Department of Pesticide Regulation
Environmental Monitoring
1001 I Street, Sacramento, California 95814
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STUDY #209: REVISED PROTOCOL FOR THE DEVELOPMENT AND MONITORING OF BIOASSESSMENT REFERENCE SITES IN THE SAN JOAQUIN VALLEY

I. INTRODUCTION

The Department of Pesticide Regulation (DPR) monitors surface waters throughout the state of California using chemical analysis to determine the presence of pesticides in surface waters. Toxicity of surface water samples has normally been determined using one test species (*Ceriodapnia dubia*) in aquatic toxicity tests. Although these standard procedures follow U.S. EPA guidelines, they may not always take the following into consideration:

- Pesticide inputs to surface water commonly occur as pulses which may be missed with occasional monitoring
- Laboratory toxicity tests do not assess integrated ecological impacts

Various monitoring studies conducted on the San Joaquin River and the Sacramento River by DPR and U.S. Geological Survey (USGS) have shown detections of pesticides in surface waters (Bacey et al., 2003; Bacey, 2002; Ross et al., 2000; Domagalski et al., 1997; Kratzer, 1998). Though the long-term risk of negative environmental impact to surface waters from pesticides is uncertain, some pesticides, along with other anthropogenic factors have a high potential for creating stressful conditions in aquatic biological communities.

Over the last several decades, zooplankton, cladoceran and benthic invertebrate populations have declined in the Sacramento-San Joaquin Basins, Delta and San Francisco Estuary. It has been suggested that one factor is the presence of pesticides in surface waters (Obrebski et al., 1992; Cooke et al., 1999). Invertebrate populations are a necessary food source for nearly all fish populations in the Sacramento-San Joaquin basins during their early life stages (Moyle et al., 1996; Meng and Moyle, 1996). Consequently a decline in invertebrate populations may have a negative impact on fish populations.

Aquatic macroinvertebrates populations are commonly monitored in bioassessment studies because they are ubiquitous, complete the majority of their life cycle in water, and are relatively stationary. They are useful in evaluating water quality and the overall health of a water system in flowing waters because they are affected by changes in a stream's chemical and/or physical structure (Karr and Kerans, 1991).

Their large species diversity also provides a range of responses to environmental stresses (Rosenberg and Resh, 1993). All of these characteristics allow them to be effective indicators of specific anthropogenic disturbances (House et al., 1993), cumulative effects of multiple stressors, and historical conditions of a water body (Friedrich et al., 1992). The use of this biological community, along with physical habitat assessment, can help determine the integrity or current condition of a water-body (Harrington and Borne, 1999).

In developing this project DPR will collaborate with the Central Valley Regional Water Quality Control Board (CVRWQCB) and the Department of Fish and Game (DFG), and will also receive technical input from the State Water Resources Control Board (SWRCB), U.S. EPA and Dr. Lenwood W. Hall of the Wye Research and Education Center, University of Maryland. Water quality criteria and sampling methods will be established and used to locate reference sites within the San Joaquin Valley watershed area. This project will promote cooperation between DPR and the SWRCB to protect water quality in accordance with the Management Agency Agreement (MAA).

II. REFERENCE SITES AND CONDITIONS

Reference sites are sections of streams that represent the desired state of stream health for a region of interest. As such they represent a standard condition by which other locations can be compared. Sites may range from a pristine, undisturbed section of a stream to "best available." Since historical anthropogenic land uses and/or water diversions may limit our ability to find minimally disturbed sites, reference sites in the San Joaquin Valley will most likely be those with the least amount of disturbances, or those "best available."

Water quality assessments will be conducted to evaluate stream condition with respect to stressors (Table 1). Physical habitat assessments will be conducted since physical habitat contributes to the variation in species composition and abundance. After conducting water quality and physical habitat assessments those with the highest biological integrity will be selected for an assessment of the biological community (benthic macroinvertebrates). The U.S. EPA defines biological integrity as "the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity and functional organization comparable to that of the natural habitats of a region." Biological integrity will be quantitatively determined using ecological indicators.

Using benthic invertebrate assemblages, ecological indicators are developed. Different structural and functional attributes of the assemblage will be characterized as "metrics" using the multi-metric approach. Although natural biological variation can reflect on the interpretation of stream conditions, quantitative measures for interpreting the degree of impairment that accounts for natural variations have been developed for multi-metric analytical techniques (Gibson *et al.* 1996; Barbour *et al.* 1999; Hawkins *et al*. 2000).

Once reference sites have been identified, they will be used to compare and interpret biological monitoring data from other sites within the same region. They may also be used to characterize the range of biotic conditions expected for minimally disturbed sites.

II. OBJECTIVE

This protocol will provide a quantitative method for selecting reference sites in the San Joaquin Valley watershed area, though the method for selecting the sites may be used for any similar low-gradient (< 2% slope), anthropogenic impacted region.

The objective of this project is to locate 30 reference sites in this region. Reference sites are necessary components in bioassessment studies, in order to compare and interpret past and future biological monitoring data. These reference sites will be used by DPR, CVRWQCB, and other agencies that may have a need for the information.

III. PERSONNEL

This study will be conducted by staff from the Environmental Monitoring Branch, Surface Water Protection Program under the general direction of Kean S. Goh, Agricultural Program Supervisor IV. Key personnel are listed below:

Project Leader:	Juanita Bacey
Field Coordinator:	Adriana Moncada
Senior Scientist:	Frank Spurlock
Consulting Scientist:	Jim Harrington, DFG
Taxonomists:	California Dept. of Fish and Game

Questions concerning this monitoring project should be directed to Juanita Bacey, Environmental Research Scientist, at (916) 445-3759.

IV. STUDY PLAN

The process for selecting reference sites will utilize current land use and pesticide use along defined waterways in the region. Due to the wide variety and amounts of pesticides used throughout this region it will be impractical to include all pesticide use in this region, therefore total pesticide use will include only those pesticides which are commonly used in the San Joaquin Valley, have a high potential to move offsite to surface waters, and have a potential for aquatic toxicity (Table 2). Due to the lack of available data, urban pesticide use (residential, roadways, golf courses, etc.) will not be included in the total pesticide use. A pool of approximately 60 potential reference sites will be measured for biological and water quality conditions. These sites will be narrowed down to approximately 30 reference sites, in which the biological community will be assessed. Due to the significant anthropogenic impact to surface water in this region, the scale of water quality criteria may have to be adjusted as sites are assessed in order to obtain the final 30 reference sites. The process for selecting reference sites will consist of the following steps:

1. Define the region of interest, including boundaries, and stream types to be evaluated.
    - The region selected is the San Joaquin Valley. The boundaries include a portion or all of the following central valley hydrobasins in the state of California, as defined by the CVRWQCB (ISWP, 1991): 32 – East of the Delta, 35A – Turlock, 35B – Merced, 40 – Westside San Joaquin River, 41 – Grasslands, 44A – Central Delta, 44C – South Delta, 45 – San Joaquin Valley floor. These hydrobasins encircle the San Joaquin River watershed, and boundaries will be limited to 500 feet in elevation (Table 3).
    - Stream types selected are those natural channels within the above boundaries that are dominated by agricultural supply water as determined by the CVRWQCB (ISWP, 1991; Table 3).

2. Use GIS-based land use maps and spatial analysis identify all land use within a 1-mile boundary around all stream types identified in step 1.
    - Land use maps were obtained from the California Dept. of Water Resources. Maps with the most recent available data for each county within the designated boundary were used (1993 to present).

3. Use GIS spatial analysis to identify all pesticide use within and adjacent to the 1-mile boundary, based on the selected pesticides (Table 2).
    - Pesticide use data will be obtained from the DPR PUR database. The most current available data is for the year 2001.
    - Overlay pesticide use on selected GIS land use maps as indicated in step 2.

4. Eliminate sections of streams with the greatest pesticide and or agriculture use in the 1-mile boundary, and those which may have impacts from inputs upstream.
    - Agriculture use is one of the most influential land uses that has the potential to impact stream condition.
    - Using GIS land use map, score by hand based on map examination.

5. Eliminate sections of streams with greatest potential of anthropogenic impact to streams with-in the 1-mile boundary.

6. Use GIS-based topographic map overlays on land and pesticide use maps
    - To determine elevation boundaries and access roads

7. Select the pool of potential reference sites from with in the 1-mile boundaries.
    - Select those with the least anthropogenic impact
    - Select those with access roads where possible

8. Site survey potential reference sites, selecting specific sites to be evaluated (65 if possible).
    - Verify land use
    - Verify sufficient water flows
    - Determine accessibility and obtain owner permission if necessary.

9. Perform water quality (chemical) and physical habitat evaluations on the 65 potential reference sites
    - As indicated on the Habitat Assessment Field Data Sheet for low gradient streams, the Physical Characterization and the Water Quality Field Data sheets (Figures 1, 2, 3).
        - Basic water quality: pH, DO, EC, turbidity, temperature
        - Nutrients: Nitrates, Phosphates, Ammonia N., Alkalinity
        - Organophosphate pesticides in water
        - Organophosphate pesticides in sediment (if funds are available)
        - Pyrethroids in sediment (if funds are available)
        - Trace elements in sediment (if funds are available)

10. Use established water quality and physical habitat criteria (to be determined); eliminate those sites that do not meet the basic criteria.
    - Using data collected from step 9, reduce the pool of potential reference sites to the final 30 reference sites.

11. Conduct macroinvertebrate sampling at each of the 30 final sites.
    - Use the multi-habitat method as described in section V.
    - Complete Substrate, Embeddedness, and Water Quality Field data sheets (Figures 3 and 4).

V. BENTHIC MACROINVERTEBRATE SAMPLING METHOD

Sampling will be conducted per DPR SOP #FSWA015.00. This SOP is modified from U.S. EPA's Environmental Monitoring and Assessment Program – Surface Waters: Western Pilot Study Field Operations Manual for Wadeable Streams (U.S.EPA, 2001).

VI. PHYSICAL HABITAT ASSESSMENT METHOD

Physical habitat assessment will be evaluated following scoring criteria as defined by the U.S. EPA (1999). A Habitat Assessment Field Data Sheet for low gradient streams will be completed at each site as indicated in step 9 (Figure 1). Modified U.S. EPA Physical Characterization and Water Quality Field Data sheets will also be completed at each site (Figures 2 and 3).

VII. WATER SAMPLING METHOD

Water samples will be collected at the furthest downstream site of each reach. Four samples will be individually collected per reach for each chemical screen. All samples collected will be grab samples consisting of a 1-liter amber glass bottle on a grab pole, collected from center channel. The amber bottles will be sealed with Teflon-lined lids. Samples will be transported and stored on wet ice or refrigerated at $4^{o}C$ until extraction for chemical analysis. Dissolved oxygen, pH, specific conductivity, and water temperature will be measured *in situ* at each site as described in section IV. Water monitoring will be conducted as described in SOP FSWA002.0 and SOP QAQC004.01.

VIII. SEDIMENT SAMPLING METHOD

Sediment samples will also be collected and analyzed for esfenvalerate and permethrin. For the 10 sites there will be a total of 10 sediment samples. Sediment samples will be collected using a 24 inch long, by 2 inch diameter, polycarbonate cylinder tube, and a 4 inch putty knife. One end of the tube will be thrust into the sediment and then removed. The top 2 inches of the sediment collected in the tube will be placed into a wide mouth polycarbonate container. This will be repeated 2 times so that each sample will be a composite of 3 grabs.

IX. MACROINVERTEBRATE AND CHEMICAL ANALYSIS

The California Department of Fish and Game will perform macroinvertebrate identification. Quality control will be conducted in accordance with previously established DFG procedures, which have been approved by DPR. A sub-sample of 500 macroinvertebrates will be identified to genera and, when possible, to species.

The California Department of Food and Agriculture's Center for Analytical Chemistry will perform chemical analysis of water. Quality control will be conducted in accordance with SOP QAQC001.00 (Segawa, 1995). The California Department of Fish and Game (DFG) will perform chemical analysis of sediment. Quality control will be in accordance with established DFG procedures, approved by the DPR lab liaison. Ten percent of the total number of analysis will be submitted with field samples as field blanks and blind spikes.

The reporting limit is the lowest concentration of analyte that the method can detect reliably in a matrix blank. Comprehensive chemical analytical methods will be provided in the final report.

X. DATA ANALYSIS

Macroinvertebrate analysis procedures are based on theU.S. EPA's multi-metric approach to bioassessment data analysis. A taxonomic list of the benthic macroinvertebrates (BMI) identified in each sample will be generated along with a table of sample values and means. Variability of the sample values will be expressed as the coefficient of variability (% CV). This data will be used to compare and interpret biological data from other monitoring sites within the same region.

It may be used at a later date to develop an Index of Biological Integrity (IBI) for the San Joaquin Valley. The IBI is a synthesis of biological information, which numerically depicts an association between anthropogenic factors and biological attributes. It is composed of several biological attributes or 'metrics' that provide reliable and relevant signals about the biological effects of human activities. The multi-metric approach compares what is found at a monitoring site to what is expected using a regional baseline condition that reflects little or no human impact.

XI. TIMETABLE

Field Sampling:	Fall 2003, Spring 2004, Fall 2005
Memorandum:	December 30, 2004
Final Report:	June 30, 2005

XII. BUDGET

<u>Bioassessment Analysis</u>		
BMI identification (separate budget, under contract)		$ 0
<u>Personnel Services</u>		
3 Env. Scientist	160 hours each @ $20/hr.	$ 9,600
Senior Env. Scientist (Spurlock)	10 hours @ $32/hr	320
Senior Scientist (Harrington)	30 hours (Separate budget, under contract)	0
Staff benefits	(31%)	3,075
Scientific Aide	40 hours @ $11/hr.	440
Staff benefits	(11%)	48
Student	160 hours Separate budget, under contract	0
Overhead	(20%)	2,697
Total		**$ 16,180**
<u>Operating expenses</u>		
Field supplies - Equipment	Ethyl alcohol, ice, misc.	$500
TOTAL		**$16,680**

XIII. REFERENCES

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Table 1. Water Quality Stressors

• Temperature • Dissolved Oxygen • Specific conductance • pH	• Nitrate • Phosphate • Ammonia • Alkalinity • Turbidity
• Select OPs in water • Select Triazines in water • Select Pyrethroids in water	• Select OPs in sediment • Select Pyrethroids in sediment • Select trace elements in sediment (Sediment analysis dependent on available funds)

Table 2. Selected Pesticides

Organophosphates	**Carbamates**
Azinphos methyl	Aldicarb
Chlorpyrifos	Aldicarb Sulfoxide
Diazinon	Aldicarb Sulfone
DDVP (dichlorvos)	Carbaryl
Dimethoate	Carbofuran
disulfoton	Mesurol
ethoprop	Mesurol Sulfone
Fenamiphos	Mesurol Sulfoxide
Fonofos	Methomyl
Malathion	Oxamyl
methidathion	3-Hydroxycarborfuran
Methyl Parathion	Ziram
Phosmet	
Thimet (Phorate)	**Other Pesticides**
Profenofos	EPTC
Tribufos	Pebulate
	Formetanate Hydrochloride (Carzol)
Pyrethroids	Benomyl
Esfenvalerate	Maneb
Permethrin	Iprodione
Bifenthrin	Endothall, disodium salt
Lambda Cyhalothrin	
Cyfluthrin	
Cypermethrin	

Table 3. Selected Streams in the San Joaquin Valley

Drainage basin 32 – East of the Delta
- Mosher Creek (Calaveras River to Interstate 5)
- Mormon Slough
- Bear Creek (Main ditch to Interstate 5)
- Pixley Slough
- Laguna-Hadselville Creek
- Consumnes River (Folsom-South Canal to Highway 99)

Drainage Basin 35A
- Little Johns Creek (Between Goodwin Dam and the North Main Canal)
- Simmons Creek

Drainage Basin 35B
- Canal Creek
- Edendale Creek
- Parkinson Creek
- Hartley Slough
- Fahrens Creek
- Black Rascal Creek
- Bear Creek
- South Slough
- Miles Creek (Upstream of the Puglizevich dam)
- Owens Creek
- Dutchman Creek
- Chowchilla River

Drainage Basin 41
- Los Banos Creek
- Garzas Creek

Drainage Basin 45
- Fresno River
- Berenda Creek
- Dry Creek
- Cottonwood Creek
- Chowchilla River
- Berenda slough
- Ash Slough

Other selected basins had no streams dominated by agricultural supply water.

Figure 1a.

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME	LOCATION	
STATION #________ RIVERMILE________	STREAM CLASS	
LAT __________ LONG __________	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY	DATE ________ TIME ________ AM PM	REASON FOR SURVEY

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Figure 1b.

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement, over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score ______

Figure 2a

Physical Characterization

(Modified EPA multi-habitat method)

Study #: ___________________ **Date/Time:**___________________________________

Sampling Crew: _____________ **Location:** ____________________________________

Weather Conditions: ____

Lat:		Long:			
Elevation:		Physical habitat quality score:			
Gradient:					
		Avg. =			
% canopy cover:					
		Avg. =			

<u>Canopy cover</u> = Take 4 measurements at each transect facing each direction (north, south, east & west) and average. Total reach canopy cover = the average of these 11 numbers.

Squares	%	Squares	%	Squares	%	Squares	%
1	4	**7**	29	**13**	54	**19**	79
2	8	**8**	33	**14**	58	**20**	83
3	13	**9**	37	**15**	62	**21**	87
4	17	**10**	40	**16**	67	**22**	92
5	21	**11**	46	**17**	71	**23**	96
6	25	**12**	50	**18**	75	**24**	100

Depth:					
		Avg. =			
Depth is measured in thalweg of each transect and averaged					
Comments:					

<u>Watershed features</u>	Description	**<u>Local watershed NPS pollution</u>**	
Forest	____________	No evidence	____________
Field/Pasture	____________	Some potential sources	____________
Agricultural	____________	Obvious sources	____________
Residential	____________	**<u>Local watershed erosion</u>**	
Commercial	____________	None	____________
Industrial	____________	Moderate	____________
Other	____________	Heavy	____________

Physical Characterization

(Modified EPA multi-habitat method)

Instream features

- Stream width is considered to be of "typical" width within approximately 5 stream widths upstream and downstream of the center of the reach.
- Stream depth is measured at center stream.

Reach length (m) ________________

Stream width (m) ________________

Sampling reach area (m^2) ________________ (feet x 0.3048m = meters)

Area in km^2 (m^2x1000) ________________ (yards x 0.9144m = meters)

Aquatic vegetation (Indicate the dominant type (%) and record the dominant species present)

Rooted emergent ________________ Free floating ____________________________

Rooted submergent ________________ Floating algae ____________________________

Rooted floating ________________ Attached algae ____________________________

Dominant species present ________________

Portion of the reach with aquatic vegetation

Note: All water chemistry measurements, water and sediment samples are to be collected from the center of the reach.

Habitat Types (Indicate the % of each habitat type present)		**Organic substrate components** (Does not necessarily add up to 100%)	
Cobble		**Substrate type**	**% Composition in reach**
Gravel		Detritus (Sticks, wood, coarse plant materials (CPOM))	
Mud			
Sand and fine sediment		Muck-mud (Black, very fine organic (FPOM))	
Snags			
Vegetated Banks (undercuts & overhangs)		Marl (Grey, shell fragments)	
Submerged macrophytes			
Other			

Figure 3a

Water Quality Field Data Sheet

(Modified EPA multi-habitat method)

Study #: ______________________ **Date/Time:**______________________________
Sampling Crew: _______________ **Location:** ________________________________

Weather Conditions: ____

GPS Coordinates				
Avg reach width		Reach Length		
Water Quality		**Samples**	**#**	
Temperature		OP –WAT		
EC		TR – WAT		
DO		PY – WAT		
PH		BU – WAT		
Nitrate		OP -SED		
Phosphate		PY - SED		
Ammonia N		Metals - SED		
Turbidity				
Alkalinity				

Water odors: (i.e. normal, fishy, sewage)	
Water Surface Oils: (i.e. slick, sheen, globs, flecks, none)	
Turbidity: (i.e. clear, slightly turbid, turbid, opaque, stained)	

Diagram of reach

Figure 3b

Water Quality Field Data Sheet

(Modified EPA multi-habitat method)

Discharge:
Measured at one channel cross section (representative of the average channel width) within the sampling reach.
Follow procedure as described in SOP FSWA009.00

					VELOCITY					SAMPLING DEPTH(S)					
Dist. From initial point	Width	Depth	.6 or .2/.8	Obser-vation Depth	FPS At Point	V.S. Coef	FPS Mean in Vertical	Area	Dis-charge	WATER DEPTH	0.6	0.2	0.8	Inches to feet	
										0.9	0.5			1	0.08
										1	0.6			2	0.17
										1.1	0.7			3	0.25
										1.2	0.7			4	0.33
										1.3	0.8			5	0.42
										1.4	0.8			6	0.50
										1.5	0.9			7	0.58
										1.6	1.0			8	0.67
										1.7	1.0			9	0.75
										1.8	1.1			10	0.83
										1.9	1.1			11	0.92
										2	1.2			12	1.00
										2.1	1.3				
										2.2	1.3				
										2.3	1.4			Vertical	
										2.4	1.4			Surface	
										2.5	1.5	0.5	2.0	Coef.	
										2.6		0.5	2.1	ratio	
										2.7		0.5	2.2	w/d	Coef
										2.8		0.6	2.2	>1	1.00
										2.9		0.6	2.3	0.50	0.95
										3		0.6	2.4	0.25	0.90
										3.1		0.6	2.5	0.01	0.65
										3.2		0.6	2.6		
										3.3		0.7	2.6		
										3.4		0.7	2.7		
										3.5		0.7	2.8		
										3.6		0.7	2.9		
										3.7		0.7	3.0		
										3.8		0.8	3.0		
										3.9		0.8	3.1		
										4		0.8	3.2		

Figure 4a

SUBSTRATE SIZE

Study #: ____________________ Date/Time: ________________________________

Sampling Crew: ______________ Location: __________________________________

PARTICLE SIZE CLASS (mm)	5 evenly spaced stabs per transect	
	Tallies	**Count**
BEDROCK (SMOOTH) (larger than a car)		
Bedrock (rough) (larger than car)		
Large Boulder 1000-4000mm (meterstick to car)		
Small Boulder 250-1000mm (basketball to meterstick)		
Cobble 64-250mm (tennisball to basketball)		
Coarse Gravel 16-64mm (marble to tennisball)		
Fine Gravel 2-16mm (ladybug to marble)		
Sand 0.06-2mm (gritty-up to ladybug size)		
Fines (silt, clay,muck, not gritty)		
Hardpan (firm, consolidated fine substrate)		
Wood (any size)		
Concrete/Asphalt		
Other		

Code	Size Class	Size Range	Description
RS	Bedrock (Smooth)	>4000	Smooth surface rock bigger than a car
RR	Bedrock (Rough)	>4000	Rough surface rock bigger than a car
HP	Hardpan		Firm, consolidated fine substrate
BL	Boulders	>250 to 4000	Basketball to car size
CB	Cobbles	>64 to 250	Tennis ball to basketball size
GC	Gravel (Coarse)	>16 to 250	Marble to tennis ball size
GF	Gravel (Fine)	>2 to 16	Ladybug to marble size
SA	Sand	>0.06 to 2	Smaller than ladybug size, but visible as particles-gritty between fingers
FN	Fines	<0.06	Silt Clay Muck (not gritty between fingers)
WD	Wood	Regardless of Size	Wood & other organic particles
OT	Other	Regardless of Size	Concrete, metal, tires, car bodies etc. (describe in comments)

Side 1

Figure 4b

SUBSTRATE EMBEDDEDNESS

TRANSECT	EMBEDDEDNESS % * **(5 evenly spaced stabs per transect)**					Average
A						
B						
C						
D						
E						
F						
G						
H						
I						
J						
K						

***** For particles larger than sand, examine the water surface for stains, markings, and algal coatings to estimate the average embeddedness. Embeddedness is the fraction of a particle's surface that is surrounded by sand or finer sediments on the stream bottom. By definition, sand, silt, clay, and mud are embedded 100 percent; bedrock and hardpan are embedded 0 percent.

Example: Fifty percent embedded.