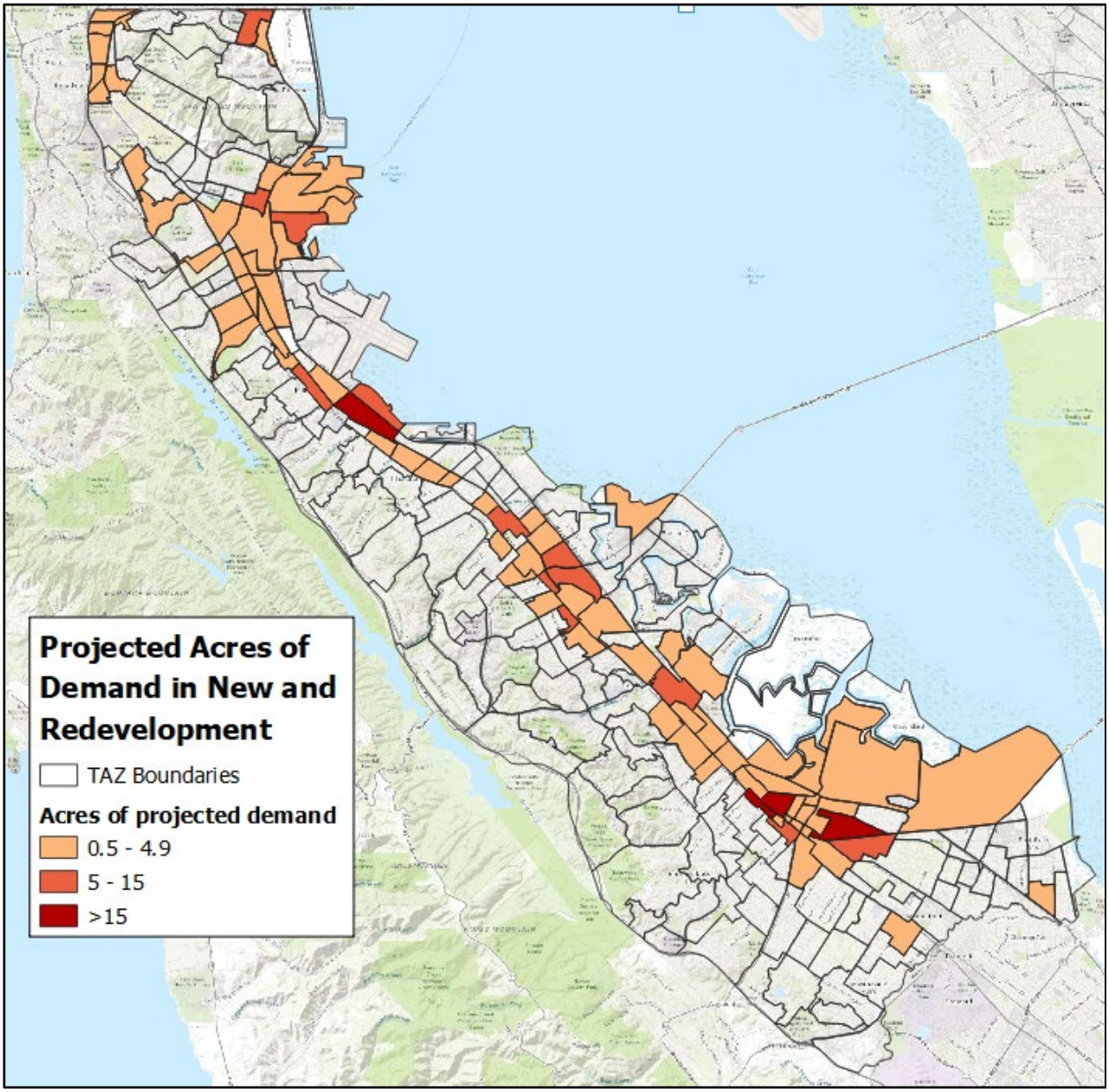


Figure 1. Projected acres of demand in high priority development areas by TAZ

4. Integration into Regional Collaboration Framework

As discussed previously in this report, C/CAG is working to advance the implementation of multi-benefit regional stormwater capture projects and distributed GSI in San Mateo County through a Regional Collaboration Framework to provide more cost-effective implementation of municipal stormwater management, while complying with MRP provisions. Stormwater credit trading could potentially become a component of the Regional Framework, with large scale regional projects, sustainable streets projects, and private parcel GSI serving as a "bank" of supply credits for public and private sector buyers. One challenge we encountered during our analysis was the task of normalizing metrics for measuring

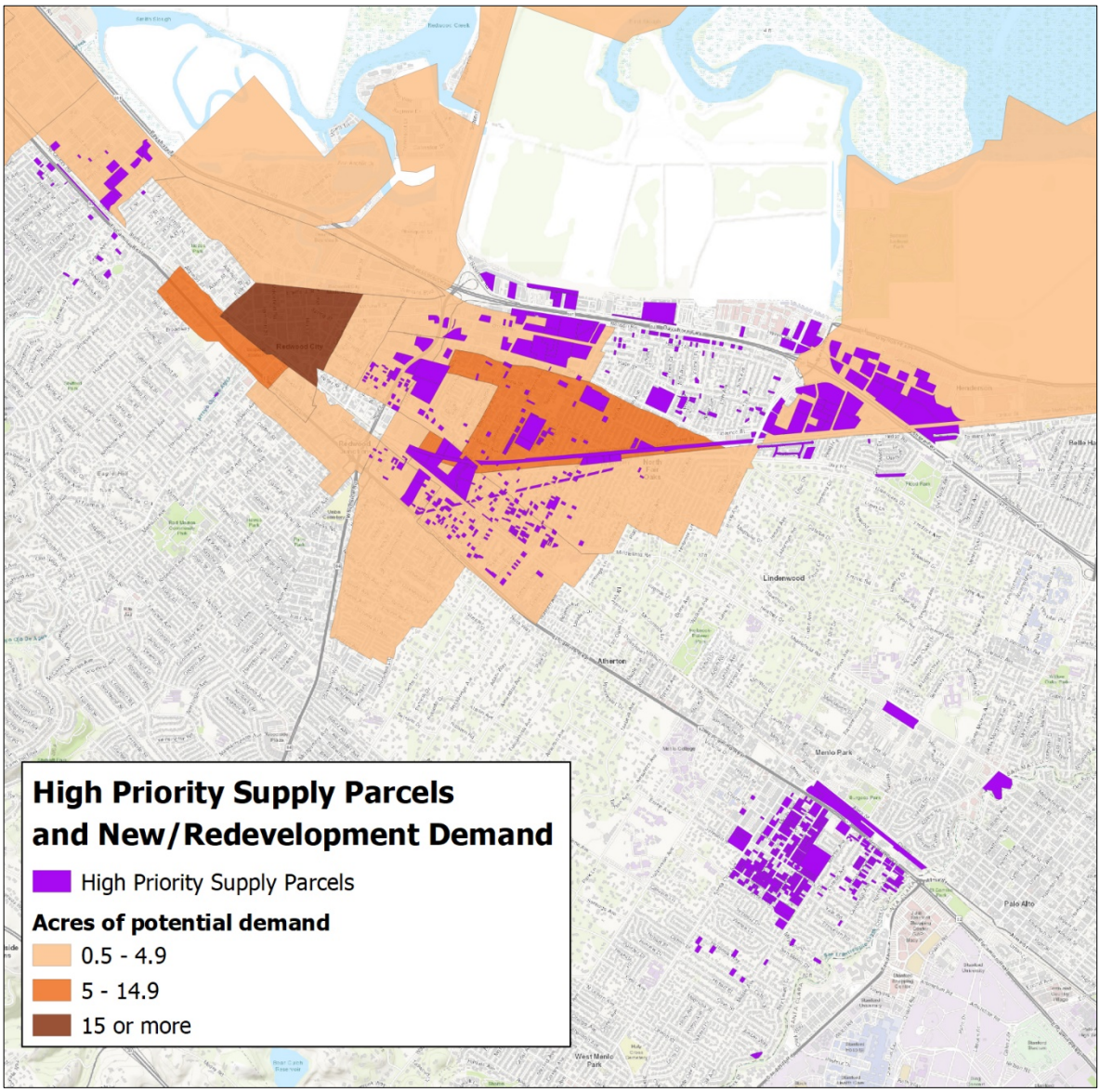
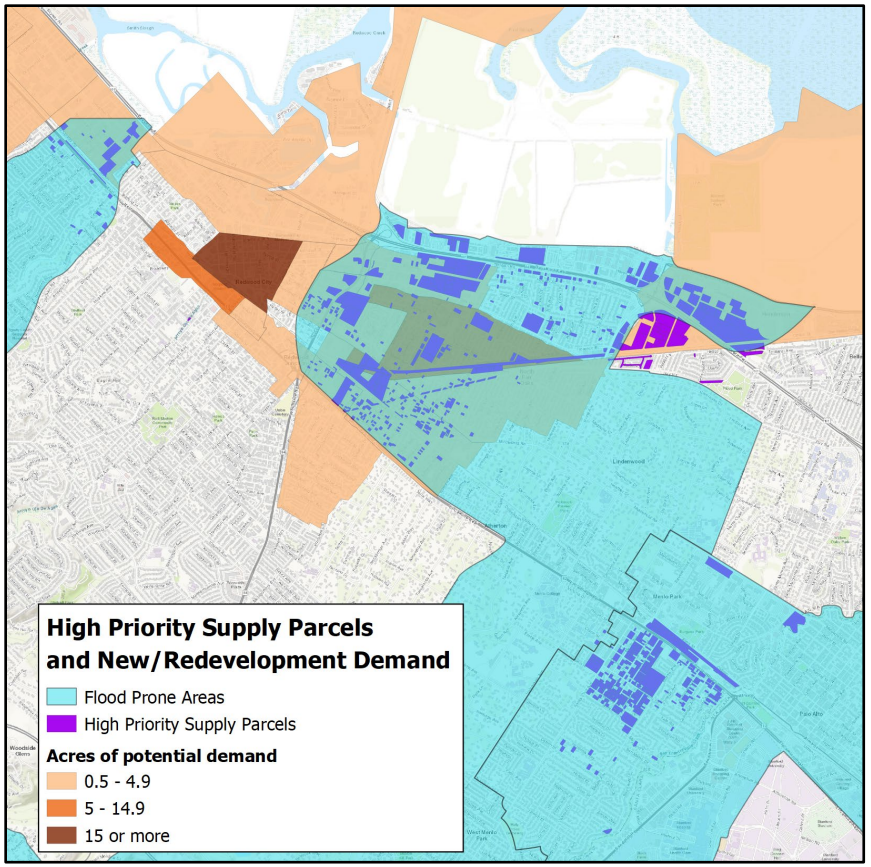
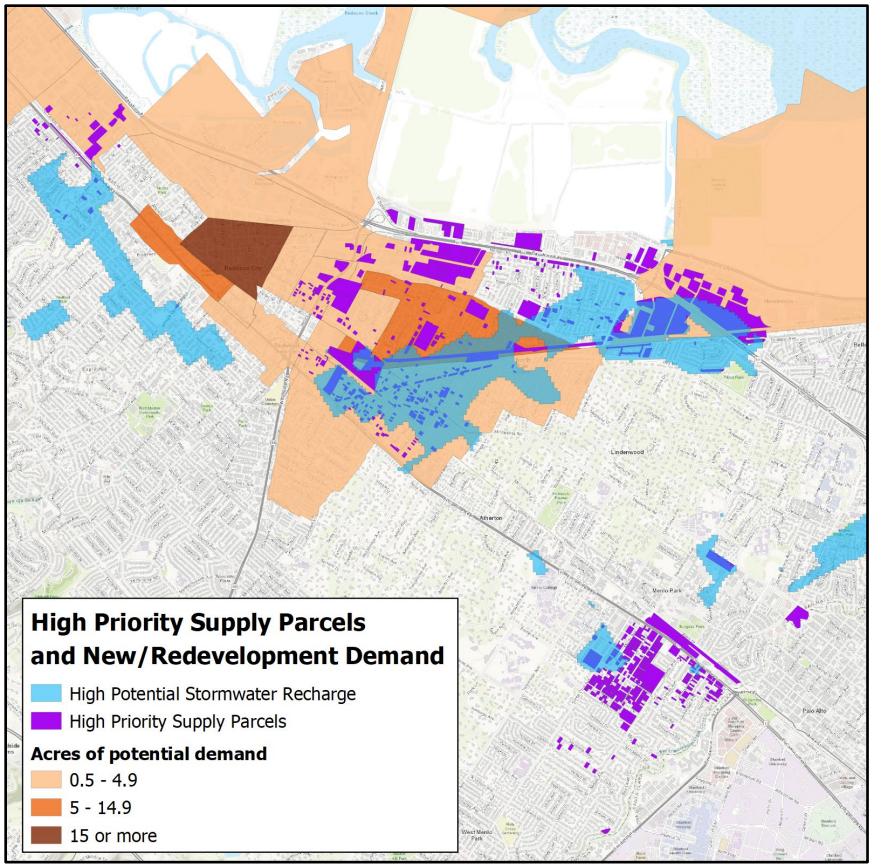


Figure 2. High potential demand in Redwood City TAZ and high priority supply parcels in the surrounding area.

acres of land or volume of stormwater managed by different project types. For consistency, we adopted the definition of a "greened acre" from Geosyntec: *treatment of stormwater runoff through green stormwater infrastructure (GSI) sized per the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) requirements, or "GSI-equivalent" treatment*. There is some ambiguity with the permit's C.3 provisions regarding standards for stormwater management, in part due to the differences in rainfall across the County. To quantify and compare supply, we applied the same stormwater capture volume standard used in the Geosyntec business case (infiltrating runoff from the 85th percentile 24-hour storm runoff event, which averages 0.57 inches across the County).


High Priority Supply Parcels
and New/Redevelopment Demand
Flood Prone Areas
High Priority Supply Parcels
Acres of potential demand
0.5 - 4.9
5 - 14.9
15 or more


High Priority Supply Parcels
and New/Redevelopment Demand
High Potential Stormwater Recharge
High Priority Supply Parcels
Acres of potential demand
0.5 - 4.9
5 - 14.9
15 or more

4.1 Potential sources of public supply

In addition to parcel-based projects, GSI investments made in the public right of way could serve as a supply of stormwater credits. Per discussions with C/CAG, any publicly owned GSI stormwater management project constructed after 2015 and not built to satisfy requirements for a regulated project would be eligible to generate credits that count towards supply or be entered into the "bank" of credits. The sources of potential supply and their associated greened acres and volume of stormwater managed are summarized in Table 1 as follows:

- Public Green Streets projects are relatively small-scale GSI projects that have been constructed in accordance with the Local San Mateo County Integrated Safe Routes to School and Green Infrastructure Project. These projects collectively manage 22.0 greened acres.
- The Sustainable Streets Master Plan Priority Projects have been designed but are not yet constructed. The 11 proposed projects would manage 18.8 greened acres.
- San Mateo County has four regional projects in varying phases of implementation (including Orange Memorial Park, which has been completed). Together, these projects will collectively manage an estimated 692 greened acres.
- Craftwater conducted an optimized regional project analysis and identified 14 high priority large-scale regional projects. These projects have only been evaluated at a high level but could collectively manage the 85th percentile runoff volume from 2,321 acres.

Table 1. Potential publicly owned sources of stormwater credit volume supply (assuming infiltration of 85th percentile storm, rainfall depth average)

Public Projects Supply	Status	Greened Acres	Volume Infiltrated (AF)
Green Streets projects	Constructed	22.0	1.1
SSMP Priority Projects	Planned	18.8	0.9
Regional Projects	Planned/Implemented	692	32.9
Regional Projects	Proposed	2,321	110.2
Total		3,072	145.9

4.2 Potential sources of public demand

In addition to generating a bank of supply credits for cost-effective stormwater management, regional collaboration could also generate additional demand for credits. Public municipalities and other permittees, CalTrans, and potentially even water supply agencies (if projects are infiltrating groundwater) could participate in the market on the purchasing side. Without an extensive survey of forecasted improvement or development plans and/or more information on the technical and economic constraints on achieving future pollutant reduction or greened acreage goals on a jurisdiction-by-jurisdiction basis, it is difficult to estimate the quantity of demand that might be generated by public agencies or other permittees. However, it is helpful to acknowledge that the demand generated by private new and redevelopment projects outlined in the previous section is just one component of total possible demand.

5. Stormwater Volume-Based Credit Cost Analysis

For private developers and public agencies alike, one of the main drivers for exploring alternative compliance is the high cost of managing stormwater on-site. Credit trading can provide an economically favorable avenue for compliance. There are two ways to consider these cost efficiencies. First, in dense areas of new and redevelopment the physical space required to manage stormwater can have a high value for other uses. Accounting for the opportunity cost of using that space for other purposes can make on-site compliance more expensive. Second, if all credits, from large scale public projects to small scale private retrofits, are banked, then purchasing volume-based credits could be less expensive than managing stormwater on-site. The costs of credits are highly dependent on the structure of the market, so the methodology presented here is purely demonstrative in nature and would likely be refined as/if the program moves forward.

We began the cost analysis by gathering regionally specific cost data (where available) for the different types of projects that could serve as a source of supply. The cost data and sources are summarized in Table 2. The costs are difficult to compare side by side since the data available did not offer a breakdown of included expenses. Capital cost and overhead and maintenance (O&M) cost estimates were sourced from the Geosyntec Business Case when possible. The Sustainable Streets Master Plan provided cost estimates for the identified priority projects. Private project costs were calculated from engineering estimates from the project team's previous work as well as grant amounts for GSI capital construction projects from the San Francisco Public Utility Commission. O&M costs were drawn from a combination of Community-enabled Lifecycle Analysis of Stormwater Infrastructure Costs (CLASIC) developed by the Water Research Foundation (2020) and estimates from previous work.

Table 2. Capital and O&M Costs by Project Type

Project Type	Capital cost per greened acre	O&M cost per greened acre	Source
Green Streets projects	$230,000 - $301,000	$9,200	Geosyntec, 2021
SSMP Priority Projects[a]	$1,605,433	$9,200[b]	SSMP, Appendix E, 2021
Implemented Regional Projects	$68,250	$4,360	Geosyntec, 2021
Proposed Regional Projects	$69,000	$4,360	Geosyntec, 2021
Private Projects	$165,000 - $736,201	$1,960 - $6,610	Various

a. The costs for the SSMP projects were obtained from the SSMP (Appendix E). The project team notes that these cost estimates are much higher than the estimates for other projects. This is because these projects include additional components such as bikeways, medians, and pedestrian improvements. A decrease in these costs (e.g., if only stormwater management costs are included) would further reduce potential credit prices. The SSMP did not separately allocate costs across project components.

b. Due to the high cost of the SSMP projects, we assumed the O&M for the stormwater component of the SSMP projects would be the same as reported by Geosyntec 2021 for green street projects (estimated at 4% of the low-end estimate for green street projects).

The value, or price, of a credit will be determined by the costs of installing and maintaining GSI projects. If all supply credits are aggregated and banked, and then credit prices could be set at the weighted/pooled average. Under these circumstances, costs to purchase credits from banked supply could be less expensive for developers than managing stormwater on-site. Understanding an average cost per volume therefore provides insight into what the value of a stormwater volume credit might be

on a market. The methodology for estimating a cost per credit outlined below is demonstrative, as the true cost per credit will depend largely on the mix of credits coming from different supply sources.

The price of a credit will also depend on how a credit trading system is structured: a one-time purchase of credits will be very different than purchasing a "capital" credit up front with an annual fee for maintenance. For example, prices in the stormwater credit trading market in D.C. reflect the annualized capital and O&M costs of the originating projects. Because the program essentially requires property owners to purchase credits every year, it increases the cumulative cost for property developers. Although this cost may be very expensive for private property owners, it is often less than the economic value of the property that can be used for non-stormwater management purposes. Because some portions of San Mateo County have comparable land values, the DOEE market model may be economically feasible. This is not the case in Grand Rapids, MI where the credit trading program (which is currently being designed by project team members and city staff) is structured around a single, up-front purchase that incorporates maintenance costs. This approach reduces overall costs for purchasing project developer while requiring a larger initial investment. This model may be a viable alternative for San Mateo County, recognizing the wide disparity of property values and stormwater management costs across the county.

As shown in Table 3, we used the cost estimates presented above to calculate a cost per cubic foot of stormwater managed by each project type. To calculate a weighted average of capital costs per cubic foot of stormwater managed, we included the total potential supply from public projects (see greened acres managed from Table 1). For potential private credit-generating sites, we assumed that 25% of the potential greened acres identified in the supply analysis would be managed through GSI installations/serve as credit supply sites (880 greened acres from the total 3,500). Based on this methodology, we estimate that the value of a credit could range from $48 - $110 (capital costs only). For O&M the weighted average cost amounts to $1.87 – 2.37. However, the actual credit price would vary based on the way a market is structured and how much supply comes from different sources.

Table 3. Potential sources of stormwater credit supply

Project Type	Capital Cost per Cubic Foot	O&M Cost per Cubic Foot
Green streets projects	$128	$4.45
SSMP priority projects	$776	$4.45
Implemented regional projects	$33	$2.11
Proposed regional projects	$33	$2.11
Private parcel-based projects[a]	$80 - $356	$0.95 - $3.19
Weighted average credit price	$61 - $208	$1.50 – $2.70

a. Low end of the range for private parcel-based projects is $165,000 per greened acre – this is based on the assumption that private property retrofits would be at least as cost-effective as public parcel-based GSI. Although based on the project teams experience private parcel-based projects are often less expensive than public projects. The high-end estimate is $736,201 – this is based on costs for retrofits funded through SFPUC's GSI grant program. Costs do not include profit/ROI for private credit suppliers.

The Reasonable Assurance Analysis (RAA) for San Mateo County (2020) reports the average cost of on-site compliance for redevelopment sites as $153,000 per greened acre, or approximately $74 per CF. This estimate for on-site compliance cost is within the middle of the estimated weighted average price of a stormwater volume credit. However, if the $153,000 reflects an average cost (as reported in the RAA), sites facing technical constraints or site conditions that make it difficult to implement GSI would likely face increased costs. In addition, this estimate does not include the opportunity cost to developers and property owners of having to use limited and valuable space to manage stormwater. Including these costs would make the value of purchasing stormwater credit on the market much more competitive with on-site compliance. Finally, the nature of credit trading will drive project developers to implement projects where they are most cost effective (and to implement the most cost-effective controls). Thus, the average costs of credit-generating retrofits may be much lower than the estimates used in this analysis. At the same time, the regional projects drive the weighted average price downwards; if fewer regional projects are implemented, the average credit price will increase.

6. Summary and Conclusions

6.1 General conclusions of analysis

Our analysis suggests that under more stringent regulatory requirements, and with the inclusion of regional stormwater projects, a credit exchange/banking program may be viable within C/CAG member communities. Under these conditions, there appears to be sufficient demand for off-site compliance. Likewise, the distribution of less densely developed parcels in areas of suitable soils indicates the potential the creation of supply credits from GSI retrofits or redevelopment projects. However, the influence of the regional projects on credit price indicates that an exchange program likely would be more successful if structured as a pooled bank of credits that developers, public agencies, and other permittees could draw upon. In this way, rather than a true credit trading program, private suppliers would essentially receive a direct incentive as a payment for their credits.

6.2 Additional analyses for consideration

While resolving some threshold feasibility questions, the team's analysis left unanswered several more detailed questions about the structure, administration and economic underpinnings of a pooled credit exchange program. In this section, we will provide some additional variables for consideration.

6.2.1 Alternative approaches to forecasting supply

When analyzing supply from private commercial parcels, this report only included potential high priority supply sites that could provide additional stormwater management benefits for locating GSI on-site (e.g. supply sites that were ranked 3 or greater in our simple prioritization methodology). However, our analysis identified a total of close to 9,500 impervious acres that could potentially be retrofitted. This includes supply from neutral sites while still excluding those parcels located in areas with poorly draining soils and/or do not have a significant amount of impervious area to manage.

Another consideration for supply is the concerns for cost-effectiveness of managing stormwater on-site. This broad analysis did not fully consider challenges that different geographies or land use types might have in implementing GSI. It's possible that some high priority supply sites we have identified in this report would not even be feasible due to locational attributes that could not be included in this analysis. A more refined analysis of potential private would likely be necessary and could further inform the

structure of the program (e.g., by identifying areas where additional incentives might be offered to encourage supply development).

6.2.2 Alternative approaches to predicting demand

When considering potential demand, it is likely that the number of new and redevelopment acres identified in this report are an undercount of total potential demand. Municipalities, other permittees, CalTrans and other public entities could increase demand through infrastructure improvement programs. A more thorough examination of potential private commercial demand could also provide additional insight. This analysis was limited to current land use types, so parcels that are un- or underdeveloped (such as vacant lots) are not included in our count of demand acres. As with supply, a more careful look at areas of planned redevelopment by local officials could improve the demand analysis.

6.2.3 Administration of a pooled credit exchange

The pooled credit approach suggested in the team's conclusions will require some form of centralized administration. This analysis did not evaluate whether or not C/CAG is the right entity to provide this administration, or whether there are other options available. For example, it may be appropriate to engage a 3rd party program administrator, or to locate administration within a county agency or special district. The team can suggest that a future analysis consider the range of program administration tasks likely to be required for the development, operation, and support of a pooled credit exchange program. One administrative role is worth drawing particular attention to. A necessary component of a trading or exchange program is the ability to ascertain compliance at the site level. In order to this, C/CAG member agencies must be assured that projects generating credits meet all technical standards (certify credits), that credit purchases meet the required off-site compliance volumes, that purchases of credits are logged to the purchaser in a way that verifies compliance, and that credits are not sold to multiple parties at the same time. All of these factors must be built into a robust credit tracking system and complemented with periodic site inspections. A program administrator must have sufficient financial and staff resources to develop and maintain a tracking system. These resources are, in turn, dependent upon the structure of that system and the degree to which it can leverage or be integrated into existing data management resources.

6.2.4 Trading Geographies and Credit Ratios

Finally, there are many geographic considerations that extend beyond the scope of this work, including the delineation of any potential trading area boundaries within the Bayside portion of the C/CAG member area. Regional authorities should consider the importance of storm sewer-shed boundaries, water quality considerations, groundwater basins, drainage areas and jurisdictional priorities when designing trading zones or regulations of a credit market. Attention to socially equitable distribution of GSI to areas with more vulnerable populations may also be a priority for C/CAG, as well as trading across different land use categories.

6.2.5 Credit Trading Ratios

It is common for alternative stormwater compliance programs to have some form of trading or off-site ratio which requires increased levels of retention or treatment or other "net benefits" for when developers opt for an off-site option. For example, Grand Rapids Michigan's MS4 permit specifies that projects seeking compliance must install (or cause to be installed) 1.5 times the volume needed to meet

compliance minimums. In some high priority watersheds, this ratio increases to 2:1. From a purely market perspective, these requirements increase costs for off-site compliance, perhaps to the point of disincentivizing participation in trading markets or similar programs. Indeed, there does not appear to be compelling evidence that the increased requirements are necessary to achieve water quality or flood control goals. Future refinement of a credit-based approach for San Mateo County should include an evaluation of necessary or desirable ratios, as current and proposed alternative compliance provisions in the MRP require any offsite compliance to achieve a net benefit.

6.2.6 Drainage District and Municipal Standards

This evaluation focused on the post-construction stormwater management requirements imposed by permittees to meet MRP obligations, and does not take into account the effects of local standards. For example, the County of San Mateo has developed a draft drainage manual which proposes prescriptive/runoff management requirements for projects between 750 sq ft and the C.3 threshold (~5,000 sq ft) as well as additional runoff management requirements for C.3 projects. If adopted, both could have the effect of increasing supply and demand within the pooled credit exchange approach.

Likewise, some C/CAG member communities (e.g., Hillsborough and Atherton) have infiltration / retention requirements that are more stringent than MRP requirements for single family home projects. A future analysis should account for such localized standards in forecasting demand and supply, and in establishing protocols for credit purchase and sale. Because the credit trading program would be volume based, there may be a translation factor that could incorporate different standards.

6.2.7 Purchase and payment structure

As indicated in a preceding section, determining the frequency that credits must be purchased, and their duration, has direct implications for not only credit price but also the administration of a pooled credit exchange. A deeper analysis of the economic effects of single vs. multiple purchase requirements will inform C/CAG member agencies' dentification of a scheme that creates a stable, self-sustaining exchange program without creating undue economic hardships on participants.

In addition, in some instances of an expanded credit trading program private project developers may essentially receive a direct incentive (e.g., payment from municipalities) to add supply to the credit bank (in the form of GSI parcel-based projects)). The way this payment is structured also requires some consideration. For example, it could be provided as a set amount per greened acre (similar to how Philadelphia has structured its Greened Acre Retrofit Program). It may be on a reimbursement basis (although this would require additional administration) or through an innovative project delivery model (e.g., community-based partnerships). Additional incentives may also be necessary to further encourage supply in high priority areas.

7. References

Water Research Foundation (WRF). Community-enabled Lifecycle Analysis of Stormwater Infrastructure Costs (CLASIC). 2020. Available: https://www.waterrf.org/CLASIC

CD+A (Community Design + Architecture). 2017. SMCWPPP Green Infrastructure Plan Development Support – Updated methodology and initial estimate of land area for new and redevelopment from 2015 to 2040. Memorandum to Green Infrastructure Committee, from Phil Erickson and Bharat Singh. January.

Geosyntec Consultants (Geosyntec). 2021. Memorandum: Advancing Regional Stormwater Capture Projects: Business Case for Regional Collaboration. Project Number CWR0650.

C/CAG and CalTrans. 2021. San Mateo Countywide Sustainable Streets Master Plan (SSMP). Available: https://ccag.ca.gov/countywide-sustainable-streets-master-plan/

San Mateo Countywide Water Pollution Prevention Program. 2020. Pollutant Control Measures Implementation Plan and Reasonable Assurance Analysis for San Mateo County, California.