18 January 2007

Technical Memorandum No. 2 - Administrative Final

To: Donette Dunaway, Central Coast Regional Water Quality Control Board and Carl Niizawa, P.E., DEE, City of Salinas

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Subject: Review of Surface Soil and Shallow Groundwater Conditions and the Feasibility of Infiltrating Urban Runoff in the Salinas Area
K/J 0695006

Executive Summary

The following provides Kennedy/Jenks final version of this technical memorandum. Significant revisions have been applied to the draft version of this memo, dated 20 October 2006, hereafter referred to as Draft TM-2. The revisions are the result of review comments and updated information provided by City of Salinas (City), Central Coast Regional Water Quality Control Board (Regional Board), and a Kennedy/Jenks soils expert.

The research conducted for this technical memorandum indicates that the soils in the Salinas area are typical of an alluvial depositional environment with discontinuous (horizontal and vertical) layers and mixtures of sands, silts and clays. However, the soils can be categorized into three main hydrologic groups based on the soil textures and thickness of restrictive layers (e.g. layers with low infiltration/percolation rates). Two main sources of soils information were collected, reviewed and mapped, including soil survey records from the Natural Resource Conservation Service (NRCS) and well log records from the Monterey County Water Resources Agency (MCWRA). In addition, shallow groundwater data from the State Water Resource Control Board's Geotracker web database and the United States Geological Survey (USGS) were considered.

It should be noted that the NRCS soil profile information was collected as part of Monterey County soil mapping, which was published by the NRCS in 1978. At the time of publication, the majority of the area was used for agricultural crops. Soil data from the NRCS generally extends to a depth of 5 feet below ground surface (bgs). In contrast, MCWRA well log information is generally collected as part of area well installation activities, often 100's of feet bgs. Commercial drilling companies typically do not provide detailed information about shallow soil conditions on well logs and they typically do not have soil scientists on staff. Therefore, the soils information provided on well logs is often relatively general and clay layers may not be reported unless they are 1 foot or more thick.

Close review of the information collected from the NRCS and MCWRA for the City area show that shallow soils (less than 20 feet bgs) generally contain restrictive layers (clayey material) at least 1 foot thick. The depth to restrictive layer is variable over the landscape and may be

dependent on topographical location. This research is a preliminary step in understanding soils in the Salinas area and the potential applicability of storm water infiltration and Low Impact Development (LID) practices. The screening tools developed for this project should be considered a part of a storm water management screening/design process. Collection of site specific information is highly recommended prior to the final design of all storm water treatment controls and LID practices.

The NRCS and MCWRA data sources researched for this project were used to generate a series of geographical information system (GIS) maps that categorize City area soils according to soil physical properties including: soil drainage; runoff and infiltration; saturated hydraulic conductivity; depth to restrictive layer; available soil water holding capacity; and clay content. The purpose of developing these maps was to review their usefulness in assisting planners, developers and designers in the Salinas area to determine, at the planning level, the feasibility of using storm water infiltration practices as a management tool for storm water in areas subject to new development and significant redevelopment.

Preliminary soils information indicates that storm water management decisions should reflect site specific soil conditions. For instance, from a policy perspective, these results indicate that unless underdrains are specified in the design of swales, bioretention systems, and porous pavements, soil infiltration/percolation testing should be conducted before storm water infiltration is proposed and/or permitted as a storm water management tool.

From this preliminary review of available soils information, it appears that storm water infiltration practices may be feasible in some areas of the City, however policies and procedures developed by the City should be carefully planned to ensure consistent implementation of storm water infiltration practices and protection of groundwater quality.

As a storm water management/LID method, the term infiltration refers to practices that retain or detain urban runoff within permeable soils. Depending on the amount of runoff, the design of the storm water infiltration practice and soil permeability in existing site soils, a portion of the runoff infiltrate into underlying soils and recharge groundwater. Storm water infiltration practices include direct infiltration systems such as infiltration basins and trenches and indirect infiltration practices such as swales, bioretention systems, and porous pavements. Infiltration is the primary mechanism in LID practices for reducing the rate, volume, and pollutant loading of urban runoff. Soil amendments are often required to increase the permeability and pollutant removal effectiveness of existing site soils, particularly in areas with clayey soils.

Recommended policies and procedures related to storm water infiltration in the Salinas area include definition of the following:

1. An acceptable range of soil infiltration/percolation rates for storm water management practices;
2. The appropriate type of infiltration/percolation testing method(s) to be applied;

3. Acceptable methods for defining the separation to shallow restrictive layers and seasonally high groundwater;
4. Storm water infiltration system setbacks from structures, water resources (wells, streams, wetlands, etc.) and areas of known soil and/or groundwater contamination;
5. Data recording and submittal requirements; and,
6. City review, approval and data management procedures.

To be successful and to ensure that the policies and procedures established by the City to implement LID do not conflict with the other agencies with jurisdictional authority in the area, they must be coordinated with the various agencies that regulate and manage water resources, surface and groundwater quality, septic systems, and vector control in the Salinas area. For this reason the Regional Board and the City were requested to review and comment on Draft TM-2 and conduct the following actions items as part of the development of the Draft Salinas Development Standards Plan (DSP):

1. Provide an opinion of the GIS map(s) to be presented in the Draft Salinas DSP based on discussing that follows and the maps presented in Appendix B.

2. Coordinate with other departments/programs in the Regional Board, Monterey County and the City in the review and approval of the proposed policies and procedures for storm water infiltration practices summarized on Table 2 of Draft TM-2.

3. Review and comment on the examples of the storm water infiltration practices implemented by the Contra Costa Clean Water Program (CCCWP) presented in Appendix E.

4. Review and comment on the Draft plant list for LID practices presented in Appendix F.

The comments received to date indicate that only Figure 4: Depth to Restrictive Soil Layer (Appendix B) should appear in the Draft Salinas DSP and additional information about areas of known shallow groundwater conditions should be shown on the map(s). The consensus has been that the GIS maps of the NRCS soil survey data produced to date do not accurately reflect the variability of shallow soil conditions in the Salinas area. There is a general concern by the City that the maps could potentially confuse or mislead planners and designers working in the area. As discussed in Section 2.1 of this memo, each map provides information which may be useful to the planning and design of storm water management and LID practices. Therefore the Regional Board may want to consider presenting all of the maps developed for this project in the version of the DSP intended as a model for the Central Coast Region. The Regional Board has requested that the map(s) presented in the Draft DSP define the approximate location of the "Creekbridge" and "Bolsa Knolls" developments due to the shallow groundwater conditions that have been reported in these areas by the MCHD. Kennedy/Jenks requested and received this information from the City and added it to the maps presented in Appendix B of this memo. In addition the City boundary was corrected and the approximate boundary of the City's Future Growth Area has also been added to the maps. Appendix B also includes a well location map for the MCWRA wells used for this project (Figure 0) and a map of topographic slope classifications for the Salinas area (Figure 7). These two maps are not discussed in this memo, but are included in Appendix B for informational purposes and potential future consideration.

The Regional Board and the City were in general agreement with the proposed policies and procedures for storm water infiltration practices presented on Table 2 of Draft TM-2. However, the City requested the removal of the proposed property line setback and a potential exemption on underground storage tank (UST) setback for relatively new UST's (e.g. double containment with leak detection monitoring systems) and UST's proposed to be installed in the vicinity of existing storm water infiltration practices. Therefore, the proposed property line setback will not appear in the Draft Salinas DSP and an exemption for underground storage tanks (USTs) will be considered if they meet the specific conditions recently provided by the Regional Board. The Regional Board may want to consider including the recommended property line setback in the DSP intended as a model for the Central Coast Region. In general, the Regional Board has requested that the UST setback remain at 500 feet. However, the setback may potentially be reduced to 250 feet if the tank site is located down gradient of a storm water infiltration device, the infiltration flow patterns would not influence a pollution plume, and no utility conduits or trenches are located in the vicinity which could influence the pathway of UST contaminants or infiltration water. Additional details about the UST setback exemption are included in Section 3.2 and Table 2, which also includes updated information and a comparison of Monterey County's policies and procedures for septic systems.

It should be noted that Kennedy/Jenks has not received any comments on the proposed polices and procedures for storm water infiltration practices from Monterey County (MCWRA or the Health Department) and numerous attempts have been made to contact personnel working at these agencies (including a letter drafted by Kennedy/Jenks and reportedly sent by the City). Therefore, the Regional Board may need to directly contact Monterey County directly to obtain the necessary reviews and approvals to ensure that interagency policy and procedure conflicts related to this issue do not occur during the implementation of LID in the City.

Finally, the Regional Board and the City were in general agreement with the proposed storm water infiltration practices presented in Appendix E and the plant list for LID practices presented in Appendix F. Any additional comments on these and other elements of this memo should be addressed as part of the review process for the Draft Salinas DSP.

1.0 Introduction

The purpose of this technical memorandum is to fulfill Task 3 of Kennedy/Jenks Consultants' (Kennedy/Jenks) Scope of Work as presented in Attachment A of National Fish and Wildlife Foundation Contract No. 98-289-21 dated 15 February 2006. This contract was established by the Central Coast Regional Water Quality Control Board (Regional Board) to facilitate the implementation of storm water pollution source control and Low Impact Development (LID) for the City of Salinas (City) as required per Regional Board Order No. R3-2004-0135.

As noted under Task 3, the purpose of this memorandum is to:

1. Discuss the results of Kennedy/Jenks' review of available soil and groundwater data for the Salinas area.

2. Present a series of Draft maps developed for use as a preliminary planning tool for determining the feasibility of sites for the infiltration of storm water.

In addition to satisfying the requirements of Task 3, Draft TM-2 provided the following:

1. A Draft Table of Contents (TOC) for the Draft Salinas DSP.

2. A discussion about infiltrating urban storm water and recommended policies and procedures for sites proposing to infiltrate storm water.

3. Examples of the storm water infiltration practices implemented by the Contra Costa Clean Water Program (CCCWP) that Kennedy/Jenks proposed to include in the Draft Salinas DSP and the proposed format of the LID fact sheets for the DSP.

4. A Draft plant list for LID practices installed in and around the City.

The results of the research conducted for this memorandum will be included in the Draft Salinas DSP, dated January 2007. A significant portion of the information that follows is provided as backup research information for potential future reference and is not intended to be presented in the Draft Salinas DSP. For example the "Map Development Procedures" section and Table 1 were not intended to be included in the Draft Salinas DSP.

The following sections present the final version of this memo and incorporate the comments received from the Regional Board and the City on Draft TM-2. Additional information and text revisions/clarifications have also been added based on the additional review and input provided by a Kennedy/Jenks soil scientist (Rebecca Bladon, Ph.D.). It should be noted that this additional review indicates that the National Resources Conservation Service (NRCS) soil survey data <u>is</u> actually consistent with the Monterey County Water Resources Agency (MCWRA) well log data. This conclusion differs from the conclusions in Draft TM-2 that indicated there were conflicts between the NRCS and MCWRA data sets. When reviewed in greater detail, both data sources indicate restrictive layers (clayey soils) are relatively extensive in the Salinas area.

For example, the majority of the soils in the vicinity of the intersection of Boronda Rd. and Natividad Rd. are identified by the NRCS as being Hydrologic Soil Group (HSG) B soils with moderate runoff and infiltration potentials (see Figure 2 in Appendix B). Whereas a number of MCWRA well logs for this area indicate that significant shallow clay layers (1 foot or more thick) exist within approximately 2 feet below ground surface (bgs). Based upon this comparison, the NRCS and MCWRA data sets appear to conflict with each other (e.g. the clay layers will impede infiltration). However, when one reviews the NRCS more detailed soil survey data sheets for this area they will discover that the shallow clay layers noted in the well logs are described in the soil survey data sheets. During the development of Draft TM-2, Kennedy/Jenks did not research the individual NRCS soil survey data sheets for each soil type in the Salinas area.

The majority of the soils in the vicinity of the intersection of Boronda Rd. and Natividad Rd. are mapped by the NRCS as being Chualar Series soils, which generally consist of 7 to 21 inches of a sandy loam underlain by clayey soils. Therefore the NRCS soil survey data accurately describes the HSG-B soils that generally occur at the surface in this area that may be favorable for agricultural crops and irrigation practices. However, HSG-B surface soils that are only 7 to 21 inches thick may not be useful in the design of storm water infiltration practices that may penetrate this relatively shallow layer and encounter clayey soils at depth with low infiltration/percolation potentials. The additional review provided by the Kennedy/Jenks soils expert indicates that soils in the Salinas area can be categorized into three main hydrologic groups based on the soil textures and thickness of restrictive layers (e.g. layers with low infiltration/percolation rates). As part of a future work effort, a separate map which characterizes Salinas area soils into these three general groups and correlates them to potentially applicable structural treatment control BMPs and LID practices may be produced.

2.0 Review of Available Shallow Soil and Groundwater Data

To develop planning level maps of shallow soil and groundwater conditions in the City area, Kennedy/Jenks conducted the following tasks:

1. A review of the NRCS (formerly the Soil Conservation Service) soil survey mapping information and hydrologic interpretations for the Salinas area.

2. A review of available shallow groundwater and soil boring data from sources such as the State Water Resource Control Board (SWRCB), the Monterey County Water Resources Agency (MCWRA), the California Department of Water Resources (DWR), and the United States Geological Survey (USGS).

3. Research on the availability of Monterey County Health Department (MCHD) percolation testing data for septic system leach fields in the Salinas area.

Appendix B presents the series of maps developed based on the research noted above. The maps were developed to assist planners, developers, engineers and designers in the City determine, at the planning level, the feasibility of infiltrating storm water in areas subject to new development and significant redevelopment. A selected subset of these maps will be provided in Section 4.0 of the Draft Salinas DSP.

Six GIS maps showing interpretations of area soil physical and hydrologic properties and shallow groundwater conditions were produced for this project (Figures 1 to 6 – Appendix B). Soil properties related to water infiltration, storage, and runoff characteristics were compiled from the United States Department of Agriculture's NRCS National Cooperative Soil Survey (NCSS). Areas mapped with shallow groundwater conditions (defined as approximately 20 feet bgs or less) and potentially restrictive subsurface soil layers within 20 feet bgs were also included in these GIS maps to show areas that may require the collection of more site-specific information before soil infiltration is used as a storm water management technique. Well completion reports obtained from the MCWRA and shallow groundwater data from the State Water Resource Control Board's Geotracker web database were used to provide the "Probable Depth to Water" and "Reported Depth to Clay" data noted on the maps.

As noted above, Kennedy/Jenks conducted research on the availability of the MCHD's percolation testing data for septic system leach fields in the Salinas area. Data on the location of septic systems and the associated leach field percolation testing data is reportedly contained is loose files at the MCHD's office in Salinas (no electronic database of this information apparently exists). One would need to physically review and compile this information (which is beyond the current scope of this project). As discussed in the following sections, obtaining this information is recommended since set-backs between septic system leach fields and storm water infiltration systems are a recommended design feature.

Soil physical and chemical properties will affect the selection and design of storm water management techniques and LID practices that will need to be implemented in the City for NPDES permit compliance. These physical and chemical properties include soil drainage; runoff; infiltration; saturated hydrologic conductivity; presence and depth characteristics of restrictive layers; available water holding capacity; and type and amount of clay in the soil. Together, these properties will allow planners, developers, engineers and designers to better evaluate the soils in the City and their potential for storm water management. For this reason, these soil properties are discussed below and presented on GIS maps in Figures 1 through 6.

Particular attention is devoted to discussing the soils in the City's Future Growth Area (see Figure LU-1 from the Salinas General Plan on the following page) as this is the area with the greatest potential for the planning and implementation of LID and storm water infiltration practices.

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Figure LU-1
Future Growth Area

City of Salinas
General Plan
September 2002
LU-23

Figure 1: Soil Drainage Classifications (Appendix B)

As defined by the NRCS, soil drainage class qualitatively refers to the frequency and duration of saturation periods and the removal of excess water from the soil. Drainage class does not generally incorporate changes to soil drainage from human activities such as grading and compaction, import of non native soils, and/or changes in natural drainage patterns from agricultural practices or urban development (e.g. crop irrigation and flood control). Seven qualitative soil drainage classes are recognized; excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained, and very poorly drained. The majority of the Future Growth Area is mapped as having well drained soils, which implies that soil water will be present in the soil during most of the agricultural growing season, but will not pond at the surface for extended periods of time.

Figure 2: Runoff and Infiltration Potential (Appendix B)

The NRCS has categorized all soils in the United States into four general Hydrologic Soil Groups (HSG - A, B, C, and D) according to their field-described infiltration, runoff, drainage, and soil texture characteristics. Soils are assigned to one of the four groups based on estimated infiltration and runoff rates for bare, saturated surface soils. Runoff potential qualitatively describes the amount of flow that occurs from precipitation that does not infiltrate the soil surface. It is generally estimated using soil texture information collected at the site. These Hydrologic Soil Groups do not account for anthropogenic alterations to the soil regime, and therefore, site-specific information should be used to make storm water management decisions. The HSG categories mapped for the Salinas area by the NRCS are generally in agreement with other soils information obtained from area well logs maintained by the MCWRA. However, City planners should not use these groupings as the only source of information since they are interpretations from soil mapping information collected in approximately 1978.

Figure 2 in Appendix B presents the soils mapped in the Salinas area by NRCS according to the general Hydrologic Soil Groups. The four groups are described below:

<u>Group A</u>: Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission and are typically classified as sands or gravels, loamy sands, or sandy loams.

<u>Group B</u>: Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission and are typically classified as silty loams and loams.

Group C: Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission and are typically classified as sandy clay loams.

Group D: Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission and are typically classified as clay loams, silty clay loams, silty clays or clays.

The majority of the City's Future Growth Area is mapped as having HSG-B soils with moderate runoff and infiltration potentials. Although these groups do not appear to include information accounting for the soil percolation, which describes the transport of soil water based on the most restrictive shallow soil layer, they can be used as a qualitative grouping of certain soil hydrologic properties. In Draft TM-2 it was noted that the data in the NRCS maps was not consistent with actual soil boring data discussed in Figure 4 below. However, upon a more in depth review of the NRCS mapping data, the NRCS soil descriptions indicate area soils vary by depth to restrictive layer, thickness of clayey layer, and dominant soil profile texture, with approximately (3) three general soil types defined in the Salinas area.

Figure 3: Saturated Hydraulic Conductivity (Appendix B)

Saturated hydraulic conductivity (K_{SAT}) refers to the soil's ability to transmit water in a saturated state, and is estimated by the NRCS using qualitative field observations of structure, porosity, and soil texture. The K_{SAT} parameter is important because it describes the entry of water into soil, the movement of water to plant roots, the flow of water to drains and wells, and the soils ability to evaporate water. Numeric K_{SAT} values, expressed in terms of micrometers per second (μm/s), have been grouped into the following classes:

Very low (0.00 - 0.01 μm/s)

Low (0.01 - 0.1 μm/s)

Moderately low (0.1 - 1.0 μm/s)

Moderately high (1 – 10 μm/s)

High (10 – 100 μm/s)

Very high (100 – 705 μm/s)

As an example, soils with very low K_{SAT} values transmit water at saturation to a lesser extent than those with very high K_{SAT} values, and therefore, this parameter is an important component to developing a comprehensive storm water management plan for the City. The majority of the Future Growth Area is mapped as having soils with high K_{SAT} values, which implies that this area may provide good storm water infiltration potential. However, the high K_{SAT} values may only be applicable for the first 1 to 2 feet of soil that is then underlain by clayey soils with relatively low K_{SAT} values. K_{SAT} information is typically not provided on soil borings or well logs. However, this information can be available if laboratory geotechnical testing was conducted on the associated soil samples.

Figure 4: Depth to Restrictive Soil Layer (Appendix B)

According to the NRCS, a 'restrictive layer' is a nearly continuous layer that has one or more physical, chemical, or thermal properties that significantly impede the movement of water and air through the soil or that restricts roots or otherwise provides an unfavorable root environment. Examples are bedrock, cemented layers, and significant increases in clayey soil textures between surface and subsurface layers.

Soil information from both the MCWRA and NRCS data sources indicates that numerous significant clay layers occur in the Salinas area. In some areas, significant clay layers occur at the surface while in other areas they are present at depths of approximately 2 to 5 feet bgs. In addition, both information sources indicate that some locations of the City have soils with clayey textures throughout the profile. The MCWRA well locations and associated depth to shallow clayey layers, and the shallow groundwater data from Leaking Underground Storage Tank (LUFT) monitoring wells (discussed below) were superimposed on NRCS soils information for each figure to provide additional information for comparison.

The description of the shallow clay layers noted on the MCWRA well logs include Adobe, Yellow, Brown and Blue Clay, Sandy Clay and Gravelly Clay. The thickness of the significant clay layers in the well logs varied from 1 foot to more than 20 feet thick with an average minimum thickness of 3 feet.

There are approximately twelve wells located in the northern portion of the City's Future Growth Area in the MCWRA database. Information from the driller's logs for these wells indicates that significant shallow clay layers may occur at depths shallow enough to present a barrier to storm water infiltration. Draft TM-2 indicated that the occurrence of shallow clay layers in this area was contrary to the NRCS soil survey data which indicates the area has relatively good infiltration/percolation characteristics (Figure 2 indicates this area has soils with moderate infiltration/percolation rates). However, when the NRCS data is reviewed in greater detail, such as reviewing the soil series descriptions in the NRCS soil survey data sheets, the same shallow clay layers are described in the soil survey data sheets. The moderate infiltration/percolation rates noted by the NRCS for much of the City's Future Growth Area values may only be applicable for the first 1 to 2 feet of soil that is then underlain by clayey soils with relatively slow infiltration/percolation rates.

Figure 5: Available Soil Water Holding Capacity (Appendix B)

Available Water Holding Capacity (AWC) refers to the quantity of water that the soil is capable of storing for use by plants. AWC is qualitatively determined by the NRCS based on organic matter content, soil texture, bulk density, and soil structure. Per the NRCS, it is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Therefore Figure 5 may be useful to landscape architects in the selection of plant species.

AWC is controlled primarily by soil texture (the size and variation of soil particles) and the percentage of organic matter and gives an indication about the amount of water stored in soils that is available for plant uptake. A soil with a high percentage of silt and clay would have relatively high AWC, whereas a soil with only clay or only sand would have a relatively low AWC.

The majority of the City's Future Growth Area is mapped as having soils with moderate AWC values (0.11 to 0.15 cm of water/cm of soil or 11 to 15%). These AWC values are typical of soils consisting of mixes of sands, silts, and clay, which is consistent with the NRCS soil survey descriptions for this area. AWC values in this range may translate to between 7 and 9 inches of water (respectively) being held within the first 5 feet of soil (bgs). It may indicate that a significant percentage of this is being held at the boundaries between surface sandy soils and subsurface clayey soils. As noted above, understanding the AWC values in the soils located in the Future Growth Area may be useful in the selection of appropriate plants and determining planning level landscape irrigation requirements for the new urban development planned for this area.

Figure 6: Soil Clay Content (Appendix B)

Clay-sized particles, which are of inorganic soil particles with diameters less than 0.002 millimeters, influence the fertility and physical condition of the soil, the ability of the soil to adsorb cations, as well as its ability to retain moisture. In addition, soils containing different types of clay minerals also influence physical and chemical characteristics such as shrink-swell potential, plasticity, and soil dispersion. For the City's future development plans, the amount and type of soil clay content may affect the ease of tillage and earthmoving operations during construction, and may also influence storm water management planning by affecting the soil's ability to adsorb storm water pollutants. As a screening tool, Figure 6 shows the estimated surface soil layer clay content given as percent clay.

According to the NRCS, the majority of the City's Future Growth Area is mapped as having soils with approximately 15 – 25% clay, which indicates the soils with moderate textures such as loams, sandy loams, and clay loams. Having an understanding of soil textures, as well as the other soil physicochemical properties described above, may direct City planners to particular storm water management techniques. As noted above, soil clay content may also be useful in estimating the pollutant removal capacity of storm water infiltration systems.

2.1 Discussion of Salinas Shallow Soil and Groundwater Maps

The maps developed for this project, presented in Appendix B, indicate that there is a significant amount of heterogeneity (lack of consistency) in the shallow soils underlying the City. Soils in developed areas of the City have been mapped by the NRCS as varying from well to poorly drained, with moderate to high runoff potential and moderate to very slow infiltration/percolation rates (hydrologic soil group B, C and D soils). A number of independent infiltration/percolation tests have reportedly been conducted in the Future Growth Area that confirms the high degree of variability in the soil infiltration/percolation rates in this area. The MCWRA well logs indicate numerous areas with significant clay layers (1 foot or more thick) are present throughout the Salinas area within the first 20 feet bgs. Wells indicating relatively shallow clay areas occur in all soil types and are particularly notable in the northern portion of the City and the currently undeveloped area north of Boronda Rd. However, these soil properties represent a broad range of soil characteristics, and therefore, site-specific information should be used during any City storm water planning.

Soils information from both the NRCS and the MCWRA show general agreement concerning the soils occurring in the Future Growth Area, with many of the soils containing moderate textures (e.g., sandy loams, loams) at the surface and clayey textures in the subsurface (e.g., clay loams, clays) potentially restricting the transport of soil water to deeper depths. Both data sources indicate that significant shallow clay layers exist within the first 5 feet bgs throughout the developed portions of the City and in at least the northern portion of the Future Growth Area. Although NRCS soils mapping information is available for the entire planned Future Growth Area, MCWRA well log information was only available in northern portion of the Future Growth Area. Therefore, there does not appear to be well log data for much of the eastern portion of the Future Growth Area which could be used to identify approximate depths to significant clay layers. However, it is likely that a number of significant shallow clay layers also exist in this area because shallow groundwater conditions have been observed by the MCWRA and the MCHD. Specifically MCHD personnel have indicated to Kennedy/Jenks that shallow groundwater conditions exist on the east side of the City in the vicinity of the "Creekbridge" and "Bolsa Knolls" areas. As noted by the Regional Board in Draft TM-2, the approximate location of these areas should be defined on the map(s) presented in the DRAFT SALINAS DSP. At a minimum, these development areas could be noted on the maps by the roads that border these areas. These development areas have been defined on the maps presented with this memo.

As noted at the bottom of each of the maps in Appendix B, the data presented is intended for general planning purposes only and site specific data should be collected prior to the design of storm water treatment facilities and LID practices. The City can use these maps to define general areas where storm water infiltration may or may not be feasible. However, site specific infiltration/percolation testing should be required if storm water infiltration without an underdrain is proposed.

In terms of storm water management planning, the results of this research indicate that direct storm water infiltration systems such as infiltration basins and trenches may not be feasible in many areas of the City. It also implies that LID practices such as swales and bioretention systems may need to include underdrain systems to drain properly. As discussed below in Section 3.2 of this memo, unless underdrains are specified in the design, infiltration/percolation testing should be completed when storm water infiltration BMPs are proposed to be installed. It should be noted that although there may be limitations on storm water infiltration practices in the City due to soil conditions, there are a number of other LID and storm water management practices that can be applied to meet the MEP standard required in Regional Board Order No. R3-2004-0135.

From a general planning perspective, the maps presented in Appendix B could potentially be used for storm water management planning as follows:

- Figure 1: Soil Drainage Classifications - to qualitatively determine the frequency and duration of soil saturation periods and the removal of excess water from the soil.
- Figure 2: Runoff and Infiltration - to qualitatively determine the general soil composition of shallow surface soils (within 5 feet bgs).
- Figure 3: Saturated Hydraulic Conductivity - to qualitatively determine the soils ability to transmit water under saturated conditions.
- Figure 4: Depth to Restrictive Soil Layer - to estimate the approximate depth to the first shallow restrictive clay layer based on the nearest group of wells.
- Figure 5: Available Soil Water Holding Capacity - to qualitatively determine appropriate plant species and irrigation requirements.
- Figure 6: Soil Clay Content - to qualitatively determine the fertility of the soil, its potential ability of the soil to adsorb cations (e.g. pollutant removal potential), and its ability to retain moisture.

For this reason the Regional Board may want to consider including all of the above maps in the DSP intended as a model for the Central Coast Region. Each of these maps also includes approximate well locations (MCWRA wells and LUFT monitoring wells) with reported depths to clayey soils (from MCWRA well logs) and probable depths to shallow groundwater (from LUFT monitoring well water level data). This information will be important to the application of the proposed separations and setbacks for storm water infiltration systems discussed in Section 3.2 of this memo. It should be noted that map data such as MCWRA well locations are estimated and based on street address information. Therefore well locations must be verified prior to the siting and design of storm water infiltration devices and other structural treatment control BMPs and LID practices. GPS coordinates of well locations in the vicinity of storm water management practices should be provided to the City during the City's plan review and permitting process.

Based on the comments received for Draft TM-2 and the conclusion that many of the soil properties mapped by the NRCS may only be applicable to the first 1 to 2 feet of soil bgs, only Figure 4 will appear in the Draft Salinas DSP. The City has expressed the concern that the maps of the NRCS soil survey data produced to date do not accurately reflect the heterogeneity of the Salinas area soils and presenting these maps in the Draft Salinas DSP could potentially confuse or mislead planners and designers working in the area. However, as noted above, the Regional Board may want to consider presenting all of the maps developed for this project in the model DSP for the Central Coast Region.

It should be noted that Kennedy/Jenks and the Regional Board are considering the development of an additional Scope of Work to create a BMP Applicability Map for Salinas based on additional research and information (such as a thorough review of the NRCS soil series descriptions and mapping the location of septic systems discussed above). The Kennedy/Jenks soil scientist has indicated that soils in the Salinas area could be grouped into three (3) general soil types and a list of the associated BMPs that could potentially be applied in those soils could be identified. However, this will require an additional effort that is beyond the scope of the current project. Therefore this map will not be available for presentation in the Draft Salinas DSP.

Kennedy/Jenks will provide the City a copy of the digital GIS files produced to date for this project. The City should consider adding this information to their GIS as part of an effort to develop a site screening tool for the siting and selection of storm water management practices (similar to the tool developed by Contra Costa County). For example, the well locations mapped for this project could be used at a planning level to define areas where mandatory setbacks should be applied. Additional information such as the approximate depth and lateral extent of the shallow groundwater conditions that exists in the vicinity of "Creekbridge" and "Bolsa Knolls" areas (discussed above) may be available from the MCHD. This information as well as additional well location and shallow soils information (e.g. GPS coordinates for wells and infiltration/percolation testing data) could be added to the City's GIS site screening tool as it becomes available. In addition, the lateral extent of the shallow clayey layers noted on Figure 4 could also be estimated and mapped by contouring the depth to clayey layer data.

2.2 Map Development Procedures

BASEMAP FEATURES

The maps discussed above and presented in Appendix B were generated using the ESRI software ArcMAP 9.1. The projection coordinate system used is NAD 1983 State Plane California Zone IV FIPS 0404 Feet. A digital ortho photograph with 1 meter resolution (May 2002) was obtained in tiff image format from the City. The aerial photo was converted to black and white, and set to 50% transparency to improve the clarity of the color-coded soil properties presented on the maps. The City also provided a shapefile of the City limit boundary. Together, the aerial photo and City boundary acted as the base map from which the map scale and the spatial coverage of soil/groundwater information required were determined. The scale of each map produced was set to 1:60,000, which allowed for inclusion of the City limits as well as a zone bordering the north and east of the City where future development may occur. However Kennedy/Jenks noted a number of discrepancies between the City limit boundary supplied by the City (on a CD dated 6/14/06) and the City limit boundary shown on Figure LU-1 from the General Plan. Therefore the City limit boundary was adjusted to match the boundary shown on Figure LU-1. In addition, the approximate boundary of the City's Future Growth Area, as shown on Figure LU-1, was also added to the maps.

Natural and man-made features obtained from Streetmap USA, including highways, major roads, waterways and railroads, were added to the maps to better define the area. A one square-mile grid and reference network of rows (1 through 5) and columns (A through E) was created to aid the users' interpretation of possible areas of interest.

The scope of the work relies on three main datasets that were created specifically for this project: NRCS surface soil characteristics, depth to shallow groundwater, and depth to the first significant clay layer. The source of these datasets and the steps involved in converting this into a useable form in ArcMAP are discussed below.

SOIL PROPERTIES

As noted previously, the soil properties presented on Figures 1, 2, 3, 5 and 6 in Appendix B were compiled from the NRCS web soil survey (http://websoilsurvey.nrcs.usda.gov/app/). Converting this complex dataset into thematic maps involved a series of steps. Once the area of interest had been selected (the entire Monterey County was selected for ease), the website allows the user to enter the Soil Data Mart. In the Soil Data Mart, spatial and tabular data for CA was requested and a link to the MS Access database was emailed to the user. Spatial data was obtained in ArcView shapefile format, selected from a dropdown option on the Soil Data Mart page. The access database generated was created in 2002 and covers soil information for Monterey County, where data exists. Once the spatial and tabular data was downloaded and saved into a relevant directory, the soil characteristics were created into individual shapefiles using Soil Data Viewer.

Soil Data Viewer is a tool built as an extension to ArcMAP that allows a user to create soil-based thematic maps. It requires both the spatial and tabular data downloaded from Soil Data Mart, a Windows XP operating platform, ArcMAP version 8.3 and Microsoft .NET Framework version 1.1. Once the Soil Data Viewer is operational, one shapefile for each soil property selected is generated, whereby the soil property information is linked with each soil type series/grouping (such as 'Pachappa Sandy Loam') as a polygon on the map. For some soil properties, a depth range must be selected. Since this project is concerned with the first 20 feet or so, a depth range of 0 to 200 inches was selected. The result of this process is the generation of a series of shapefiles, each with one specific soil property. Each of the relevant soil property shapefiles was projected on the same coordinate system as the base map information (NAD 1983 California State Plane Zone IV) and added as a layer to the maps. In some cases, pre-existing ranges for the soil property were defined (for example, 'low', 'moderate', 'high', 'very high' saturated hydraulic conductivity). For other soil properties, arbitrary ranges were defined to segregate the data and color-coded for visual display. This was the case for 'Depth to Restrictive Layer', 'Available Water Capacity' and 'Soil Clay Content'.

REPORTED DEPTH TO CLAY INFORMATION

Permission was obtained from the MCWRA to review the photocopied well completion reports and an MS Access database of well construction details for various types of wells in the Salinas area. These data were acquired and used previously for another project in the area undertaken by Kennedy/Jenks. The purpose for its use in this project was to determine the depth to significant clay layers, or other soil layers likely to impede water infiltration through the soil profile to the groundwater at depth. Areas where clay is noted within the first 20 feet bgs may not be suitable for infiltration of storm water. If the well completion reports noted a distinct clay layer near the surface (within the 0 to 20 feet bgs interval), perched groundwater may exist in that area at least part of the year, thereby affecting storm water infiltration or runoff potentials.

Some of the photocopied well completion reports were not entered in the electronic database. Consequently both data sources were accessed and evaluated. First, a database query was run to identify all wells in the electronic database located in Township 14 South / Range 03 East, Sections 1-36 (14S/03E Sections 1 through 36), 15S/03E Sections 1 through 12, 14S/04E Sections 6, 7, 18, 19, 30 and 31, and 15S/04E Sections 6 and 7, which were those within the City Boundary or its vicinity (that is, in the map extent). Following this, a criterion was added so that the query would only return records where the top of the soil layer, for a particular well, was no greater than 25 feet below ground surface. This was added to reduce the number of rows of data to import into Excel, and also because any soil layer that begun from greater than 25 feet below ground surface was considered not relevant to this study. This query returned the majority of the wells mapped.

In addition to this, well installation reports for the same township-range-sections as above were filtered out from the well installation reports previously received from MCWRA. Some of these had already been entered into the database, however a handful of them were not.

Consequently, data for those wells were added to the excel spreadsheet with information extracted from the database. At this point, the wells were divided into those that showed a significant clay or impeding layer within the first 20 feet bgs, and those that did not encounter clay layers until depths of greater than 20 feet bgs. The criteria used to determine if the soil layers were likely to impede infiltration through the soils profile, or considered a 'significant clay layer', mainly related to soil texture. All soils where the predominant texture was listed in the well log as clay (such as yellow, brown, red, sandy, blue, or adobe clays) were considered possible impediments to water infiltration. This analysis resulted in 75 wells with a clay layer within the first 20 feet bgs, and 14 wells that did not have any clay or infiltration-impeding material in the first 20 feet bgs. The latter were generally composed of thick sand, gravel or sediment layers taking up most of the first 20 feet bgs. The spatial data for each well was tabulated with soil texture information as far down as the first clay layer to at least 20 feet bgs, well ID, well type and depth to the significant clay layer. The table was imported into Arcview and presented on each of the 6 maps.

The project manager performed a quality assurance exercise on the interpretation of the presence of clayey layers noted in the wells logs and in the excel spreadsheet with the values plotted on the maps. The MCWRA well locations on each map are denoted by a green dot and labeled with "Reported Depth to Clay" elevation (in feet bgs). It should be noted that the data is only as reliable as the interpretation of the soils by the licensed driller when the wells were installed. As such, there is an element of uncertainty about the depth to clayey layer information reported on the figures, and thereby we note that this is the probable depth to clayey layer only.

It should be noted that there may be additional shallow clayey layer information for the Salinas area from a number of additional well logs maintained by the California Department of Water Resources (DWR). However, this information is not publicly available and obtaining this information was beyond the scope of this project.

DEPTH TO GROUNDWATER INFORMATION

A number of State and regional agencies were contacted to obtain shallow groundwater information in the zone from ground surface to approximately 20 feet bgs. The California DWR did not have depth to groundwater information for the Salinas area. The United States Geological Survey (USGS) National Water Information System (NWIS) website was accessed with an inventory created of all groundwater sites within a latitude/longitude boundary box encompassing the Salinas area (Latitude: 36°50'00" to 36°30'00", Longitude: 121°50'00" to 121°30'00"). Approximately 25 sites were found to have at least one groundwater measurement within that bounding box. However, none of these wells had shallow groundwater information within 20 feet bgs because they were drilled to extract and monitor groundwater from deeper aquifers.

The third possible source of shallow groundwater data was the Geotracker web database. Geotracker (http://www.geotracker.swrcb.ca.gov/) is an online database created by the State

Water Resource Control Board to inventory leaking/non leaking underground storage tank (UST) sites, many of which are monitored for water quality on a regular basis as required by specific remediation regulations. A search in Geotracker for all sites in 'Salinas - Monterey County' identified 165 Leaking Underground Fuel Tank (LUFT) properties (some with many monitoring wells on a single property) with some information related to sampling activities, depth to water, boring logs or simply location information. Each individual site was then queried to identify if any depth to water information was available. If this existed, data from the latest date when depth to water information was available was downloaded in excel format. Additionally, location information in latitude/longitude was also obtained and added to the excel spreadsheet. This was repeated for all sites with groundwater information, resulting in a list of 61 sites with adequate information in the Salinas area. This excel spreadsheet was converted to dbf format, imported into ArcMAP, then converted to a shapefile, displayed on each of the 6 maps, and finally, labeled with the respective depth to groundwater measurements (in feet bgs). This information has been labeled as "Probable Depth to Water" since we only quote the most recent groundwater level available to us, which may have fluctuated since the original data collection.

PERCOLATION TESTING DATA

The MCHD was contacted regarding the location and availability of percolation testing data for septic system leach fields in the Salinas area. This information has reportedly not been compiled into a database. To use this data, one would need to review the County's files (Maryanne Dennis, MCHD, personal communication). The City has indicated there are only a few septic systems with leach fields present in older developments within the City limits and new leach fields are not permitted. Therefore, the City does not have infiltration/percolation testing requirements for septic systems. However, there are existing developments north of the City, developed in the County but located adjacent to the City that are on septic systems. In addition the MCHD has indicated that the east side of the City needs to be sewered. Percolation testing data from these areas and the infiltration/percolation testing data collected by the developers of the future growth area and other areas in the City could be compiled and added to the maps produced for this project and to the City's GIS.

The percolation testing method required by the MCHD for septic system leach fields follows the methods of the U.S. EPA's Method of Septic Tank Practices document. This information can be found in the applicable sections of Monterey County Code at http://municipalcodes.lexisnexis.com/codes/montereyco/

15.20.070 Standards and Specifications

15.20.060 Septic Tank System/Graywater System Permits.

To obtain comparable results, similar testing methods are recommended for the permitting and design of storm water infiltration devices. Since there is potential for pollutant transport and groundwater contamination any time urban runoff is infiltrated, similar groundwater separation and well setback requirements should also be applied to protect groundwater quality. These and additional policy and procedure considerations when infiltrating urban storm water are discussed below. In addition, standard data collection and reporting procedures based on the MCHD method for septic systems are recommended for storm water infiltration practices.

3.0 Infiltration of Urban Storm Water

A significant portion of the following discussion will be provided in Section 4.7 of the Draft Salinas DSP (see Draft Table of Contents in Appendix A – updated from Draft TM-2).

If site conditions allow, infiltration can be the most effective method to reduce the volume, rate, and pollutant loading of urban runoff. As a storm water management method, the term infiltration refers to practices that retain or detain urban runoff within existing or imported permeable materials (clean gravel and/or engineered soils – a mix of topsoil, sand and compost or peat). Pollutants within urban runoff are typically removed within storm water infiltration practices by a variety of physical, chemical and biological processes. Depending on the amount of runoff, the design of the storm water infiltration practice, and the permeability of the existing site soils, a portion of the treated runoff may recharge groundwater. Site planning and grading can minimize runoff and promote infiltration at almost any site. LID practices such as filter strips, swales, bioretention systems (e.g. storm water planters, landscape detention, rain gardens, etc.), and porous paving systems can be used on sites with clayey soils, provided imported permeable soils, drain rock and underdrains are included in the design. Sites with more permeable existing soils may be able to install these devices without underdrains and realize a significant cost savings by reducing or eliminating the need to install expensive conventional underground storm drain infrastructure (e.g. reinforced concrete drop inlets and storm drain pipe). Direct storm water infiltration methods such as infiltration trenches and basins can also be used on sites with permeable existing site soils, provided the potential threat to groundwater quality is assessed and found to be very low. It should be noted that the potential threat to groundwater quality from direct infiltration of urban storm water typically can not be eliminated. Therefore the use of these systems should be limited and only considered where other storm water management practices (e.g. bioretention systems) can not be applied.

A variety of factors may limit or prevent the use of certain urban storm water infiltration methods. In addition to existing site soil infiltration/percolation properties, the factors that must be considered when assessing the feasibility of a particular site for storm water infiltration include: site slopes; depth to groundwater; expansive clays; land uses and practices within the drainage area; the proximity to water resources such as streams, wetlands and wells; proximity to structures; and proximity to septic systems, underground storage tanks, and areas of known soil and/or groundwater contamination. These factors must be evaluated during the design of storm water treatment devices and LID practices to prevent slope failures and settlement, storm water in foundations, basements and crawl spaces, groundwater contamination, and mosquito breeding.

Site Topography: Flatter sites typically provide the most feasible areas for storm water infiltration. Storm water routed to slopes may run off rather than soak into the ground. In addition, storm water infiltrated on hillsides may resurface a short distance down slope and may also cause geotechnical instability. For this reason direct storm water infiltration systems such as infiltration basins and trenches should never be placed on slopes. In addition, indirect storm water infiltration systems such as bioretention systems may need to incorporate impermeable liners and underdrain systems if sited near or on slopes.

Vegetated or grassy swales should have minimum and maximum longitudinal slopes and side slopes to maximize infiltration/percolation and storm water treatment potential. The design guidance provided in a number of the storm water management manuals developed for the western states varies and indicates vegetated or grassy swales should have minimum longitudinal slopes from 0.2 to 0.5 percent and maximum longitudinal slopes from 2.5 to 6.0 percent. Adjacent side slopes typically vary from a maximum of 5.0 to 25.0 percent.

Geotechnical Considerations: Infiltration of storm water can increase water pressure in soil pores, reducing soil strength and making slopes more susceptible to failure. It can also make foundations more susceptible to settlement. With the exception of bioretention systems designed with impermeable waterproof membranes and underdrains (or enclosed in a concrete box with an underdrain connected to the conventional storm drain system), storm water infiltration systems should be set back from slopes and foundations. Some storm water management manuals indicate that a qualified geotechnical and/or structural engineer should determine site specific requirements whenever site slopes exceed 7 percent.

Depth to Groundwater: To protect groundwater quality, direct storm water infiltration methods such as infiltration trenches and basins should be designed with a minimum separation between the base of the imported permeable materials and the seasonally high groundwater level. The minimum separation noted in a number of the storm water management manuals developed for the western states varies from 2 to 10 feet. Indirect storm water infiltration methods, such as bioretention basins that filter urban runoff through amended surface soils and vegetation are sometimes allowed to have less separation (2 to 6 feet) between the base of the device and the seasonally high groundwater level because these devices provide a greater level of treatment and groundwater protection. The infiltration of storm water near the ground surface helps increase the separation to groundwater, providing a greater filtration layer and decreasing the risk of groundwater contamination.

Potential Groundwater Contamination: Direct storm water infiltration methods such as infiltration trenches and basins should not be used where there is a reasonably high potential for materials or liquids to spill and be transported in runoff. These devices should not be used at industrial or light industrial areas, near gas stations, automotive repair shops, car washes, fleet storage areas, nurseries, or other areas that provide outdoor storage, use or disposal of chemicals and materials. Direct storm water infiltration should also not occur adjacent to roadways subject to high vehicular traffic. Per the Contra Costa Clean Water Program

(CCCWP), the San Francisco Regional Board prohibits direct infiltration of runoff from main roadways with 25,000 or greater average daily traffic (ADT) loads and 15,000 or greater ADT on any intersecting or minor roadways. Indirect storm water infiltration methods, such as bioretention basins can potentially be used within the drainage area of the industrial and commercial land uses and roadways noted above if a pretreatment device such as an oil and water separator is included in the design to capture spills and/or the bioretention system includes an impermeable liner the prevents infiltration/percolation to underlying soils and an underdrain system that connects to the conventional storm drain system (to ensure proper drainage).

Areas with Existing Groundwater Pollution: Storm water infiltration should be avoided near areas of known groundwater contamination, such as the Leaking Underground Fuel Tank (LUFT) sites listed by the Regional Board. Infiltration of storm water near these sites can contribute to the movement and dispersion of pollutants in groundwater. The guidelines developed by the CCCWP indicate that direct storm water infiltration methods such as infiltration trenches and basins should not be sited within 500 feet of underground storage tanks (USTs) that contain fuels or other hazardous materials. Indirect storm water infiltration methods such as swales and bioretention basins should also not be sited within 500 feet of these areas, unless they include an impermeable liner and an underdrain system that connects to the conventional storm drain system.

Underground Storage Tank (UST) Sites: The Regional Board indicates that 60 - 65% of new (1998 or newer) UST sites are found to leak, even USTs with double-containment, improved installation techniques, and leak detection systems. Per the Regional Board, the setback may be potentially reduced to 250 feet if the UST is located down gradient of the proposed storm water infiltration device, the infiltration flow patterns would not influence a pollution plume, and no utility conduits or trenches are located in the vicinity which could influence the pathway of UST contaminants or infiltration water.

Wells and Septic Systems: Wells (domestic and irrigation water supply and monitoring wells) can capture infiltrated storm water and become contaminated when infiltration trenches and basins are sited near the wellhead. And direct storm water infiltration methods sited near septic system leach fields can promote the migration of nitrates and pathogens to groundwater. Therefore direct storm water infiltration methods should be placed a minimum distance from wells and leach fields. The design guidance provided in a number of the storm water management manuals developed for the western states indicates the minimum distance from wells and leach fields should be 100 to 150 feet. They also note that direct storm water infiltration methods should not be sited within wellhead protection zones. Indirect storm water infiltration methods such as swales and bioretention basins are also not typically allowed to be located near wells and septic systems, unless they include an impermeable liner and an underdrain system that connects to the conventional storm drain system.

Mosquito Breeding and Vector Control: Direct and indirect storm water infiltration systems must be designed and maintained to ensure long-term performance and to prevent standing water for extended periods of time that allows mosquitoes and other vectors to breed. The design guidance provided in a number of the storm water management manuals developed for the western states varies and indicates direct and indirect storm water infiltration systems should not hold standing water for more than 48 hours in some areas and up to 7 days in other areas. The local Vector Control District typically sets this standard. For example, the Contra Costa Mosquito & Vector Control District (CCMVCD) requires that storm water infiltration systems should not hold standing water for more than 72 hours during the primary mosquito breeding season (June through October). The CCMVCD notes that the mosquito production periods typically extend to 2 weeks during the months of December, January and February and storm water infiltration devices that hold standing water fewer than 5 days during these months rarely cause problems. A number of other design and maintenance considerations are also typically applied for vector control. They include measures to avoid the entry of fine sediment that may clog storm water infiltration systems and avoiding the use of loose riprap or concrete depressions that may retain standing water.

Table 1 (Appendix C) presents a comparison of storm water infiltration and bioretention system underdrain requirements for a number of jurisdictions in the western United States. As can be seen in this table, there is a significant variation in factors such as the type of infiltration testing method required, the acceptable range of existing site soil infiltration/percolation rates, the required separation to seasonally high groundwater, and the required setbacks from structures, water resources and areas of known groundwater contamination. To produce consistent and comparable results that will help to ensure storm water infiltration practices are designed properly and do not create standing water for extended periods of time, a standardized testing method and standard data collection and reporting procedures are recommended. The following sections provide an overview of the common infiltration/percolation testing methods applied and the recommended policies and procedures for infiltration of storm water in the Salinas area.

As noted by the City in their comments on draft TM-2, “excess moisture coupled with inadequate drainage are believed to be the primary causes of roadway distress and failure. Manifestations of moisture-related distresses such as rutting, potholes, longitudinal and shrinkage cracking are commonly observed in bituminous pavements. In concrete pavements, moisture-related distresses are manifested as pumping, faulting corner breaks, and longitudinal cracking. These distresses diminish the structural integrity of the pavement and reduce pavement life. To address moisture-related distresses, pavement engineers typically construct subsurface pavement drainage systems.” Therefore, the design of storm water infiltration systems located in the vicinity of roadways must ensure adequate drainage to prevent potential excess moisture and related roadway distress and failure. In addition, Geocomposite Capillary Barrier Drains (GCBDs) are reportedly effective at stopping upward unsaturated water flow (Henry, K.S. et. al., 2002). Therefore GCBDs placed under roadway base materials in the vicinity of storm water infiltration systems may effectively protect roadways from excess moisture.

3.1 Infiltration Testing Methods

The most common method of determining the infiltration/percolation rate of soils is with the use of a ring infiltrometer (single or double ring). The procedure involves filling the area within the ring with water completely to pre-saturate the soils (usually at least twice or for 24 hours in advance of the test). The area within the ring is then filled (sometimes only half way) and the rate of infiltration/percolation is observed by:

1. Measuring the rate at which the level of ponded water decreases over time until the infiltrometer is empty or near empty (a falling head test), or

2. Measuring the rate at which water has to be added to maintain a constant level of ponding (a constant head test), and then

3. By solving a water balance equation.

One empirical model used to compute infiltration/percolation rate is the Green-Ampt model. This model assumes that infiltrating water uniformly wets to a depth and stops abruptly at a front. This front moves downward as infiltration proceeds. The soil above the wetting front is in a saturated wet condition throughout the wetted zone. The equation and its use in sizing storm water infiltration structures can be found in the article “Sizing Stormwater Infiltration Structures” (Akan, A.O., Journal of Hydraulic Engineering, Vol. 128, No. 5, May 1, 2002). As noted on Table 1 in Appendix C, when specified in storm water design manuals, usually the double ring infiltrometer test is required (ASTM 5126 or D3385). However, the California Stormwater BMP Handbook for New Development and Redevelopment specifies USBR 7300-89 or Bouwer-Rice test procedures and the 2005 Stormwater Management Manual for Western Washington specifies the Pilot Infiltration Test (PIT) method. Occasionally it is also recommended that a geotechnical test or a basic soil texture classification also be conducted. It should be noted that infiltration/percolation testing with a double ring infiltrometer is difficult, time consuming and expensive and often does not produce significantly more accurate results than simpler more cost effective methods such as those typically used to test percolation rates for septic system leach fields (Nathan Stoopes, P.G., Kleinfleder, Salinas, CA; Steve Bowman, Ph.D., P.E., LEED AP, Terracon Consulting, Reno, NV; Dal Hunter, Ph.D., P.E., Black Eagle Consulting, Reno, NV; personal communications).

It should be noted that percolation testing methods for the permitting of septic system leach fields typically report the results in minutes per inch (min/in), which are dimensionally opposite from infiltration/percolation rates reported in inches per hour (in/hr). Therefore, as can be seen on Figure 7, as infiltration/percolation rates reported in in/hr go down, the corresponding percolation rate reported in min/in goes up (e.g. 1.0 in/hr = 60 min/in and 0.5 in/hr = 120 min/in).

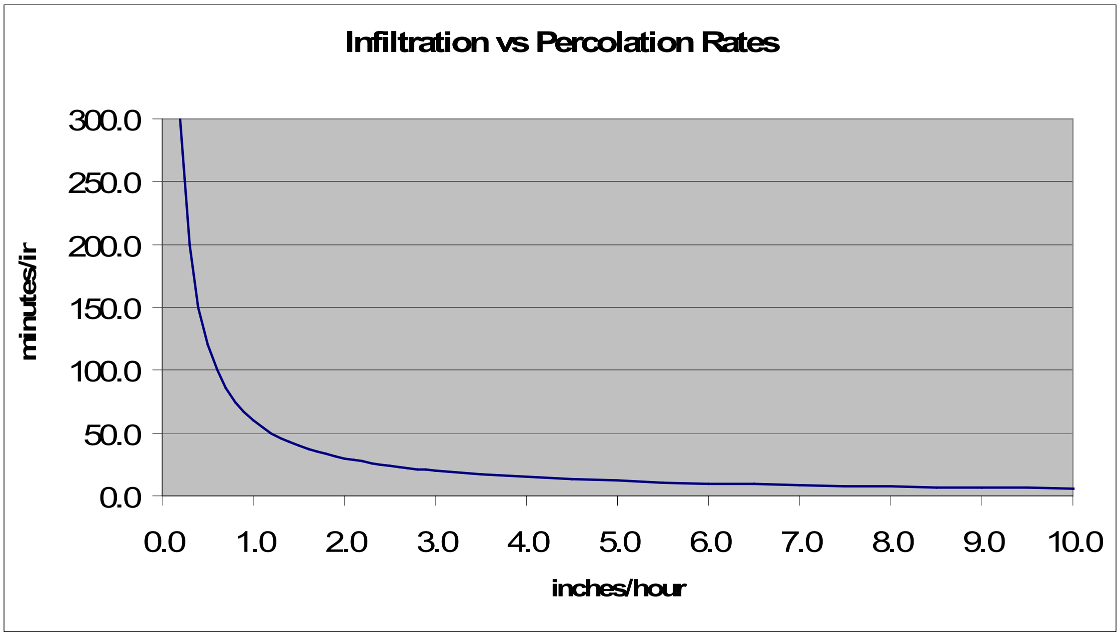

Figure 7. Relationship between infiltration rates (in/hr) and percolation rates (min/in).

As seen in Table 1, the most common minimum allowable infiltration/percolation rate for storm water infiltration practices is 0.5 in/hr (120 min/in). However, the range is from 0.3 in/hr to 2.0 in/hr. When specified in design manuals, if the infiltration/percolation rate in the underlying existing site soils (at the location and depth of the proposed device) is less than the recommended infiltration/percolation rate, then direct storm water infiltration is not allowed and an underdrain system is required in indirect storm water infiltration systems to ensure they drain properly and do not create standing water for extended periods of time. In addition, the most common maximum allowable infiltration/percolation rate for storm water infiltration practices is 2.4 in/hr (25 min/in) due to concerns about potential groundwater contamination. However, several storm water design manuals allow a maximum infiltration/percolation rate of 3.0 in/hr (20 min/in). They note that areas with soil infiltration/percolation rates faster than the maximum value may be prohibited from infiltration of storm water, or they may be required to incorporate additional pretreatment measures prior to infiltration (e.g. runoff is first conveyed through a grassy swale to remove fine sediment and other pollutants prior to entrance into a direct storm water infiltration practice). They also note that additional evaluation of the potential impacts to groundwater may be required. Therefore minimum and maximum allowable infiltration/percolation rates should be established to guide management decisions which impact the proper siting, design and maintenance of storm water infiltration systems.

3.2 Recommended Policies and Procedures for Infiltration of Storm Water

The following sections of the Attachment 4 Storm Water Management Program Revision Requirements (Order R3-2004-0135, NPDES No. CA0049981) apply to storm water infiltration and separation and setback standards to protect groundwater quality.

Section III.a.i.1. Minimize the amount of impervious surfaces and directly connected impervious surfaces in areas of new development and redevelopment and use on-site infiltration of runoff in areas with appropriate soils where the infiltration of storm water would not pose a potential threat to groundwater quality.

Section III.c.vii. *Infiltration and Groundwater Protection*: To protect groundwater quality, the Permittee shall apply restrictions to the use of structural BMPs designed to primarily function as infiltration devices (such as infiltration trenches and infiltration basins). Such restrictions shall ensure that the use of such infiltration structural treatment BMPs shall not cause a violation of applicable groundwater quality standards.

Table 2 provides the recommended design standards for storm water infiltration systems developed to address these requirements. These recommendations are based on a review of similar standards developed by the City of Boise, Idaho; the California Stormwater Quality Association (CASQA); the Center for Watershed Protection (CWP); the Contra Costa Clean Water Program (CCCWP); the Urban Drainage and Flood Control District (UDFCD) of the greater metropolitan Denver, Colorado area; the Idaho Department of Environmental Quality (IDEQ); the City of Portland, Oregon, Bureau of Environmental Services; the Truckee Meadows Storm Water Management Program (TMSWMP) that includes the Cities of Reno and Sparks and Washoe County, Nevada; and the Washington State Department of Ecology (WDOE).

Table 2 presents the recommended storm water infiltration system policies and procedures for the City of Salinas. The recommendations have been developed based on a review of the allowable infiltration/percolation rates, limits on standing water, and separation and setback standards adopted by a number of other municipalities and agencies in the Western U.S. (presented on Table 1 in Appendix C). Table 2 in this memo also notes some of the similar standards Monterey County has adopted for septic systems.

It should be noted that a number of jurisdictions in California and the western U.S. do not require infiltration/percolation testing when storm water infiltration practices are proposed at sites mapped as having NRCS hydrologic soil group (HSG) A or B soils. It is assumed that areas with these types of soils will have good infiltration/percolation properties and underdrains will not be necessary. However, the research conducted for this project indicates that management decisions to permit storm water infiltration practices without underdrains in the Salinas area should not be based solely on NRCS mapping of HSG groups. The heterogeneity of the Salinas area soils and the frequent occurrence of shallow clayey soils indicate that infiltration/percolation testing should be applied every time a direct or indirect storm water infiltration practice is proposed. In addition, the collection of site specific information must be conducted prior to the final design of all storm water treatment controls and LID practices, particularly storm water infiltration practices.

Because there is a significant amount of variability in storm water infiltration policies and procedures throughout California and the western U.S., Kennedy/Jenks recommended in Draft TM-2 that the proposed policies and procedures noted on Table 2 be confirmed with other departments/programs in the Regional Board, Monterey County and the City. In Draft TM-2 it was recommended that the values noted on Table 2 above be established and agreed upon prior to distribution of the Draft Salinas DSP. However, as noted previously, Kennedy/Jenks has made numerous attempts to contact staff at the MCWRA and the MCHD (including a letter Drafted by Kennedy/Jenks and sent by the City). To date Kennedy/Jenks has not received any comments from the MCWRA or the MCHD on the proposed polices and procedures for storm water infiltration practices in the City of Salinas. Therefore, the Regional Board may need to directly contact Monterey County to bring this matter to their attention and obtain the necessary reviews and approvals to ensure that interagency policy and procedure conflicts related to this issue do not occur during the implementation of LID in the City.

As noted previously, the recommended infiltration/percolation testing method is the percolation testing method that is commonly used for the permitting of septic system leach fields in the Salinas area. This information can be found in the applicable sections of Monterey County Code at http://municipalcodes.lexisnexis.com/codes/montereyco/. In addition standard data collection and reporting procedures are recommended. Sample infiltration/percolation testing methods and standard procedures developed for the City of Boise, Idaho and the CCCWP are provided in Appendix D, which can be used as a model for City of Salinas to consider.

Table 2. Recommended Storm Water Infiltration System Policies and Procedures for the City of Salinas and Monterey County

Recommended Design Standards	Direct Storm Water Infiltration Practices[1]	Indirect Storm Water Infiltration Practices[2]	Agencies with Similar Design Standards	Monterey Co. Septic System Requirements[3]
Allowable Infiltration / Percolation Rates[4]	min 1.0 in/hr (60 min/in) max 3.0 in/hr (20 min/in)[5]	min 0.5 in/hr (120 min/in)[6] max 3.0 in/hr (20 min/in)[5]	CASQA, CCCWP, CWP, TMSWMP	min 1.0 in/hr (60 min/in) max 12.0 in/hr (5 min/in)
Standing Water[7]	< 72 hrs	< 72 hrs	CASQA, CCCWP	NA
Seasonally High Groundwater Separation[8]	≥ 10 feet	≥ 5 feet[11]	Boise, CASQA, CCCWP, CWP, Portland, UDFCD, WDOE	≥ 10 feet
Bedrock Separation[9]	≥ 10 feet	≥ 5 feet[11]	Boise, CASQA, CCCWP, CWP, Portland, UDFCD, WDOE	≥ 10 feet
Well Setback[10]	≥ 150 feet	≥ 100 feet[11]	Boise, CASQA, CCCWP, CWP, TMSWMP, WDOE	≥ 250 feet
Surface Water Setback	≥ 100 feet	≥ 50 feet[11]	Boise, CCCWP, TMSWMP	≥ 100 feet
Septic System Setback[12]	≥ 150 feet	≥ 100 feet[11]	CCCWP	Not specified
Groundwater Contamination Setback[13]	≥ 500 feet	≥ 500 feet[11]	CCCWP	Distance not specified[14]
Underground Storage Tank Setback[15, 16]	≥ 500 feet	≥ 500 feet[11]	CCCWP	Not specified
Building and Bridge Foundation Setback	≥ 100 ft up slope and ≥ 20 ft down slope	≥ 100 ft up slope and ≥ 20 ft down slope[11]	CASQA, IDEQ, TMSWMP, WDOE	≥ 10 feet
High Use Roadway Setback[17]	Prohibited	≥ 20 feet[11]	CCCWP	NA
Basement and Crawl Space Setback	≥ 100 ft up slope and ≥ 20 ft down slope	≥ 100 ft up slope and ≥ 20 ft down slope[11]	IDEQ, TMSWMP, WDOE	≥ 10 feet
Property Line Setback[18]	≥ 5 feet	≥ 5 feet[11]	Portland	≥ 10 feet
Slope Setback[19]	100 feet from the top of slopes >15%	50 feet from the top of slopes >15%[11]	WDOE	Prohibited where slopes exceed 30%[20]

Abbreviations and Acronyms:

Boise – City of Boise, ID

CASQA – California Stormwater Quality Association

CCCWP – Contra Costa Clean Water Program, CA

CWP – Center for Watershed Protection

IDEQ – Idaho Department of Environmental Quality

Portland – Portland Bureau of Environmental Services, OR

TMSWMP – Truckee Meadows Storm Water Management Program, NV

UDFCD – Urban Drainage and Flood Control District, Denver, CO

WDOE – Washington State Department of Ecology

Table 2 Notes

1. Direct storm water infiltration practices include infiltration trenches, infiltration basins, and any structure designed to infiltrate storm water into the subsurface, and by design, bypass the natural groundwater protection afforded by surface or near surface soils.

2. Indirect storm water infiltration practices include unlined swales, bioretention systems and porous pavements that drain to subsurface soils. Unlined vegetated swales and open bioretention systems (e.g. landscape detention or rain gardens) typically maintain soil permeability with plant root systems. However, vegetated systems may require supplemental irrigation during extended dry periods.

3. Monterey County Code 15.20.060 Septic Tank System/Graywater System Permits and 15.20.070 Standards and Specifications.

4. If testing results indicate existing site soil infiltration/percolation rates are less than or slower the minimum value, direct storm water infiltration practices are not allowed and indirect storm water infiltration systems are required to install underdrains. If testing results indicate existing site soil infiltration/percolation rates are greater or faster than the maximum value, additional pretreatment and evaluation of potential impacts to groundwater must be conducted.

5. A faster maximum design infiltration/percolation rate up to 12.0 in/hr (5 min/in) may be allowed for some storm water infiltration practices provided conditions exist such as the drainage area for the device has a low pollutant loading and spill potential and there is a very low potential for groundwater contamination. Site conditions which might allow a faster maximum design infiltration/percolation rates must be evaluated, verified and certified by a CA Registered Civil Engineer, Geotechnical Engineer, Geologist, or Hydrogeologist, and approved by the City Engineer.

6. A slower minimum design infiltration/percolation rate is allowed for indirect storm water infiltration practices such as unlined swales and bioretention systems because the roots of the vegetation incorporated into these practices generally maintain the permeability of existing and imported soils. Direct storm water infiltration practices can clog if the storm water is not pretreated to remove fine sediment (e.g. pretreated by a grassy swale prior to entering an infiltration basin or trench). In addition, direct storm water infiltration practices typically do not incorporate vegetation and therefore do not have plant root systems to maintain soil permeability. Unlined porous paving systems should consider underdrain systems when existing site soil infiltration/percolation rates are less than 1.0 in/hr (60 min/in) because they are also susceptible to clogging by fine sediment.

7. Additional design standards and maintenance requirements apply for mosquito and vector control (see the Monterey County Code for Mosquito Abatement and Vector Control).

8. The minimum separation applies to the vertical distance between the bottom of a proposed storm water infiltration practice and the seasonally high groundwater level (includes "perched" groundwater). A boring or test pit shall be used to identify the seasonally high groundwater level. Indirect storm water infiltration practices such as unlined swales, bioretention systems, or porous pavement systems may be allowed to reduce the separation to 5 feet if conditions apply such as the device has a relatively small drainage area with a low pollutant loading and spill potential or existing site soils have relatively slow infiltration/percolation rates. Seasonally high groundwater levels and site conditions which might allow a reduction in the separation from 10 feet to 5 feet must be evaluated, verified and certified by a CA Registered Civil Engineer, Geotechnical Engineer, Geologist, or Hydrogeologist, and approved by the City Engineer.

9. The minimum separation applies to the vertical distance between the bottom of a proposed storm water infiltration practice and the top of a shallow restrictive soil layer (e.g. bedrock or clayey soils). A boring or test pit shall be used to identify potential shallow restrictive soil layers. Depths to shallow restrictive soil layers and site conditions which might allow a reduction in the separation from 10 feet to 5 feet must be evaluated, verified and certified by a CA Registered Civil Engineer, Geotechnical Engineer, Geologist, or Hydrogeologist, and approved by the City Engineer.

10. Wells include domestic and irrigation water supply wells and monitoring wells. Shallow monitoring wells associated with areas of groundwater contamination may be subject to greater setbacks.

11. Indirect storm water infiltration practices may be placed within the separation and/or setback limits noted above, or directly adjacent to the structures noted above, provided an impermeable surface (e.g. liner or concrete box) and an underdrain system prevents infiltration/percolation to the underlying soils within the setback limits.

12. Setback applies to known septic system leach fields. The Monterey County Health Department maintains records of permitted septic system leach fields in the Salinas area.

13. Setback applies to areas of known groundwater contamination, such as the Leaking Underground Fuel Tank (LUFT) sites listed by the Regional Board.

14. Monterey County Code 15.20.060 Section I: No septic tank/graywater system permit shall be issued in any area where continued use of on-site systems, constitutes a pubic health hazard, or where there is an existing or threatened condition of water pollution, contamination or nuisance.

15. Setback applies to known underground storage tank (UST) sites. The Geotracker web database (http://www.geotracker.swrcb.ca.gov/) is an online database created by the State Water Resource Control Board to inventory leaking/non leaking UST sites. A greater setback may be required at areas with sandy soils where flow patterns from a storm water infiltration device could potentially influence a pollution plume. Per the Regional Board, the setback may potentially be reduced to 250 feet if all of the following conditions can be met:
    a. The UST site is located down gradient of a proposed storm water infiltration device; and,
    b. Groundwater flow patterns from a proposed storm water infiltration device would not influence a pollution plume, should there be one from an UST site within the 500 foot setback; and,
    c. There are no utility conduits or trenches located in the vicinity or between the storm water infiltration device and the UST site which could influence the pathway of contaminants or infiltrated storm water.

16. If site conditions exist which would argue for a setback of less than 500 feet, such site conditions must evaluated, verified and certified by a CA Registered Civil Engineer, Geotechnical Engineer, Geologist, or Hydrogeologist, and approved by the City Engineer. Site conditions may include but not be limited to observations that a groundwater mound from a storm water infiltration device could not extend laterally in a manner that would influence a potential UST pollution plume. This setback exemption could potentially be applied to a proposed UST to be installed in the vicinity of an existing storm water infiltration system.

17. The setback applies to main roadways with 25,000 or greater average daily traffic (ADT) and 15,000 or greater ADT on any intersecting or minor roadways.

18. The setback applies to the centerline of a swale or a bioretention system. Variances may apply for storm water infiltration systems located in the City right of way (ROW) or systems designed to treat more than one property.

19. A CA Registered Civil Engineer, Geotechnical Engineer, Geologist, or Hydrogeologist should determine site specific requirements whenever site slopes exceed 7 percent.

20. Monterey County Code 15.20.070: New septic tank systems are prohibited in areas where the natural ground slope exceeds thirty (30) percent unless a variance is granted by the RWQCB.

Based on their review of Draft TM-1, the Regional Board and the City were in general agreement with the proposed policies and procedures for storm water infiltration practices noted on Table 2 above. However, the City has requested the removal of the proposed property line setback and a potential exemption for relatively new underground storage tanks (e.g. double containment with leak detection monitoring systems). Therefore, the proposed property line setback noted on Table 2 above (and note # 18) will not appear in the Draft Salinas DSP. However the Regional Board may wish to consider including this setback in the model DSP for the Central Coast Region. The potential setback exemption for underground storage tanks (USTs) was considered by the Regional Board and their comments have been incorporated into Table 2 in this memo.

3.2.1 Recommended Policies and Procedures for Mosquito and Vector Control

As noted in note # 7 above, additional design standards and maintenance requirements will likely apply for mosquito and vector control. These requirements will need to be coordinated with the MCHD, Environmental Health Division. An example of the additional requirements that the Contra Costa Mosquito & Vector Control District requires are presented below:

- Design structures so that they do not hold standing water for more than 72 hours. Special attention to groundwater depth is essential.
- Locate and design facilities to avoid entry of fine sediment, which may cause systems to clog and fail and may also result in standing water.
- Select locations that will allow flow by gravity to, through, and away from the facility. Pumps are not recommended because they are subject to failure and often require sumps.
- Design distribution piping and containment basins with adequate slopes to drain fully and prevent standing water. Take into consideration the buildup of sediment between maintenance periods. Compaction during grading may be needed to avoid slumping and settling, which can create depressions that will hold water. However, avoid compaction of infiltration/percolation areas.
- Avoid the use of loose riprap or concrete depressions that may hold standing water for more than 72 hours.
- Avoid barriers, diversions, or flow spreaders that may retain standing water for more than 72 hours.

- Completely seal structures that retain water permanently or longer than 72 hours to prevent entry of adult mosquitoes. Adult female mosquitoes can penetrate openings as small as 1/16 inch to gain access to water for egg laying. Screening can exclude mosquitoes but is subject to damage and is not a method of choice.
- Design devices with the appropriate pumping, piping, valves, or other necessary equipment to allow for easy dewatering if necessary.
- Design devices for easy access for inspection and without the need for confined-space entry.

Maintenance requirements include the following:

- Observe soil at the bottom of the swale or filter for uniform percolation throughout. If portions of the swale or filter do not drain within 48 hours after the end of a storm, the soil should be tilled, replanted, or replaced. Remove any debris or accumulations of sediment.
- Confirm that check dams and flow spreaders are in place and level and that channelization within the swale or filter is effectively prevented.

4.0 Example LID Practices and Design Standards

Appendix E presents selected examples of the storm water infiltration practices and design standards presented in by the CCCWP, Stormwater Quality Requirements for Development Applications, Stormwater C.3 Guidebook (2005). The CCCWP fact sheets are similar to the fact sheets being developed for the Draft Salinas DSP. It should be noted that the CCCWP fact sheet for "Dry Wells" was not included because this practice is not recommended for use in Salinas. Shallow dry wells, infiltration galleries, and subsurface drainfields that discharge storm water or other fluids directly below the land surface are considered Class V injection wells and may be subject to regulation by the Regional Board the U.S. EPA. By definition, a Class V injection well is any bored, drilled, or driven shaft, or dug hole that is deeper than its widest surface dimension. A pipe that conveys storm water to an underground infiltration gallery is also considered a Class V injection well. These types of facilities are considered storm water disposal systems, not treatment systems, and have impacted groundwater quality in a number of communities across the nation. The U.S. EPA is concerned that there may be a dramatic increase in the use of Class V injection wells as a result of NPDES storm water permit requirements to implement BMPs. When not allowed to filter through surface soils and plant roots, storm water contaminated with sediments, hydrocarbons, nutrients, metals, salts, fertilizers, pesticides, bacteria, or other pollutants can contaminate groundwater supplies, resulting in costly treatment alternatives and the closure of drinking water wells. However, when storm water is allowed to temporarily pond in an open basin that is exposed to the atmosphere, the basin is wider than it is deep, and the ponded water infiltrates through engineered soils and gravel, the system is not considered a Class V injection well and typically presents little risk to groundwater (Barraud et al., 1999, Dierkes and Geiger, 1999, Legret et al., 1999, Pitt et al., 1994). The storm water infiltration practices presented in Appendix E are not considered Class

V injection wells and should not present a threat to groundwater quality if sited and designed correctly.

As discussed during the 19 September 2006 conference call with the City of Salinas and the Regional Board, the general format of the fact sheets developed for the Draft DSP will be as follows:

- General Description – common names typical design features, and one or two photos
- Applications – typical areas where the BMP has been applied in other areas
- Performance Data – International BMP database influent and effluent concentrations
- Limitations – maximum slopes, separations from groundwater and setbacks
- Siting Criteria - maximum drainage area and applicable land uses
- Design and Construction Criteria – material specifications, dimensions and sizing criteria
- Inspection and Maintenance Requirements – during and after construction
- Examples – experiences with similar LID practices implemented in other areas, particularly from California
- References and Additional Resource Information

The LID practices and related structural treatment controls that will utilize this fact sheet format include the following:

- Swales and Filter Strips
- Storm Water Planters
- Landscape Detention (Bioretention)
- Tree Box Filters
- Porous Concrete and Asphalt
- Permeable Pavers
- Cisterns and Rain Barrels
- Green Roofs
- Storm Water Ponds and Wetlands
- Infiltration Trenches and Basins
- Media Filtration Systems
- Extended Detention Basins

5.0 LID Planting Zones and Plant List for the City of Salinas

Appendix F presents landscaping guidance for vegetative LID practices such as swales and bioretention basins to be implemented in the City of Salinas. This guidance document was developed by Joni L. Janecki & Associates and was based on similar LID landscaping guidance developed for the Cities of Livermore, Oakland, and Santa Monica, California, the City of Seattle, Washington and the City of Portland, Oregon. Planting zones refer to the areas within vegetative LID practices where storm water either ponds temporarily (the low zone), transitions to the low zone through vegetation that filters and slows the velocity of runoff (the mid zone), or creates a barrier bordering the low and mid zones (the high zone). The plants selected for these zones were based on the climate, soils, and biodiversity of the Salinas area. Preference was given to plant species native to the Central Coast region. In addition to swales and bioretention basins that typically incorporate low, mid and high planting zones, recommended plant species are provided for LID practices such as filter strips and green roofs and flood control practices such as detention basins. The LID landscaping guidance document presented in Appendix F will be located in Section 4.2 of the Draft Salinas DSP (see Draft Table of Contents in Appendix A)

6.0 References

Bureau of Environmental Services, 2004. Stormwater Management Manual, Portland, OR.

California Stormwater Quality Association (CASQA), 2003. California Stormwater Best Management Practices Handbook, New Development and Redevelopment, January 2003 (Updated September 2004).

Center for Watershed Protection, 2006. Stormwater Manager's Resource Center, Bioretention and Infiltration Trench Fact Sheets.

Contra Costa Clean Water Program, CA, 2005. Stormwater C.3 Guidebook, March, 2005.

Henry, K.S., J.C. Stormont, L.A. Barna, and R.D. Ramos, 2002. Geocomposite capillary barrier drain for unsaturated drainage of pavements, Proceedings, 7th International Conference on Geosynthetics.

Idaho Department of Environmental Quality, 2005. Catalog of Stormwater BMPs for Idaho Cities and Counties, September 2005.

The City of Boise, ID, 2000. Stormwater Management: A Design Manual

Truckee Meadows, NV, 2005. Low Impact Development Handbook, Guidance on LID Practices for New Development and Redevelopment, August 2005 Draft.

Truckee Meadows, NV, 2004. Structural Controls Design Manual, Guidance on Source and Treatment Controls for Storm Water Quality Management, January 2004.

Urban Drainage and Flood Control District (UDFCD), 1999. Urban Storm Drainage Criteria Manual, Volume 3 – Best Management Practices (Revised 2005). Denver, Colorado.

Washington State Department of Ecology, 2005. Stormwater Management Manual for Western Washington: Volume III -- Hydrologic Analysis and Flow Control Design/BMPs.

Enclosures:

Appendix A – Draft Table of Contents for the Draft City of Salinas Development Standards Plan

Appendix B – Salinas Shallow Soil and Groundwater Conditions

Appendix C – Storm Water Infiltration and Bioretention System Underdrain Requirements in the Western U.S.

Appendix D – Sample Infiltration/Percolation Testing Procedures

Appendix E – Example Storm Water Infiltration Practices and Design Standards

Appendix F – LID Planting Zones and Plant List for the City of Salinas

Appendix A

Draft Table of Contents for the Draft City of Salinas Development Standards Plan

Draft

City of Salinas Development Standards Plan – LID Designs and Practices for Urban Storm Drainage Management

Table of Contents

Draft

Section 4: LID Design Considerations

List of Tables

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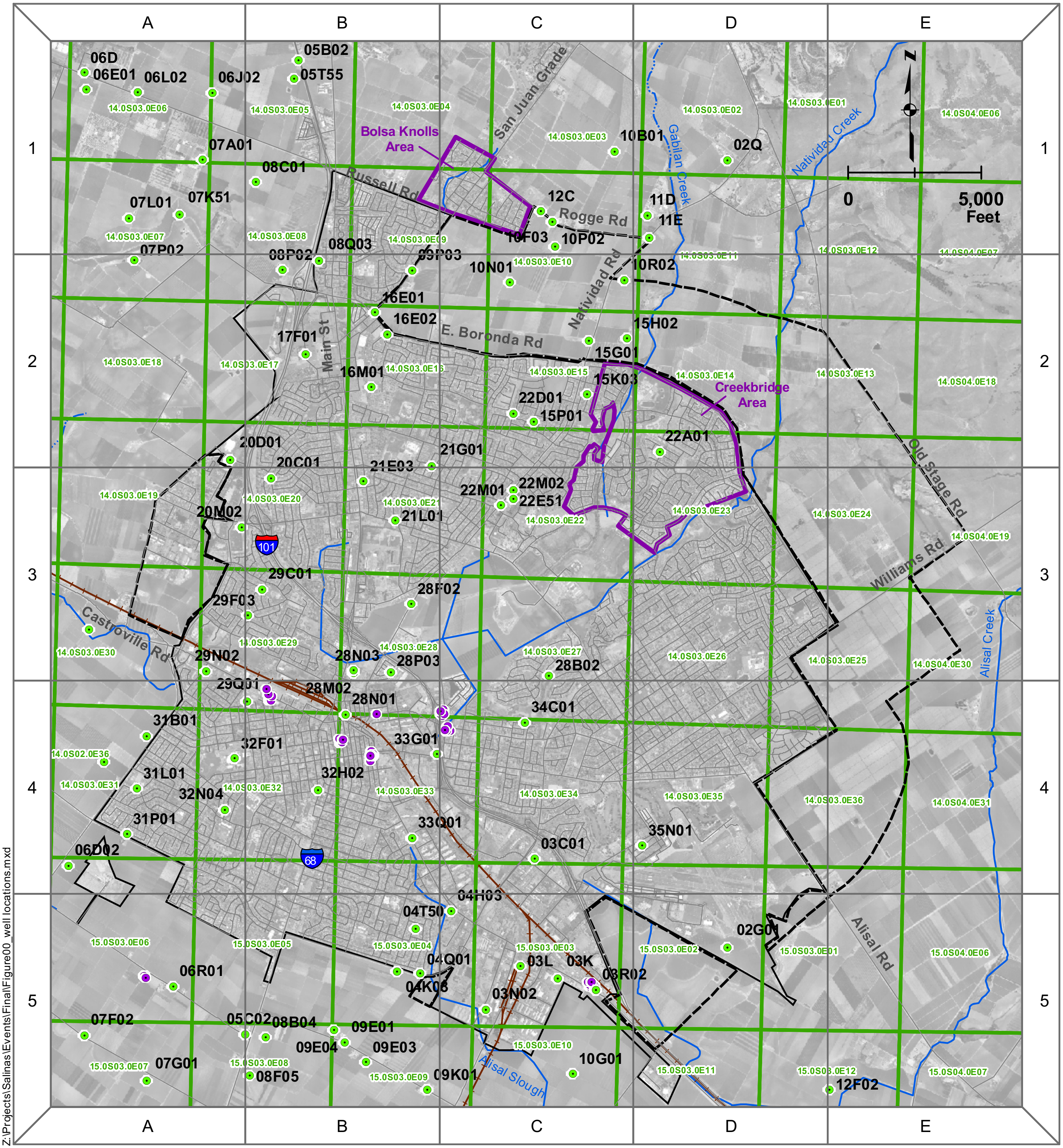
List of Appendices

Appendix B

Salinas Shallow Soil and Groundwater Conditions



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Legend

Boundaries/Features

- City of Salinas Boundary
- Future Growth Area
- Road
- Highway
- Railroad
- Waterway

Shallow Groundwater Data

- LUFT Monitoring Well
- Areas of reported shallow groundwater (MCHD)

Shallow Clay Layers

- **10G01** MCWRA well

Data Sources

LUFT monitoring wells: Geotracker website
MCWRA wells: Monterey County Water Resources Agency well logs
Aerial photo and City Boundary: City of Salinas, May 2002

Kennedy/Jenks Consultants

City of Salinas, CA
MCWRA well locations

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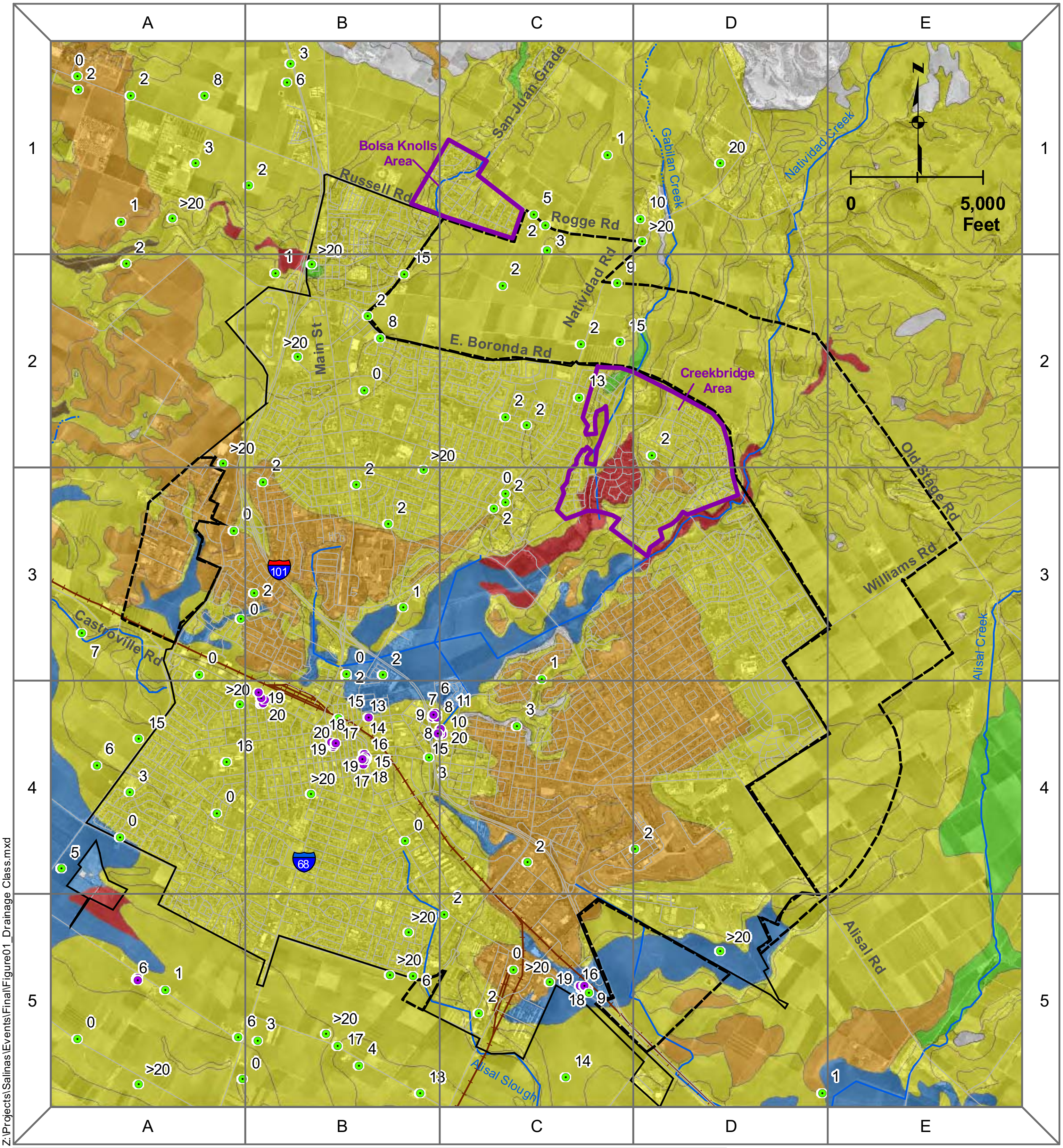
K/J 06950006
January 2007

Figure 0

Note: The data presented on this map are intended for Planning Purposes only. Site specific data should be collected prior to design.



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Legend

Boundaries/Features

- City of Salinas Boundary
- Future Growth Area
- Road
- Highway
- Railroad
- Waterway

Shallow Groundwater Data

- 16 LUFT Monitoring Well and Probable Depth to Water (ft below ground surface)
- Areas of reported shallow groundwater (MCHD)

Shallow Clay Layers

- 2 Reported Depth to Clay (ft below ground surface)

Soil Drainage Classification

- Excessively drained
- Somewhat excessively drained
- Well drained
- Moderately well drained
- Somewhat poorly drained
- Poorly drained
- Very poorly drained
- Undefined drainage type
- Soil Type Series/Grouping

Data Sources

Probable Depth to Groundwater: Geotracker website
Reported Depth to Clay: Monterey County Water Resources Agency well logs
Drainage Classification Data: NCSS-NRCS web soil survey
Aerial photo and City Boundary: City of Salinas May 2002

Kennedy/Jenks Consultants

City of Salinas, CA
Soil Drainage Classifications

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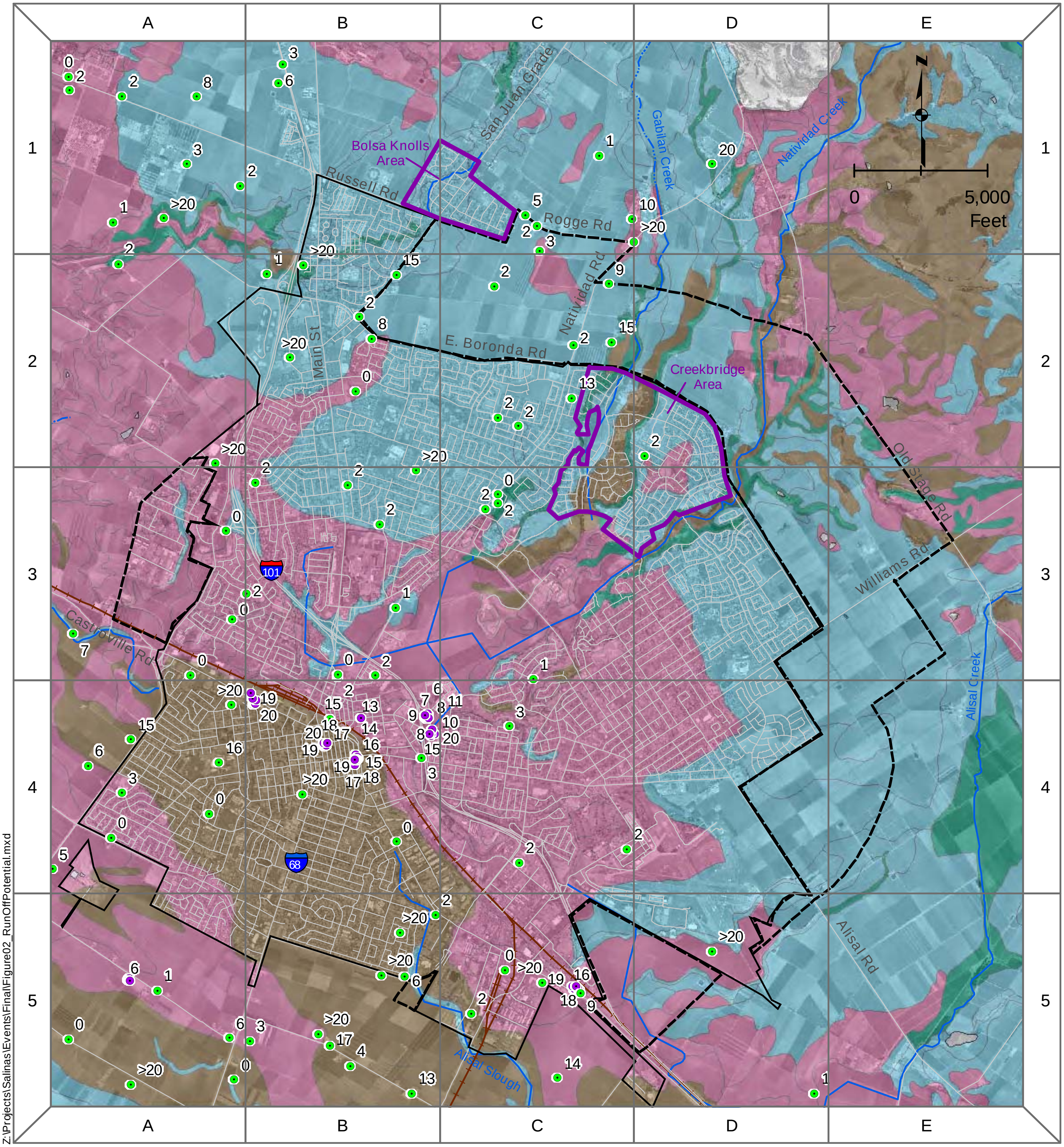
Figure 1

Note: The data presented on this map are intended for Planning Purposes only. Site specific data should be collected prior to design.



Legend

Boundaries/Features
- City of Salinas Boundary
- Future Growth Area
- Road
- Highway
- Railroad
- Waterway

Shallow Groundwater Data
- 16 LUFT Monitoring Well and Probable Depth to Water (ft below ground surface)
- Areas of reported shallow groundwater (MCHD)

Shallow Clay Layers
- 2 Reported Depth to Clay (ft below ground surface)

Hydrologic Soil Group
- A - Low Runoff Potential (High Infiltration Rate)
- B - Moderate Runoff Potential (Moderate Infiltration Rate)
- C - Moderate Runoff Potential (Slow Infiltration Rate)
- D - High Runoff Potential (Very Slow Infiltration Rate)
- Undefined runoff potential
- Soil Type Series/Grouping

Data Sources
Probable Depth to Groundwater: Geotracker website
Reported Depth to Clay: Monterey County Water Resources Agency well logs
Hydrologic Soil Group data: NCSS-NRCS web soil survey
Aerial photo and City Boundary: City of Salinas May 2002

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City of Salinas, CA
Runoff and Infiltration Potential

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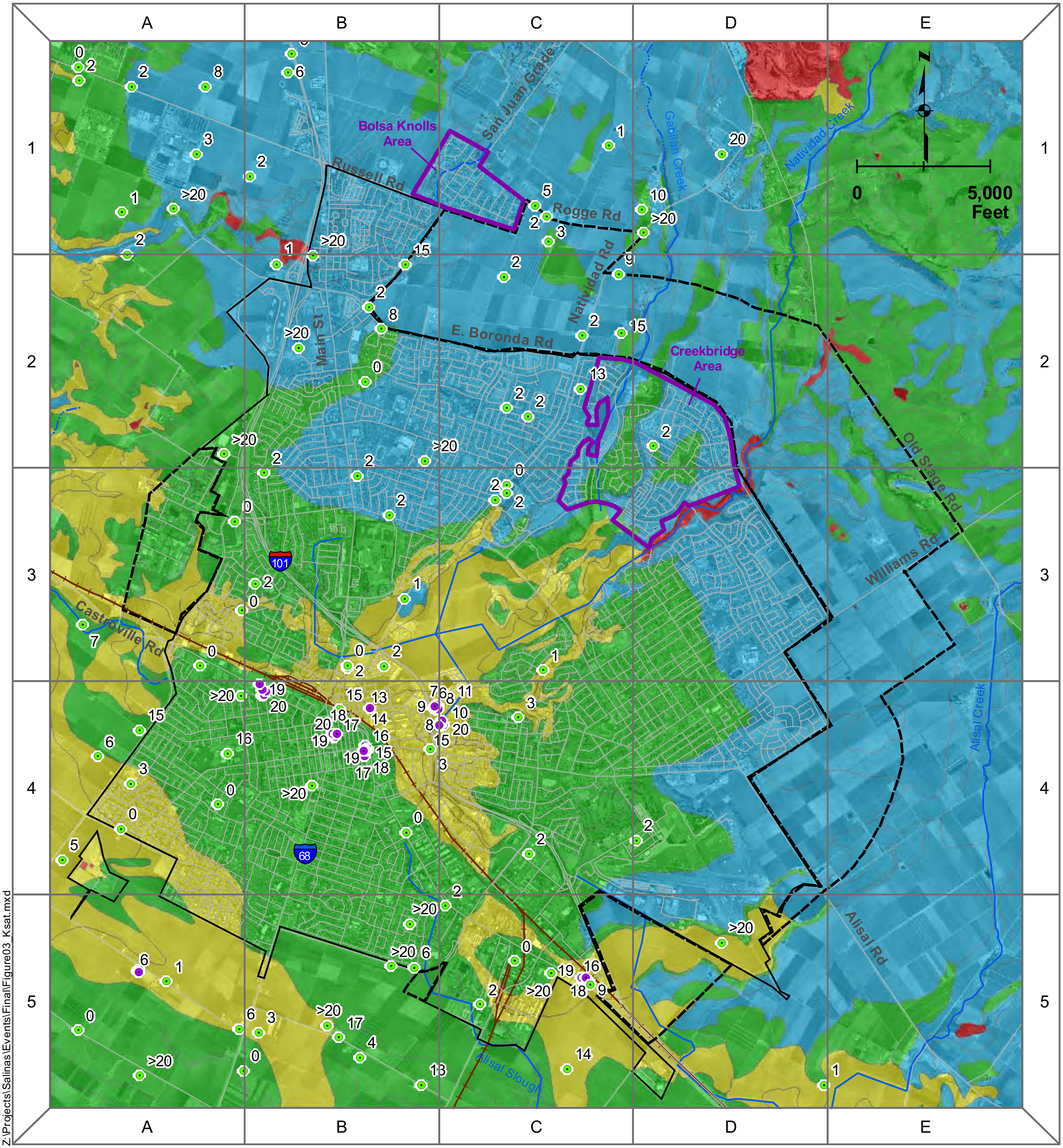
Figure 2

Note: The data presented on this map are intended for Planning Purposes only. Site specific data should be collected prior to design.



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Legend

Boundaries/Features
- City of Salinas Boundary
- Future Growth Area
- Road
- Highway
- Railroad
- Waterway

Shallow Groundwater Data
- 16 LUFT Monitoring Well and Probable Depth to Water (ft below ground surface)
- Areas of reported shallow groundwater (MCHD)

Shallow Clay Layers
- 2 Reported Depth to Clay (ft below ground surface)

Saturated Hydraulic Conductivity
- Very low: 0.00 - 0.01 μm/s
- Low: 0.01 - 0.1 μm/s
- Moderately Low: 0.1 - 1.0 μm/s
- Moderately High: 1 - 10 μm/s
- High: 10 - 100 μm/s
- Very High: 100 - 705 μm/s
- Soil Type Series/Grouping

Data Sources

Probable Depth to Groundwater: Geotracker website
Reported Depth to Clay: Monterey County Water Resources Agency well logs.
K_{SAT} Data: NCSS-NRCS web soil survey
Aerial photo and City Boundary: City of Salinas May 2002

Kennedy/Jenks Consultants

City of Salinas, CA
Saturated Soil Hydraulic Conductivity

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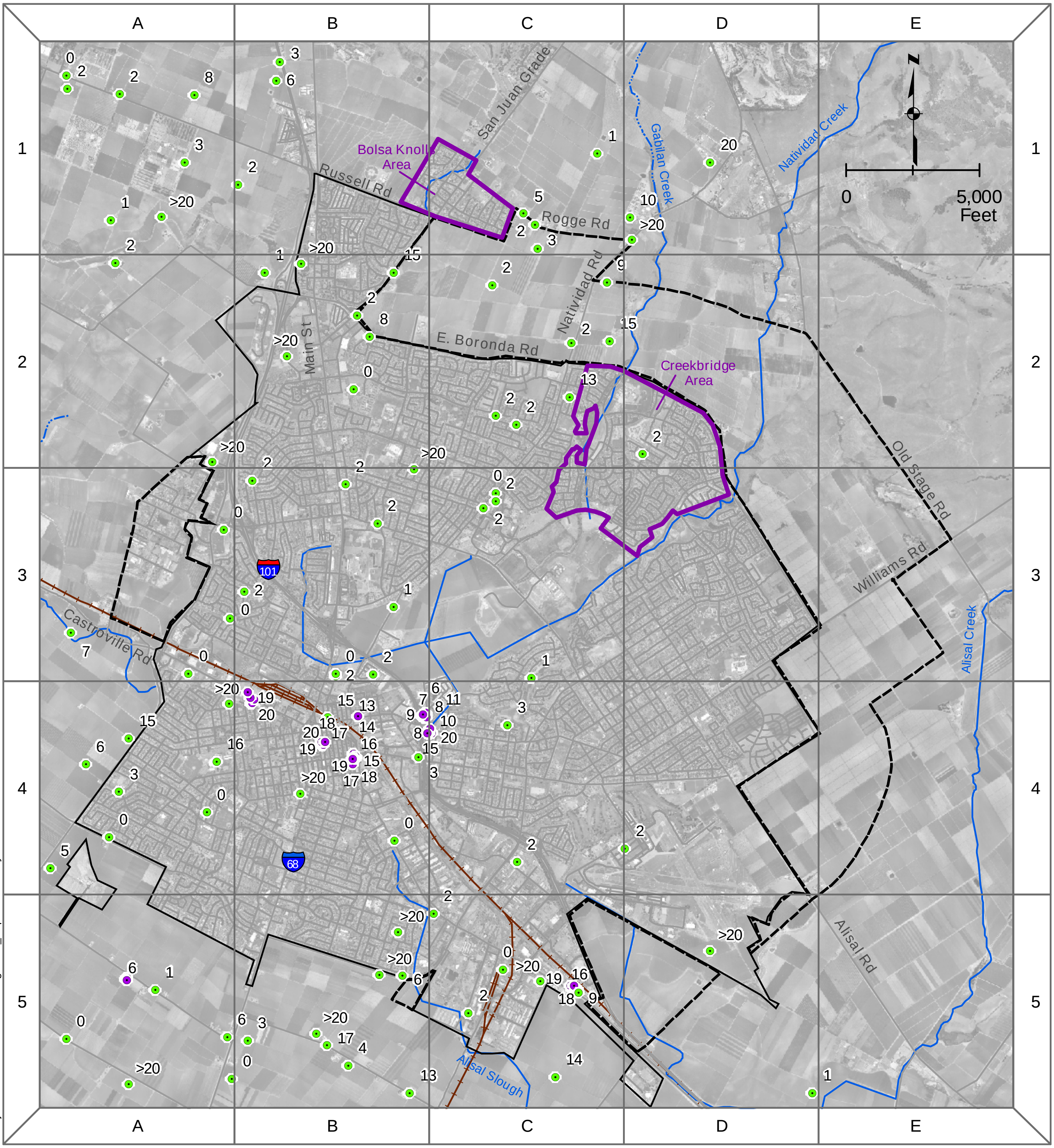
Figure 3

Note: The data presented on this map are intended for Planning Purposes only. Site specific data should be collected prior to design.



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Legend

Boundaries/Features

- City of Salinas Boundary
- Future Growth Area
- Road
- Highway
- Railroad
- Waterway

Shallow Groundwater Data

16 LUFT Monitoring Well and Probable Depth to Water (ft below ground surface)

Areas of reported shallow groundwater (MCHD)

Restrictive Soil Layer Data

2 Reported Depth to Clay (ft below ground surface)
* See text for explanation

Data Sources

Probable Depth to Groundwater: Geotracker website
Restrictive Soil Layer Data: MCWRA well logs
Aerial photo and City Boundary: City of Salinas May 2002

Kennedy/Jenks Consultants

City of Salinas, CA
Depth to Restrictive Soil Layer

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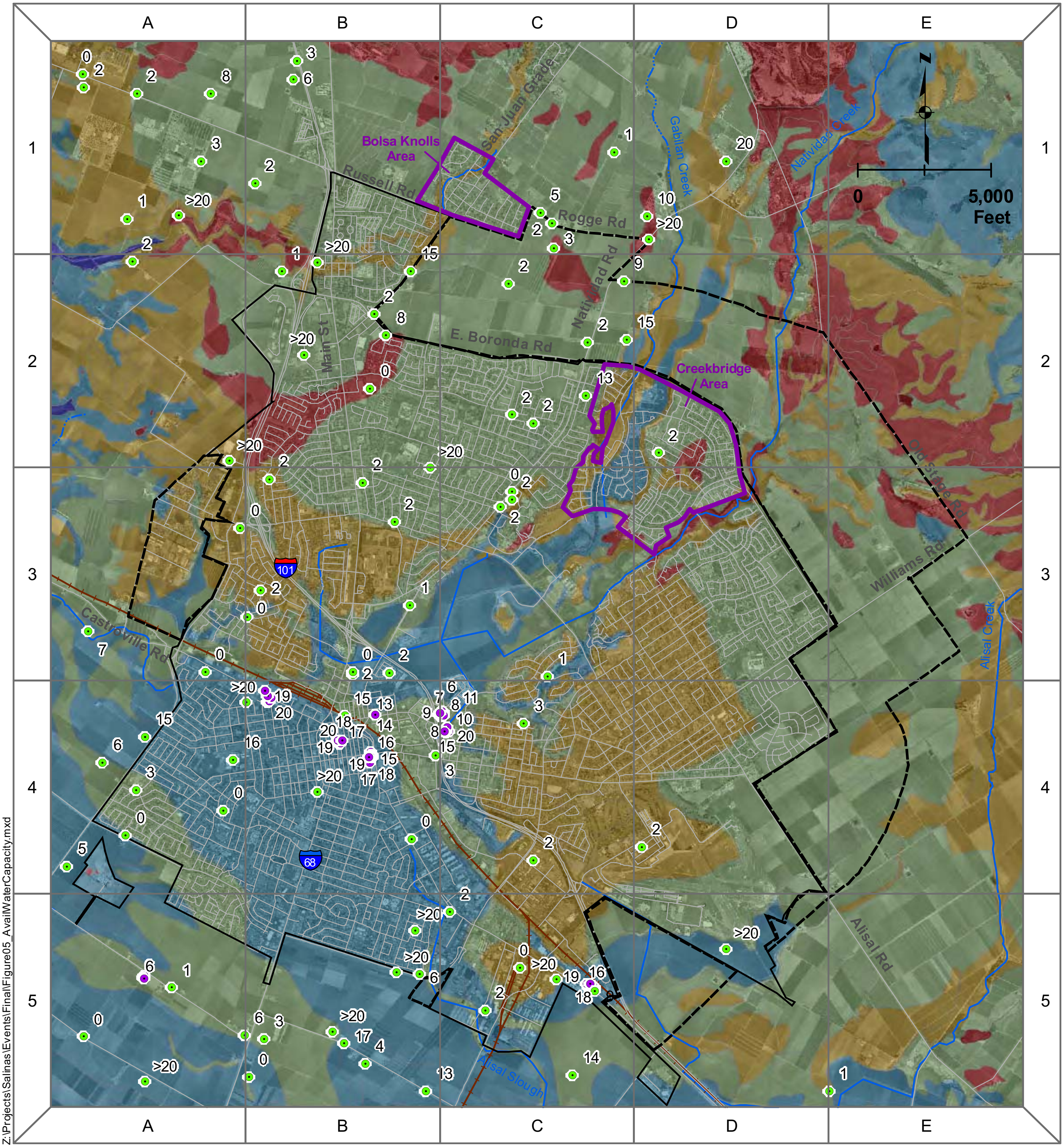
Figure 4

Note: The data presented on this map are intended for Planning Purposes only. Site specific data should be collected prior to design.



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Legend

Boundaries/Features
- City of Salinas Boundary
- Future Growth Area
- Road
- Highway
- Railroad
- Waterway

Shallow Groundwater Data
- 16 LUFT Monitoring Well and Probable Depth to Water (ft below ground surface)
- Areas of reported shallow groundwater (MCHD)

Shallow Clay Layers
- 2 Reported Depth to Clay (ft below ground surface)

Available Water Holding Capacity (cm of water/cm of soil)
- 0 - 0.05
- 0.06 - 0.1
- 0.11 - 0.15
- 0.16 - 0.2
- >0.2
- Soil Type Series/Grouping

Data Sources
Probable Depth to Groundwater: Geotracker website
Reported Depth to Clay: Monterey County Water Resources Agency well logs
Soil Water Capacity Data: NCSS-NRCS web soil survey
Aerial photo and City Boundary: City of Salinas May 2002

Kennedy/Jenks Consultants

City of Salinas, CA
Available Soil Water Holding Capacity (AWC)

K/J 06950006
January 2007

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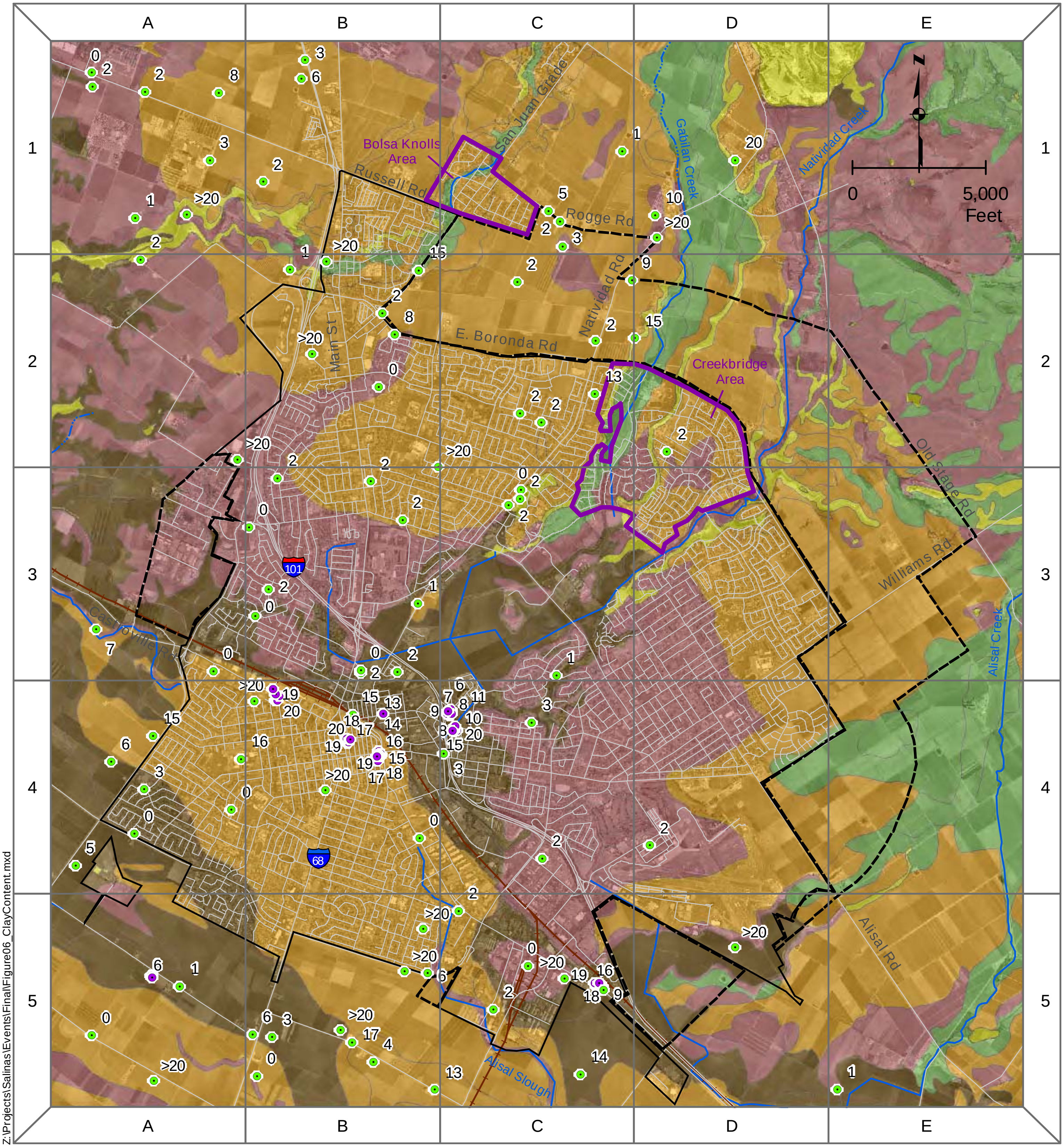
Not For Distribution

Figure 5

Note: The data presented on this map are intended for Planning Purposes only. Site specific data should be collected prior to design.



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Legend

Boundaries/Features
- City of Salinas Boundary
- Future Growth Area
- Road
- Highway
- Railroad
- Waterway

Shallow Groundwater Data
- 16 LUFT Monitoring Well and Probable Depth to Water (ft below ground surface)
- Areas of reported shallow groundwater (MCHD)

Shallow Clay Layers
- 2 Reported Depth to Clay (ft below ground surface)

Soil Clay Content (%)
- 0 - 5
- 5 - 15
- 15 - 25
- 25 - 35
- >35
- Soil Type Series/Grouping

Data Sources

Probable Depth to Groundwater: Geotracker website
Reported Depth to Clay: Monterey County Water Resources Agency well logs
Soil Clay Content Data: NCSS-NRCS web soil survey
Aerial photo and City Boundary: City of Salinas May 2002

Kennedy/Jenks Consultants

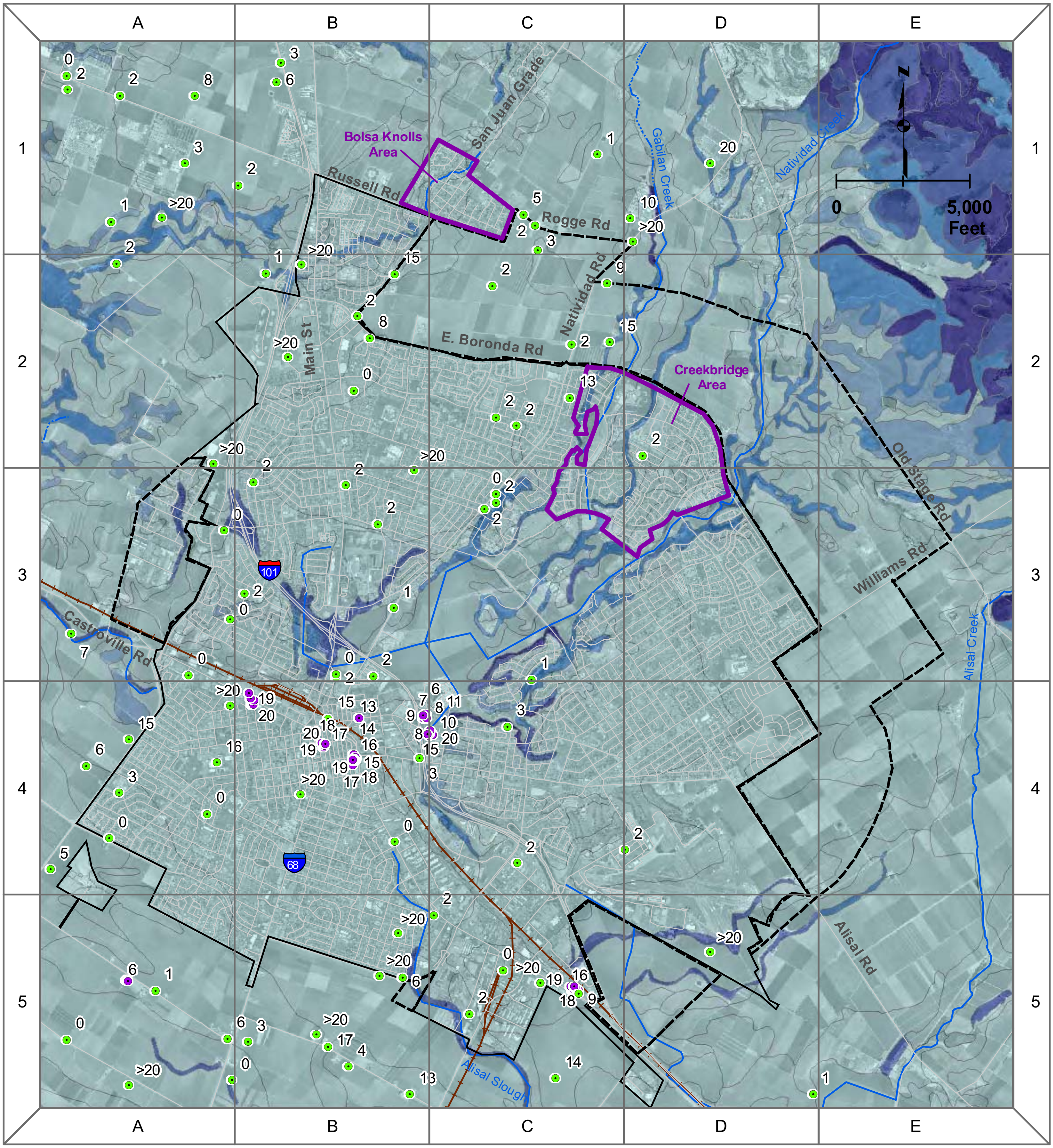
City of Salinas, CA
Soil Clay Content

K/J 06950006
January 2007

DRAFT
Not For Distribution

Figure 6

Note: The data presented on this map are intended for Planning Purposes only. Site specific data should be collected prior to design.



Z:\Projects\Salinas\Events\Final\Figure07_Slope.mxd

Legend

Boundaries/Features
- City of Salinas Boundary
- Future Growth Area
- Road
- Highway
- Railroad
- Waterway

Shallow Groundwater Data
- 16 LUFT Monitoring Well and Probable Depth to Water (ft below ground surface)
- Areas of reported shallow groundwater (MCHD)

Shallow Clay Layers
- 2 Reported Depth to Clay (ft below ground surface)

Topographic Slope Classification
- 0 - 7% slope
- 7 - 12% slope
- 12 - 30% slope
- 30 - 45% slope
- 45 - 75% slope
- Soil Type Series/Grouping

Data Sources

Probable Depth to Groundwater: Geotracker website
Reported Depth to Clay: Monterey County Water Resources Agency well logs
Slope Classification Data: NCSS-NRCS web soil survey
Aerial photo and City Boundary: City of Salinas May 2002

Kennedy/Jenks Consultants

City of Salinas, CA
Topographic Slope Classifications

K/J 06950006
January 2007

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Figure 7

Note: The data presented on this map are intended for Planning Purposes only. Site specific data should be collected prior to design.

Appendix C

Storm Water Infiltration and Bioretention System Underdrain Requirements in the Western U.S.

Table 1. Storm Water Infiltration and Bioretention System Underdrain Requirements in the Western U.S.

Agency/Organization	Document	Infiltration Testing Requirements	Infiltration Testing Specifications	Allowable Infiltration / Percolation Rates	Bioretention Underdrain Requirements	Required Separation & Setbacks	Other Requirements or Recommendations
The City of Boise, ID	Stormwater Management: A Design Manual, 2000	Required for each direct infiltration facility. One initial feasibility test required within 200 ft of proposed BMP and one boring and one test per each 1000 ft^2 of BMP surface area.	Single-ring infiltrometer installed 24" below proposed BMP bottom. Pre-soak for 24 hours then apply constant head test for 4 hours.	≥ 0.5 in/hr and ≤ 8.0 in/hr	Manual does not include a bioretention system design.	10 ft from ground water (1) 5 ft from bedrock 10 ft from structures and property boundaries 20 ft from basements 100 ft from surface waters and water wells	Soil boring must be installed to a depth of 10ft below the proposed infiltration facility bottom. Infiltration testing must be conducted by a registered professional engineer, a soils scientist or a geologist licensed in the State of Idaho.
California Stormwater Quality Association	California Stormwater BMP Handbook, New Development and Redevelopment, January 2003 (Updated September 2004)	For infiltration trenches and basins at least three in-hole conductivity tests are required using USBR 7300-89 or Bouwer-Rice procedures (the latter if groundwater is encountered within the boring), two tests at different locations within the proposed basin and the third down gradient by no more than approximately 10 m.	The tests shall measure permeability in the side slopes and the bed within a depth of 3 m of the invert. The minimum acceptable hydraulic conductivity as measured in any of the three required test holes is 13 mm/hr. If any test hole shows less than the minimum value, the site should be disqualified from further consideration.	≥ 0.5 in/hr and ≤ 2.4 in/hr Infiltration trenches and basins are not appropriate at sites with Hydrologic Soil Types C and D. Sites constructed of fill, having a base flow or with a slope greater than 15 percent should not be considered for infiltration.	Underdrain should be provided if native soils have infiltration rates of 0.5 in/hr or less	3 m from ground water (1) 6 m from buildings, slopes and highway pavement 30 m from wells and bridge structures.	NRCS soil survey data can be used if soil permeability data is available. The soil should not have more than 30 percent clay or more than 40 percent of clay and silt combined. The geotechnical investigation should be such that a good understanding is gained as to how the storm water runoff will move in the soil (horizontally or vertically) and if there are any geological conditions that could inhibit the movement of water. Bioretention is not a suitable BMP at locations where the water table is within 6 feet of the ground surface and where the surrounding soil stratum is unstable.
Center for Watershed Protection	Stormwater Manager's Resource Center (SMRC) Bioretention and Infiltration Trench Fact Sheets www.stormwatercenter.net	The infiltration rate and textural class of the soil needs to be confirmed in the field; designers should not rely on more generic information such as a soil survey.	The minimum geotechnical testing is one test hole per 5000 ft^2 of BMP surface area, with a minimum of two borings per facility (taken within the proposed limits of the facility).	≥ 0.5 in/hr and ≤ 3.0 in/hr	Bioretention areas should be designed with an underdrain system to collect filtered runoff at the bottom of the filter bed and direct it to the storm drain system	2 - 5 ft from ground water (1) 25 ft from structures 150 ft from surface/drinking water wells	Detailed soil tests are needed to determine if clay layers, hardpans or other confining layers are present. In addition, the soils should have no greater than 20% clay content, and less than 40% silt/clay content. Finally, infiltration basins may not be used in regions of karst topography, due to the potential for sink hole formation, or groundwater contamination. An observation well (i.e. a perforated PVC pipe that leads to the bottom of the trench) is needed to enable inspectors can monitor the drawdown rate
Contra Costa Clean Water Program, CA	Stormwater C.3 Guidebook, March, 2005	Testing is required only when the infiltration rate of native subsurface soils is used to size the infiltration device. Testing is not required for Category "B" (indirect infiltration) systems equipped with underdrains.	Pits, borings, or double-ring infiltrometer (ASTM D3385) At least two (2) soil permeability tests are typically required or a minimum one (1) test is required for every 5,000 ft^2 of infiltration system bottom area. The soil test(s) must be taken at the proposed bottom of the infiltration system. The test location must not be more than 20 feet from the final location of the infiltration system.	≥ 0.5 in/hr and soils underlying the infiltration basin should not contain more than 20 percent clay content and do not contain more than a combined 40 percent silt/clay content.	Underdrain required in hydrologic soil groups "C" and "D" or when infiltration is not desired.	10 ft from ground water (1) 3 ft from bedrock 10 ft from structures 100 ft from surface/drinking water wells 100 ft from septic systems Bioretention systems: 50 ft minimum setback from, and no connection to, any on-site septic system or leach field.	Locations with high soil infiltration rates (≥2.4"/hr.) receive additional evaluation of potential effects on groundwater quality and need for pretreatment.

Notes: 1 – groundwater separation defined as distance from the bottom of the infiltration facility (basin or trench) to the seasonally high groundwater elevation.

Table 1. Storm Water Infiltration and Bioretention System Underdrain Requirements in the Western U.S.

Agency/Organization	Document	Infiltration Testing Requirements	Infiltration Testing Specifications	Allowable Infiltration / Percolation Rates	Bioretention Underdrain Requirements	Required Separation & Setbacks	Other Requirements or Recommendations
Urban Drainage and Flood Control District, Denver, CO	Drainage Criteria Manual, Volume 3 (Revised 2005)	Not specified	Not specified	Not specified	Underdrains necessary for NRCS Type D soils or where there is a potential for groundwater contamination	5 ft from ground water (1) 5 ft from bedrock	
Idaho Department of Environmental Quality	Catalog of Stormwater BMPs for Idaho Cities and Counties, September 2005	Suggests that testing be conducted pre- and post-construction	The pre-construction infiltration rate should be measured using single ring infiltrometer test (ASTM D 5126). A double ring infiltrometer test (ASTM D5126) should be conducted (a local option) after final grading, and the determined rate of infiltration should be at a minimum 0.5 in/hr.	Minimum 0.5 in/hr, maximum 3.0 in/hr	If the surrounding soils have considerably lower rates of infiltration than the planting soil, an underdrain may be required to avoid water ponding.	3 ft from ground water (1) 4-6 ft from bedrock 100 ft upslope and 20 ft downslope from building foundations or water supply well	An observation well should be installed for every 50 feet of infiltration trench length
Portland Bureau of Environmental Services, OR	2004 Stormwater Management Manual	The following general criteria apply to all proposed infiltration facilities: (1) initial feasibility testing, (2) design testing, and (3) post-construction testing.	Design testing - Single ring infiltrometer, falling head infiltration test typically required. 1 initial feasibility test required within 200 ft of proposed BMP and 1 boring and 1 test per each 200 ft^2 of BMP surface area.	≥ 2.0 in/hr	Underdrains required for pervious pavement and vegetated infiltration basins where native soils have infiltration rates less than 2.0 in/hr.	4 ft from ground water (1) 4 ft from bedrock 5 ft from property lines 10 feet from building foundations	Excavate a test pit or dig a standard soil boring to a minimum depth of 4 ft below the proposed facility bottom elevation. Also conduct Standard Penetration Testing (SPT) every 2 feet to a depth of 4 feet below the facility bottom. Testing shall be conducted or observed by a qualified professional. This professional shall either be a registered professional engineer in the State of Oregon, or a soils scientist or geologist licensed in the State of Oregon.
Truckee Meadows, NV	DRAFT Low Impact Development Handbook, 2005 Structural Controls Design Manual, 2004	Required at the location of the proposed infiltration BMP	Single-ring infiltrometer per District Health Dept. septic system leach field testing requirements	≥ 0.5 in/hr (120 min/in) and ≤ 2.4 in/hr (25 min/in)	Underdrain should be provided if native soils have infiltration rates of 0.5 in/hr or less	3 ft from ground water (1) 100 ft from surface waters and water wells 100 ft upslope and 20 ft downslope from building foundations Not within a Wellhead Protection Zone	Where native soil infiltration rates exceed 2.4 in/hr, runoff should be fully pretreated prior to infiltration to protect groundwater. Addition of soil amendments to slow infiltration and allow adequate treatment of storm water may also be considered.
Washington State Department of Ecology	2005 Stormwater Management Manual for Western Washington: Volume III -- Hydrologic Analysis and Flow Control Design/BMPs	Information gathered during initial geotechnical and surface investigations are necessary to know whether infiltration is feasible.	Pilot Infiltration Test (PIT) method. For infiltration basins, at least one test pit or test hole per 5,000 ft^2 of basin infiltrating surface (in no case less than two per basin). For infiltration trenches, at least one test pit or test hole per 50 feet of trench length (in no case less than two per trench).	≥ 1.0 in/hr and ≤ 2.4 in/hr	Not specified	5 ft from groundwater (1) 5 ft above bedrock 100 ft from drinking water wells, septic tanks or drainfields, and springs used for public drinking water supplies. 100 ft upslope and 20 ft downslope from building foundations 50 feet from the top of slopes >15%	A geotechnical investigation should be conducted to evaluate the suitability of the site for infiltration, slope stability, foundation capacity, and other geotechnical design information needed to design and assess constructability of the facility. The depth and number of test holes or test pits, and samples should be increased, if conditions are highly variable and such increases are necessary to accurately estimate the performance of the infiltration system.

Notes: 1 – groundwater separation defined as distance from the bottom of the infiltration facility (basin or trench) to the seasonally high groundwater elevation.

Appendix D

Sample Infiltration/Percolation Testing Procedures

Sample Storm Water Infiltration Testing Procedures
City of Boise, Idaho

General Notes

1. For seepage beds, infiltration basins, and infiltration swales, a minimum field infiltration rate of 0.5 inches per hour is required. Areas yielding a lower rate preclude these practices. Areas yielding a lower rate preclude these practices. For sites with infiltration rates that are more than 8" per hour, a 12-inch layer of ASTM fine grade 33 sand, or greater, is required at the bottom of the facility.

2. Number of required borings is based on the size of the proposed facility. Testing is done in two phases, (1) Initial Feasibility, and (2) Concept Design.

3. Testing is to be conducted by a qualified professional. The professional shall either be a registered professional engineer in the State of Idaho, a soils scientist or a geologist licensed in the State of Idaho.

Initial Feasibility Testing

Feasibility testing is conducted to determine whether full-scale testing is necessary, screen unsuitable sites, and reduce testing costs. Initial testing involves either one field test per facility, regardless of type or size, or previous testing data, such as the following:

- Percolation testing on-site, within 200 feet of the proposed BMP location, and on the same contour which can establish initial rate, water table and/or depth to bedrock, or

- Geotechnical report on the site prepared by a qualified geotechnical consultant, or

- Natural Resources Conservation Service (NRCS) County Soil Mapping showing Hydrologic Soil Classifications (Type A, B, C, D).

Concept Design Testing

If the results of initial feasibility testing as determined by a qualified professional show that an infiltration rate of greater than 0.5"/hour and less than 9.0"/hour is probable, then the number of soil borings shall be 1 soil boring and 1 infiltration test for infiltration areas up to 1000 SF. For infiltration facilities greater than 1000 SF, one additional soil boring and one additional infiltration test for each additional 1000 SF of infiltration area. If test borings show uniform subsurface characteristics throughout the proposed stormwater facility location, then only 1 infiltration test/2000 SF is required.

Documentation

Infiltration testing data shall be documented, and include a description of the infiltration testing method. This is to ensure that the tester understands the procedure.

As part of a design submittal, the infiltration facility must be sized and documented with a calculation. The sizing of an infiltration facility is related to the design infiltration rate, among other factors. Infiltration rates should be based on laboratory or in-situ tests that correlate or measure infiltration. Some commonly used test methods are laboratory gradations (ASTM C136 and ASTM D1140 often including the No. 270 sieve size for correlation with agricultural guides) used in conjunction with recognized infiltration guidelines (e.g. Ada County Highway District - Policy Development Manual), in-situ percolation tests (State of Idaho - Technical Guidance Manual for Individual and Subsurface Sewage Disposal), laboratory permeability tests (e.g. ASTM D2434 or D5084), full-scale infiltrations tests (designed by a professional), and other tests.

A design infiltration rate should be developed from correlated or measured infiltration rate(s) for each infiltration facility area. A qualified professional should recommend a design infiltration rate that considers the potential variability of the area in the immediate vicinity of the infiltration facility, possible degradation by construction practices, the reproducibility of the test method, and the applicability of the test method. Correlated or measured infiltration rates should be appropriately reduced to develop the design infiltration rate.

The drainage design professional, based on the geotechnical report findings, shall state the final infiltration rate reduction factors (i.e., infiltration basin size safety factor). The factor recommended by the design professional may be larger to account for site variability or construction considerations.

Calculations for the sizing of an infiltration facility should include the following information for each infiltration area:

- The test method used to correlate or measure infiltration,
- The correlated or measured infiltration rate,
- The reduction factor used to develop a design infiltration rate, and
- The design infiltration rate (inches per hour).

A general validation of the appropriate selection of a design infiltration rate will occur after construction of the drainage facility through the required swale performance infiltration test. Drainage design professionals may request the opportunity to review the condition of the subgrade of infiltration facilities during construction to verify that the exposed subgrade condition is similar to the assumed design condition."

Test Pit/Boring Requirements

1. Dig a standard soil boring to a depth of 10' below the proposed facility bottom
2. Determine depth to groundwater table (if within 10 feet of proposed bottom) upon initial digging or drilling, and again 24 hours later
3. Determine United States Department of Agriculture (USDA) or Unified Soil Classification (USC) System textures at the proposed bottom
4. Determine depth to bedrock (if within 5' of proposed bottom)

5. The soil description should include all soil horizons and vadose zone
6. The location of the boring shall correspond to the BMP location

Infiltration Testing Requirements

1. Install casing (solid 5" diameter, 30" length) to 24" below proposed BMP bottom.
2. Remove any smeared soiled surfaces and provide a natural soil interface into which water may percolate. Remove all loose material from the casing. Upon the tester's discretion, a 2" layer of coarse sand or fine gravel may be placed to protect the bottom from scouring and sediment. Fill casing with clean water to a depth of 24" and allow to pre-soak for 24 hours.
3. Twenty-four hours later, refill casing with another 24" of clean water and monitor water level (measured drop from the top of the casing for 1 hour. Repeat this procedure (filling the casing each time) 3 additional times, for a total of 4 observations. Upon the tester's discretion, the final field rate may either be the average of the four observations, or the value of the last observation. The final rate shall be reported in inches/hour.
4. The location of the test shall correspond to the BMP location.
5. Upon completion of the testing, the casings shall be immediately pulled.

Laboratory Testing

Grain-size sieve analysis and hydrometer tests, where appropriate, may be used to determine USDA soils classification and textural analysis. Visual field inspection by a qualified professional may also be used, provided it is documented. The use of lab testing to establish infiltration rates is prohibited.

Swale Performance Testing

Bulk infiltration testing for swales and basins consists of filling the swale or basin with water to the 50-year storm event level to test the infiltration rate. The swale should infiltrate the water within the time utilized in the design calculations. For larger swales with capacities greater than 5000 gallons (668 cubic feet) a section of the swale equal to 2000 gallons may be tested by damming an appropriately sized section, not less than 5% of the swale area. Recommended dam materials are sandbags with visqueen. On swales greater than 1500 cubic feet (11,220 gallons) in size, two tests will be required.

An acceptable infiltration test is one where all water is infiltrated within the test period. For example, where 75% of the test volume is infiltrated within the first 24-hour period and all water is infiltrative within the next 24-hour period (i.e., 48 hours from the start of the test). Please note that swale/basin testing shall not be performed until system vegetation has been established.

If the proposed infiltration tests cannot satisfy the above criteria, the swale must be reconstructed. An investigation to determine the cause of unacceptable infiltration rate performance is important prior to reconstruction. Reconstruction may be based upon either of the following two conditions:

- Inadequate or improper plan by system designer

- Contractor failed to construct swale in accordance to plan and material specification requirements

For those situations where a swale fails the infiltration test, the City of Boise is to be notified of the failure, the reasons for the failure, and either the corrective construction measures or the modified swale design. When a modified design is required, designer shall submit modified plan to City for approval before swale modifications commence.

Swale/Basin Test Guidance

1. Identify swale/basin size to determine number of tests required.

2. For larger systems, enclose sections of the swale/basin to provide for infiltration tests with approximately 2000 gallon capacities. If in-situ sand filters have been included in the constructed swale, the proportion of the swale with and without sand filtration is to reflect the overall swale drainage design objectives. For example, if the design storm is to be infiltrated proportionately 25% through the vegetated or permeable soil section and 75% through in-situ sand filters, then the size and location of the swale test shall approximate these same proportions.

3. Place a stake and note the elevation within the swale or swale section to be tested that reflects 25% of the design storm volume (maximum swale/basin volume at the end of the first 24 hour test period).

4. Fill the swale/basin or the section of the swale/basin to be tested with the design test volume. Filling procedures should use low velocity and spreading techniques in order to prevent any erosion or damage to the established vegetation. Make a note as to the time and date that the swale basin is filled to the testing limit.

5. Examine the test section 24 hours later and note whether the test volume has decreased by 75% within the first 24 hour period. Swale/basin will pass testing if all water has infiltrated into the system. If water remains in the test section (25% of test volume or less), proceed to next step.

Examine the test section once more 24 hours later (i.e., 48 hours after filling with the test volume) and note whether the volume has fully drained. Swale/basin will pass testing if all water has infiltrated into the system. If water remains in the system after the 48 hour test period, infiltration test shall be considered a failure. Retesting will be required.

CONTRA COSTA CLEAN WATER PROGRAM

Stormwater Quality Requirements for Development Applications

Stormwater C.3 Guidebook

SECOND EDITION—MARCH 2005

Site Feasibility Confirmation Testing Methods

Site Feasibility Confirmation Testing

To support use of the stormwater infiltration guidance in Appendix C, a standardized soil screening and testing procedure has been developed. Standards are similar to those developed by the Wisconsin Department of Natural Resources (WDNR 2004). Alternatively, project proponents may also use similar testing methods described in the California Department of Transportation BMP Retrofit Pilot Program Final Report (CALTRANS 2004) or based on specific written recommendations provided by the local municipality's engineer.

Note: Testing is required only when the infiltration rate of native subsurface soils is used to size the infiltration device. Testing is not required for Category "B" (indirect infiltration) systems equipped with underdrains.

Initial screening identifies the potential for using infiltration methods at a site and identifies potential location on the site for infiltration devices. The purpose of the initial screening is to determine if installation of infiltration methods is feasible on the site and to determine where fieldwork may be needed for subsequent field verification.

► INITIAL SCREENING STEPS

The initial stormwater infiltration screening evaluation involves nine screening steps; the initial evaluation shall identify the following site-specific characteristics of the proposed development site:

1. Site topography and slopes greater than 20%
2. Site Hydrologic Soil Group(s) as defined in NRCS Soil Survey data
3. Presence of areas with potentially vulnerable groundwater
4. Regional or local depth to bedrock and groundwater (use seasonally high groundwater information where available)
5. Presence and/or nearby proximity to known areas with identified soil and/or groundwater contamination (existing and/or closed remediation sites and/or underground storgae tanks within or adjacent to the project parcel)
6. Relevant site land use category(s)
7. Presence of sensitive ecological habitat (including wetlands and endangered species habitat)
8. Presence of flood plains and/or flood fringes

9. Potential impact to adjacent property

► **FIELD VERIFICATION**

Field verification of information collected during the initial site feasibility screening process includes further investigation of specific areas on a development site that have been considered potentially suitable for infiltration. This includes verification of steps 1, 2, 3, 4, and 7.

Sites shall be tested for depth to groundwater, depth to bedrock, and percent fines to verify findings from initial screening steps. Following is a description of the percent fines expected for each type of soil textural classification.

Fill soils utilized for stormwater infiltration systems should contain a minimum of 20% fines by volume and a maximum of 40% fines by (clay and silt combined). Several textural classes are assumed to meet the minimum percent fines limitations. These classifications include sandy loams, loams, silt loams, and clay textural classifications. Coarse sand is the only soil texture that by definition will not meet the minimum limitations for a soil layer consisting of 20% fines. Other sand textures and loamy sands may need the percent fines level verified with a laboratory analysis.

Borings and pits shall be dug to verify soil infiltration capacity characteristics and to determine depth to groundwater and bedrock.

The following information shall be recorded for field verification of the initial screening:

1. The date or dates the data were collected.

2. A legible site plan/map that is presented on paper that is no less than 8½" by 11" and:

    a. Is drawn to scale or fully dimensional.

    b. Illustrates the entire development site.

    c. Shows all areas of planned filling and/or cutting.

    d. Includes a permanent vertical and horizontal reference point.

    e. Shows the percent and direction of land slope for the site or contour lines. Highlights areas with slopes over 20%.

    f. Shows all flood plain information that is pertinent to the site.

    g. Shows the locations of all pits/borings included in the report.

    h. Shows the locations of wetlands as field delineated and surveyed.

i. Shows the locations of water supply wells within 100 feet of the development site.

3. It is recommended that soil profile descriptions be written in accordance with the descriptive procedures, terminology, and interpretations found in the "USDA Field Book for Describing and Sampling Soils" (USDA NRCS 1998). In addition to the soil data determined above, soil profiles should include the following information for each soil horizon or layer:

   a. Thickness, in inches or decimal feet.

   b. Munsell soil color notation.

   c. Soil mottle or redoximorphic feature color, abundance, size, and contrast.

   d. USDA soil textural class with rock fragment modifiers.

   e. Soil structure, grade size, and shape.

   f. Soil consistence, root abundance, and size.

   g. Soil boundary.

   h. Occurrence of saturated soil, groundwater, bedrock, or disturbed soil.

► EVALUATION OF SPECIFIC INFILTRATION AREAS

This step is to determine if specific locations identified for stormwater infiltration devices are suitable for infiltration, and to provide the required information to design the device. A minimum number of borings or pits shall be constructed for each infiltration device (Table C-3-1). The following information shall be recorded for this evaluation:

1. All the information required by previous evaluation steps.

2. A legible site plan/map that is presented on paper no less than 8½" by 11" and:

   a. Is drawn to scale or fully dimensional.

   b. Illustrates the locations of the infiltration devices.

   c. Shows the locations of all pits and borings.

   d. Shows distance from device to wetlands.

3. One of the following methods shall be used to determine the design infiltration rate:

   a. Infiltration Rate Not Measured - Table C-3-2 shall be used if the infiltration rate is not measured. Select the design infiltration rate from Table C-3-2 based on the least permeable soil horizon 5 feet below the bottom elevation of the infiltration system.

   b. Measured Infiltration Rate - The tests shall be conducted at the proposed bottom elevation of the infiltration device. The standardized infiltration test pit/boring requirements and the standard testing protocol is described below.

      To select the correction factor from Table C-3-3, the ratio of design infiltration rates must be determined for each place an infiltration measurement is taken. The design infiltration rates from Table C-3-3 are used to calculate the ratio. To determine the ratio, the design infiltration rate for the surface textural classification is divided by the design infiltration rate for the least permeable soil horizon. For example, a device with loamy sand at the surface and a least permeable layer of loam will have a design infiltration rate ratio of about 6.8 and a correction factor of 4.5. The depth of the least permeable soil horizon (a limiting layer) should be identified within 5 feet of the proposed bottom of the proposed infiltration facility.

      Final infiltration testing data shall be documented, and include a description of the infiltration testing method. This is to ensure that the tester and reviewer fully understand the procedure.

► STANDARDIZED TEST PIT/BORING REQUIREMENTS

Boring is required in the infiltration facility area to a minimum depth of 5 feet below the proposed bottom of the facility (i.e., trench). Infiltration is not feasible if evidence of groundwater or bedrock/hard pan is within 5 feet of proposed bottom of facility. The following steps describe the main elements necessary to support test pit/boring requirements:

1. Excavate a test pit or dig a standard soil boring to a depth of approximately 3 feet below the proposed facility bottom.

2. Determine depth to groundwater table (if potentially within the top 10 feet below the existing ground surface).

3. Conduct Standard Penetration Testing (SPT) every 1 foot to a depth of 3 feet below the facility bottom.

4. Determine US Department of Agriculture (USDA) or Unified Soil Classification (USC) System textures at the proposed bottom and 3 feet below the bottom of the infiltration system.

5. Describe soil horizons and determine depth to bedrock (if within 3 feet of proposed bottom of facility).

6. The location of the test pit or boring shall correspond to the BMP location; test pit/soil boring stakes are to be left in the field for inspection purposes and shall be clearly labeled as such.

► STANDARDIZED INFILTRATION TESTING PROTOCOL

At least two (2) soil permeability tests are typically required or as an absolute minimum one (1) test is required for every 5,000 square feet (s.f.) of infiltration system bottom area. The soil test(s) must be taken at the proposed bottom of the infiltration system. The test location must not be more than 20 feet from the final location of the infiltration system. Test location(s) should be located/identified on plans, to be verified by field observation. The following protocol provides an accepted procedure for conducting bore hole infiltration tests. A similar acceptable protocol is described in the California Department of Transportation BMP Retrofit Pilot Program Final Report (CALTRANS 2004). Alternatively, if the infiltration rate is measured with a *Double-Ring Infiltrometer* the requirements of ASTM D3385 shall be used for the field test.

1. Install casing to a minimum of 2.0 feet below proposed BMP bottom.

2. Remove any smeared soiled surfaces and provide a natural soil interface into which water may percolate. Remove all loose material from the casing. Upon the tester's discretion, a layer of coarse sand or fine gravel may be placed to protect the bottom from scouring and sediment. Fill casing with clean water to a depth of 2.0 feet and allow to pre-soak for 24 hours.

3. Twenty-four hours later, refill casing with another 2.0 feet of clean water and monitor water level (measured drop from the top of the casing) for 1 hour. Repeat this procedure (filling the casing each time) three additional times, for a total of four observations. Upon the tester's discretion, the final field rate may either be the average of the four observations, or the value of the last observation. The final rate shall be reported in inches per hour.

4. May be done through a boring or open excavation.

5. The location of the test shall correspond to the BMP location.

6. Upon completion of the testing, the casings shall be pulled and the test pit shall be backfilled.

7. For infiltration trench and basin practices, a minimum field infiltration rate of 0.5 inch/hour is typically required; areas yielding a lower rate preclude these practices without special considerations. For bioretention practices and vegetated swales, no minimum infiltration rate is required if these facilities are designed with a "day-lighting" underdrain system and with permeable soils having less than 20 percent fines (clay and/or silt particles).

8. Number of required borings is based on the size of the proposed infiltration facility. (At least one test per 5,000 square feet of infiltration bottom area)

9. Testing is to be conducted by a qualified professional. This professional shall either be a registered professional engineer, a soils scientist, or geologist licensed in California.

Table C-3-1. Evaluation Requirements Specific to Proposed Infiltration Devices

Infiltration Device	*Tests Required*[1]	*Minimum Number of Borings/Pits Required*	*Minimum Drill/Test Depth Required Below the Bottom of the Infiltration System*
Irrigation Systems[2], *Rain Gardens*[2], *Green Roofs*[2]	NA[2]	NA[2]	NA[2]
Infiltration Trenches (≤2,000 square feet of impervious drainage area)	Pits, borings, or double- ring infiltrometer	1 test/100 linear feet of trench	5 feet or depth to limiting layer, whichever is less
Infiltration Trenches (>2,000 square feet of impervious drainage area)	Pits, borings, or double- ring infiltrometer	1 pit required and an additional 1 pit or boring/ 100 linear feet of trench	Pits to 5 feet or depth to limiting layer. Borings to 15 feet or depth to limiting layer
Bioretention Systems	Pits, borings, or double- ring infiltrometer	Minimum of 1 test per 5,000 s.f. of infiltration bottom area	5 feet or depth to limiting layer
Infiltration/Dry Vegetated Swales	Pits, borings, or double- ring infiltrometer	1 test/1,000 linear feet of swale or, 1 test per 5,000 s.f. of infiltration bottom area	5 feet or depth to limiting layer
Surface Infiltration Basins	Pits, borings, or double- ring infiltrometer	Minimum of 1 test per 5,000 s.f. of infiltration bottom area	Pits to 10 feet or depth to limiting layer. Borings to 20 feet or depth to limiting layer
Subsurface Dispersal Systems (i.e. dry wells)	Pits, borings, or double- ring infiltrometer	Minimum of 1 test per 5,000 s.f. of infiltration bottom area	Pits to 10 feet or depth to limiting layer. Borings to 20 feet or depth to limiting layer

Notes:

1. Continuous soil borings shall be taken using a bucket auger, probe, split-spoon sampler, or shelby tube. Samples shall have a minimum 2-inch diameter. Soil pits must be of adequate size, depth, and construction to allow a person to enter and exit the pit and complete a morphological soil profile description.
2. Information from the initial stormwater infiltration screening steps is adequate to design rain gardens and irrigation systems.

Table C-3-2. Design Infiltration Rates for Soil Textures Receiving Stormwater

Soil Texture1	*Design Infiltration Rate Without Measurement inches/hour2*
Coarse sand or coarser	3.60
Loamy coarse sand	3.60
Sand	3.60
Loamy sand	1.63
Sandy loam	0.50
Loam	0.24
Silt loam	0.13
Sandy clay loam	0.11
Clay loam	0.03
Silty clay loam	0.043
Sandy clay	0.04
Silty clay	0.07
Clay	0.07

Notes:

1. Use sandy loam design infiltration rates for fine sand, loamy fine sand, very fine sand, and loamy fine sand soil textures.
2. Infiltration rates represent the lowest value for each textural class presented in Table 2 of Rawls, 1998.
3. Infiltration rate is an average based on Rawls, 1982, and Clapp & Hornberger, 1978.

Table C-3-3. Total Correction Factors Divided into Measured Infiltration Rates

Ratio of Design Infiltration Rates1	Correction Factor
1	2.5
1.1 to 4.0	3.5
4.1 to 8.0	4.5
8.1 to 16.0	6.5
16.1 or greater	8.5

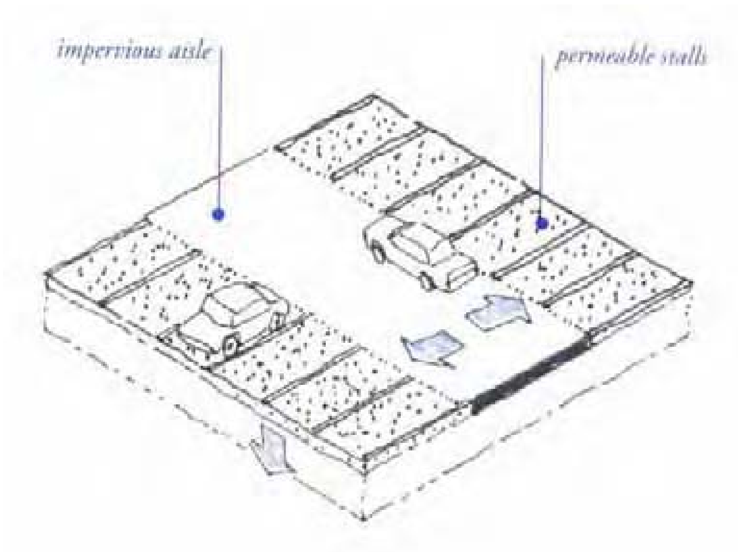
Note:

1. Ratio is determined by dividing the design infiltration rate (Table C-3-2) for the textural classification at the bottom of the infiltration device by the design infiltration rate (Table C-3-2) for the textural classification of the least permeable soil horizon. The least permeable soil horizon used for the ratio should be within 5 feet of the bottom of the device or to the depth of the limiting layer.

Appendix E

Example Storm Water Infiltration Practices and Design Standards

Grading, Paving, and Landscaping



Bay Area Stormwater Management Agencies Association, *Start at the Source* (1999)

The need for stormwater treatment can be minimized by designing pervious areas so that they retain the first 1" of rainfall before any runoff enters storm drains. In paved areas, permeable pavements may substitute for traditional asphalt or concrete.

Runoff from roofs or impervious paving can be allowed to drain on to pervious areas without any additional requirement for stormwater treatment. Up to a 2:1 ratio of impervious area to pervious area is acceptable.

Where native soils are clayey, a thick gravel base course provides additional storage under permeable pavements. In some cases, an underdrain system, connected to the storm drain or leading to a discharge point, may be needed.

Design and Construction. Grade landscaped areas to be concave. If drains are necessary, set the inlet elevation above the low point or drainage line. Select pervious pavements to serve site aesthetics and uses. Pervious concrete is most suitable to low-traffic areas. Turf block pavers may be appropriate for overflow parking areas. Unit pavers such as brick, and crushed aggregate, are used in plazas and pedestrian walkways.

Maintenance. Permeable asphalt and concrete may require periodic pressure washing or vacuuming to dislodge fines. Unit pavers may require seasonal weed suppression.

Best Uses

- Parking lots
- Common areas
- Lawns and landscape buffers

Advantages

- Reduce or eliminate need for stormwater treatment
- Does not require annual verification of maintenance
- Reduce drainage system cost and potential for flooding
- Can be an attractive landscape element

Limitations

- Potential for prolonged ponding if soils are poorly drained
- New varieties of pervious asphalt and concrete have not yet been widely accepted
- Typically higher costs for pervious pavements

CONTRA COSTA CLEAN WATER PROGRAM

Infiltration Feasibility Fact Sheets

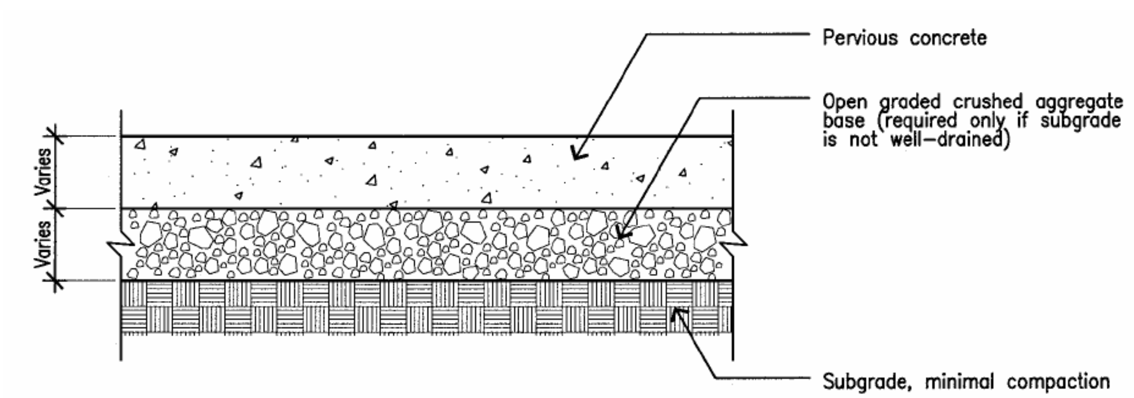
Category A—Site Design Practices

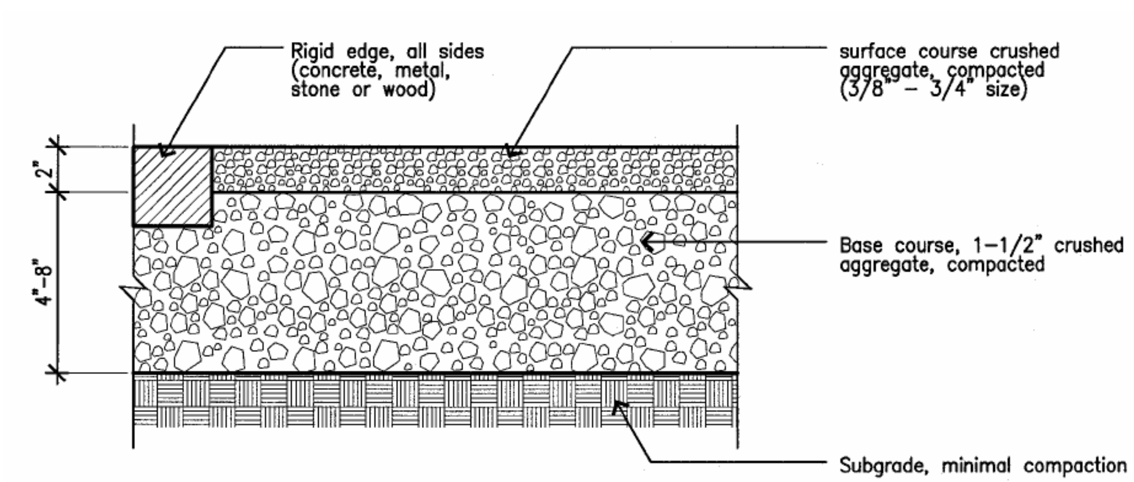
Design Checklist for Landscaped Self-Retaining Areas

- ❒ Entire self-retaining area is graded concave (i.e., will retain 1" rainfall over entire surface). Drain inlets, if any, are set above low point or flow line.
- ❒ Receiving landscaped area is at least ½ tributary impervious area.
- ❒ Lawn or other landscaped areas are graded with at least 6" curb reveal below adjacent pavement (to allow for turf growth without blocking sheet flow into landscaped area).
- ❒ Soils are suitable or will be adequately amended with organic matter to increase moisture-holding capacity.
- ❒ In clay soils: Slopes, gravel underlayer, and/or underdrain will protect against prolonged ponding.

Design Checklist for Permeable Pavements

- ❒ No erodable areas drain on to pavement.
- ❒ Reservoir base course is of open-graded crushed stone. Base is adequate to retain rainfall and to support loads.
- ❒ Subgrade is uniform and slopes are not so steep that subgrade is prone to erosion.
- ❒ Rigid edge is provided to retain granular pavements and unit pavers.
- ❒ Permeable pavements will be installed by experienced professionals according to vendor's recommendations.
- ❒ Selection and location of pavements incorporates Americans with Disabilities Act requirements, site aesthetics, and uses.





Bay Area Stormwater Management Agencies Association, *Start at the Source* (1999)

Infiltration Planter

City of Portland *2004 Stormwater Manual*

Infiltration planters may receive runoff by piped inlet (see illustration on reverse) or by sheet flow across the adjoining pavement. An overflow inlet conveys flows which exceed the infiltration capacity of the planter. Pollutants are removed as runoff passes through the soil layer and is collected in an underlying layer of gravel or drain rock.

Treated runoff may be allowed to infiltrate into the underlying native soil. A perforated pipe underdrain must be incorporated into the design when native soils are clayey (hydrologic soil groups "C" and "D") or when infiltration is not desired. The underdrain must be piped to a storm drain or other discharge point.

Design and Construction. Infiltration planters in Contra Costa County may be designed with a 0.04 sizing factor (surface area of planter/surface area of tributary impervious area). A sandy loam with a minimum infiltration rate of 5"/hour is required. Infiltration planters can be designed with curbs and curb-cut inlets (min. 12" width), which may be poured monolithically with the planter walls. Plantings should be selected for viability in a well-drained soil. Irrigation is required to maintain plant viability.

Maintenance. Maintain vegetation and irrigation system; inspect periodically to ensure structural integrity and that the planter has not clogged.

Best Uses

- Parking lot islands
- Plazas
- Along walkways

Advantages

- Space-efficient
- Versatile
- Can be any shape
- Low maintenance

Limitations

- Requires underdrain in clay soils
- Requires careful selection of plant palette
- Irrigation required to maintain plant viability.
- Must be installed level

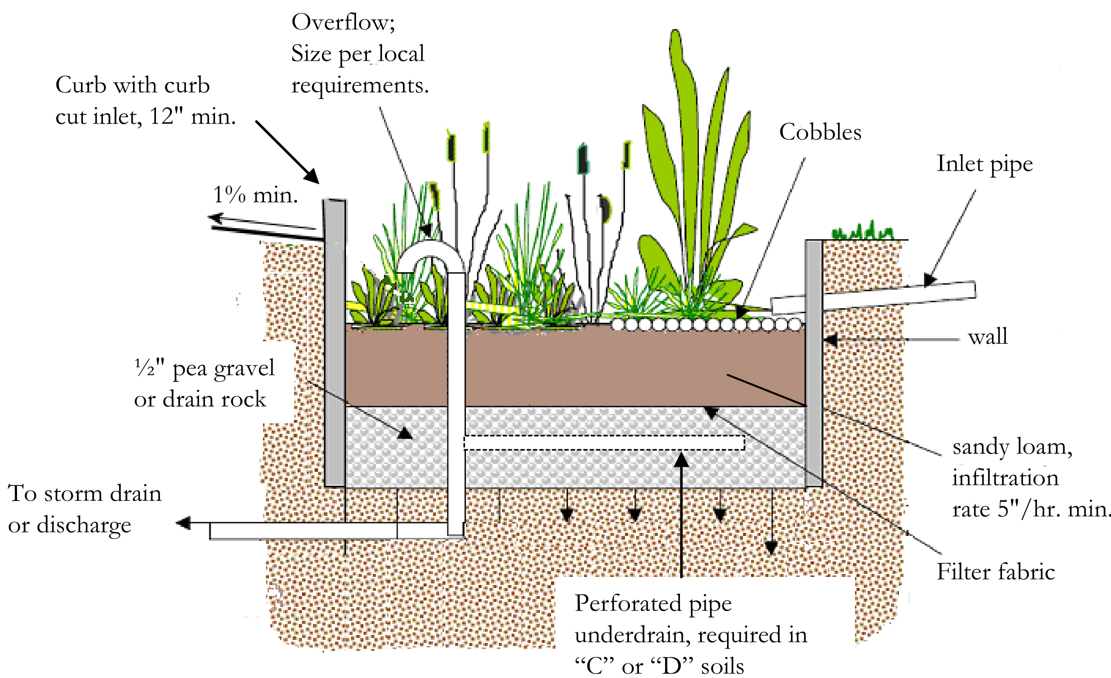
CONTRA COSTA CLEAN WATER PROGRAM

Infiltration Feasibility Fact Sheets

Category B—Indirect Infiltration Practices

Design Checklist for Infiltration Planter

- ❒ Set back from structures 10' minimum or as required by structural or geotechnical engineer.
- ❒ Ratio (surface area of planter)/(tributary impervious area) does not exceed 0.04.
- ❒ Planter is installed level.
- ❒ Overflow adequate to meet municipal drainage requirements
- ❒ Minimum 12" deep reservoir at top of planter
- ❒ 18" deep sandy loam with minimum infiltration rate of 5"/hour.
- ❒ 12" deep pea gravel or crushed rock.
- ❒ Filter fabric between soil and gravel layers
- ❒ Perforated pipe underdrain (in “C” and “D” soils and where infiltration rate of native soils is less than 0.5"/hour) with cleanouts and connection to storm drain or discharge point.
- ❒ If underdrain required, adequate head exists to reach storm drain or discharge point.
- ❒ 12" minimum width of curb cut
- ❒ Splash blocks or cobbles at inlets and inlet pipes
- ❒ Plants selected for viability and to minimize need for fertilizers and pesticides.
- ❒ Native soils protected against compaction during construction.
- ❒ Irrigation system with connection to water supply.



Adapted from the City of Portland *2004 Stormwater Manual*

Bioretention Areas

(Prince George's County 1993)

Bioretention areas remove stormwater pollutants through a combination of overland flow through vegetation, surface detention, and filtration through soil.

Treated runoff may be allowed to infiltrate into the underlying native soil. A perforated pipe underdrain must be provided for installations where native soils are clayey (hydrologic soil groups "C" and "D") or infiltration is not desired.

Design and Construction. Bioretention areas in Contra Costa County may be designed with a 0.04 sizing factor (surface area of bioretention/tributary impervious area). The topsoil must be a minimum of 18" deep and have a minimum infiltration rate of 5"/hour. A typical soil mix comprises 50% construction sand, 20-30% topsoil with less than 5% maximum clay content and 20-30% organic leaf compost.

Beneath the soil, a layer of drain rock or pea gravel, up to 4' deep, stores treated runoff before it seeps into the native soil or underdrain.

Surface ponding depths should be between 4" and 12". Plant species should be suitable to the well-drained soil and occasional inundation. If desired, larger trees are best planted at the periphery of the area.

Maintenance. Soils and plantings must be maintained, including routine pruning, replenishment of mulch, and weeding. The bioretention area should be inspected regularly and after storms. Erosion at inflow points must be repaired.

Best Uses

- Commercial, mixed-use and multi-family sites
- To treat runoff from areas up to 2 acres
- As a landscape design element

Advantages

- Low maintenance
- Reliable operation once established
- Versatile planting options

Limitations

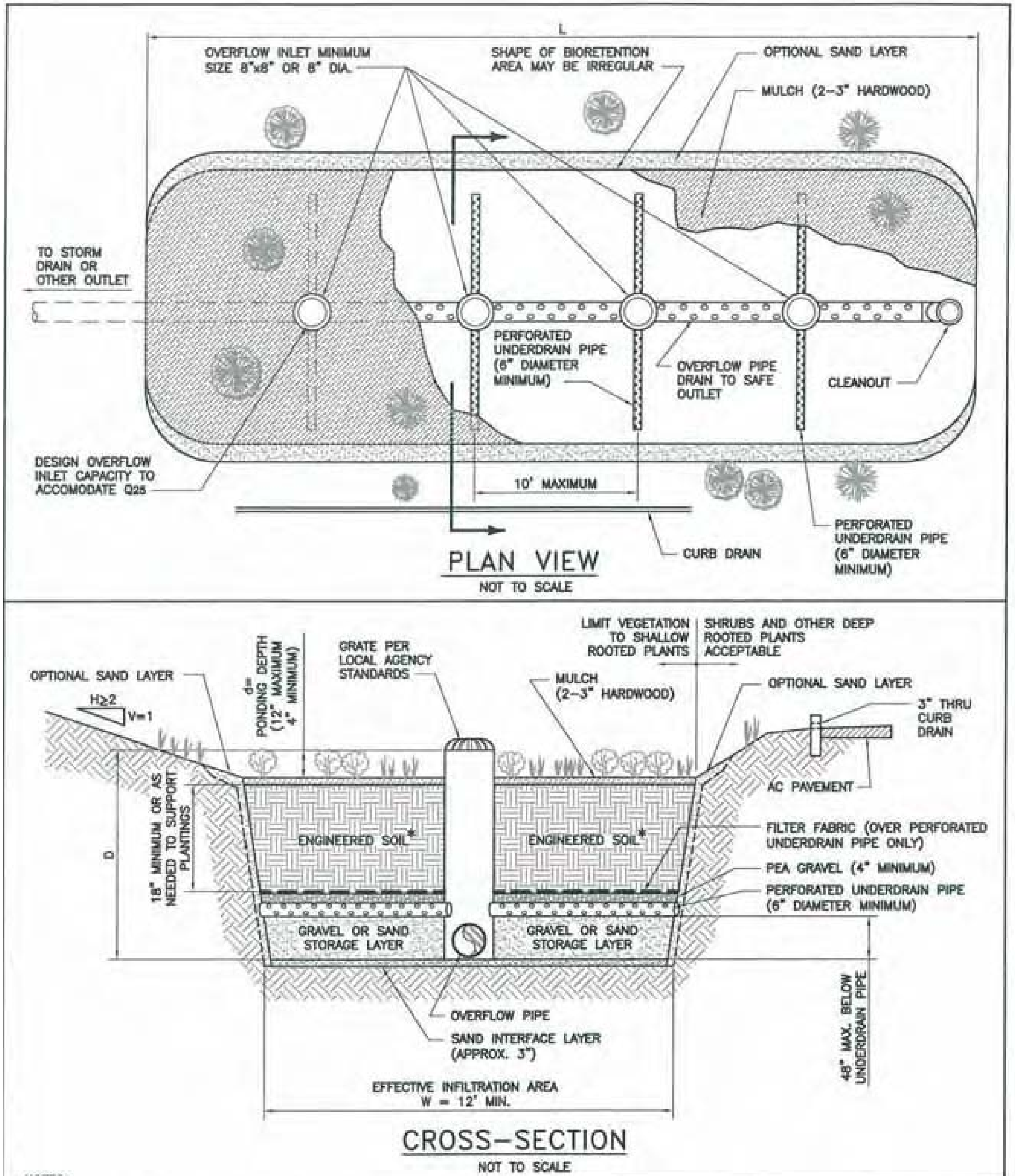
- Vegetation requires frequent maintenance until established
- Irrigation typically required to maintain plant viability

Infiltration Feasibility Fact Sheets

Category B—Indirect Infiltration Practices

Design Checklist for Bioretention

- ❒ Set back from structures 10' or as required by structural or geotechnical engineer.
- ❒ Ratio (surface area of planter)/(tributary impervious area) does not exceed 0.04.
- ❒ Tributary impervious area does not exceed 2 acres.
- ❒ Tributary area does not contain a significant source of soil erosion.
- ❒ 50' minimum setback from, and no connection to, any on-site septic system or leach field.
- ❒ Sloped areas immediately adjacent to the bioretention area are less than 20%—but greater than 0.5% for pavement and greater than 1% for vegetated areas.
- ❒ Side slopes do not exceed 2:1
- ❒ Design ponding depth is between 4" and 12"
- ❒ Surface is covered with 2"–3" mulch
- ❒ Inlets are protected with rock or splash blocks. Curb cuts have 12" minimum width.
- ❒ Overflow inlet can safely convey design flood flows to a downstream storm drain or discharge point.
- ❒ Plantings are suitable to the climate and a well-drained soil with seasonal, periodic inundation.
- ❒ Irrigation system with connection to water supply.
- ❒ Trees and vegetation do not block inflow, create traffic or safety issues, or obstruct utilities.
- ❒ The planting mixture consists of a mixture of sand (40%), compost (20-30%) and topsoil (30-40%) with a minimum infiltration rate of 5"/hour and adequate nutrient content to meet plant growth requirements.
- ❒ Filter fabric between soil and gravel layers.
- ❒ Perforated pipe underdrain (in "C" and "D" soils and where infiltration rate of native soils is less than 0.5"/hour) with connection to storm drain or discharge point.
- ❒ Underdrain has a clean-out port consisting of a vertical, rigid, non-perforated PVC pipe, with a minimum diameter of 6 inches and a watertight cap fit flush with the ground.
- ❒ When excavating, avoid smearing of the soils on bottom and side slopes. Minimize compaction of native soils. Protect the area from construction site runoff.



NOTES:

1. ALL PERFORATED PIPE SHALL HAVE A MINIMUM OF THREE 3/4" DIAMETER HOLES, EQUALLY SPACED ALONG THE CIRCUMFERENCE OF THE PIPE AND NOT LESS THAN THREE HOLES PER LINED FOOT OF PIPE.

2. DETERMINE DIMENSIONS FROM L x W x D = INFILTRATION DESIGN VOLUME.

* SANDY LOAM/LOAMY SAND; FINES SHOULD BE LIMITED TO TWENTY PERCENT OR LESS PASSING THROUGH A #200 SIEVE.

SOURCE: MODIFIED FROM PAZ, 2004

Bioretention Detail

Contra Costa Clean Water Program Infiltration Site Characterization Criteria and Guidance Study

LFR
LEVINE•FRICKE

Vegetated or Grassy ("Dry") Swale

City of Portland *2004 Stormwater Manual*

In a "dry" swale, pollutants are removed as runoff seeps through a layer of topsoil. Treated runoff then infiltrates into the underlying native soil. A perforated pipe underdrain is incorporated into the design where native soils are clayey (hydrologic soil groups "C" and "D") or when infiltration is not desired. The underdrain must be piped to a storm drain or other discharge point.

Because the main mode of treatment is by filtration through the topsoil—not by settling and contact with vegetation—required detention times are minimal (~10 min.). Multiple inlets may be located along the length of the swale.

Design and Construction. Swales in Contra Costa County may be designed with a 0.04 sizing factor (surface area of swale/surface area of tributary impervious area). A sandy loam with a minimum infiltration rate of 5"/hour is required.

Swales may be planted with turfgrass or with a palette of plants and trees. If grass is used, the design should include gentle slope transitions and access for mowing equipment. Plantings should be selected for viability in a well-drained soil with occasional inundation. Irrigation is typically required to maintain plant viability.

Maintenance. Maintain vegetation and irrigation system. Inspect periodically and after storms to ensure that inlets and outlets have not clogged and rivulets have not formed.

Best Uses

- Landscape buffers
- Parking lots
- Where drainage is used as a design element

Advantages

- Provides treatment for lower flows
- Conveys high flows
- Versatile planting options
- Low maintenance

Limitations

- Minimum width required.
- May require underdrain in clay soils
- Requires careful selection of plant palette
- Typically requires irrigation

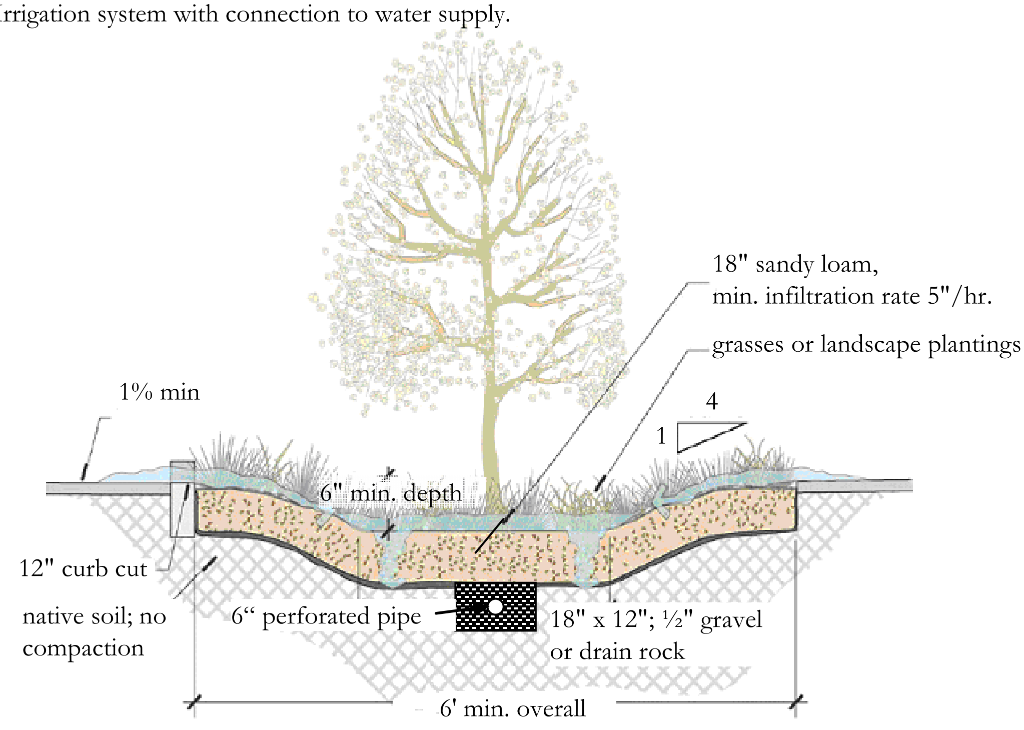
Contra Costa Clean Water Program

Infiltration Feasibility Fact Sheets

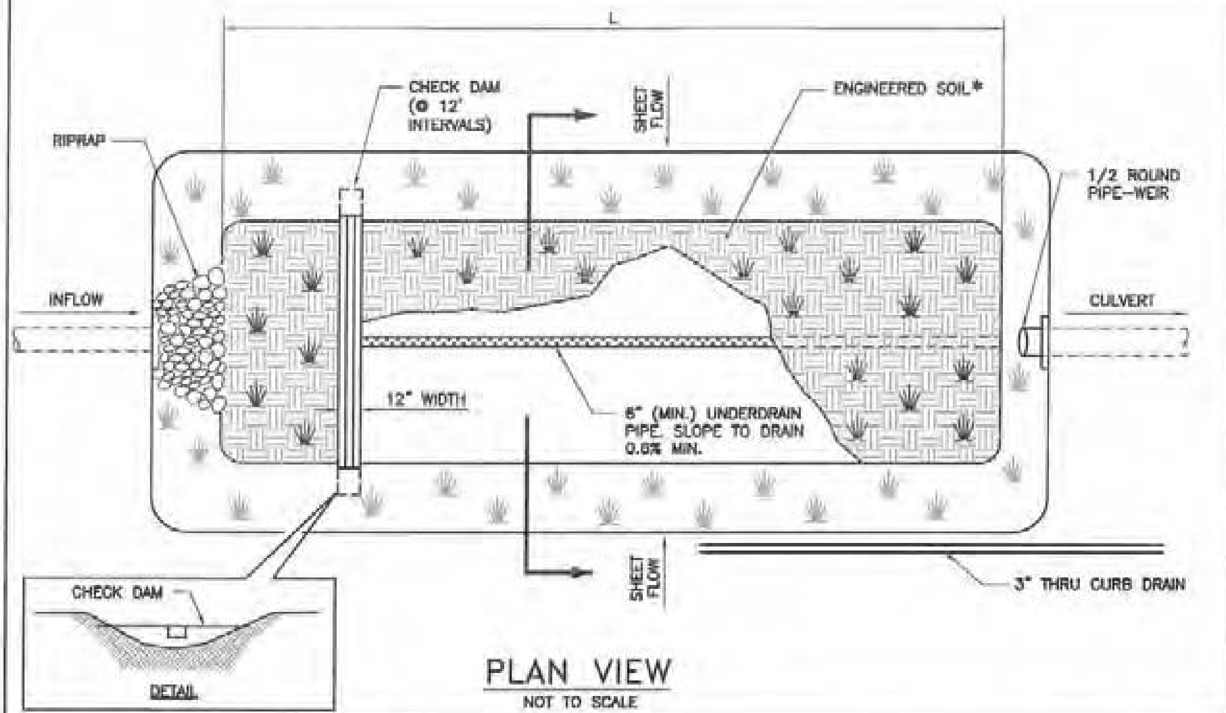
Category B—Indirect Infiltration Practices

Design Checklist for Vegetated or Grassy ("Dry") Swale

- ❒ Set back from structures 10' minimum or as required by structural or geotechnical engineer.
- ❒ Ratio (surface area of swale)/(tributary impervious area) does not exceed 0.04.
- ❒ 6" minimum depth.
- ❒ Sides slopes no greater than 4:1. Smooth transitions, particularly if vegetation must be mowed.
- ❒ Longitudinal slope between 0.2% and 6%.
- ❒ On steeper slopes, check dams fashioned of rock, concrete, or similar material extend across the swale and are keyed into the side slopes. Check dams should be a minimum of 12" wide.
- ❒ Swale can convey the flood-protection design storm (see municipal requirements). Suggested Manning's n = 0.025–0.040 depending on height and density of vegetation.
- ❒ 18" deep sandy loam with minimum infiltration rate of 5"/hour.
- ❒ 6" perforated pipe underdrain (in "C" and "D" soils) with connection to storm drain or discharge point.
- ❒ Perforated pipe underdrain, with cleanouts, in minimum 12" deep by 18" wide trench filled with pea gravel or crushed rock. wrapped in filter fabric.
- ❒ If an underdrain is required, adequate head exists to reach storm drain or discharge point.
- ❒ 12" minimum width of curb cut, with ½" drop across cut to avoid collection of debris.
- ❒ Splash blocks or cobbles at inlets and inlet pipes
- ❒ Plants selected for viability and to minimize need for fertilizers and pesticides.
- ❒ Native soils protected against compaction during construction.
- ❒ Irrigation system with connection to water supply.

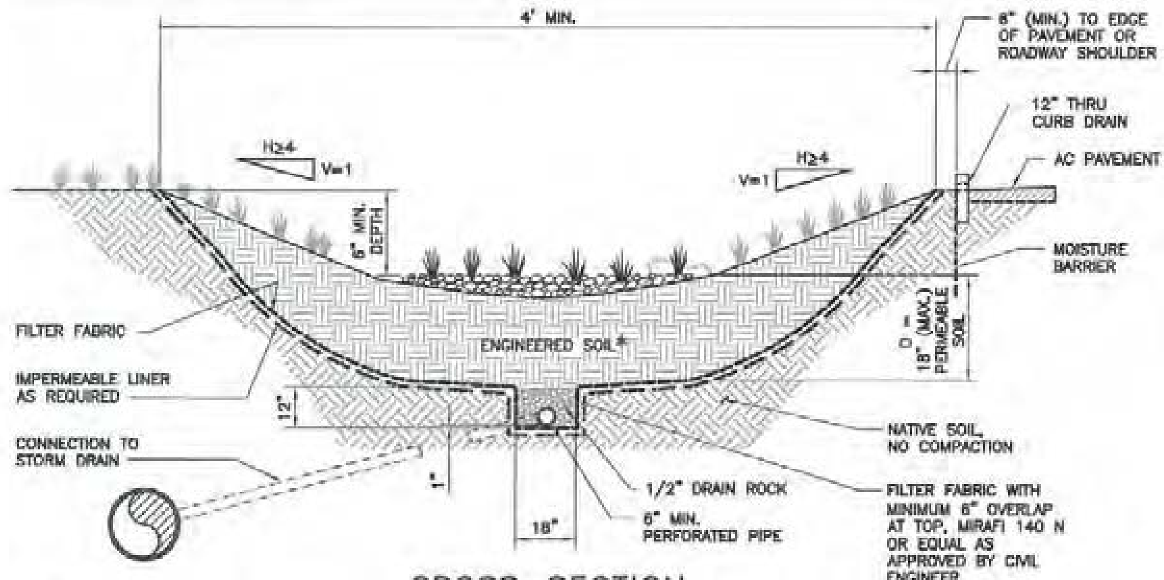


Adapted from City of Portland *2004 Stormwater Manual*



PLAN VIEW

NOT TO SCALE



CROSS-SECTION

NOT TO SCALE

NOTES:

1. SWALE SHALL BE GRADED TO DRAIN TOWARD OUTLET AT A MINIMUM SLOPE 0.2%
2. ALL PERFORATED PIPE SHALL HAVE A MINIMUM OF THREE 3/4" DIA. HOLES EVENLY SPACED ALONG THE CIRCUMFERENCE OF THE PIPE AND NOT LESS THAN THREE HOLES PER LINEAL FOOT OF PIPE.
3. DETERMINE DIMENSIONS FROM (L x W x D) x SOIL VOIDS RATIO = INFILTRATION DESIGN VOLUME
4. PLANTINGS MAY INCLUDE TREES, MINIMUM INFILTRATION RATE 5"/HR

* SANDY LOAM/LOAMY SAND; FINES SHOULD BE LIMITED TO TWENTY PERCENT OR LESS PASSING THROUGH A #200 SIEVE.

SOURCE: MODIFIED FROM CENTER FOR WATERSHED PROTECTION, 2000

Vegetated Swale Detail

Contra Costa Clean Water Program Infiltration Site Characterization Criteria and Guidance Study

LFR LEVINE•FRICKE

Infiltration Basin

Stormwater Infiltration Basin/Recreation Field—Stanford University

Infiltration basins are shallow impoundments, typically without no outlet, designed to temporarily store and infiltrate stormwater.

Suitable sites—flat, vegetated open spaces with highly permeable soils and sufficient depth to groundwater—are relatively rare in the Bay Area. The low cost of construction and low maintenance costs make infiltration basins an attractive option where they are feasible.

Design and Construction. The basin must be designed to retain the required water quality volume (see Appendix H). The soil infiltration rate must be sufficient to infiltrate the depth holding this volume within 48 hours. A safety factor of 2 is applied to the measured minimum infiltration rate.

An underdrain system is a valuable backup to ensure the basin can be drained even as soils begin to clog.

The side slopes and bottom of the basin should be vegetated with a dense turf or other water-tolerant grass immediately after construction. The root systems of healthy vegetation will help keep soil pores open and help maintain the infiltration rate.

Maintenance. The basin should be inspected following storms to ensure the infiltration rate is adequate. Inlets and stilling basins should be inspected and accumulated sediment removed. Eroded or barren areas should be re-vegetated.

Best Uses

- Flat open spaces with highly permeable soils
- Large developments

Advantages

- Can be combined with lawns, ballfields, or other park amenities
- Can serve drainage areas up to 50 acres
- Low initial cost
- Low maintenance

Limitations

- Not appropriate for clayey soils
- 10' minimum depth from bottom of basin to seasonal high groundwater
- Not suitable for industrial or "high risk" commercial areas or arterial streets
- Difficult to restore permeability once clogged.

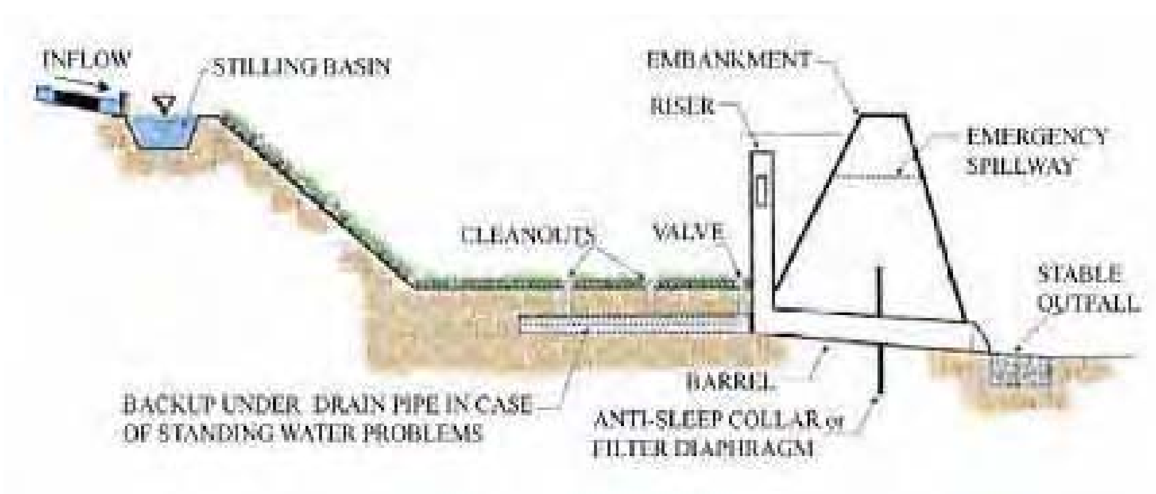
CONTRA COSTA CLEAN WATER PROGRAM

Infiltration Feasibility Fact Sheets

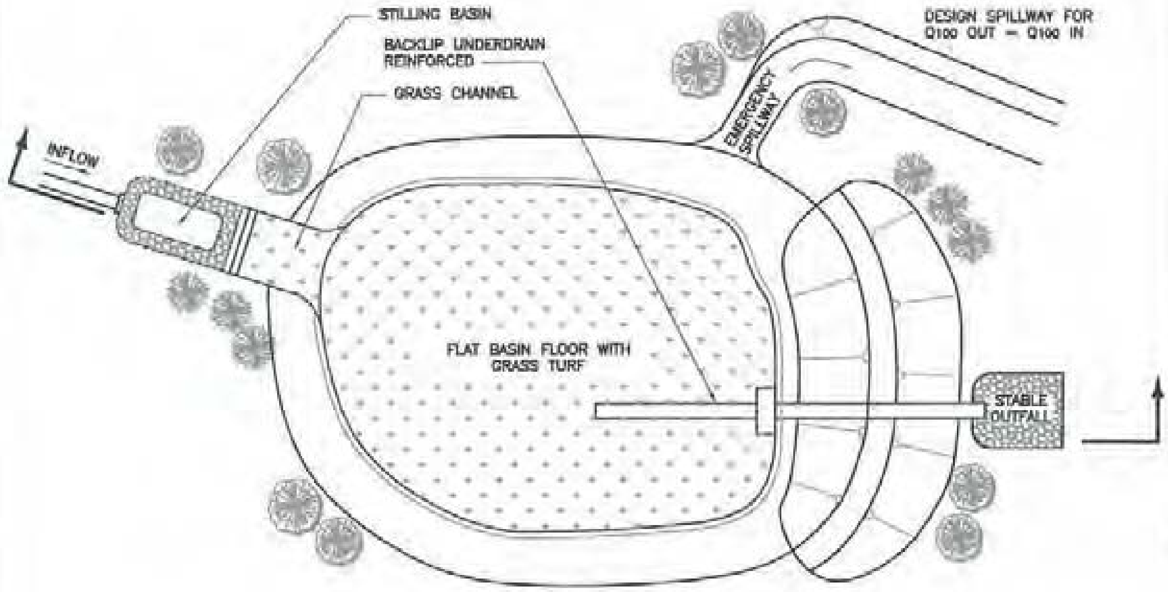
Category C—Direct Infiltration Methods

Design Checklist for Infiltration Basin

- ❒ Depth from bottom of basin to seasonally high groundwater elevation is ≥10'.
- ❒ Areas tributary to the infiltration basin do not include automotive repair shops; car washes; fleet storage areas (bus, truck, etc.); nurseries, or other uses that may present an exceptional threat to groundwater quality.
- ❒ The infiltration basin is separated by at least 100 feet from any adjacent drinking water supply wells.
- ❒ Set back basin from structures 10' or as required by structural or geotechnical engineer.
- ❒ Locations with high soil infiltration rates (≥2.4"/hr.) receive additional evaluation of potential effects on groundwater quality and need for pretreatment.
- ❒ Areas tributary to the basin do not exceed 50 acres.
- ❒ Infiltration rate at the bottom of the basin is 0.5 in/hr or greater. Soils underlying the infiltration basin do not contain more than 20 percent clay content and do not contain more than a combined 40 percent silt/clay content. Depth to bedrock is ≥ 3'.
- ❒ All upstream drainage areas are stabilized prior to construction of the infiltration trench.
- ❒ The infiltration basin is equipped with an underdrain system, with cleanouts, for dewatering and in situations when the system becomes clogged.
- ❒ The infiltration basin is designed with an emergency spillway or overflow riser to prevent uncontrolled overflows.
- ❒ The side slopes and bottom are vegetated with a dense turf of water-tolerant grass immediately following construction.
- ❒ The floor of the basin is graded uniformly as possible for uniform ponding and infiltration. Basin side slopes are no greater than 3:1. Flatter side slopes are preferred for vegetative stabilization.
- ❒ One or more simple observation wells made of perforated PVC pipe, a footplate, and locking cover is installed in the infiltration basin.

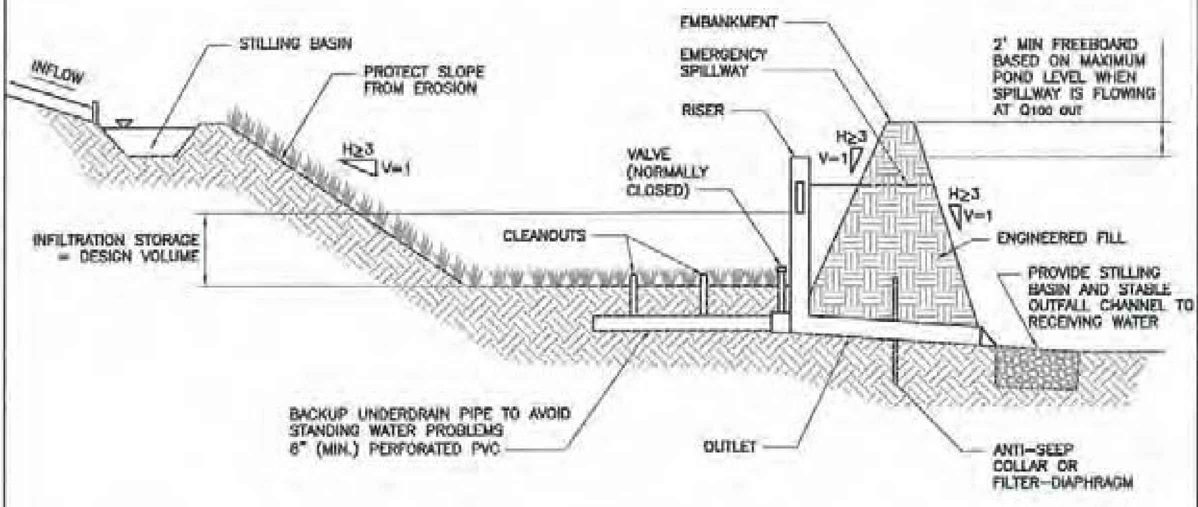


PDEP 2004



PLAN VIEW

NOT TO SCALE



CROSS-SECTION

NOT TO SCALE

NOTES:

1. CONFIRM WHETHER OR NOT THE BASIN IS WITHIN THE JURISDICTION OF THE STATE OF CALIFORNIA DIVISION OF SAFETY OF DAMS. (HEIGHT ≥ FEET OR CAPACITY ≥ 50 ACRE-FEET.
2. THE RISER AND OUTFALL SHALL BE SIZED TO PREVENT DISCHARGE OVER THE EMERGENCY SPILLWAY WITH Q_{100} FLOWING INTO THE BASIN. THE DESIGN ANALYSIS SHALL ASSUME THAT THE INFILTRATION STORAGE VOLUME IS NOT AVAILABLE FOR FLOOD ROUTING ALTERNATION.

SOURCE:
MODIFIED FROM WISCONSIN DNR, 2000

Infiltration Basin Detail

Contra Costa Clean Water Program Infiltration Site Characterization Criteria and Guidance Study

LFR LEVINE·FRICKE

Infiltration Trench

California Storm Water Quality Handbook (2003)

An infiltration trench is typically long, narrow, and filled with gravel or other permeable material. The trench stores runoff and infiltrates it through the bottom and sides into the subsurface soil. In a variation of this method, perforated drain pipes may convey and exfiltrate runoff to gravel-filled trenches and thence into the native soil.

Design and Construction. The trench is sized to accommodate the required water quality volume (see Appendix H) within the void space of the rock or gravel (typically 35% of total volume). The required surface area to drain this volume within 72 hours is calculated from the infiltration rate of the underlying native soil.

Following excavation, the trench is lined with a geotextile filter fabric. A sand layer is placed on the bottom, and the trench is backfilled with clean, open-graded gravel or rock. A horizontal layer of filter fabric is placed over the gravel or rock before a final surface layer of topsoil, sand or pea gravel. A simple observation well can be fashioned from a footplate, perforated PVC pipe, and a locking cover.

Maintenance. Trenches should be inspected following storms to ensure that water drains within 72 hours. If clogging occurs, it may be necessary to remove and replace the top layer of filter fabric and possibly the coarse aggregate fill.

Best Uses

- Mixed-use and commercial
- Parking lots
- Roof runoff

Advantages

- Simple; low-cost
- Provides disposal as well as treatment

Limitations

- Generally not appropriate for clayey soils (Hydrologic Soil Groups C & D)
- 10' minimum depth from bottom of trench to seasonal high groundwater
- Not suitable for industrial or "high risk" commercial areas or arterial streets
- Clogging frequency depends on amount of fine sediment in influent

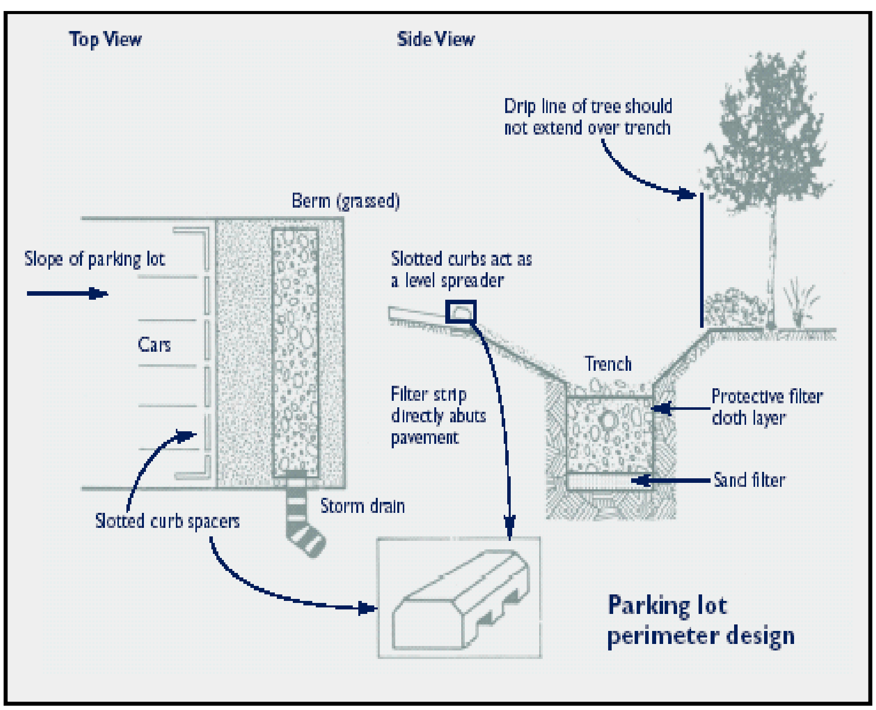
CONTRA COSTA CLEAN WATER PROGRAM

Infiltration Feasibility Fact Sheets

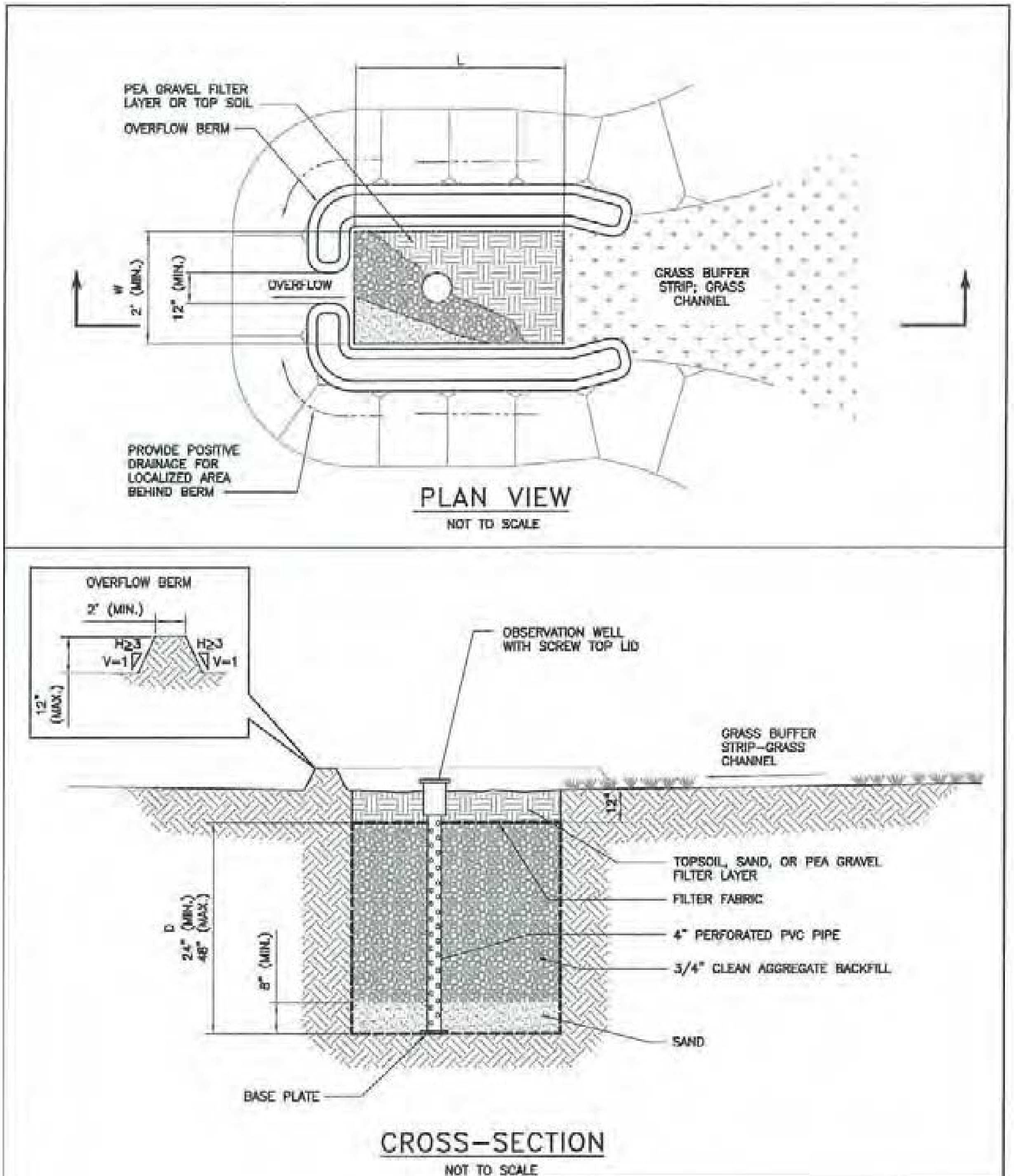
Category C—Direct Infiltration Practices

Design Checklist for Infiltration Trench

- ❒ Depth from bottom of trench to seasonally high groundwater elevation is ≥10'.
- ❒ Areas tributary to the infiltration trench do not include automotive repair shops; car washes; fleet storage areas (bus, truck, etc.); nurseries, or other uses that may present an exceptional threat to groundwater quality.
- ❒ The infiltration trench is separated by at least 100 feet from any adjacent drinking water supply wells.
- ❒ Set back from structures 10' or as required by structural or geotechnical engineer.
- ❒ Locations with high soil infiltration rates (≥2.4"/hr.) receive additional evaluation of potential effects on groundwater quality and need for pretreatment.
- ❒ Areas tributary to the infiltration trench do not exceed 5 acres.
- ❒ Infiltration rate at the bottom of the trench is 0.5 in/hr or greater. Depth to bedrock is ≥ 3'.
- ❒ All upstream drainage areas are stabilized prior to construction of the infiltration trench.
- ❒ Vegetated strip or other pretreatment has been incorporated where possible and appropriate.
- ❒ A horizontal layer of filter fabric is installed just below the surface of the trench to retain sediment and to reduce the potential for clogging.
- ❒ Trench backfill is 1.5" to 2.5" diameter clean drain rock.
- ❒ The sides of the infiltration trench are lined with a geotextile fabric.
- ❒ The infiltration trench is located a minimum of 50 feet away from slopes in excess of 15%.
- ❒ Void spaces in trench fill accommodate the required water quality volume.
- ❒ Soil infiltration rate has been confirmed (Attachment C-3).
- ❒ Bottom surface area is sufficient to ensure drainage within 72 hours.
- ❒ Design includes an observation well.



Young et al. 1996



NOTE:
L = DESIGN LENGTH BASED ON DESIGN INFILTRATION VOLUME AND 3/4" CLEAN AGGREGATE VOID VOLUME.

SOURCE:
MODIFIED FROM CENTER FOR WATERSHED PROTECTION, 2000

Infiltration Trench Detail

Contra Costa Clean Water Program Infiltration Site Characterization Criteria and Guidance Study

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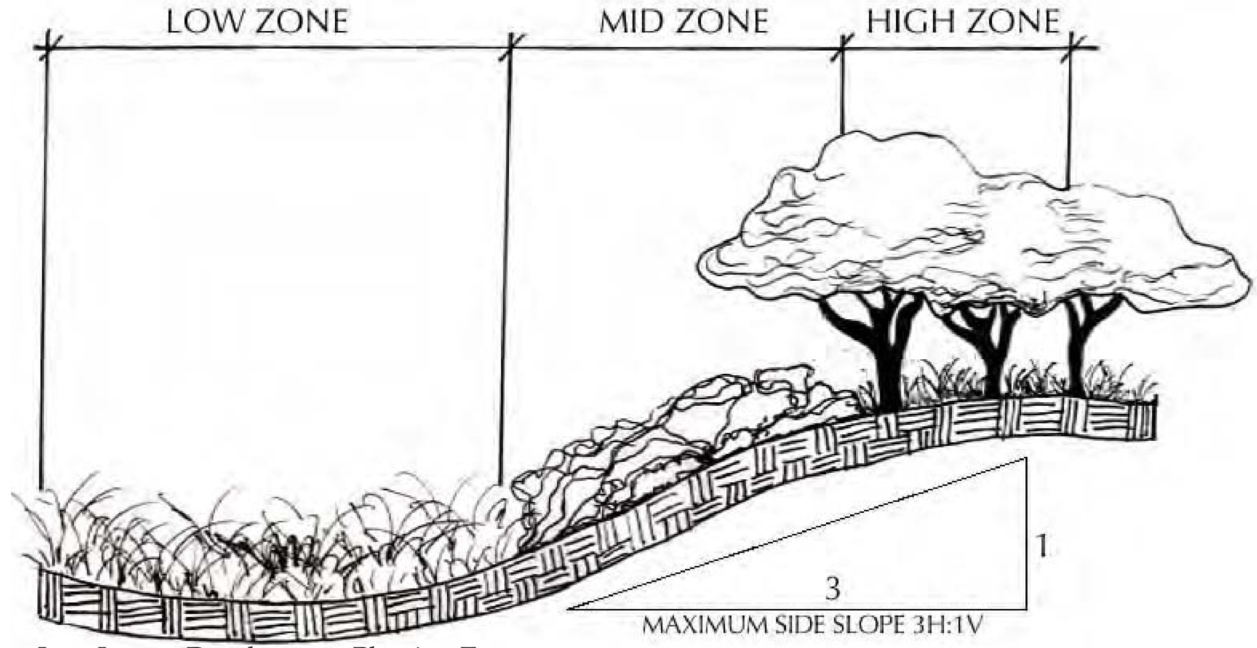
Appendix F

LID Planting Zones and Plant List for the City of Salinas

Low Impact Development Planting Zones

Planting zones refer to the planted areas in drainage features of Low Impact Development (LID) practices and flood control detention basins. LID practices include vegetated swales and bioretention basins. Plants are an integral element of their function. The plants in these zones facilitate natural infiltration of surface runoff, increase evapotranspiration, reduce the heat-island effect of urbanized areas, and reduce the rate, volume, and pollutant loading of urban runoff that ultimately ends up in local streams, rivers, estuaries, and the Monterey Bay. For the drainage features to function optimally, numerous plant characteristics have been considered in indicating the appropriate plant species for the three plant zones such as: water requirements, tolerance for inundation, root and leaf structure and a species' ability to filter pollutants. The plant zone guidelines and planting list can also be utilized for the revegetation, restoration , and bank stabilization of local streams, rivers, and estuaries.

In all instances, native plant species are recommended since they are adapted to the Cenral Coast climate and generally require less water and fertilization. Non-native invasive plant species are discouraged as water can quickly spread their occurrence and alter downstream habitats. Likewise turf grasses are discouraged for LID drainage features since they require large amounts of supplemental water, fertilizers and regular maintenance.



Low Impact Development Planting Zones

LOW ZONE – The low zone is an area where runoff temporarily ponds in response to a rain event or dry weather flows such as upgradient washing or irrigation activities The low zone should be designed to drain and not hold standing water for more than 72 hours. However, it may be inundated for extended periods of time during the rainy season. Water tolerant plants with dense root structure and/or vegetative cover provide maximum pollutant filtration, discourage erosion and slow water runoff velocities (in drainage features that cross-drain, such as bioswales). Native grasses and groundcovers are recommended for these areas.

MID ZONE – The mid zone is an area that slows the storm water runoff as it flows into the drainage feature. Water passes through and saturates this area, but will not stand there for extended periods of time during typical storm events. The plants for this zone must tolerate periods without water *and* periodic inundation. The plants in the mid zone should provide a root structure to prevent erosion of the side slope.

HIGH ZONE – The high zone is an area that creates the top of the bank of the drainage facility. Water will not stand in this zone. Deep roots give natural base structure to the edge of the drainage facility. These plants must be tolerant of extended periods without water and occasional saturation.

Low Impact Development (LID) Plant List

Developed for the City of Salinas, California

Draft

For internal review only

Botanical Name	Common Name	Low Zone**	Mid Zone**	High Zone**	Swale or Filter Strip	Planting Strips (< 5')	Large planting areas (> 5')	Bioretention/Detention Basins	Green Roofs	Tolerates Prolonged Saturation	Tolerates Periodic Flooding	Tolerates Prolonged Dry Periods	Requires Good Drainage	Tolerates Mowing	Wind Tolerant	Notes
TREES																
Acer cercinatum	Vine maple		X	X	X	X	X				X	X				Needs some shade
Acer macrophyllum	Big-leaf maple		X	X			X	X		X	X				X	Clay tolerant
Aesculus californica	Buckeye			X			X	X		X	X	X			X	Clay tolerant
Alnus rhombifolia	White alder		X	X			X	X		X	X					Keep protected from prevailing winds
Alnus rubra	Red alder		X	X			X	X		X	X					
Cercis occidentalis	Western redbud		X	X		X	X				X	X	X			
Fraxinus latifolia	Oregon ash		X	X			X	X			X					
Juglans californica var. hindsii	Black walnut			X		X	X			X	X	X				
Populus fremontii	Western cottonwood			X			X	X		X					X	Water loving, aggressive roots, fast growing
Prunus lyonii	Catalina cherry			X		X	X			X	X	X			X	Clay tolerant
Pseudotsuga menziesii ssp menziesii	Coast Douglas fir			X			X				X	X			X	
Salix coulteri	Coulter willow	X	X	X			X	X		X	X				X	
Salix laevigata	Red willow	X	X	X			X	X		X	X				X	
Salix lasiolepis	Arroyo willow	X	X	X			X	X		X	X				X	
Sambucus mexicana	Elderberry		X	X		X	X			X	X	X			X	Clay tolerant
Umbellularia californica	California bay laurel			X			X			X	X				X	Needs large scale planting area
SHRUBS																
Baccharis douglasii	Marsh baccharis	X	X	X	X	X	X	X		X	X	X				
Baccharis pilularis	Coyotebrush			X		X	X				X	X			X	
Bachharis salicifolia	Mulefat		X	X			X	X		X	X	X			X	
Cornus stolonifera	Red-twig dogwood	X	X	X		X	X	X		X	X				X	Clay tolerant
Fremontodendron californica	Flannelbush			X			X						X	X		High zone, needs to dry between waterings
Garrya elliptica	Silk tassle			X		X	X					X				Clay tolerant with drainage
Gaultheria shallon	Salal					X	X				X					Prefers shade
Mimulus aurantiacus	Stickey monkey flower		X		X	X	X		X			X				
Mimulus cardinalis	Scarlet monkey flower	X	X		X	X	X	X	X	X	X				X	Clay tolerant
Rhamnus californica	Coffeeberry		X	X			X	X	X			X	X		X	Low water requirements
Ribes sanguineum	Pink-flowering currant		X	X	X	X	X	X		X	X	X			X	Clay tolerant
Ribes speciosum	Fuchsia-flowering gooseberry		X			X		X		X	X				X	Clay tolerant, prefers shade
Ribes viburnifolium	Catalina perfume		X	X		X	X	X		X	X	X			X	Extremely drought tolerant in clay soils
Rosa californica	California wild rose		X	X		X	X	X		X	X	X				Can be invasive, likes moisture
Rubus parvifolius	Thimbleberry					X	X	X			X	X			X	

** Plant species are considered native to California. California native selections are suggested to limit impact on native habitats downstream.*
***Refer section drawing for planting zones.*

Low Impact Development (LID) Plant List

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Botanical Name	Common Name	Low Zone**	Mid Zone**	High Zone**	Swale or Filter Strip	Planting Strips (< 5')	Large planting areas (> 5')	Bioretention/Detention Basins	Green Roofs	Tolerates Prolonged Saturation	Tolerates Periodic Flooding	Tolerates Prolonged Dry Periods	Requires Good Drainage	Tolerates Mowing	Wind Tolerant	Notes
GRASSES, GROUNDCOVERS, FERNS, & BULBS																
Achillea millefolium	Yarrow		X	X	X	X	X	X	X				X		X	Clay tolerant
Aquilegia formosa	Western coulmbine	X			X	X	X			X	X	X				Clay tolerant with drainage and organic matter
Bromus carinatus	California brome		X	X	X	X			X			X				
Calamagrostis Karl Foerster	Feather reed grass	X	X			X	X	X		X	X	X			X	
Calamagrostis nutkentensis	Calamagrostis nutkaensis		X			X	X		X		X	X			X	
Calochortus albus	Globe lilies		X		X	X	X	X			X	X			X	
Carex globosa	Globe sedge	X	X		X	X	X	X	X	X	X				X	
Carex obnupta	Slough sedge	X	X					X		X	X				X	
Carex pansa	Sand dune sedge	X	X		X		X	X	X		X		X		X	Needs sandy soil
Carex tumulicola/ Carex divulsa	Berkeley sedge/ Gray sedge	X	X	X	X	X	X	X	X	X	X	X		X	X	Clay tolerant
Castilleja miniata	Indian paintbrush		X	X		X	X		X			X	X		X	
Deschampsia caespitosa	Tufted hair grass		X		X		X	X	X		X	X	X		X	Needs irrigation
Dudleya caespitosa	Dudleya		X	X					X			X	X		X	
Eleocharis macrostachya	Common spike rush	X	X		X	X	X	X	X	X	X				X	Sand to clay tolerant
Eschscholzia californica	California poppy		X	X	X	X	X		X			X	X		X	
Festuca californica	California fescue		X	X	X	X	X		X		X	X			X	Do not plant in low zone
Festuca idahoensis	Western fescue	X	X	X	X	X	X		X		X	X			X	Do not plant in low zone
Festuca rubra	Red fescue	X	X		X	X	X	X	X	X	X	X	X	X	X	Needs irrigation
Fragaria chiloensis	Beach strawberry		X		X	X		X	X		X	X	X		X	
Heuchera micrantha	Coral bells		X	X	X	X	X		X		X	X	X		X	
Iris douglasiana	Douglas iris		X		X	X	X		X		X		X		X	
Juncus effusus	Common rush	X	X		X	X	X	X		X	X	X			X	
Juncus patens	California grey rush	X	X		X	X	X	X		X	X	X			X	
Leymus triticoides	Creeping wildrye	X	X		X	X	X	X	X		X	X		X	X	Fast spreading, clay tolerant
Melica imperfecta	California melic		X	X	X	X			X		X				X	
Mulhenbergia rigens	Deer grass		X	X		X	X	X	X		X	X			X	Clay tolerant
Polystichum minutum	Sword fern		X		X	X	X	X			X					Prefers shade or part shade
Salvia ssp.	Sage		X	X		X	X		X		X	X			X	Higher zones, predominantly dry zones
Scirpus cernuus	Fiber optic grass	X	X		X	X	X	X	X	X	X	X			X	Prefers sandy soil
Sedum ssp.	Stonecrop		X			X			X			X	X		X	
Sisyrinchium bellum	Blue-eyed grass		X	X	X	X	X		X			X		X	X	
Satureja douglasii	Yerba buena	X	X		X	X			X		X				X	Clay tolerant, part shade
Vines																
Clematis ligusticifolia	Clematis	X	X			X	X			X	X	X	X			
Lonicera involucrata	Twinberry honeysuckle		X	X	X	X	X				X				X	
Vitis californica	California wild grape	X	X	X		X	X				X	X	X		X	Needs partial sun, do not plant at low point

** Plant species are considered native to California. California native selections are suggested to limit impact on native habitats downstream.*

***Refer section drawing for planting zones.*

Low Impact Development Planting Guidelines

DESIGN CRITERIA

There are numerous conditions to consider when choosing plant species to be used in LID drainage features. Many of the criteria are found in species that tolerate the various and (sometimes) disparate conditions in their native habitats. For example, the plant species need to tolerate periods of flooding as well as extended dry periods without supplemental irrigation. California native plant species are highly recommended as they are best adapted to the local climate.

The LID plant palette is intended to serve as a baseline for plant species selection for LID drainage features. Other plant species may be proposed for use in LID drainage features; the City will have the right to permit or deny their use. The following planting criteria and characteristics are to be considered when proposing other species for LID drainage features:
- The planting zones where the plant species are to be planted (Low, Mid, High, see Planting Zones).
- California native or easily naturalized plant species are preferred
- Non native invasive species should not be used
- Drought tolerant / low-supplemental irrigation requirements
- Tolerant of season flooding/inundation
- Low maintenance requirements
- Adaptability

As an element of a drainage feature, LID plant selections should aim to control erosion and wick water from soils. Accordingly, groundcovers and grasses that quickly cover exposed soils are the best choices for the low zone (see Planting Zones). Trees and large shrubs are best planted in the high zone where their roots can absorb the infiltration. Low shrubs, grasses and groundcovers may be used in the mid zone depending on the slope, soil type, and drainage patterns (sheet flow vs. concentrated flow, or flooding).

If a planted LID drainage feature receives a concentrated flow, energy dispersion devices will be required at the entry point to deter damage or erosion to the planted areas. Examples of erosion protection/energy dissipation designs include cobblestones, gabions, small hardscaped areas, or other approved devices.

Gabbion for Energy Dispersion

PLANT LAYOUT

The following shall be considered when planting LID drainage features:
- The smallest practical area of land should be exposed at any one time during development. Mulching or other protective erosion control measures should be used temporarily to protect exposed areas.
- Vegetation should be installed as soon as possible in the development after the land is exposed.
- Plants should be planted in staggered rows to ensure that plants grow together for maximum soil coverage.

Low Impact Development
Planting Guidelines

SOIL TESTING

A soils report shall be prepared prior to planting . The report shall be prepared by a qualified soils specialist or laboratory. The report shall be submitted to the City as part of the landscape and irrigation plans for final approval. Soil samples should be collected after grading operations are complete. Since surface soils are highly variable in the alluvial plain of the Salinas Valley, a sufficient number of soils samples shall be collected to account for variations that may be present in the areas to be planted. The report should include:
- Native soil composition
- Infiltration rates
- A texture test
- Cation exchange capacity
- An agricultural suitability analysis
- Recommended amendments for planted species to thrive

The following list includes some qualified soil testing laboratories in the region:

Perry Soil Laboratory, 424 Airport Blvd., Watsonville, CA 95076, T: (831) 722-7606
Soil and Plant Laboratory, Inc., 352 Matthew Street, Santa Clara, CA 95052, T: (408) 727-0330

AMENDMENTS

Prior to planting the recommended amendments shall be added as described in the soils report. A copy of the soils report shall be attached to the irrigation schedule provided to the owner and/or operator of the project.

MULCH

After planting, exposed soils shall be covered with mulch to discourage erosion. Mulch should only be maintained until plant growth has covered the majority of the exposed soil. Biodegradable erosion control mats and materials may also be used to provide same function as mulch.

Mulch should be large enough in size to be easily cleaned away from drain inlets and not fit through the openings of drain grates. Mulch shall be free of sticks and other debris. Always hold mulch away from root crown. Acceptable mulch types include:
- Nitrogen fortified bark (1″ to 2″ diameter)
- Redwood bark (1″ to 2″ diameter)
- Chipped gravel, crushed stone, or cobbles (1/2″ – 2 1/2″ diameter)
- 50/50 blend of top soil and aged compost

"Gorilla Hair" (shredded redwood bark) will not be permitted by the City of Salinas as it causes an impervious layer that encourages mold growth in Salinas's soils.

MAINTENANCE

Native plant species naturally reduce the need for maintenance. These species will minimize pests and disease problems, require less fertilizer, reduce the need for excessive pruning and conserve water. Woody plants require less maintenance once established while perennials adjust to their new environment quickly but may require more care over the long run.

Care requirements should be considered when choosing plant species for LID drainage features. Trash and debris should be cleaned out of LID planting areas periodically, especially after large storm events. Drain inlets shall be cleaned out periodically.

Planted LID Feature in Parking Lot

Low Impact Development
Plant List Development

PROCESS

The LID plant list was developed through a research process. Characteristics of LID drainage features such as bioswales, bioretention basins, rain gardens and tree filters were considered. Key local factors such as the climate, soils, and biodiversity of Salinas, California provided further parameters for development of appropriate plants. Preference was given to plants native to the Central Coast region for their compatibility with sensitive downstream habitats and to keep exotics form spreading and invading those habitats. Documents and conversations with and documents from other municipalities such as the Cities of Livermore, Oakland, and Santa Monica, California, The City of Seattle, Washington and The City of Portland, Oregon provided valuable guidance and insight towards successful implementation, operations and maintenance of LID drainage features.

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