



Contra Costa Clean Water Program

Draft Hydrograph Modification Management Plan

Progress Report
November 15, 2004

Submitted to the California Regional Water Quality Control Boards
for the San Francisco Bay and Central Valley Regions
in compliance with NPDES Permit Provision C.3.f

November 15, 2004

Bruce H. Wolfe, Executive Officer
California Regional Water Quality Control Board
San Francisco Bay Region
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Mr. Thomas R. Pinkos, Executive Officer
California Regional Water Quality Control Board
Central Valley Region
11020 Sun Center Drive #200
Rancho Cordova, CA 95670-6114

Re: Draft Hydrograph Modification Management Plan (HMP) Progress Report

Dear Messrs. Wolfe and Pinkos:

This report is submitted pursuant to Provision C.3.f of San Francisco Bay Board Order R2-2003-0022. We take this opportunity to thank San Francisco Bay Board staff, and particularly Christine Boschen, Jan O'Hara, Keith Lichten, Dale Bowyer, and Bill Hurley, for their comments and ongoing assistance as we prepare the HMP.

Introduction

Provision C.3.f of Water Board Order R2-2003-0022 requires Contra Costa Clean Water Program Co-permittees to submit a Hydrograph Modification Management Plan (HMP). The HMP, once approved by the Water Board, will be implemented so that "... post-project runoff shall not exceed estimated pre-project rates and/or durations, where the increased stormwater discharge rates and/or durations will result in increased potential for erosion"

In accordance with Provision C.3.f.viii, the Program submitted a Work Plan and Literature Review in February 2004. In April, Program staff met with Water Board staff to resolve all issues related to the Work Plan. In June, the Program revised the Work Plan and issued an RFP. In July, the Program selected a team led by Philip Williams and Associates, Ltd., (PWA). Work on the HMP started in August.

This draft HMP Progress Report provides an additional opportunity for Water Board staff and interested parties to review and participate in ongoing development of the technical approach and methodology to be used in the HMP. The final HMP is to be submitted for Regional Board approval by May 15, 2005.

Contents of this Submittal

This submittal includes:

- A summary of recent progress developing the HMP.
- Presentation of a continuous-simulation-based method for sizing hydrograph modification best management practices (BMPs), including small-scale integrated management practices (IMPs). The presentation includes technical background (Attachment 1) and an example development of sizing factors (Attachment 2).
- Presentation of a working draft of a proposed stream classification methodology (Attachment 3).

Summary of Progress

Working with Program staff and the Program's C.3 Technical Work Group, the PWA team identified some critical avenues to success for the Contra Costa HMP:

- Translate Provision C.3.f's watershed-scale objectives into objectives and criteria applicable to individual development sites.
- Coordinate with the approach to site design and BMP design in the draft Contra Costa Clean Water Program's draft *Stormwater C.3 Guidebook*.
- Avoid design methodologies that "force" the use of detention basins.
- Accurately characterize the hydrologic performance of soil-filtration-type integrated management practices such as "dry" swales, planter boxes, and bioretention areas.
- Develop methods to accurately characterize pre-project site hydrology.

The PWA team accomplished the following:

- Reviewed hourly rainfall data from eight Contra Costa gauges to evaluate their suitability for use in continuous hydrologic modeling.

- Determined that a Martinez gauge had a sufficiently long and continuous record and that other areas of the County could be represented—for the purpose of comparing pre- and post-project runoff—by adjusting the record for average annual rainfall.
- Examined the potential for using or interfacing with the Contra Costa County Flood Control and Water Conservation District's flood management software (HYDRO) and determined that it was probably not suitable for hydrograph modification management applications.
- Reviewed and considered approaches to hydrograph modification management being developed and implemented by the Washington Department of Ecology, the City of Portland, OR, and the Santa Clara Valley Urban Runoff Pollution Prevention Program.
- Outlined development of a methodology to test an event-based design procedure to demonstrate that the resulting designs were equivalently protective to those developed using continuous simulation. (This effort was later dropped in favor of a continuous simulation approach developed for application to small projects, described below.)
- Met with the Program's C.3 Technical Work Group and eight members of Water Board staff on September 27th to discuss this methodology and project progress.
- Developed an approach to use the continuous-simulation model HSPF to develop sizing factors for IMPs (Attachment 1 and Attachment 2).
- Developed a draft methodology to classify streams as being of low, medium, or high risk of accelerated erosion due to increased watershed imperviousness (Attachment 3).

Background: HMP Work Plan

Figure 1 in the Program's May 12, 2004 "Work Plan and Literature Review for the Hydrograph Modification Management Plan" diagrams a 3-step process for selecting hydrograph modification BMPs. As stated on page 11 of the Work Plan,

...the applicant may demonstrate that the proposed project will not increase peak flows and durations of site runoff. Failing that, the applicant may propose on-site or off-site BMPs that will mitigate the potential increases in runoff. If these BMPs are not feasible, the applicant has a third option of assessing stream vulnerability to erosion.

The Work Plan envisioned the first step—determining whether the proposed project would increase peak flows and durations—could be accomplished by a simple comparison of composite “C” factors (runoff factors, as applied in the rational method) or of composite curve numbers (as applied in SCS methods.). The comparison of pre- and post-project composite curve numbers is consistent with the Low Impact Development hydrologic analysis method (*Low Impact Development Hydrologic Analysis*, Department of Environmental Resources, Prince George’s County, Maryland, 1999).

The Work Plan envisioned in the second step, the applicant would prepare charts showing—for both the pre-project and post-project conditions—the peak flow, volume, and duration of runoff for a range of small to large storms.

A more “realistic” calculation of runoff response can be achieved by using computer-based runoff simulation models to simulate hydrologic events from continuous rainfall data over an extended period (e.g., 50 years). Continuous simulations calculate soil moisture, infiltration, evapotranspiration and other parameters to estimate runoff at each time step.

The Program noted two reasons for using an SCS method or other event-based method as a basis for comparing the pre-project condition to the post-project condition.

1. The SCS and other event-based hydrological methods are well-documented and easy to apply, and land development engineers are familiar with them. By comparison, setting up and running a 50-year continuous simulation model seems excessively costly and complex, especially for smaller development sites.
2. Existing continuous-simulation models (e.g., the Western Washington Hydrology Model) support design of detention basins but not other BMPs. Detention basins are impracticable for sites smaller than about 20 acres, and are becoming less widely used in Contra Costa County (and elsewhere) because of aesthetics, high maintenance costs, and because they can harbor mosquitoes.

Development of a Continuous-Simulation Approach for Small Sites

In addition to developing and evaluating event-based methods and criteria for assessing hydrologic impacts of developments, the PWA team examined whether it might be possible to adapt continuous-simulation models to overcome the limitations noted above.

The PWA team developed an approach which simulates 50 years of rainfall and runoff flows from a set of pre-designed devices (swales, planter boxes, and other “integrated management practices,” or IMPs, as shown in the “BMP Gallery” in Chapter 5 of the draft *Stormwater C.3 Guidebook*).

The results of those simulations are used to develop sizing factors (ratio of IMP surface area to tributary drainage area) for the IMPs. Applicants may access the appropriate sizing factor by inputting information about their site design and pre-project conditions into a spreadsheet-based interface.

This procedure eliminates the need for complex and expensive set-up of model runs for small development sites and also encourages the use of IMPs rather than detention basins. Technical development of the sizing factors and spreadsheet-based interface are discussed in Attachment 1 and Attachment 2.

Application of the Continuous-Simulation Approach to Small and Large Sites

Application of the procedure is shown in Figure 1. The procedure begins *after* the applicant has:

- Incorporated measures to reduce imperviousness to the maximum extent practicable (in accordance with Provision C.3.b).
- Divided the site into drainage areas as recommended in Chapter 5 of the draft *Stormwater C.3 Guidebook*.
- Sized IMPs to treat stormwater from each drainage area in accordance with the criteria in Provision C.3.d and the instructions in Chapter 5.

For each drainage area, the applicant inputs the square footage and selects from “pick lists” to characterize soils and pre-project land cover. The spreadsheet-based interface returns a facility size, which must be compared to the facility size required for stormwater treatment (Provision C.3.d). The larger of the two is used to determine the required dimensions of the IMP.

A draft of the spreadsheet-based interface is presented in Attachment 1.

The applicant must then decide whether the dimensions of the IMPs are suitable to the site and whether to proceed to detailed design of the IMPs. As shown in Figure 1, the applicant may opt to redesign IMPs or add conventional hydrograph modification management facilities (e.g. detention basins). If so, the applicant would need to set up and run a continuous simulation of the site, using HSPF or a similar program and parameters to be set in the final HMP, to size these facilities and demonstrate their effectiveness.

Alternatively, the applicant may opt to assess the risk of downstream erosion and to develop additional watershed-specific mitigation measures (unless the risk can be shown to be “low”).

Limiting Storm Event

Under event-based criteria, synthetic design storms for specified recurrence intervals are typically used to derive required detention volumes and allowable release rates of stormwater management facilities. The Program proposes to use a continuous simulation approach instead of event-based criteria. The continuous simulation approach applies a long-term record of hourly rainfall to compare runoff durations under pre-project and post-project conditions. Since the entire rainfall record is used in the analysis, the approach does not lend itself to defining a limiting storm *per se*. Instead, design criteria for detention basins and other management facilities typically specify a range of runoff events for which a flow duration standard must be met. The Program is evaluating the appropriate range of runoff events necessary to ensure projects do not contribute to downstream erosion, and will include this range in its HMP guidance.

Proposed Stream Classification Methodology

A working draft of a proposed stream classification methodology is presented in Attachment 3.

Next Steps

Program staff and the PWA team look forward to receiving your comments on this submittal. To help us complete the final HMP by the Board’s May 15, 2005 deadline, we ask that comments on this submittal be provided no later than Monday, December 6, 2004. In the meantime, we have directed the PWA team to continue development of the approach outlined above and in Attachments 1, 2, and 3.

Mr. Bruce Wolfe
Mr. Thomas Pinkos
November 15, 2004
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We look forward to continuing our productive interaction with your staff as we complete the HMP. Should you have any questions regarding this report, please contact Tom Dalziel at (925) 313-2392.

Sincerely,

Donald P. Freitas
Program Manager

DPF:td
cc. C. Boschen, SFBRWQCB
C. Palisoc, CVRWQCB

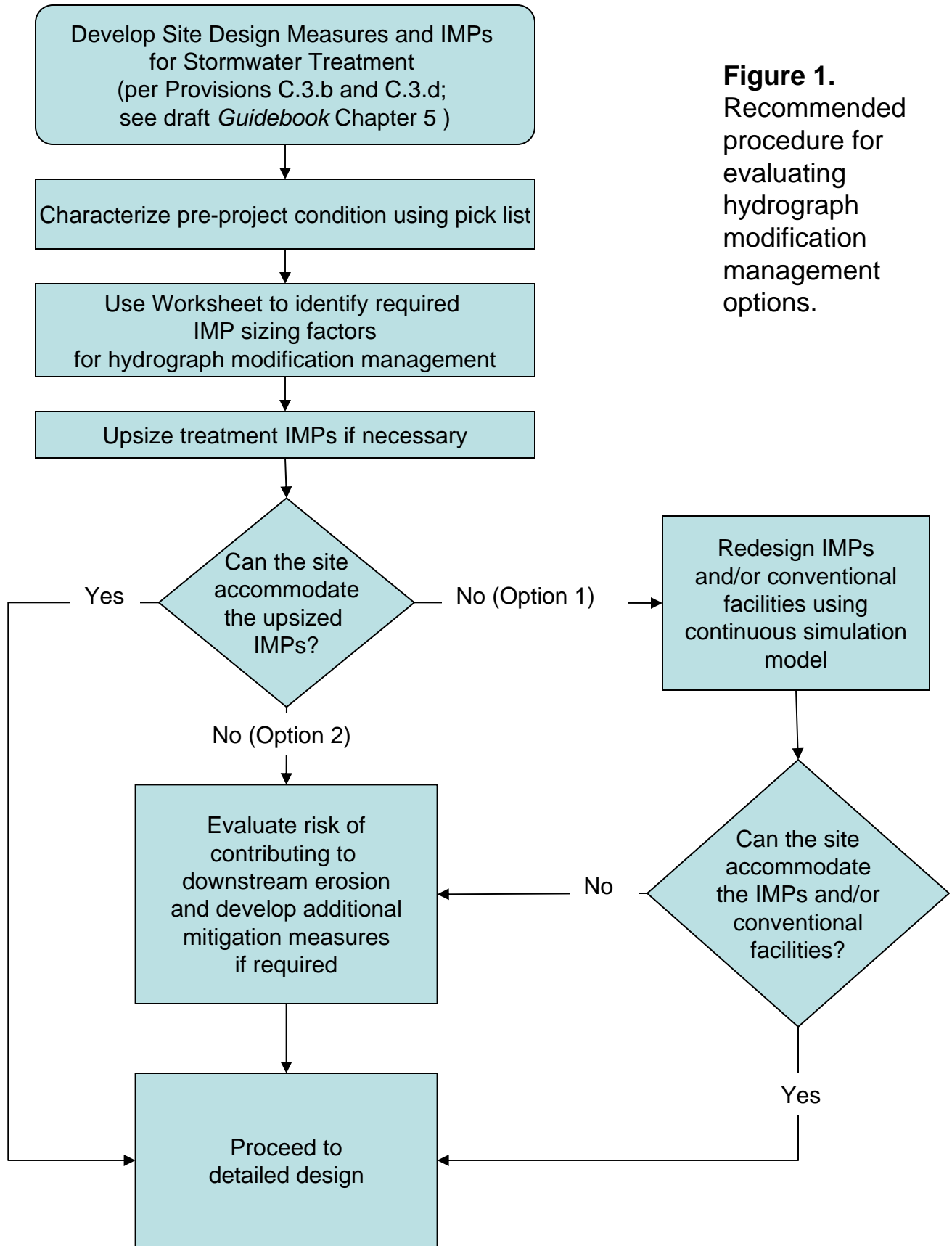


Figure 1. Recommended procedure for evaluating hydrograph modification management options.

ATTACHMENT 1**MEMORANDUM**

DATE: November 12, 2004
TO: Tom Dalziel, Contra Costa Clean Water Program
FROM: Steve Anderson, Tony Dubin – Brown & Caldwell
Christie Beeman, Jeff Haltiner - PWA

RE: Hydrograph Modification Assessment Methodology

PWA Ref. #: 1742

This memorandum describes proposed methods and tools for implementing the Contra Costa Hydrograph Modification Management Plan (HMP). The goal of the Program is to create a hydrograph modification assessment methodology that has a strong technical basis but that is simple to apply to a wide variety of potential projects. This memorandum outlines the Program's hydrograph modification management assessment approach and the technical basis for this approach.

Proponents of developments subject to C.3.f will have two options for analysis and design:

1. For areas up to 20 acres, proponents may use a spreadsheet and instructions provided by the Program to determine if changes in site hydrology can be mitigated by applying site design Integrated Management Practices (IMPs). Projects larger than 20 acres may be subdivided for this purpose.
2. Areas greater than 20 acres in size—and projects that require flow and duration control facilities (e.g. detention ponds and vaults), in addition to IMPs, to adequately manage hydrograph modification—must be evaluated using a continuous simulation hydrology model, such as HSPF (Hydrologic Simulation Program Fortran). Flow and duration control facilities must be sized using the continuous model results.

The IMP Accounting worksheet provides a simple tool for project proponents to use in selecting and sizing IMPs and determining whether the project will meet HMP requirements. The standardized worksheet will also allow for streamlined review of HMP compliance by municipal staff. The worksheet will be applicable to most of the projects subject to provision C.3.f. It works by accounting for the runoff from new

impervious areas and landscaping changes with site design IMPs, such as stormwater infiltration planters and micro-detention. IMP sizing factors are included within the spreadsheet to facilitate IMP selection and design. If all new developed areas drain to appropriately sized IMPs, then the site runoff is considered controlled for peak flow and durations. This simplified method for evaluating HMP compliance should encourage the use of distributed IMPs and integrated stormwater management rather than large detention ponds, which tend to require more space and for which the HMP evaluation method is significantly more complex.

The IMP Accounting Worksheet will be developed by modeling different combinations of pre-project conditions, development scenarios and IMP options using HSPF. For each pre-project condition, a corresponding sizing factor will be determined for each IMP to achieve flow and duration control. For example, the worksheet will contain a lookup table that determines the impervious area that can be managed per square foot of stormwater infiltration planter installed (facility surface/area managed = sizing factor). Because the HMP requires post-development flows and durations to be managed to pre-project conditions, the sizing factor will depend on the model parameters affecting existing runoff (e.g. local soil and land cover characteristics, rainfall patterns, etc.). The precompiled continuous hydrologic modeling results will cover a range of actual Contra Costa conditions and allow the IMP sizing to reflect the local needs of each project.

ASSESSMENT METHODS AND TOOLS

The following sections provide a detailed description of the assessment methods and tools that will be provided to guide project proponents through the IMP selection and sizing process. The technical basis, components and application for each assessment tool are provided below.

Select and Evaluate On-Site IMPs

Figure 1 is a preliminary draft of the IMP Accounting worksheet to assist project proponents in selecting and sizing appropriate site design IMPs for drainage areas less than 20 acres in size. The draft worksheet includes a preliminary list of site design IMPs, which may be expanded to include additional IMPs (e.g. stormwater storage for reuse) for the final HMP. IMP sizing factors imbedded in the worksheet will be developed using a continuous runoff simulation model to achieve the HMP performance criteria. This section discusses each step in completing the worksheet.

The starting point for analysis and design to comply with Provision C.3.f. will be a preliminary project design that already incorporates measures to minimize directly connected impervious areas (per Provision C.3.b) and also includes IMPs sized per Provision C.3.d to treat runoff from impervious areas.

SITE DESIGN IMP SIZING WORKSHEET

Average Annual Rainfall

Total site area sf

Sub-areas Area 1 Area 2

Acres

Pre-development cover Cover Type 1 Cover Type 2

Pre-development soil Soil Type 1 Soil Type 2

Allowable Discharge cfs/acre

Impervious Area BMP Options			Landscaped Area IMP Options (Do not include areas preserved as native vegetation)		
Stormwater Management Approach	Impervious Area Managed	Required IMP Surface Area	Stormwater Management Approach	Pervious Area Managed	
Bioretention	<input type="text"/> sf	<input type="text"/> sf	Concave vegetated surfaces	<input type="text"/> sf	
Stormwater Infiltration Planter	<input type="text"/> sf	<input type="text"/> sf	Soil amendment/equal cover	<input type="text"/> sf	
Micro Detention/Infiltration	<input type="text"/> sf	<input type="text"/> sf	Micro Detention/Infiltration	<input type="text"/> sf	
Roof Infiltration Drain	<input type="text"/> sf	<input type="text"/> sf	Reuse*	<input type="text"/> sf	
Reuse*	<input type="text"/> sf				
Total Area Managed	<input type="text"/> sf		Total Area Managed	<input type="text"/> sf	

Remaining Impervious Area sf

Remaining Landscaped Area sf

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graph TD
    A{Unmanaged Impervious > 0?} -- No --> B(Stop)
    C{Unmanaged Pervious > 0?} -- No --> B
    A -- Yes --> D[Proceed to Site Runoff Calculation Process]
    C -- Yes --> D
  
```

Figure 1. IMP Accounting Worksheet

As seen in Figure 1, the following information and calculations are included in the worksheet:

1. Average Annual Rainfall at Site

Rainfall and stormwater runoff vary throughout the County due to topography and other factors. The project proponent will identify the average annual rainfall for the project site using Contra Costa County Flood Control District maps. The spreadsheet will select the family of IMP sizing factors appropriate to the rainfall characteristics of the project site based on average annual rainfall.

2. Sub-Area

A separate spreadsheet is created for each drainage sub-area of the proposed project. The project proponent will enter the total area of the sub-area to be managed.

3. Soil and Cover Type by Sub-area

The worksheet allows the project proponent to specify two soil/cover combinations, and the proportion of each, for the pre-project condition and for the post-project condition. Soil options in the pick list will include the dominant local Soil Conservation Service soil types (A - sandy soils and D - clay soils). Cover options in the pick list preliminarily include: scrub brush, range land, light forest (live oak), irrigated pasture/landscaping, and impervious.

4. Impervious Areas to be Managed with Each IMP

The project proponent will identify the amount of impervious area to be managed by each site design IMP.

5. Required IMP surface areas (impervious)

The worksheet will calculate the required surface area for each IMP selected, based on the area to be managed and the sizing factors imbedded in the worksheet. (A detailed description of the methodology used to develop the IMP sizing factors is provided in a separate memorandum.)

6. Maximum Allowable Release Rate for Underdrains

Depending on the site soils, some IMPs may require underdrains. These underdrains would connect to the drainage system, and therefore would need to comply with the performance standard. The worksheet will calculate the allowable release rate for underdrains as discharge (cubic feet per second) per acre. The calculation will be based on the combination of site cover and soil included on the pick lists, and the lower limit of applicability of the HMP standard (to be selected).

7. Newly Landscaped Areas to be Managed with Each IMP

The project proponent will identify the amount of non-self-retaining landscaped area to be managed by each site design IMP listed in the IMP gallery.

8. Required IMP surface areas (landscaping)

The worksheet will calculate the required surface area for each IMP selected, based on the area to be managed and the sizing factors imbedded in the worksheet.

If the user is unable to account for all the new impervious and landscaped areas using the site design IMPs, they can either proceed to the Stream Vulnerability Risk Assessment, or select, size and evaluate flow duration control BMPs (e.g., vaults, detention ponds) to achieve the HMP performance standard. The steps for sizing and evaluation of duration control BMPs using continuous hydrologic modeling are described below.

Size and Evaluate Conventional Hydrograph Modification BMPs

If a project proponent is unable, or does not desire, to manage runoff for all the required areas with site design techniques and IMPs as described above, they will be required to develop a continuous simulation hydrologic model to evaluate HMP compliance. This step involves hydrologic modeling of site runoff, and design of flow duration control facilities (if required) to ensure the performance standard is met. (Alternatively, the project proponent may choose to proceed to the Stream Stability Classification step, which is described in a separate memorandum.)

Facilities typically used for flow duration control include stormwater detention vaults or ponds, and infiltration facilities. Detention vaults and ponds temporarily store surface water runoff and discharge it at a reduced rate, often through multiple outlets at varying elevations. Infiltration basins or other infiltration systems (e.g., underground infiltration chambers) store water until it is able to soak into the ground. Such facilities are typically located at the most “downstream” location on the site adjacent to the point of stormwater discharge. In cases where a project has multiple sub-basins and discharge points, more than one flow duration control facility may be required.

For consistency with the site design IMP sizing approach described above, the final HMP will provide guidance to developers on the use of the continuous runoff simulation model, HSPF, for flow duration control BMP design. The following section describes the process for evaluating flow duration control facilities using a continuous runoff simulation model.

Flow Duration Control BMP Design Process

Hydrograph Modification BMP design typically involves

- 1) simulating pre- and post-project runoff from the project site using a continuous rainfall record;
- 2) generating flow-duration curves from the results; and
- 3) designing a flow duration control BMP that generates a discharge pattern that matches the pre-project flow-duration curve when the post-project runoff is routed through the facility.

Each flow duration control BMP diverts and retains a certain portion of the runoff. The portion to be retained is essentially the increase in surface runoff volume created between the pre-project and post-project condition. This captured volume must be discharged to the ground via infiltration (and/or evapotranspiration if vegetation present), released at a very low rate to the receiving stream, and/or diverted to a safe discharge location or other infiltration site.

Flow duration control design usually involves sizing of two pools: a low flow pool and a high flow pool. The low flow pool is designed to capture the difference in volume of runoff between the pre- and post-project conditions. It will also capture small to moderate size storms, the initial portions of larger storms, and dry weather flows. The high flow pool is designed to store and release higher flows to maintain, to the extent possible, pre-project runoff conditions. The BMP is sized using an iterative process of adjusting pool storage as well as selecting and adjusting orifice sizes in the outlet structure.

Once the lower pool is sized to capture the correct volume of runoff, the upper pool is sized to detain and discharge larger flows through an outlet structure in such a way as to reproduce the flow duration curve. The outlet structure commonly consists of a series of orifices at set elevations. The number, diameter, and elevation of these orifices are determined by a trial and error approach such as that used in Western Washington (King County, 1998). The number, size and placement will vary from basin to basin depending on project conditions. A weir and orifice combination could also be designed to accomplish the same level of control. The combination of sizing the lower portion of the basin and the upper portion to detain and discharge high flows has the affect of capturing the correct volume of runoff and matching the pre-project distribution of hourly flows.

In some cases, duration control BMPs can also serve as water quality treatment basins and can be designed to treat dry and wet weather flows using a combination of extended detention and natural treatment processes.

Tom Dalziel
Contra Costa Clean Water Program

Continuous Simulation Modeling Guidance

The final HMP will provide specific guidance for using continuous runoff simulation modeling for evaluating HMP compliance. This guidance will include:

- Overall modeling and flow duration control IMP sizing steps
- Time series (rainfall, evaporation) data
- Model parameters for current and proposed site conditions
- Model parameters for site design IMP modeling
- Development of flow duration statistics
- Performance standard compliance

References

Booth, Derek B. and C. Rhett Jackson. 2002. Forest Cover, Impervious-Surface Area, and the Mitigation of Stormwater Impacts. *Journal of the American Water Resources Association* 38(3):1077-1089. June.

King County. 1998. *Surface Water Design Manual*. Department of Public Works, Water and Land Resources Division. September.

Santa Clara Valley Urban Runoff Pollution Prevention Program. 2004. *Hydrograph Management Plan Report – Public Review Draft*. June.

State of Washington Department of Ecology, 2001. *Stormwater Management Manual for Western Washington*. August.



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ATTACHMENT 2

MEMORANDUM

DATE: November 12, 2004
TO: Tom Dalziel, Contra Costa Clean Water Program
FROM: Steve Anderson, Tony Dubin – Brown & Caldwell
Christie Beeman, Jeff Haltiner – PWA
RE: Development Of IMP Sizing Factors

PWA Ref. #: 1742

The Program will use a continuous runoff simulation model to determine sizing factors for each Integrated Management Practice (IMP) included in the IMP Accounting worksheet. This memorandum describes the technical approach for developing the sizing factors.

Unlike flood control design, which relies on individual design rainfall events as in an event model, IMP sizing will be based on simulation of each facility's performance using a 50-year time series record of simulated post-development flows, and comparison of the results to the pre-development results. The required facility size is achieved when the 50-year flow-duration curve for post-development conditions does not exceed the pre-development curve. .

The IMP sizing analyses will involve the following steps:

Develop Runoff Simulations

A local rainfall time series provided by Contra Costa County will be the basic rainfall input to the model. Currently we anticipate using the Martinez gage for which over 50 years of record exist. We will apply adjustment factors to the basic rainfall record to reflect the range of average annual rainfall experienced throughout the county.

A variety of combinations of pre- and post-project soil types and land cover scenarios will be modeled in HSPF for a unit area. The model will be set up for 12-15 different land cover and soil type combinations, selected to reflect typical pre- and post-development site conditions. Table 1 outlines the current list of land cover/soil scenarios, which may be revised or expanded as modeling efforts proceed. Each scenario will be

applied to a unit area in the model, which will then be run for a series of rainfall inputs to generate a family of simulated runoff records.

Table 1. HSPF Land Cover and Soil Type scenarios

Scenario No.	Land Cover 1	Land Cover 2	Soil Class	% Imperv.
<i>Undeveloped:</i>				
1	Scrub		A	0%
2	Scrub		D	0%
3	Range		A	0%
4	Range		D	0%
5	Live Oak		A	0%
6	Live Oak		D	0%
7	Irrigated Pasture		A	0%
8	Irrigated Pasture		D	0%
<i>Developed:</i>				
9	Low Density	Landscaping	A	31%
10	Low Density	Landscaping	D	31%
11	Med Density	Landscaping	A	65%
12	Med Density	Landscaping	D	65%
13	High Density	Landscaping	A	96%
14	High Density	Landscaping	D	96%

Develop Model Parameters for Each IMP

Each IMP will be simulated in HSPF with the following losses:

- Deep infiltration – This represents water that infiltrates through the bottom of the IMP and is considered lost to runoff.
- Evapotranspiration – This represents evaporation as well as plant transpiration (for IMPs that incorporate dense plantings, such as bioretention facilities).
- Subsurface drain – IMPs on D soils may require underdrains to prevent extended periods of standing water. As mentioned earlier, the maximum allowable discharge rate from these underdrains will be set equal to the lower end of the control standard (e.g. 0.5Q2 flow). Project proponents will be required to design IMPs to limit outflows to this rate.
- Overflow – This would be provided (as appropriate) to prevent certain IMPs (such as stormwater infiltration planter boxes) from backing up and ponding against homes during storms that exceed the required control volume.

Establish IMP Sizing for Each Model Scenario

Each site design IMP will be applied to each post-development runoff scenario to generate runoff simulations for sizing. We will develop a family of sizing factors for each IMP by comparing pre- and post-development modeling results for each soil/cover combination. (For example, a new development on clay soils might require smaller site design IMPs than construction on sandy soils, because predevelopment flows would be higher for the clay soils.)

Design guidance provided in the IMP Gallery will specify the recommended depth for each site design IMP. Hence the sizing factors will be developed by varying surface area in the model until the performance standard is met for each soil/land cover combination and rainfall category. Sizing factors will then be expressed as the surface area of IMP divided by the unit development area. Specific IMPs proposed for inclusion in the IMP Accounting worksheet include:

- Bio-retention areas
- Stormwater infiltration planter boxes
- Micro-infiltration or detention
- Roof infiltration trenches
- Amended soils/areas for landscaped areas
- Self retaining landscaping

Sizing Factor Example

The following example provides a brief summary of the process for computation of sizing factors for a stormwater infiltration planter box.

1. Develop standard design criteria for a planter box, including planter box depth, soil and fill material types, overflow height, etc. The Contra Costa Clean Water Program *Stormwater C.3. Guidebook* calls for an 18-inch thick loamy soil layer over a 12-inch thick pea gravel layer, with a 12-inch reservoir on top.
2. Quantify the following terms: infiltration rate through the bottom of the planter to the native soil (two rates: sand and clay), porosity of the soil and fill (determines the available storage volume), evaporation rate from soil, and transpiration rate from plants. Assume the vertical transport rate in the planter is high relative to the other terms, so the planter will fill from the bottom-up during a rainstorm, and that planter soil becomes saturated before any discharge from underdrains occurs.
3. Develop HSPF models for variety of combinations of pre- and post-project conditions for a unit area (e.g. 10,000 square feet). The post-project HSPF will include the IMP, and it will track the inflow, water surface, and outflow terms continuously.

4. Fix planter box materials and dimensions to be as stated in the *Stormwater C.3. Guidebook* and use the model to see how the planter box performs for over 50-year modeling period for the different pre- and post-project scenarios. Vary surface area until performance standard is achieved for each model scenario (land cover, soil and rainfall).
5. Develop a family of ‘sizing factors’ based on results of item 4, i.e. (planter box size)/(impervious area controlled) = sizing factor. The sizing factors will become the behind-the-scenes lookup table described above and will supplement the water-quality-based (Provision C.3.d) sizing factors based on a fixed storm intensity (e.g., 0.2 inches/hour).

Figure 1 is an example of the pre- and post-development flow duration curves that will be used in this sizing exercise. As can be seen in the figure, post-development flow durations before application of IMPs exceed predevelopment flow durations for equivalent flow rates. Note that this figure shows the stormwater infiltration planter box performance exceeding the required standard by capturing all runoff between the lower (e.g. 0.5Q2) and upper discharge bounds (e.g. Q10), while outflow from the facility is limited to 0.5Q2.

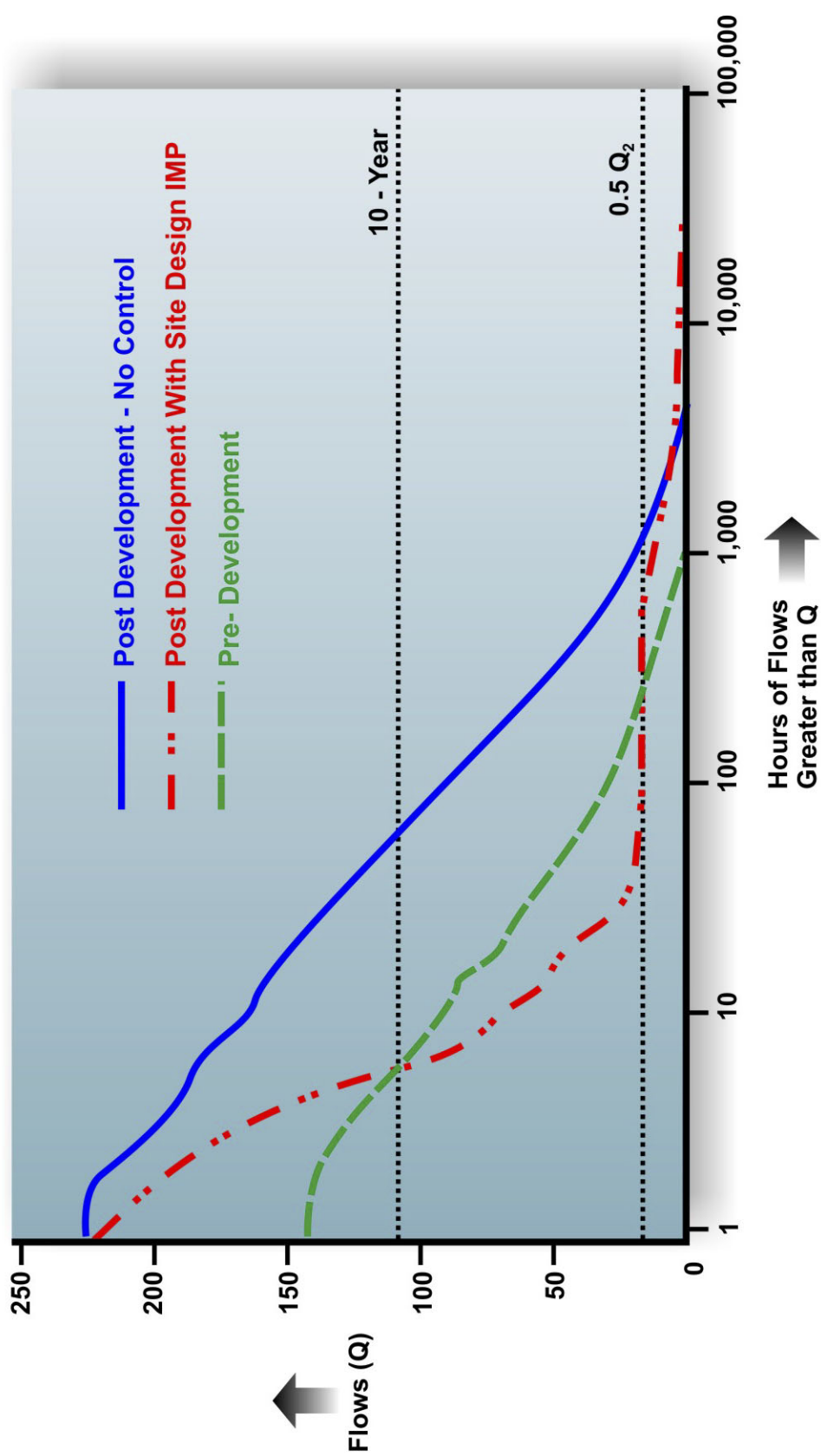


Figure 1. Infiltration Planter Box Sizing Example - flow duration curves

ATTACHMENT 3

MEMORANDUM

DATE: November 12, 2004
TO: Tom Dalziel
COMPANY: Contra Costa Clean Water Program
FROM: Christie Beeman,
Andy Collison
Jeff Haltiner
RE: Stream Classification Methodology (Working draft)
PWA Ref. #: 1742

4.1 INTRODUCTION

The purpose of the stream classification methodology is to determine the sensitivity of a stream to erosion due to development-related increases in flow peak and duration, and to assign a “risk” classification for stream erosion (high, medium or low). Based on this classification, an additional assessment using either existing or new data may be required, leading to possible off-site or in-stream mitigation requirements.

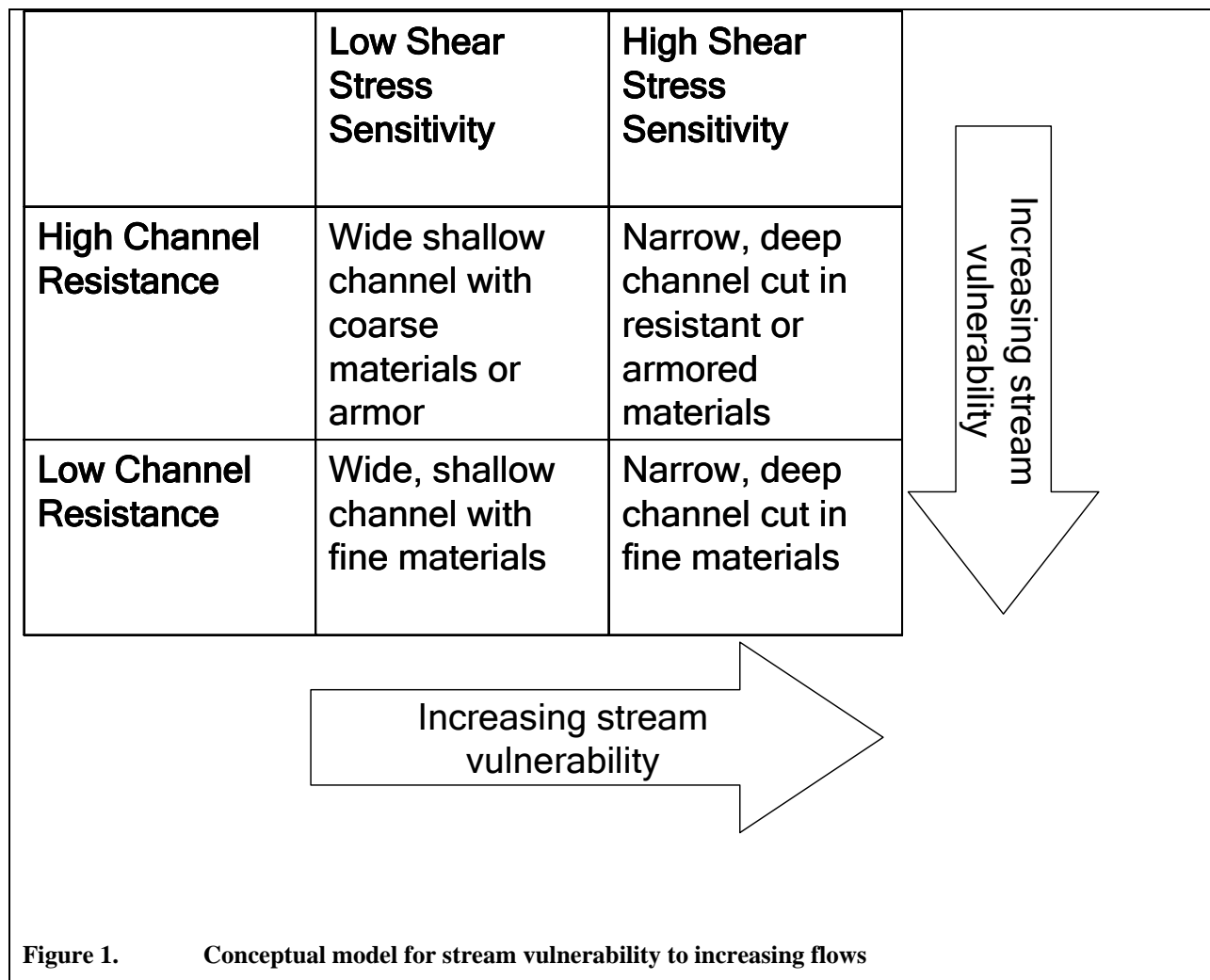
4.2 SUMMARY OF TECHNICAL APPROACH

Erosion occurs when *boundary shear stress* (the force of water flowing on a surface such as the bed or banks of a creek) exceeds *critical shear stress* (the erosion threshold of the bank or bed material). A stream’s vulnerability to increased flow is determined by two factors: the rate at which boundary shear stress increases relative to increases in flow (shear stress sensitivity), and the margin between the boundary shear stress of the flow and the critical shear stress of the channel materials (channel resistance).

In some channel reaches large increases in peak flow bring about relatively small increases in boundary shear stress, and so erosion vulnerability is likely to be relatively low (low shear stress sensitivity). Such

channels are likely to be wide and shallow, or have unconfined floodplains where additional peak flows can escape out of the channel. On the other hand, in confined channels small increases in peak flow bring about relatively large increases in flow depth, and boundary shear stress is increased proportionally (high shear stress sensitivity). These channels are more vulnerable to flow increases.

Likewise, channels composed of resistant materials are less sensitive to additional peak flows because the channel resistance is large. Channel composed of erodible materials are vulnerable to smaller increases in boundary shear stress (low channel resistance).



4.2.1 Low Risk Channel Definition

We have used the conceptual model of stream vulnerability shown in Figure 1 to define the high, medium and low sensitivity classes. The first step is to identify low risk channels. These are channels where the

boundary shear stress is likely to be greatly below the critical shear stress, either because the channel is hardened or because the gradient is so low that the channel is dominated by deposition rather than transport or erosion.

We recommend that channels that are hardened on all sides (bed and banks) be automatically classified as low risk, since even elevated peak flows will not exceed critical shear stress. These include channels constructed from concrete, brick or gabions. Note that channels that have hardened banks but with earth bottoms should not be exempted, as bed erosion may still occur.

In addition to the automatic low vulnerability classification for hardened channels, we propose developing empirical relationships so that channels that are depositional or very low gradient can also be designated as low risk after an initial assessment. These procedures are likely to involve establishing relationships between watershed area and stable or depositional channel slope, so that for any given watershed area stable channels can be eliminated from further analysis. The relationships would yield curves that could be used to identify low risk channels for inclusion in the final HMP.

4.2.2 Medium Risk Channel Definition

Medium risk channels are those where boundary shear stress could exceed critical shear stress as a result of hydrograph modification, but where either the sensitivity of boundary shear stress to flow is low or the resistance of the channel materials is relatively high. The first condition is met in oversize channels with high width to depth ratios (e.g. large earth flood control channels or some naturally wide, shallow channels with easy access to floodplains during high flow events) where increases in peak flow have little effect on flow depth and therefore shear stress. The second condition is met in channels that have coarse or armored bed material (e.g. cobble or boulder beds), and vegetated banks.

4.2.3 High Risk Channel Definition

High-risk channels are those where the sensitivity of boundary shear stress to flow is high and/or the channel resistance is low. The first condition is met in confined channels where flow increases result in large increases in flow depth (steep rating curves). Examples include incised or entrenched channels, channels with low width to depth ratios, and narrow channels with levees. The second condition is met in channels that are composed of fine-grained, erodible bed or bank materials, or that have little or no bank vegetation. Channels that show evidence of active erosion will also be defined as high risk, since active erosion indicates that boundary shear stress already exceeds critical shear stress during high flows, and there is no margin of channel resistance.

The distinction between medium and high risk channels will be based on a combination of methods, to allow flexibility for projects of different sizes and with different amounts of available data. Rather than develop a mechanistic ‘cook book’ approach we recommend a set of approved field, desk and numerical analyses, which will provide a consistent framework for stream classification while allowing project

proponents and the municipal reviewers to use their professional judgment in borderline cases. We recommend that a selection of the following methods be used, with a classification into ‘medium’ or ‘high’ vulnerability being made based on the preponderance and weight of evidence.

4.3 ANALYSIS METHODS AND INTERPRETATION

Eight methods for identification of medium and high risk channels are recommended for inclusion in the final HMP. The methods are described below and summarized in Table 1. The final HMP will include detailed guidance for applying each of these methods. The assessment methods will be applied to the receiving channel from the project site (discharge point) downstream to either the point at which all further downstream reaches are classified as ‘low’ vulnerability (e.g. the start of hardened flood channel) or the point at which tributaries dilute the project’s additional flow below the threshold increase (i.e. the point at which the flow duration curve matches the pre-project curve for the contributing watershed area).

4.3.1 Hydraulic and Sediment Transport Modeling

On large-scale projects where the impact has more regional significance and project budget can provide for more detailed analyses we recommend the use of hydraulic and sediment transport modeling to support classification.

4.3.2 Historic Geomorphic Assessment

Channels that have been significantly altered and/or eroded in the past are likely to be currently unstable, and highly vulnerable to increases in peak flow. Recommend analysis methods include comparison of historic and present cross sections to test for channel incision or bank erosion (e.g. at bridge crossings). Evidence of past channel erosion supports classification as a ‘high’ vulnerability reach.

4.3.3 Geomorphic Reconnaissance: Evidence of Current Channel Erosion

Erosion can be detected by field assessments (e.g. presence of knickpoints, undercutting of structures such as culverts and bank protection, vertical, non vegetated banks, absence of bed depositional features such as point bars).

4.3.4 Channel Entrenchment

Channel entrenchment is an indicator of past or present channel incision, and makes the channel sensitive to increases in flow (shear stress sensitivity). Channel entrenchment can be calculated based on field measurements using the Rosgen method. Channel entrenchment can also be calculated where hydraulic models are available by assessing the recurrence interval of out of channel flows.

4.3.5 Width to Depth Ratio

Width to depth ratio can be used as an indicator of channel entrenchment.

4.3.6 Channel Bed Materials

Coarse bed materials such as cobbles and boulders suggest that the channel is somewhat resistant to increases in flow, whereas fine materials (sand size and smaller) suggest that the channel has little resistance.

4.3.7 Bank and Toe Vegetation

Bank and toe vegetation increase the resistance of the channel to erosion, and are indicators of relative channel stability.

4.3.8 Grade Control

Grade control structures or natural grade control (e.g. bedrock outcrops) provide increased channel resistance in the event of downcutting.

Table 1. Stream Vulnerability Analysis Methods

	Characteristics supporting a ‘Medium’ vulnerability classification	Characteristics supporting a ‘High’ vulnerability classification
↓ Decreasing weight given to indicators	Sediment transport model shows little additional erosion due to hydrograph modification	Sediment transport model shows considerable additional erosion due to hydrograph modification
	Field evidence shows little or no active erosion	Field evidence shows active erosion (e.g. knickpoints, undercut banks, few bed depositional features)
	Comparison of current and historical cross-sections shows little or no evidence of erosion	Comparison of current and historical cross-sections shows evidence of channel incision and/or bank erosion
	Channel is not entrenched (Rosgen classification)	Channel is entrenched (Rosgen classification)
	Channel has high width to depth ratio	Channel has low width to depth ratio
	Channel bed is coarse or armored	Channel bed is fine
	Channel has bank and toe vegetation	Channel has little or no bank and toe vegetation
	Channel has periodic grade control	Channel has no grade control