Santa Clara Valley
Urban Runoff Pollution Prevention Program

Hydromodification Management Plan
Literature Review

EXECUTIVE SUMMARY

Background
The California Regional Water Quality Control Board (RWQCB), San Francisco Bay Region, issued a Permit Amendment revising Provision C.3 to the Santa Clara Valley Urban Runoff Pollution Prevention Program on October 17, 2001. The Program's NPDES Permit is jointly issued to thirteen Cities in Santa County, Santa Clara County, and the Santa Clara Valley Water District, all of which are Co-permittees.

A literature review was prepared in response to the NPDES Permit requirements to address the impacts from new and redevelopment projects on stream morphology, habitat, and erosion potential. Permit Provision C.3 requires the Co-permittees to address these impacts through the creation and implementation of a Hydromodification Management Plan (HMP).

The purpose of the literature review was:

1) To meet the permit requirement (Provision C.3.f.viii.2);
2) To provide technical information to assist in the development of the Plan; and
3) To educate stakeholders and regulatory staff.

Articles included peer reviewed journal articles and local and regional sources. Topics included physical processes that influence stream channel characteristics, effects of urbanization on channel stability, thresholds of channel stability, assessment methods, guidance on watershed management strategies, control measures, and habitat quality. Most of the research has been conducted in regions with different climatic, geologic and physiographic conditions than those found in the Bay Area. Reports on local streams conducted by professionals in the Bay Area were also included. The potential list of literature grew to about 80, of which about 50 were ultimately used in this literature review.

Problem Statement (Chapter 1)
Hydromodification refers to the effects of urbanization on runoff and stream flows that in turn may cause erosion and/or sedimentation in the stream channels. Figure E1 presents a *Conceptual Model* of the hydrologic and geomorphic processes that influence the condition of streams and can be affected by hydromodification. Climate, geology, and landscape affect runoff and sediment discharged to stream channels. Land use, soil and vegetation characteristics affect the proportion of rainfall that infiltrates the ground or runs off the surface. Urbanization increases the peak flow and volume of surface runoff by adding impervious surfaces and drainage facilities. Stream flow energy imposed on the stream channel may also be increased due to urbanization, causing erosion of the streambed and banks, sediment transport, and deposition.

HMP Goals and Objectives (Chapter 2)

The primary goal of the HMP and the RWQCB is to protect and restore the physical, chemical, and biological functions of stream systems in urban areas. A top priority is protecting existing healthy stream systems with a goal that urbanization will not result in a net loss of ecological functionality. For impaired streams, the goal is to achieve the maximum attainable practical restoration of functions.

In order to meet these goals the following objectives were defined:

a) Develop a watershed-based HMP to address the impacts of hydromodification on the beneficial uses of streams;

b) Characterize stream segments currently having erosion problems,

c) Develop, test, and apply an assessment method to evaluate possible future erosion problems,

d) Develop design criteria, control measures, and guidance on management strategies,

e) Involve the public, stakeholders, and other interested parties to ensure acceptability of the HMP,

f) Manage the impacts of hydromodification on streams through the implementation of the HMP,

g) Monitor the effectiveness of the control measures and management strategies, and amend the HMP as needed.

Hydrologic Processes (Chapter 3)

Urbanization causes increases in the drainage density and degree of networking (rain gutters, curbs/gutters, drainage pipes), and increases in the percent imperviousness and connectivity of impervious areas. Urbanization also may result in soil compaction, removal of native vegetation, and reductions in the width of the riparian corridors. Increases in impervious surface increases peak flows, especially in the more frequent events, increases runoff volume, increases the duration of smaller flow events, and increases the frequency and duration of sediment transporting flow events. Seasonal flow regimes may also change with urbanization. Dry season baseflows can decrease where the loss of infiltration is significant. In turn, reduced baseflows may limit riparian vegetation. Summertime baseflows can increase in areas where excess irrigation is significant compared to normal dry season flows and alter wetland and riparian hydro-periods.

Geomorphic Processes (Chapter 4)

Fluvial geomorphology deals with forms and characteristics of stream channels and the processes that create them. Over time and before human disturbances, channel planform, slope, and cross sectional dimensions evolved to balance stream flow energy and the need to transport sediment load. A natural stream channel is “stable” when its cross section, plan form, and profile features are in dynamic equilibrium such that the stream neither aggrades, degrades, or changes in geometry or meander pattern during the present climatic regime.

Increases in impervious surfaces and the associated changes in runoff have the potential to destabilize streams. The degree of change is highly variable and depends on the characteristics of the watershed

and on the development style. Effects include increasing the frequency and duration of geomorphically significant flows and increasing the amount of "*work done*" on the stream bed and banks. These in turn can lead to increases in stream depth, or incision, and erosion of stream banks in some segments; increased sediment transport, and deposition in downstream segments closer to the Bay.

Riparian Ecology (Chapter 5)

Habitat and its associated plant and animal types are strongly correlated to the available water supply, its frequency of inundation, and watershed disturbance patterns. The frequency and duration of inundation on floodplain surfaces and side channels create hydro-periods that establish different ecological communities and add to the diversity of the riverine corridor. Flooding creates habitat that varies in its productivity and structural complexity depending on the timing and duration of inundation, type of substrate, vegetation, and upstream erosional processes. Riparian vegetation along abandoned channels and emergent wetlands creates off stream habitat and provides increased physical structure to habitats including refuges, spawning/nesting and rearing habitat, and food resources.

Assessment Methods (Chapter 6)

Chapter 6 of the literature review summarizes several assessment tools that can be combined to formulate an assessment method. These tools include classification, empirical methods, mapping and modeling. An assessment method must incorporate factors that describe the characteristics of watersheds, stream types, development style, and existing riparian conditions. Watershed and stream channel characterization is the first step towards any assessment addressing the physical and ecological conditions of a watershed and stream network. The watershed scale characterization helps focus attention on the processes impacted by development and the actual causes of the observed impacts rather than focusing in on the symptoms, such as bank failures.

Historical information can be used to help explain the observed physical and ecological processes and existing stream channel conditions. The historical analysis can provide insight into likely response to hydromodification and can be used to verify assumptions on the expected channel response.

The current direction of research is to utilize simplified methods, or indices that can be used to distinguish between eroding or non-eroding, or stable and unstable channel conditions. Indices, such as ratios of stream power, are attractive because they are simple to use and inexpensive to apply. Indices of stability, energy, or erodibility must be referenced to the erodibility of the most sensitive boundary condition.

Management Strategies (Chapter 7)

Management strategies often integrate a series of progressive control measures including land use planning, distributed on-site control measures, regional facilities, and stream restoration.

Elements of such a strategy are as follows:

a) Preserve the natural hydrologic conditions and protect sensitive hydrologic features, sediment source characteristics and sensitive habitats. Avoid, to the extent possible, the need to mitigate for hydromodification.

b) Minimize the effects of development through strategic design (e.g., reduce connected impervious surfaces) and through the implementation of environmentally sensitive on-site distributed BMP's (e.g., wetlands, swales, infiltration gardens, etc.)

c) Manage the stream corridor itself by implementing in-stream controls, such as grade controls, biotechnical bank stabilization controls, and restoration. Provide allowances for the modified stream flow characteristics and enhance the beneficial uses of streams.

d) In some cases, a regional stormwater management system may be cost effective. These strategies could include regional floodplain management, secondary collection and drainage systems, and large-scale detention and infiltration basins.

Available Local Data (Chapter 8)

Chapter 8 of the literature review summarizes the *Available Local Data* that could be useful in addressing hydromodification, implementing an assessment method, and identifying solutions.

Conclusion

The literature review covered many aspects of hydromodification in response to the RWQCB requirements to address the impacts from new and redevelopment projects on the beneficial uses of streams in the Santa Clara Basin. Important elements of hydrologic and geomorphic processes have been described and discussed in terms of changes caused by urbanization. Assessment tools and management strategies have also been discussed and summarized. Information from the literature review was used in creating the overall approach to developing the HMP.

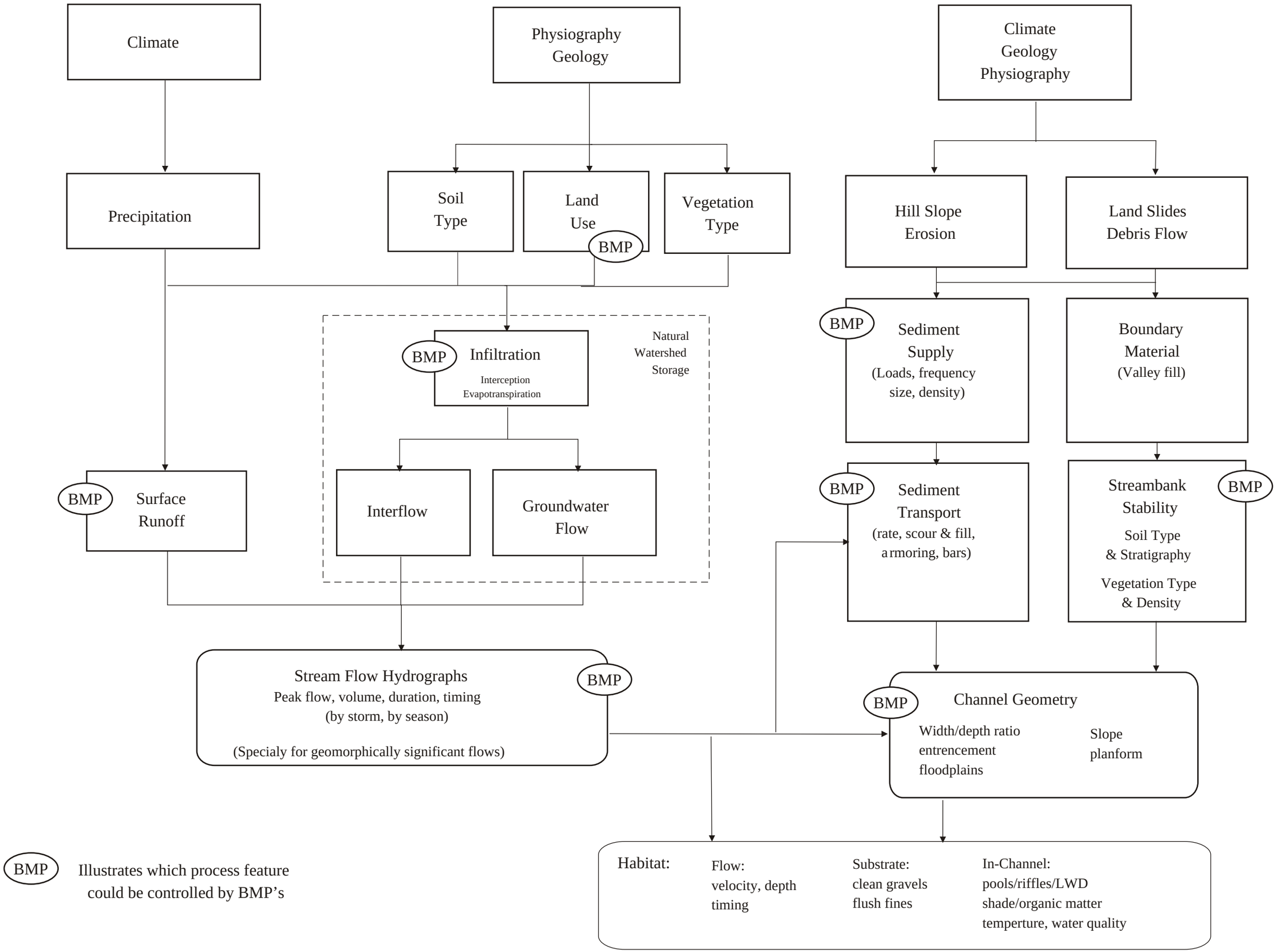

Figure E1. CONCEPTUAL MODEL ILLUSTRATING THE LINKAGES BETWEEN THE HYDROLOGIC AND GEOMORPHIC PROCESSES TO BE ADDRESSED IN HYDROMODIFICATION

Source: GeoSyntec Consultants, Walnut Creek