Discussion and Recommendations

Chapter 4

The GreenPlan-IT Toolkit is a planning level tool that provides users with the ability to evaluate the cost effectiveness of GI for addressing stormwater management in urban watersheds. The case study in City of San Mateo demonstrated how the GIS Site Locator tool was used to screen potential sites for GI implementation, while case study in San Jose PDA highlighted the power and utility of the Toolkit and demonstrated how to use the Toolkit to support a cost-benefit evaluation of stormwater runoff control. The two case studies provide useful and practical information that can help managers to understand and evaluate the benefits of GI in urban watersheds.

As illustrated by the San Jose case study, the application of the Toolkit requires careful formulation of the management questions and the optimization objectives. Setting up the Modeling Tool requires deciding on the appropriate spatial scale such as the number of sub-catchments and resolution used to represent GI, as well as the input data collection, model calibration, and development of the baseline condition. The Optimization Tool can be very powerful when combined with hydrologic modeling and cost analysis. Successful and meaningful application of the Optimization Tool largely depends on accurate representation of the watershed baseline condition, GI configurations, and the associated GI costs. The sensitivity analysis demonstrated that the optimization process is highly sensitive to GI cost data used in selecting solutions, and as a result, sensitivity analysis and evaluation of cost control measures or economies of scale are recommended wherever the Toolkit is applied. This section discusses the lessons learned from these case studies, identifies major data gaps, and makes recommendation on future enhancements.

4.1 Lessons learned

The case studies presented in this report provide useful and practical guidance for conducting similar studies in other watersheds. The lessons learned from these case studies could benefit potential GreenPlan-IT users.

- **Determination of Spatial Scale**

The first challenge in any modeling study is to determine how detailed the model needs to be in order to properly represent the system. The model should only be as complex as necessary to address modeling objectives and answer the management questions. In the context of optimization for GI placement, the study area should be delineated into sub-basins that are small enough to be meaningful for guiding GI implementation while not adding extra burden on model run time. There will always be a trade-off between model spatial resolution and run time. Different choices might be made by first time users versus seasoned users.

- **Importance of Model Calibration**

The model baseline is the foundation upon which all subsequent analyses depend and is crucial for meaningful results. The importance of a representative baseline model highlights the importance of model calibration. In the San Jose case study, a significant amount of effort was invested to calibrate SWMM using a weight-of-evidence approach to ensure the baseline model adequately represents the existing watershed conditions. Future users of the Toolkit should always bear this in mind and invest effort in model calibration with local data to ensure the meaningful application of the Toolkit.

- **Interpretation of Optimization Results**

The Optimization Tool performs iterative searches to identify cost-effective solutions. The search process is dependent on the problem formulation, model assumptions, GI cost and GI treatment effectiveness. Therefore, the cost-effective solutions from the optimization process would very much depend on the user-defined goals and assumptions and must be interpreted within the context that defines each specific application. The application of GreenPlan-IT Toolkit must also be accompanied by an intimate understanding of the study area and all influential factors that affect local stormwater management in order to ensure meaningful interpretation of optimization outcomes.

- **Consideration of Optimization Run-time**

The total number of iterative runs needed for the optimization process to converge to the optimal solutions is dependent on the number of decision variables, model simulation period, and the complexity of the model (number of sub-basins and stream neatwork). More model runs usually leads to longer computation time. For the San Jose case study, it took about two hours for the optimization process to reach optimal solutions after 200 runs, and this short computation time is largely benefited from a very short simulation period (24 hours). If the Optimization Tool is applied to a large watershed with many feasible GI sites and a complex stream network and the optimization process is based on long-term continuous simulation, a large amount of computation time will be needed to reach the optimal solutions. In general, the computational efficiency can be achieved through reducing the number of decision variables, simulation time, and complexity of the problem.

4.2 Data Gaps

The GreenPlan-IT Toolkit is a data-driven tool whose performance is dependent on the availability and quality of the data that support it. Through the two case studies, major data gaps for each tool were identified.

- **GIS data**

The placement opportunities for GI define the extent to which GI can beneficially impact flow volume. In each of the case study, limitations were placed on the locations available for GI placement, which in turn led to a definition of the maximum potential effectiveness of the GI in controlling runoff volume. Some of these limitations were physical constraints of the landscape that were derived during the engineering and design process. Other limitations were defined based on land use or ownership criteria resulting from the local decision making process. The restrictions placed on GI must be understood in order to evaluate the management scenarios.

- **Monitoring data**

Developing the Modeling Tool to establish a representative baseline requires the calibration of the model with monitoring data. For the San Jose case study, there were good precipitation time series, long-term flow monitoring data at a number of gages, and good spatial data to characterize land use and impervious cover to support model development. While in the San Mateo case study, lack of monitoring data limited the full utilization of the Toolkit. Lack of monitoring data, in particular water quality data, and general quality issues associated with model input data will be a major hurdle when applying the Toolkit to other watersheds in the Bay Area.

- **GI cost information**

As demonstrated by the sensitivity analysis of the San Jose case study, the optimization strongly depended on the available GI cost information, and uncertainties in local cost data can greatly influence the management conclusions. GI cost could vary widely from one location to another, influenced by site-specific factors such as physical characteristics, constrains, and local economy. For the San Jose case study, there was very limited information available on GI cost, most of which was for bioretention and little for infiltration trench or permeable pavement. The understanding and utilization of the optimization results must take this limitation into account. To ensure a meaningful application of the Toolkit, reliable local cost information must be collected to drive the optimization process. While it is important to have accurate cost information for each GI type, it is the relative cost difference between GI types that determines what constitutes the optimal GI types and combinations. Therefore, it is crucial to have reliable estimates on relative cost difference between various GI types and interpret the price tags associated with each GI scenario as the relative merits of one scenario verse another, not as the true cost of implementation.

4.3 Future Steps/Enhancements

The case studies showcased in this report were focused on stormwater volume control and represent the first phase of the GreenPlan-IT Toolkit development. To develop a tool that is comprehensive and flexible enough to handle a variety of situations and address a wide range of management questions, the Toolkit needs to be continuously evolving. Future enhancements on the Toolkit are identified through experiences and insights gained from the Toolkit development, case studies, and discussion with the TAC and stakeholders.

- **Site Locator Tool**

During the next development stage, more GI types could be included in order to develop a wide range of management alternatives. In addition to new GI types, some cities may also be interested in keeping centralized regional facilities such as enlarged bioretention as an option to supplement GI implementation. A diverse set of management options should be evaluated through the Toolkit to provide solutions to a wide range of stormwater management problems. Such additional features could then be considered within the modeling and optimization tool components thus keeping the tool flexible enough to address multiple endpoints such as drinking water supply augmentation or storm sewer master planning. Furthermore, changes to the Site Locator Tool's Opportunities and Constraints ranking functionality would allow for final ranked locations to contain information showing the reasons it was ranked high or low. Additional work could be done to allow for final outputs to be exported automatically to PDF formats as well as improving current KMZ/ Google Earth format functionality. Moreover, guidance and/or models could be developed to help municipalities create potential location layers needed in the Location Analysis of the Site Locator Tool.

- **Water quality simulation/optimization**

  Currently, SWMM5 lacks mechanisms to simulate water quality reduction through GI implementation. This deficit is the reason why water quality simulation/optimization was not performed for the San Jose case study. Developing methodology and corresponding modules to quantify the pollutant removal efficacy for various GI types will be the first major task for future enhancements. EPA's SUSTAIN modeling system includes a BMP module that uses a first-order decay approach to estimate the GI performance on pollutant removal. Incorporating this first-order method or use the module directly can be one way to tackle the water quality problems.

- **Flexibility in Optimization Tool**

  The current setup of the Optimization Tool is tailored to the setting of the San Jose case study to expedite the tool development. Many important decision variables such as the total number of iterative runs and the size of the population were predetermined and coded in the tool programs. Next phase of the tool development should make key decision variables of an optimization problem as user-defined inputs to provide flexibility for broad applicability. Having users define these variables will also help them better understand how the tool functions.

- **Improved cost function.**

  A major weakness in the current cost information is associated with cost data being derived from pilot scale one-off implementations. Future improvements of the cost function could include reasonable project batching scales (3- and 4-way intersections redevelopments that include multiple GI features, blocks or multi-block scale redevelopments, neighborhood scale redevelopments, and combinations of GI feature types (e.g. perviois pavement in concert with small and large bioretention)).

- **Additional case studies of different settings**

The Toolkit was applied to two case studies to demonstrate its power and utility. Additional applications of the Toolkit at other watershed settings will not only provide much needed insights on what the region needs, but also in the process will help improve/refine the Toolkit functionalities to meet these needs.
