Multiple Lines of Evidence Approach to BMP Implementation

Newport Bay Watershed

DRAFT REPORT

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This report partially fulfills the requirements under Task 1.5 of the NSMP Year 2 Work Plan, and fits within the overall NSMP framework as shown below:

NSMP Task – Document Key
Task 1 Complementary Monitoring
Task 1.1.3 Identify Data Gaps
Task 1.2 Sources and Loads of Nitrogen and Selenium
Task 1.3 Bioavailability and Impacts of Selenium
Task 1.4 Impacts of Nitrogen
➲ **Task 1.5 Lines of Evidence Approach for BMP Implementation**
Task 1.6 Selenium Speciation Method(s)
Task 1.7 Support for BMP and Trading Tasks
Task 2 Develop and Evaluate BMPs/Treatment Technologies
Task 3 Develop Offset, Trading or Mitigation Program
Task 4 Evaluate Nutrient TMDL
Task 5 Develop Site-Specific Objective (SSO) for Selenium
Task 6 Management and Communication

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Acronyms and Symbols

BMP: Best Management Practice

dw: dry weight

IRWD: Irvine Ranch Water District

mg/kg: milligram per kilogram

mg/L: milligram per liter

NSMP: Nitrogen and Selenium Management Program

SARWQCB: Santa Ana Region Water Quality Control Board

T-Se: total selenium

μg/L: micrograms per liter

EXECUTIVE SUMMARY

This report compiles various lines of evidence into a ranking tool for evaluating Best Management Practices (BMPs) for the Newport Bay Watershed for the control of selenium and nitrogen loading. Several steps were necessary to create the overall, weight of evidence approach:

- Creation of assessment areas: Assessment areas were created throughout the watershed as subsets of hydrologic subbasins based on drainage relationships to the historical "Swamp of the Frogs" area and the area's general potential for contributing downstream constituent loads. These areas represent the different groupings of habitat types associated with differing ranges of concentrations and loads for selenium and nitrate.
- Assemble list of ecological thresholds: Thresholds for selenium and nitrogen enrichment effects were compiled for use in assigning ranks to assessment areas based on the potential for threshold exceedance.
- Incorporation of BMP flow and load modeling: The previously developed BMP assessment model compares BMPs on the basis of effectiveness of treatment for downstream locations. That tool is an integral part of an overall weight of evidence approach to comparing BMPs and potential BMP sites.
- Assessment of the habitat potential and relative ecological receptor abundance and diversity: In addition to the potential for chemical loading it was important to rank assessment areas for their habitat value and relative density of receptors.
- Creation of a summary weight of evidence tool: A table was created that pools chemical exposure, habitat, and receptor abundance and diversity. The resulting ranks offer relative scores among assessment areas that can be used to help select the appropriate BMPs for each area. It is recognized that final BMP choice will include more site-specific information than that presented here at the more general assessment level.

The conclusions were that upstream San Diego Creek and Peters Canyon Wash drainage channels that directly drain the area known as the "Swamp of the Frogs" provide little habitat value and support few ecological receptors but may provide the greatest opportunity for successful implementation of BMPs to control downstream loading of selenium or nitrate. The results of this weight of evidence approach must be combined with site-specific and BMP-specific information to evaluate the choice, placement, and sizing of individual BMPs for specific locations

1. INTRODUCTION

The purpose of this report is to describe an approach for developing multiple lines of evidence for Best Management Practices (BMP) implementation in the Newport Bay watershed as part of the Nitrogen Selenium Management Program (NSMP). The BMPs are being developed to decrease waterborne concentrations of selenium (Se) and nitrogen (N) in the surface waters of San Diego Creek and Newport Bay. The techniques for evaluating and comparing the effectiveness of BMPs will incorporate multiple lines of evidence, including:

- A summary of ambient concentrations of selenium and nitrate throughout the watershed and rankings by assessment area,
- The relative frequency of exceedance of ecological threshold concentrations throughout the watershed,
- Ranking of sub-basins based on habitat potential and presence of ecological receptors,
- Modeled effects of potential BMP implementation on resulting improvements in surface water concentrations of Se and N.
- A combined ranking system to evaluate BMP effectiveness in conjunction with environmental priorities.

The final tool will be a table that incorporates various ranking systems into an overall weight of evidence approach to BMP implementation.

2. MULTIPLE LINES OF EVIDENCE

The ecological basis for the evaluation of BMPs for Se and N removal from the San Diego Creek watershed should be based on multiple lines of evidence, as listed above. Increasing evidence shows that urban stream ecosystems (such as Newport Bay watershed) possess a variety of stressors that must be considered before attempting restoration and improvements beneficial to fish and wildlife (e.g. Palmer et al., 2005; Walsh et al., 2005). There is a basic understanding in the modern bioassessment literature that tracking complex systems requires measures that integrate multiple factors and that biological indicators can be reliable indicators of risk (e.g. Karr and Chu, 1999). When developing management strategies for urban watersheds, it is important to track biological and well as chemical characteristics of the environment (Booth et al., 2003).

The multiple lines of evidence most appropriate for evaluation of the Newport Bay watershed fall into general groupings of:

- Watershed assessment areas by location, with comparisons to criteria and ecological thresholds by location,
- Rankings of assessment areas by their habitat value and presence of ecological receptors, and
- Estimated BMP removal efficiencies by design, sizing, and location.

Concentrations of selenium and nitrate in surface water, surficial sediment, and the tissues of aquatic organisms (selenium) provide excellent measures of exposure and the potential for risk throughout the watershed, but they vary greatly in terms of sample density and how closely they are spatially tied to specific drainage sources. In addition to an evaluation based on constituent concentrations and exceedances, it is recognized that some BMPs may be impractical or not cost-effective in some locations and may be eliminated as a first step in evaluation.

2.1 WATERSHED PATTERN OF CONCENTRATIONS BY LOCATION

The Newport Bay watershed was grouped into assessment areas as derived from subbasins and clusters of channels relative to hydrologic subbasins, smaller drainage channels versus mainstem creeks, and areas with elevated groundwater (and surfacing groundwater) concentrations of selenium or nitrate. The spatial pattern of assessment area groups is shown in Figure 1. The pattern of clustered, elevated concentrations of Se and N in all media in the mid-watershed area known as the historical "Swamp of the Frogs" has been documented in a number of previous reports both preceding and as part of the NSMP program (e.g., Miexner et al., 2004; CH2M HILL, 2006 a,b,c; LWA, 2007). The basic pattern is that drainages upstream of this old, built-over wetland begin as relatively low in Se and N concentrations but then increase dramatically moving downstream through the historic marsh area and continue downstream to the bay at concentrations often above ecological and regulatory threshold values. As in any watershed, flow volumes and dilution also increase moving downstream and concentrations are therefore reduced downstream of the mid-watershed increase, as the water moves to the lowermost reaches of the creek and into the bay. The highest constituent concentrations are in upstream, mid-watershed areas of Peters Canyon Wash and associated channels that are characteristically high in Se and N concentrations but low in flow (CH2M HILL, 2006b, c). The same basic spatial pattern of concentrations and threshold exceedances is repeated for sediment and the tissues of aquatic biota (CH2M HILL, 2006c).

In general, water concentrations in Newport Bay are considerably lower than most values found in the creeks and channels. San Diego Creek ranges as high as 58 ug/L and 26 mg/L for Se and N, respectively. Drainage channel concentrations range as high as 80 ug/L and 21 mg/L for Se and N, respectively. In contrast, concentrations in the off-channel wetlands and bay range from 2.5 to 5 ug/L for Se and about 1 to 3 mg/L for N. Table 1 ranks the assessment areas for concentrations and loading potential on relative scales of 1 to 4 (with 4 being the highest concentration or load categories). Water concentration and load are independently important in estimating risk because concentration is an immediate measure of exposure while loads contribute to downstream exposure and concentrations. Ranks based on sediment and biota tissue concentrations are only available for selenium and were used in assessing threshold exceedances by assessment areas (Section 2.3), but not as a separate, independent line of evidence for BMP evaluation (Section 2.5). Ranks were based on geometric means by location as compared to simple quartiles of data for the 4 categories. Loads in Table 1 are instantaneous loads for those samples with co-measured flow and concentration (not extrapolated values).

Surface sediment concentrations do not show the same pattern for Se concentrations as for surface water but were not sampled in most assessment areas. Concentrations range up to 4.3 mg/kg in the more contaminated creek areas and 1 or 2 mg/kg in upstream locations but up to 8.3 mg/kg in surficial sediments of the bay. The elevated Newport Bay value probably represents the accumulation of watershed products into the lower energy, bay environment with more organically-enriched (and typically more selenium-associated) sediments than are sustainable in the flowing creek .

Biota tissue samples for Se were divided into various categories based on the food webs of the creek and bay, as developed as part of the Conceptual Site Models (CH2M HILL, 2006a). It is impractical to rank biota by all assessment areas because comparable biota types are not available across all areas. Instead, the tissue concentration results were summarized by taxonomic grouping and by site in the Sources and Loads and Bioavailability reports (CH2M HILL, 2006b and 2006c) and repeated here.

Filamentous algae and plants had relatively low concentrations of Se in comparison to other biota. Values for algae ranged from 0.2 to 1.2 mg Se/kg dw in the upper watershed (above the influence of the historical Swamp of the Frogs) to maximum values of 6.7 mg Se/kg dw in the lower creek and 8.1 mg Se/kg dw in the off-channel wetlands. Algae tissue concentrations represent short-term bioaccumulation from water, limited to the immediate growing season.

The results for rooted aquatic plants indicated somewhat higher Se bioaccumulation than for algae. The upper creek area was not sampled, but areas of the creek within or downstream of areas of elevated Se loading had plant tissue values ranging from 0.18 to 32 mg Se/kg, with plants in the bay, wetland ponds, and channels having relatively lower concentrations. Rooted plant tissue concentrations represent variable duration of bioaccumulation (mostly annual except for rhizomes) from both sediments and water. The highest values were found in cattail and Olney's rush in Peters Canyon Wash.

The invertebrates sampled were diverse and highly variable with respect to Se bioaccumulation. The highest selenium concentrations were found in the lower creek (water boatmen, midge larvae) and wetland locations (midge larvae) rather than more upstream areas or areas of greater dilution and settlement loss (Bay). Values ranged from 0.70 to 47 mg Se/kg dw for horned snails (whole body with shells; soft tissue was 2.3 mg Se/kg) collected from Upper Newport Bay and midge larvae from lower Peters Canyon Wash, respectively.

Whole-body fish concentrations varied from 1.3 to 30 mg Se/kg dw. The upper Newport Bay samples of 5.4 and 5.8 mg Se/kg dw in this dataset were very comparable to the range of 3.1 to 9.6 mg Se/kg dw found for similar species collected from the upper bay in 2002 (Allen et al., 2004). Amphibian larvae ranged from 2.5 to 5.8 mg Se/kg dw.

Selenium concentrations in bird eggs also varied by area; eggs from San Diego Creek had significantly higher geometric mean Se concentrations than those from Newport Bay. However, eggs from the wetland sites (UCI and IRWD marshes) had higher individual eggs than were found at the other creek sites. Both the wetland sites and the Newport Bay site had a few individual eggs above the 10 mg Se/kg dw threshold for toxicity.

Table 1. Concentrations, Loads, and Ranks for Selenium and Nitrate in Surface Water and Sediment by Assessment Areas. Ranks: 1 = 0-25%tile, 2 = 26 – 50 %tile, 3 = 51 – 75 %tile, 4 = 76 – 100 %tile

Assessment Area	**Geomean concentration rank**		**Geomean loading rank**		**Sediment rank**
	Selenium	Nitrate	Selenium	Nitrate	Selenium (only)
Upper SDC	1	2	Assumed 1	Assumed 1	1
Upper PCW	1	1	1	1	1
Non-marsh drains	1	2	1	1	1
Marsh drains	2	2	2	2	Assumed 4
Lower SDC	2	3	3	3	4
Lower PCW	3	2	4	3	Assumed 4
SADC	2	2	3	2	Assumed 3
Off-channel wetlands	Assumed 2	Assumed 2	NA	NA	4
Upper Bay	2	1	NA	NA	4
Lower Bay	Assumed 1	1	NA	NA	Assumed 3
Upper Bay channels	Assumed 1	Assumed 2	Assumed 2	Assumed 2	4
Lower Bay channels	Assumed 1	Assumed 2	Assumed 2	Assumed 2	Assumed 4
Percentile values					
25 %tile	3.5 (ug Se/L)	1.91 (mg N/L)	4.5 (g Se/d)	2.63 (kg N/d)	0.53 (mg/kg dw)
50 %tile	12	6.35	25.1	16.7	1.33
75 %tile	20.3	11.97	164.7	72.3	3.05

As seen in Table 1, some smaller channels have not been well characterized whereas the main channels are well sampled. The rankings of potential risk based on selenium and nitrate waterborne concentrations and loads indicate that the general area of the historic "Swamp of the Frogs", in the middle drainages and reaches of Peters Canyon Wash, show the highest risk and greatest potential for BMP effectiveness based on treating relatively lower flows with higher constituent concentrations. Sediment ranks are less useful for establishing spatial patterns of contaminant sources because of the relative lack of samples in the watershed and their more limited spatial variability as compared to surface water.

2.2 HABITAT POTENTIAL AND PRESENCE OF RECEPTORS

The San Diego Creek watershed and Newport Bay possess extreme variability in their ability to provide habitat and support populations of ecological receptors. Separate Conceptual Site Models (CSMs) were developed for the creek and bay environments that list a number of different receptors and fully developed food webs (CH2M HILL, 2006a). Shorebirds, marine aquatic birds, waterfowl, and a variety of fish and invertebrates are present in both creek and bay portions of the watershed. However, it is important to note that this watershed is almost all urbanized and, as a result, many of the smaller channels are concrete-lined, vertical-walled channels designed to carry off debris, sediment, and water. By design they do not hold water or much substrate material during periods between runoff events. During low, baseflow periods, these channels may be slightly wet but without pooled water. A ranking of the relative potential for habitat by subbasin is provided in Table 2.

The channels throughout the watershed have not been quantitatively surveyed for the extent of habitat but could be in the future as part of a refined measure of habitat potential and an application of the methods of assessment as presented in this memorandum. The current summary of habitat potential as provided in Table 2 is a relative and qualitative assessment based on personal observations of NSMP team members. A possible, future refinement of this approach would be to create habitat categories as multiplied by length of channel or wetted areas. Habitat quality was judged as ranging from 1 (minimal) to 4 (best) for this watershed. The bay and off-channel wetlands stand out as the best habitat (4) with all other parts of the watershed in lower categories.

Habitat categories and ranks include:

- Steep or vertical-sided concrete channels with little or no substrate and intermittent flow (1),
- Wider, sloped-sided channels with intermittent flow or baseflow and with some substrate and pools (2),
- Deeper, lower-basin channels with continuous flow and pools (3),
- Off-channel wetlands (4), and
- Upper and lower Newport Bay (4).

The presence, abundance, and diversity of receptors by subbasin and channel (Table 2) are based on the observations of NSMP team members over the last several years of data collection throughout the watershed and upper bay. It is not meant to be an exhaustive species list, but rather a qualitative comparison of subbasins and habitat types for their observed potential to support diversity and various activities (e.g. feeding, nesting) of receptors. Similar to the assessment of habitat quality, receptor abundance and diversity were judged as ranging from 1 (very low) to 3 (highest). The results mirror the habitat quality assessment. The assessment areas of highest cumulative habitat and receptor ranks offer the greatest potential for improvements from BMP implementation either in those locations or (more likely) in upstream locations where drainage directly impacts those locations. Assessment area with the lowest habitat and receptor ranks offer the least potential for harm to receptors from BMP construction and maintenance. In fact, those low ranking areas can tolerate higher concentrations of Se and N in water or sediment without causing significant environmental harm. Thus, BMPs may be located in (or adjacent to) those low-value habitats as a means of protecting higher value habitats downstream while causing minimal impact to local fish and wildlife. The location of the BMPs towards the downstream end of the low-value channels would serve to capture maximal flows for downstream protection without sacrificing significant upstream receptors or habitat (that would then be left free of BMP treatment).

Table 2. Habitat Quality and Relative Abundance and Diversity of Ecological Receptors by Assessment Area.

Assessment Area	Habitat Type	Habitat Rank	Receptors	Receptor Rank	Added Ranks
Upper SDC	Channelized, riparian	2	Riparian, limited shorebird, waterfowl, limited fish	2	4
Upper PCW	Channelized, limited substrate and riparian	1.5	Limited shorebird, waterfowl, limited fish	1	2.5
Non-marsh drains	Concrete channels, limited water	1	Limited, temporary	1	2
Marsh drains	Concrete channels, limited water	1	Limited, temporary	1	2
Lower SDC	Open channels, pools	3	Riparian, shorebirds, waterfowl, piscivorous birds, abundant fish	3	6
Lower PCW	Sloping channel, limited substrate and riparian, shallow	2	Limited shorebirds, waterfowl, limited fish	2	4
SADC	Concrete channel, limited water	1	Limited, temporary	1	2
Off-channel wetlands	Freshwater wetlands, open water	4	Shorebirds, waterfowl. Limited fish.	3	7
Upper Bay	Open water, tidal, estuarine	4	All categories	4	8
Lower Bay	Open water, estuarine	4	All categories	4	8
Upper Bay channels	Concrete channels, limited water	1	Limited, temporary	1	2
Lower Bay channels	Concrete channels, limited water	1	Limited, temporary	1	2

2.3 FREQUENCY OF THRESHOLD EXCEEDANCES BY AREA

The subbasin areas and channels can be ranked for their frequency of exceedance of ecological thresholds based on chemistry. Table 3 shows selenium thresholds and a cumulative-effects index as originally developed for the Bioavailability memorandum (Task 1.3, CH2M HILL, 2006c). Nitrogen-related impacts (through secondary effects) are summarized in Table 4, as originally presented in the algae survey memorandum (LWA, 2007). In both cases, the results have been recompiled here to match the BMP assessment areas. The selenium-based index values are weighted by the relative importance of various media (e.g., water, sediment, food concentrations) in determining bioavailability and risk (CH2M HILL, 2006c). The examples shown for selenium effects in Table 3 are somewhat uncertain due to the lack of tissue sampling results from the smaller channels in the watershed. However, the table is included to show how this method of screening could be used to compare various watershed areas as part of the development of a weight of evidence tool.

Environmental risk due to excessive selenium is assessed as the potential for selenium toxicity to fish, wildlife, and humans who eat fish. The risks due to excessive nitrogen concentration and load is measured as the effects of eutrophication (nutrient enrichment), with potential detrimental effects to fish, wildlife, and humans through enhanced algae growth in the creeks or bay and associated oxygen depletion or toxic levels of pH or ammonia. Excessive algae growth also causes problems with recreational use and aesthetics of the watershed.

In addition to nitrate concentrations, surface water locations were ranked for N effects on algal growth by measuring the secondary effects of algal biomass and percentage algal mat cover along with algae's associated impacts on dissolved oxygen (DO) and pH values in the channels (LWA, 2007). Those rankings based on secondary effects of nutrient concentrations are important in determining the areas where N-control BMPs will be most needed. Nitrate-N effects were estimated by comparisons to surface water concentrations of pH and DO and algal growth parameters as indicated by narrative Basin Plan criteria (SARWQCB, 1995; LWA, 2007). N-based threshold exceedances were assigned a value of 1 and added for the estimation of cumulative effects (Table 4).

The cumulative index values by area provide overall ranks based on the relative potential for risk from selenium and nitrate (Tables 3 and 4). The assessment areas of higher ranks offer the greatest need for improvements from BMP implementation. However, some assessment areas with higher index values may be located in low-value habitats with minimal receptors. In those cases it may be most practical to locate BMPs at the downstream end of the channel or drain (or adjacent to them) just prior to entry into the higher value, downstream habitat. In so doing, the higher index assessment areas may maintain elevated Se and N concentrations but in areas limited to only the lowest of habitat values.

Table 3. Selenium Toxicity Threshold Numeric Evaluation of Potential Selenium Toxicity. The Index is the First Number and the Range of Selenium Concentrations in Parentheses. Ranks by Assessment Area assigned as: 1 = 0-12, 2 = 13-16, 3 = 17-20, 4 = > 20.

Habitat	**Water µg Se/L**	**Speciation %**	**Particulate mg Se/kg dw**	**Diet mg Se/kg dw**	**Fish Tissue mg Se/kg dw**	**Bird Egg mg Se/kg dw**	**Total Index**
Guideline	**5 µg Se/L (freshwater) 71 µg/L (bay)**	**80% Se(VI)**	**4 mg Se/kg dw**	**7 mg Se/kg dw**	**6 mg Se/kg dw**	**10 mg Se/kg dw**	
Weighting Factor	**0.5**	**0.5**	**0.5**	**1**	**2**	**2**	
Upper SDC	1	1	4	1	1	1	8
Upper PCW	1	1	1	4	1	1	9.5
Non-marsh drains	1	1*	1*	4*	1*	1*	9.5
Marsh drains	3	1*	2*	4*	4*	2*	19
Lower SDC	4	1	1*	4	4	2	19
Lower PCW	3	1	1*	4*	4*	2*	18.5
SADC	2	1	1*	4*	4*	2*	18
Off-channel wetlands	4	3	4	4	4	3	23.5
Upper Bay	2	1	4	3	3	2	16.5
Lower Bay	2*	1*	4*	3*	3*	2*	16.5
Upper Bay channels	1	1*	1*	3*	1*	1*	8.5
Lower Bay channels	1	1*	1*	3*	1*	1*	8.5

Indicators derived from frequency of exceedance: 1. No exceedances, low probability of effect. 2. Exceedances <10%, uncertainty about exceedance. 3. Exceedances 10 – 50%, uncertainty about exceedance. 4. Exceedance frequency >50%, exceedance likely.

[d] Presser et al. (2004) except speciation, particulates, and marine value for bay water (71 µg/L). Speciation is scored as higher risk if <80%. Particulates (suspended solids) are scored by comparison to the guideline for sediment. Marine value from USEPA (2002).

[h] Upper Newport Bay, geomean and maximum values, 1976 – 2005 (discontinuous monitoring).

* = estimated value.

[i] High end of range from Allen et al. (2004)

Table 4. Secondary Nitrogen Effects: Exceedance by Assessment Area. [Y (yes) results added as 1 each with 1 as the minimum total score].

Assessment	**DO**	**pH**	**Chlorophyll a**	**Excessive Periphyton Algae**	**Excessive Floating Algae**	**Y/N (additive index)**
Area (with algae sampling sites)	**< 5 mg/L in morning**	**Threshold exceeded**	**> 150 mg/m2**	**> 60% coverage**	**> 30% coverage**	
Upper SDC (ACWF18)	Y	N	Y	N	N	**Y (2)**
Upper PCW (none)	-	-	-	-	-	**(assumed 2)**
Non-marsh drains (LANF08)	Y	N	Y	N	N	**Y (2)**
Marsh drains (MIRf07, CICF25)	N, N	Y, Y	Y, N	N, N	N, N	**Y/N (1)**
Lower SDC (WYLSED)	N	N	N	N	N	**N (1)**
Lower PCW (BARSED)	Y	N	Y	N	Y	**Y (3)**
SADC (SADF01)	Y	N	Y	N	N	**Y (2)**
Off-channel wetlands (none)	-	-	-	-	-	**(assumed 1)**
Upper Bay (none)*	-	-	-	Y*	-	**Y* (1)**
Lower Bay (none)*	-	-	-	N*	-	**N* (1)**
Upper Bay channels (CMCG02)	Y	Y	Y	N	N	**Y (3)**
Lower Bay channels (none)	-	-	-	-	-	**(assumed 2)**
*SCCWRP study of Newport Bay algae (Schiff and Kamer, 2000)						

The ranks of potential impairment from Se or N by assessment area indicate the highest risk and greatest potential value for BMP improvements at the downstream ends of small drainage channels and for the lower Peters Canyon Wash area (Tables 3 and 4).

2.4 BMP EFFECTIVENESS MODELING AND SITING CONSIDERATIONS

A modeling tool has been developed to assess BMP effectiveness in the Newport Bay watershed as measured by their cumulative effects on downstream concentrations and loads (CH2M HILL, 2007). The model allows the user to select specific types and sizing of BMPs by location and computes the effect of their implementation on downstream constituent concentrations and loads. The modeling nodes (points where flow, water quality, and load are estimated) capture all of the major watershed categories listed as assessment areas in this memorandum except off-channel wetlands. The results of such modeling are complementary to the measures of Se and N ranks by assessment area, as presented in the sections above. Areas selected for BMPs because of elevated Se or N concentrations and/or habitat considerations may prove to be ineffective in the model (for example) by failing to produce significant downstream improvements in concentration or load as compared to other, lower ranked locations. In addition, siting considerations may prove prohibitive if (for example) no practical sites exist for locating BMPs in what might otherwise be a desired location.

BMP effectiveness modeling, siting considerations, and relative cost/benefit analyses may prove extremely important in the multiple lines of evidence used to select BMPs by location. However, those considerations will be developed as part of a future task (Task 2.5) and are not presented here. Instead, the general scheme for their inclusion in an overall, cumulative weight of evidence approach is presented below.

2.5 WEIGHT OF EVIDENCE APPROACH

The procedure for weighting and combining multiple lines of evidence to set priorities for BMP implementation is presented in Table 5. This represents a first attempt at combining disparate sources of information and it is recognized that as more data is summarized from the watershed there may be reason to adjust the weighting factors. Note that some factors, not yet developed, may provide binary yes/no decisions concerning the implementation of any particular BMP. Table 5 is a method for relating lines of evidence assuming a particular BMP has survived any fatal flaws associated with cost/effectiveness and siting issues. Higher weighting factors indicate a greater relative importance of that index in the evaluation of BMPs for any given assessment area. In the case of off-channel wetlands and upper and lower Newport Bay it is recognized that BMPs will be implemented upstream of those habitats to decrease the effects of Se and N in those higher value downstream locations.

The overall equation for summarizing the weight of evidence adds the factors describing Se and N concentration and load and divides by the habitat and receptor indices.

Sediment scores were not added in Table 5 because sediment is poorly characterized in the watershed, does not show variability, and is generally redundant of the water values (Table 1). Higher scores for habitat and receptors as used in the weight of evidence index decrease the BMP score because BMPs are needed upstream of that assessment area, but not in that area, itself. Lower habitat values are a positive indicator for locating BMPs at locations that have a probability of causing improvements to downstream concentrations and load with better habitat but relatively less harm in the actual area of BMP siting.

$$\text{BMP score} = \frac{((\text{Concentration}*f)+(\text{Load}*f)+(\text{Exceedances}*f)+(\text{Model\_Results}*f))}{(\text{Habitat and Receptors}*f)}$$

Table 5. Weight of Evidence Technique for Selecting Newport Bay Watershed BMPs for Se or N control.

	Habitat and Receptors (2-8)	**Se/N Concentrations (1-4)**	**Se/N Load (1-4)**	**Se/N Threshold exceedance (1-4)**	**BMP model Effectiveness (1-4) (default = 1)**	
Weighting factors (f)	**2**	**2**	**2**	**1**	**3**	**Cumulative**
Assessment Area						**BMP Score Se/N**
Upper SDC	4	1/2	1/1	1/2	1	1/1.4
Upper PCW	2.5	1/1	1/1	1/2	1	1.6/1.8
Non-marsh drains	2	1/2	1/1	1/2	1	2/2.8
Marsh drains	2	2/2	2/2	3/1	1	3.5/3
Lower SDC	6	2/3	3/3	3/1	1	1.3/1.3
Lower PCW	4	3/2	4/3	3/3	1	2.5/2
SADC	2	2/2	3/2	3/2	1	4/3.3
Off-channel wetlands	7	2/2	-/-	4/1	1	0.8/0.6
Upper Bay	8	2/1	-/-	3/1	1	0.5/0.4
Lower Bay	8	1/1	-/-	3/1	1	0.5/0.4
Upper Bay channels	2	1/2	2/2	1/3	1	2.5/3.5
Lower Bay channels	2	1/2	2/2	1/2	1	2.5/3.3

The highest cumulative Table 5 scores indicate areas of the best general locations for the implementation of BMPs and were found in the upstream drainage channels in the Swamp of the Frogs area, the SADC, and the upper and lower bay channels, whereas lower values were found both upstream (lower Se and N loads) and downstream (higher habitat values). However, any final choice for BMP implementation must include a thorough quantification of all lines of evidence. For example, some locations (upper and lower bay channels) are incompletely characterized whereas others (e.g., main San Diego Creek) have been thoroughly sampled for all media and receptors. In addition, the BMP effectiveness model (not used here) may affect the final choice of BMP location.

3. DISCUSSION AND CONCLUSIONS

There are many ways in which the various lines of evidence, quantified as part of indices, could be added to create an overall BMP score. However, the above technique (Table 5) captures the concept that low habitat value areas with high relative Se or N concentrations may offer the best sites for construction of BMPs to protect higher habitat values and receptor-rich areas downstream. The weighting factors currently give greatest value to the presence of habitat and the modeling of BMP effectiveness. BMP effectiveness values show no differentiating effect in Table 5 but will when comparative results become available by assessment area. The results of Table 5, without taking into account BMP effectiveness modeling, indicate that the most favorable areas for BMP implementation are the drainage channels draining the historic "Swamp of the Frogs" area, including the Santa Ana Delhi Channel (SADC).

Proposed BMP locations must be evaluated using this technique (as developed here for NSMP Task 1.5) in conjunction with evaluating specifics of sizing or design in the BMP loading model (Task 2.3; CH2M HILL, 2007). In that way the two evaluating techniques can be used in an iterative fashion to refine the selection process (as will be defined as part of Task 2.5). In addition, various aspects of the model as presented in Table 5 can be continually updated as new data is added to the NSMP database. In particular, habitat potential and receptor abundance and diversity indices could be greatly refined by conducting a simple watershed-wide quantitative survey during the spring/summer period. In addition, water, sediment, and biota tissue sampling results are relatively unknown for some of the smaller drainage areas.

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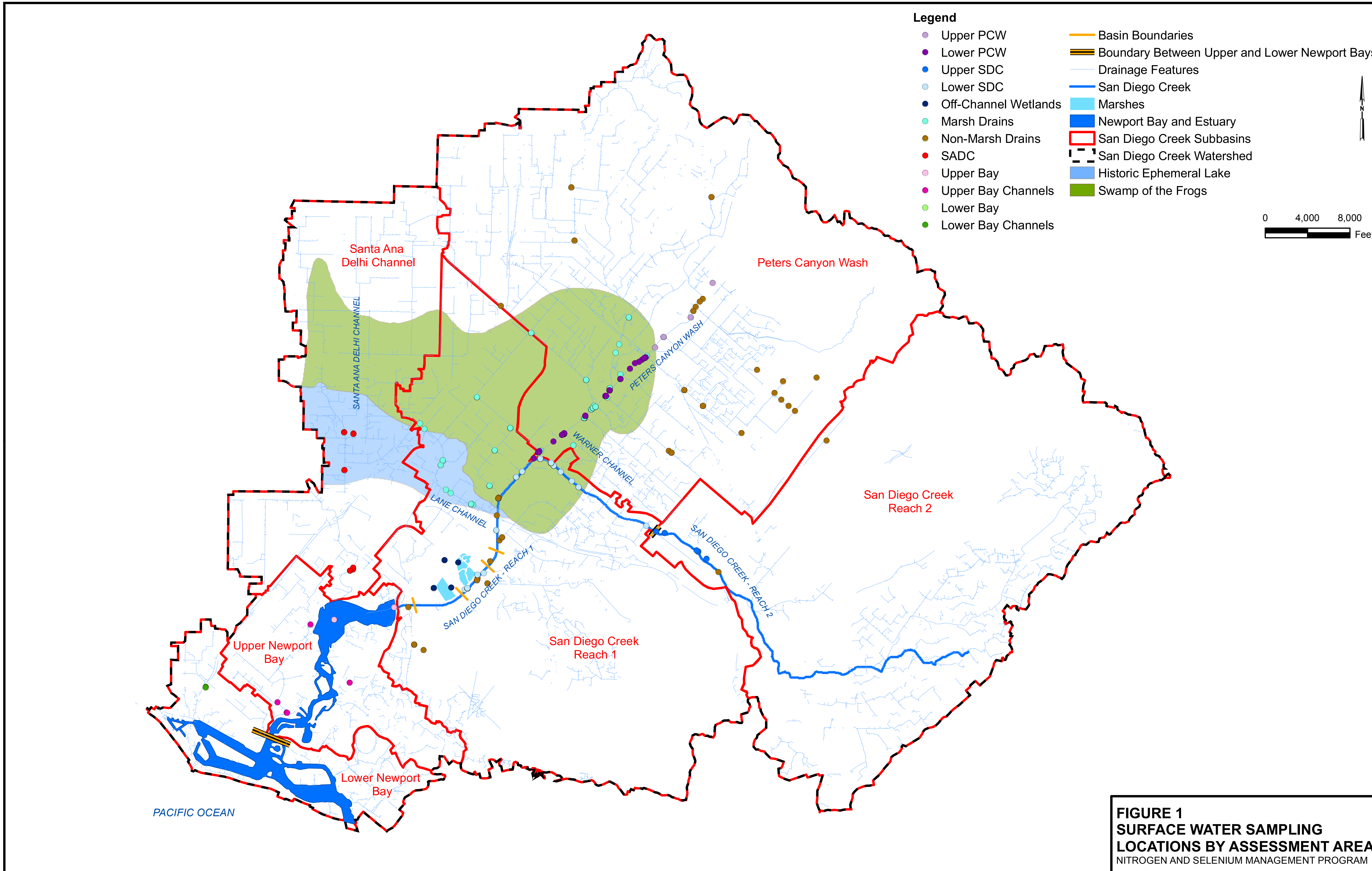

FIGURE 1
SURFACE WATER SAMPLING LOCATIONS BY ASSESSMENT AREA
NITROGEN AND SELENIUM MANAGEMENT PROGRAM

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