An Evaluation of Regulations, Effects, and Management of Aggregate Mining in Northern and Central Coastal California

Prepared for

National Marine Fisheries Service
Southwest Region

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EXECUTIVE SUMMARY

Gravel mining in rivers, floodplains, and terraces within the northern and central coast of California has had varying degrees of impacts to river ecosystems and the anadromous salmonids that inhabit them. The objective of this document is to assist National Marine Fisheries Service (NMFS) in its efforts to avoid or minimize potential and probable impacts of instream gravel mining on listed salmonid species and their critical habitat.

Chapter 1 explores the relationship between local land use planning, state or federal environmental regulations, the Public Trust Doctrine, and mining in the river corridor. While local governments determine the use of lands within their jurisdiction, many state and federal agencies administer statutes that may restrict these land uses to avoid or minimize their effects on natural resources. In northern and central coastal California regulatory uncertainty is a consequence of the administration of often overlapping jurisdictions. While new laws are not needed, we do conclude that land use decisions and existing regulatory programs could be more effectively applied to mining in river corridors. Institutional remedies at each level of government are recommended that we believe will more effectively protect public trust resources, including salmon and their habitat. Ultimately, local land use decision makers must consider limiting uses in the river corridor to those which are compatible with the restoration of these federally listed salmonids and their critical habitat. A primary challenge to regulators is the difficulty of understanding, predicting, and monitoring probable and potential impacts of gravel extraction; therefore, regulatory programs must encourage and improve scientific input.

Chapter 2 summarizes the current scientific understanding of gravel extraction impacts to channel morphology, habitat, and biota. In the case of anadromous salmonids (and other species of concern), habitat is not simply confined to the bankfull channel or commonly flooded areas. It is contained within the entire river corridor. Direct impacts (direct harassment and disturbance of fish) are relatively easy to minimize by limiting extraction to dry bars during the summer, or pit extraction on floodplains and terraces. However, cumulative effects are far more difficult to predict, measure, and mitigate, and consequently have not been effectively evaluated in most mined rivers. Such effects include channel downcutting, braiding, bank erosion, channel widening, pit capture, reduced channel/floodplain connectivity, loss of riparian vegetation and woody debris recruitment, and reduced channel migration from bank revetments. Potential effects of instream mining at a single site can be delayed, distributed offsite, and combined with effects from nearby mining sites or other river influences (i.e., cumulative effects). Collectively, these potential effects will significantly reduce salmonid habitat quality and quantity.

Chapter 3 describes approaches to identifying riparian areas potentially affected by instream mining and a range of possible extraction strategies tailored to several generalized river situations and gravel mining management objectives. Our primary objectives were twofold. The first was to describe a tier of extraction strategies that spanned a wide range of annual extraction volumes expressed as a percentage of the "mean annual recruitment" (long-term average annual bedload supply to a river reach, or MAR), a tool we recommend for avoiding or minimizing cumulative effects from instream aggregate mining. The second objective was to link potential habitat impacts to recommended monitoring and adaptive management strategies that are incrementally more sophisticated as expected impacts increase.

Only by excluding gravel extraction from the river corridor can future mining impacts to salmonid habitat be avoided. Therefore, minimizing potential impacts is the best that can be expected if mining is to continue within the river corridor.

GLOSSARY OF HYDROLOGIC AND GEOMORPHIC TERMS

Aggradation: a net increase in channel bed elevation by deposition of sediment on the channel bed surface.

Avulsion: the process of catastrophic development of an entirely new channel adjacent to the original.

Bankfull channel: the channel within the bankfull stage and below the floodplain.

Base level: the downstream controlling elevation for a river or river reach.

Bed material: the sediment resting on the bed of the channel.

Bedload: the sediment moving along and just above the channel bed during high flow.

Braided channel: a channel form having multiple low flow threads.

Channel migration: the lateral movement of a channel through time as a result of bank erosion or Avulsion (see also meander belt).

Channelization: straightening of a river channel or containment of a river between levees.

Constriction: location of significantly narrowed channel width relative to average width upstream and downstream.

Conveyance: ability of a channel to pass water downstream.

Degradation: a net decrease in channel bed elevation by erosion of sediment on the channel bed surface

Entrenchment: the ratio of flood-prone width to bankfull channel width.

Fluvial geomorphology: the science of river form and process

Geomorphology: the science of changes in the shape of the earth's surface

Headward erosion: the process of channel bed erosion upstream from an abrupt drop in the longitudinal profile of a stream.

Incision: vertical erosion of a channel bed.

Knickpoint migration: see headward erosion.

Lateral migration: lateral movement of a river channel due to erosion of a bank at the outside of a bend.

Meander belt: the zone within which channel migration occurs, as indicated by abandoned channels, oxbow lakes, and accretion topography.

Meander: one of a series of a somewhat symmetrical , loop-like bends in the course of a stream.

Meander cutoff: the shortened channel resulting when a stream cuts across the inside of a meander bend.

Meandering channel: a characteristic of mature rivers wandering freely across a well-developed floodplain

Planform: the nature of the alignment of a river when viewed from above

Recruitment: the volume of bedload passing a specific point on a river over the course of a single high flow season.

Replenishment: the net change in bed material volume (stored sediment) that occurs on a river reach over the course of a single high flow season.

Sediment: mobile material in storage or episodically transported within a river channel and floodplain.

Sediment transport: the process of sediment movement by the force of flowing water.

Sediment balance/budget: an accounting of sediment inflows, outflows, and storage changes in a river or river reach.

Sinuosity: a measure of the degree of channel planform wandering, calculated as the channel length divided by downvalley length.

Skimming: gravel extraction by removing the near-surface bed material on a bar surface.

Suspended sediment: the sediment in suspension within the water column, usually during high flow.

Sustained yield: the volume of gravel that can be removed by mining without causing changes to river morphology or mean bed elevation. Can be considered on a variety of spatial scales, from the individual bar, to a reach, to an entire river system.

Thalweg: the deepest point within the channel.

Trenching: extraction below the water surface elevation within the active channel of a river.

Turbidity: cloudiness in water produced by suspension of sediment.

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1. REVIEW OF THE REGULATION OF INSTREAM AGGREGATE MINING IN NORTHERN AND CENTRAL COASTAL CALIFORNIA

1.1. INTRODUCTION

The complexity of natural ecosystems is well known, but the regulatory world affecting these natural ecosystems is nearly as complex. In the regulatory world, property rights are universal and pervasive principles. But the interplay between local, state and federal governments affecting public versus private property rights has created regulatory uncertainty in the arena of commercial mining in river environments.

This chapter will explore the adequacy of existing mining regulations applied at three levels of government, local, state and federal, to regulate commercial mining in riverine environments in northern and central coastal California; will summarize commercial mining (defined as both extraction and reclamation) regulatory standards in northern and central coastal California; will discuss the current regulatory uncertainty surrounding the regulation of commercial mining in riverine environments; and will present recommendations to facilitate institutional remedies.

The Secretary of Commerce based his decisions to list Chinook salmon, Coho salmon, and Steelhead, in northern and central coastal California, in part, on the finding that existing regulatory mechanisms have been inadequate in protecting these species (Federal Endangered Species Act (ESA) Section 4 (a)(1)(A)), which are now listed as threatened under the ESA. Commercial aggregate mining in river corridors can threaten these listed species. To prevent the extinction of these species as a society we must address whether we need new regulations, or whether we need to more effectively apply and/or modify existing regulations.

In California, land ownership determines who has the authority to regulate land uses. California's constitution (Article XI, Section 7) grants police powers to local government to regulate use of privately held lands that are within it's the local governments jurisdiction (see Figure 1). Commercial aggregate mining is one such land use, regulated by local government. Local governments decide, for each land use zone, which land uses are to be principally or conditionally permitted or prohibited. Therefore, local governments determine where commercial aggregate mining will be allowed. In coastal California local government has decided that commercial mining is a conditionally permitted use within certain zoning districts. When local government issues a Conditional Use Permit (CUP), to a commercial mine operator the local government establishes the volume and manner in which extraction and reclamation will occur.

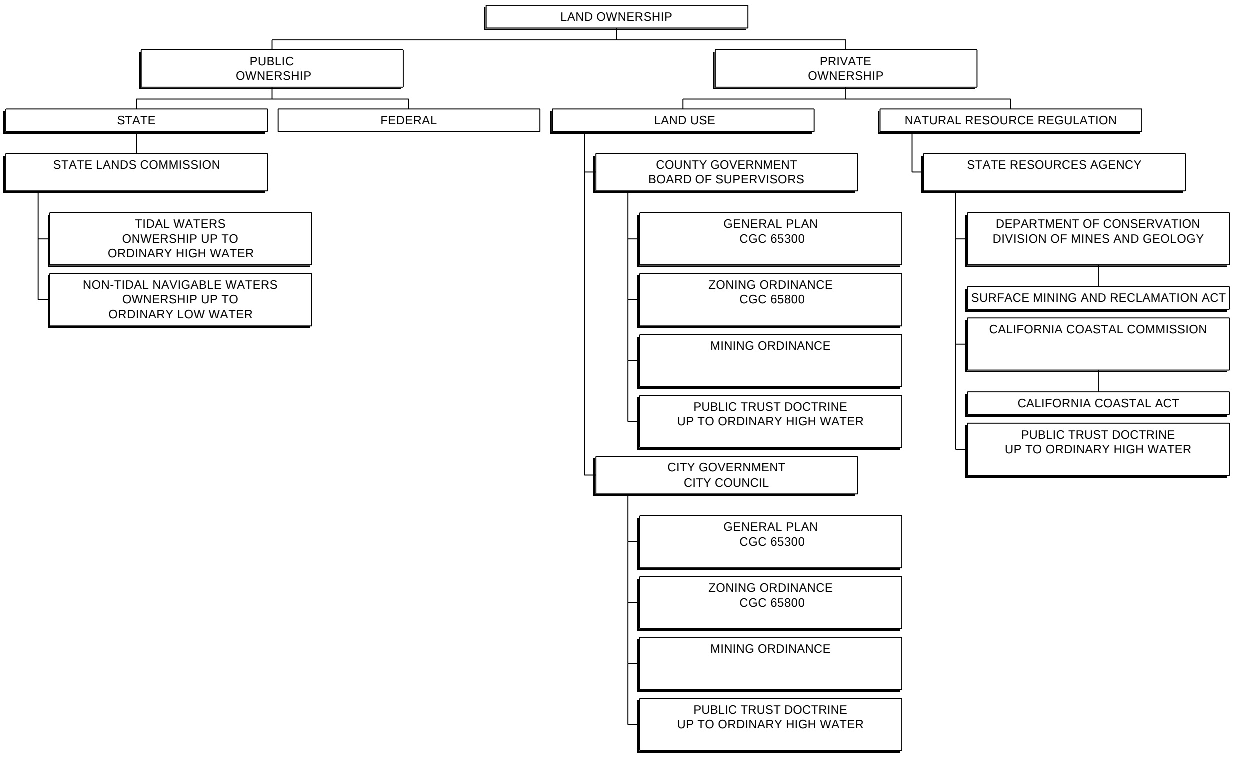
State and federal regulatory agencies may also impose additional operational restrictions on mining on private lands, when the additional restrictions are necessary to protect public resources. However, in California, only local government can designate which private lands are permitted to be mined; State or Federal agencies have no authority to designate land use on private land.

In California Coastal Commission v. Granite Rock, the U.S. Supreme Court held that:

> "*Land use planning in essence chooses particular uses for the land; environmental regulation, at its core, does not mandate particular uses for the land but requires only that, however the land is used, damage to the environment is kept within prescribed limits.*"

The State of California attempts to keep "damage to the environment within prescribed limits" through two legislative acts, the Surface Mining and Reclamation Act in 1975 (SMARA) (Public Resources Code (PRC), Sections 2710 et seq.), and the California Environmental Quality Act (CEQA) (PRC, Section 21000 et seq.). The Department of Conservation's Division of Mines and Geology administers SMARA. In 1993, SMARA was amended (California Code of Regulations (CCR), Title 14, Divisions 2, Chapter 8, Sections 3700 et.al), to establish minimum surface mining and reclamation standards on private lands. To retain local control over a land use such as commercial aggregate mining, all coastal California counties, within the range of anadromous salmonids, have adopted Surface Mining and Reclamation Ordinances; at a minimum, these ordinances incorporate the state's mining and reclamation act. Aggregate mining operators must obtain a Special Permit to mine, a CUP, and have an approved reclamation plan. The local lead agency's issuance of the two permits, and its approval of a reclamation plan, are discretionary decisions which require compliance with the CEQA. Three coastal counties, (Humboldt, Mendocino, and Sonoma) have prepared Programmatic Environmental Impact Reports (PEIR) for commercial aggregate mining. Mendocino and Sonoma Counties have also prepared aggregate management plans in addition to their PEIRs, Sonoma County has implemented its aggregate management plan to regulate commercial aggregate mining.

Figure 1. Land ownership and the regulation of commercial aggregate mining in California



1.2. CALIFORNIA PLANNING AND ZONING LAW

In California, the responsibility for regulating a land use such as commercial aggregate mining is ultimately derived from the state's planning and zoning laws. In 1971 the state required local legislative bodies (i.e. counties) to adopt a general plan and a conforming zoning ordinance (California Government Code (CGC) Sections 65300, 65800). The general plan requires a land use element, and a land use map that identifies the location of each land use district and determines which property is included in each district. A local legislative body is the sole authority that assigns land use districts where commercial aggregate mining is allowed. For example, in Humboldt County, commercial aggregate mining is an allowable use in a "natural resource district" but not in an "agricultural district", while in Sonoma County, aggregate mining is an allowable use in an agricultural district.

A General Plan contains policies meant to guide all land use decisions within the County's jurisdiction. The implementation of land use policies may require adoption of land use ordinances covering zoning, grading, riparian protection or surface mining and reclamation. Land use ordinances are the regulatory vehicle by which local legislative bodies govern uses such as commercial aggregate mining. Zoning ordinances are parcel-specific. For each land use district, zoning ordinances establish which land uses are to be principally versus conditionally permitted; any uses not listed are prohibited. Principally permitted lands uses, are compatible with all other uses in the district and are appropriate for any parcel in the district. Land uses not principally permitted could be prohibited. However, a conditional use permit (CUP) can be issued by land use authorities; the CUP provides an exception to the practice of limiting uses to those that are suitable for every parcel in a district. A CUP contains conditions of operation to mitigate adverse effects to the public, other property and the environment. In California's coastal counties, commercial aggregate mining has been designated as an allowable use, not as a principally permitted use, but as a conditionally permitted use. Since 1971, or from the date of adoption of each county's general plan and zoning ordinance, land use authorities can regulate the location, method, and volume of any new commercial aggregate operation through the CUP process. The local land use authorities in Mendocino and Sonoma counties have also developed Aggregate Management Programs to mitigate adverse cumulative effects of multiple commercial aggregate mining operations on a river reach.

Despite the zoning ordinances and the CUP process, local land use entities do not have sufficient authority to effectively manage commercial aggregate mining. Two conditions affect the orderly planning and management of commercial aggregate extraction by local authorities: 1) non-conforming uses, and 2) vested rights.

As the designated lead agency under California's general plan and zoning laws, and SMARA local land use authorities' ability to comprehensively manage the location, and number of mine operations or cumulative amount of commercial aggregate extracted, is complicated by operators with pre-existing property rights. Mine operations that pre-date the adoption of a local zoning ordinance became legal non-conforming uses; those that pre-date adoption of state statutes (such as SMARA in 1975) have vested property rights. Therefore, on any given river in coastal California, depending on their inception date of mining, operations can be subject to different degrees of land use restrictions. This study did not receive sufficient information from coastal counties, and therefore did not attempt, to quantify the number of commercial mining operations which pre-date 1975. These early mining operations could be either a non-conforming use if they pre-date the local zoning ordinance or have a vested right if they pre-date SMARA or the California Coastal Act (CCA). Information provided by local governments indicates that this situation does occur in practically every county, and on most rivers.

Land uses, such as commercial aggregate mining are normally not allowed to operate without a CUP. However, some commercial aggregate mining operations are considered to be a non-conforming use, and do not have a CUP because they have been in continual operation prior to the adoption of a local general plan or zoning designation. As a non-conforming use, these earlier mining operations are allowed to continue to conduct their activity similar to a principally permitted use, even if this use does not conform to the General Plan or may have adverse environmental effects. Increasing the degree of nonconformity by the expansion of a non-conforming use or moving the use to another location on the property is prohibited. One goal of California's planning and zoning laws is to eventually eliminate non-conforming uses, with the immediate objective being to restrict, not increase, the nonconforming use.

Those commercial aggregate mining operations vested with a previously existing property right, are allowed to continue to mine without the mining permit that SMARA requires for new operations. These vested right operations can continued to mine, provided they operate in the same method, location, volume, and frequency; they are not required to adhere to SMARA or the local Surface Mining and Reclamation Ordinance. In California, non-conforming operations or operators with vested rights have impaired the ability of local land use authorities to comprehensively manage the number, location, and quantity of commercial aggregate being extracted. Again, this study did not receive sufficient information from each county to be able to quantify the magnitude of this problem in central & northern coastal California.

1.3. CALIFORNIA ENVIRONMENTAL QUALITY ACT

Adopting a reclamation plan, and granting a Special Permit (for commercial mining) and a CUP, are discretionary decisions of a local lead agency; they are considered a project under CEQA. Non-conforming and vested commercial aggregate mining operations may not have a CUP. Those commercial aggregate mining operations without a CUP have not complied with CEQA. One of CEQA's primary purposes is to publicly disclose all potential significant impacts from a proposed project before its approval. If the lead agency is presented with a fair argument that a project may have a significant effect on the environment, or if the lead agency determines there is substantial evidence that the project may have a significant effect on the environment, the lead agency must prepare an EIR. To comply with CEQA, an analysis of the potential environmental impacts from commercial aggregate extraction must address whether the aggregate mining, within the active channel, meander zone, or river corridor has a substantial adverse effect either directly or through habitat modifications, on any federally or state listed species, on any riparian habitat or other identified sensitive natural community (riverine ecosystem), and on federally protected wetlands (riverine ecosystem) as defined in Section 404 of the Clean Water Act through direct removal of aggregate?

CEQA Guidelines (PRC Section 15065 (a) (b) and (c)) require a "Mandatory Finding of Significance" and the preparation of an EIR, if a lead agency determines that a project has the potential:

1. to substantially reduce the habitat of a fish, cause a fish population to drop below self-sustaining levels, or reduce the number or restrict the range of an endangered, rare or threatened species,

2. to achieve short-term environmental goals to the disadvantage of long-term environmental goals, and

3. to cause environmental effects which are individually limited but cumulatively considerable.

Chapter 2 of this report provides a detailed discussion of significant biological and physical effects from commercial aggregate mining.

If an EIR is to be prepared to comply with CEQA, alternatives to the proposed project are required to be evaluated. Therefore, a clear statement of the underlying purpose of the proposed project is necessary. Limiting an EIR's discussion of a project's alternatives to those that utilize just the property owned by the applicant, or limiting the analysis to just instream sources of aggregate, does not comply with CEQA. CEQA states that decision-makers have a duty to avoid or minimize environmental damage where feasible (PRC Section 15021 (a)). If putting a project in another location, such as outside of the river corridor would avoid or minimize any of the significant effects of the project, then that location, is a credible alternative to the project despite its ownership. Unfortunately, lead agencies often conduct a limited alternative analysis with a bias towards the proposed project's location; this occurred in 1999 in an EIR's alternative analysis of a commercial aggregate extraction operation in Sonoma County. Clearly, there are alternative locations for commercial aggregate mining that have less significant adverse impacts than mining in the active channel, yet they were not reviewed in the Sonoma County case because the project proponent did not have a lease to mine anywhere else. A lead agency should not approve a project as proposed if there are feasible alternatives or mitigation measures available that would substantially lessen any significant effects that the project would have on the environment (PRC Section 15021 (a)(2)). In the example above, in Sonoma County, the project's underlying purpose was to provide commercial aggregate for the local community. The duty of a lead agency to avoid or reduce environmental damage from a project is a constraint on approving projects that have environmental effects which can be avoided at an alternative location.

CEQA requires that each potentially significant adverse impact be mitigated to less than significant when possible. A lead agency must establish a threshold for significance for each potential significant impact identified during the project's Initial Study. The purpose of a mitigation measure is to reduce the project's impact to below that threshold. Mitigation measures that are acceptable under CEQA must be disclosed in sufficient detail so that public and decision-makers can assess whether the measures will avoid, minimize, rectify, reduce over time, or compensate for the project's significant impacts. Mitigation measures that are not acceptable include those that consult with, submit for review, coordinate with, study further, inform; encourage/discourage, facilitate, or strive to achieve, mitigation.

In 1992, Humboldt County prepared a Programmatic EIR (PEIR) for the lower Eel and Van Duzen Rivers; the PEIR identified an adverse significant cumulative impact from 13 commercial aggregate mining operations that could potentially remove a total annual volume of 1,480,000 cubic yards. The mitigation measure proposed in the 1992 PEIR was to develop a "River Management Plan" (RMP). The PEIR did not disclose the significant impact threshold nor how the RMP would reduce the cumulative impact to less than significant. The proposed mitigation measure was inadequate because: 1) it deferred to a future study (a RMP that the County would have prepared), and 2) there was no guarantee that the RMP would be commissioned or implemented. In fact, the RMP has never been prepared. All mitigation measures approved must have a monitoring plan to document that the measure was implemented correctly, and that the measure achieved the stated mitigation of the adverse significant impact.

Before decision makers approve a project, CEQA Guidelines (PRC Section 15064 (A)(2)) require a finding, for each significant impact identified, that the adverse environmental effect has been mitigated to less than significant, or that a statement of overriding considerations has been adopted for the project. However, a statement of overriding consideration requires a finding that the benefits of the project outweigh the <u>unavoidable</u> adverse environmental effects. If an adverse environmental effect of a project could be avoided by relocating the project, a statement of overriding consideration would not be supportable.

1.4. SURFACE MINING AND RECLAMATION ACT

In 1975, the state legislature adopted the Surface Mining and Reclamation Act, which pre-empted local government's authority that had heretofore regulated surface mining and reclamation activities (PRC Sections 2710 et.al). After 1975, if a local land use authority wanted to be the lead agency and regulate commercial aggregate mining or processing, it must adopt a Surface Mining and Reclamation Ordinance, which incorporated SMARA. SMARA required all new mine operations to obtain a permit to mine, and to prepare a reclamation plan that would outline restoration of mined lands to a future beneficial use (PRC Section 2711 and 2712). SMARA (PRC Section 2772 (c) (8) (B)) requires that the reclamation plan describe the manner in which affected streambed channels and streambanks will be rehabilitated to a condition minimizing erosion and sedimentation.

SMARA was not enacted specifically to regulate commercial mining or reclamation in river ecosystems. SMARA's primary function is to mandate reclamation of mined lands to insure a future beneficial use. According to Kondolf (1993), the concept of reclamation was developed for terrestrial landscapes not dynamic riverine ecosystems. Reclamation is limited in its ability to maintain dynamic fluvial processes or mitigate impacts from mining in the river corridor. The requirement for mine reclamation (to provide for a future beneficial use) under SMARA is not the same as the CEQA's requirement to mitigate adverse effects from mining; as a result SMARA is not well adapted to the protection of natural resources such as anadromous fish.

By 1990, the state amended SMARA to require all mine operations, even those with vested rights, to obtain approval of their reclamation plans in conformance with SMARA (PRC Section 2776). The approval of a reclamation plan is a project under CEQA and is a discretionary decision that requires lead agency compliance with CEQA. Since 1993, SMARA has required that new mining operations, and existing reclamation plans which are substantially amended, must be brought into conformance with SMARA's new "minimum verifiable reclamation standards" (California Code Regulations (CCR) Sections 3700 et.al). When substantial amendments are proposed to reclamation plans, that were approved prior to January 15, 1993, the new "minimum verifiable reclamation standards" will apply.

1. Section 3700 requires conformance with mitigation identified in conformance with CEQA.

2. Section 3703 establishes that mitigation performance standards be incorporated for rare, threatened, or endangered species that are in accordance with the provisions of the Endangered Species Act.

3. Section 3710 establishes performance standards for stream protection. Specifically section (c) states, "Extraction of sand and gravel from river channels shall be regulated to control channel degradation", to prevent undesirable impacts that may result from degradation.

In 1996, the Resources Agency developed a draft "Instream Mining Monitoring Program" which included an adaptive management approach to instream mining activities. The goal of the monitoring program was to collect information for tracking streambed elevations and trends in fluvial geomorphology. Section 3710(c) states that "changes in channel elevations and bank erosion shall be evaluated annually using records of annual extraction quantities and benchmarked annual cross sections/or sequential aerial photographs to determine appropriate extraction locations and rates." The monitoring program's results were to be used by land use and regulatory agencies, to make informed river management decisions. However the California Board of Mines and Geology declined to adopt the Resource Agency's instream mining monitoring program; the program became voluntary.

Neither SMARA nor local land use authorities regulate all instream aggregate mining activities. Mine operations that extract less than 1,000 cubic yards annually, or disturb less than 1.0 acre in size per site, are exempt from SMARA. These small-scale, single entry mine operations are associated with allowable land uses such as agriculture or timber production; as such they do not require a CUP and receive no review under CEQA. In 1994, a comprehensive inventory of aggregate mining operations; those with "1600 agreements" with the California Department of Fish and Game was conducted (Trinity Associates, 1994). The inventory covered each county and watershed of coastal California within the San Francisco District of the Army Corps of Engineers (COE) (see Table 1).

Table 1. Number of aggregate mine sites, on file with CDFG from 1991-1993, in San Francisco District of COE.

COUNTY	TOTAL SITES	INSTREAM SITES	TERRACE SITES	EXEMPT	DATA N/A
Del Norte	21	21	0	7	1
Siskiyou	10	10	0	2	4
Trinity	10	9	1	4	3
Humboldt	118	118	0	51	10
Mendocino	60	58	2	13	14
Lake	13	13	0	5	4
Sonoma	38	35	3	9	14
Napa	3	3	0	1	0
San Benito	10	10	0	0	7
Monterey	15	15	0	2	2
San Luis Obispo	32	32	0	3	11
TOTAL	**330**	**324**	**6**	**97**	**70**

Exempt sites are those sites that extract less than 1,000 cubic yards or that disturbs less than 1.0 acres.

The 1994 inventory project, also created a database and AutoCAD map files that identify aggregate mining sites within the river corridor, for each watershed from Siskiyou County to San Luis Obispo County (see Table 2).

The 1994 inventory found that over a three year period (1991-1993), the California Department of Fish and Game (CDFG) issued 324 Streambed Alteration Agreements (SAA) in this region of coastal California for instream aggregate mining. Of the 324 instream mine operations, 52% of these were either exempt (97 sites) from SMARA, and local Surface Mine and Reclamation Ordinances, or had no volume or permit data available (70 sites). In some instances, CDFG issued a single SAA to a timberland owner or operator; the SAA covered instream extraction at multiple instream mining within a single watershed. Therefore, the actual number of exempted instream aggregate mining sites may have been substantially greater than that listed in Table 2.

These small (less than 1,000 cubic yards) mine sites are most often associated with, or incidental to, an otherwise principally permitted land use, such as agriculture or timber production. Until a Mendocino County Superior Court decision in 1999 (Mendocino Environmental Center v. CDFG, Superior Court, County of Mendocino), these locally exempted instream aggregate extraction projects needed only a CDFG Streambed Alteration Agreement. CDFG is now required to be lead agency under CEQA for these exempted projects, if the projects have not already complied with CEQA.

Table 2. Number of aggregate mine sites, on file with CDFG from 1991 to 1993 by watershed in coastal California.

WATERSHED	MINES	INSTREAM	TERRACE	EXEMPT	DATA
	SITES	SITES	SITES		N/A
SMITH RIVER	12	12	0	1	0
PACIFIC OCEAN TRIBUTARY	1	1	0	1	0
KLAMATH RIVER	11	11	0	7	1
SCOTT RIVER	8	8	0	0	3
TRINITY RIVER	8	7	1	0	1
SOUTH FORK TRINITY RIVER	3	3	0	2	1
MAD RIVER	14	14	0	2	2
REDWOOD CREEK	3	3	0	1	1
LOWER EEL RIVER	34	34	0	7	1
VAN DUZEN TOTAL	43	43	0	33	1
SOUTH FORK EEL RIVER	10	10	0	4	0
UPPER EEL RIVER	14	14	0	0	0
MIDDLE FORK EEL RIVER	7	7	0	0	2
BEAR RIVER	3	3	0	0	0
MATTOLE RIVER	13	13	0	13	5
GARCIA RIVER	5	4	1	2	0
PACIFIC OCEAN TRIBUTARY	4	3	1	1	1
NAVARRO RIVER	4	4	0	2	0
GUALALA RIVER	7	7	0	4	1
RUSSIAN RIVER	46	43	3	5	19
CLEAR LAKE TRIBUTARIES	7	7	0	6	0
PUTAH CREEK	6	6	0	1	2
NAPA RIVER/SAN PABLO BAY	3	3	0	1	1
SAN BENITO RIVER	5	5	0	0	0
PAJARO RIVER	1	1	0	0	0
ESTRELLA RIVER	4	4	0	1	1
SALINAS RIVER	29	29	0	3	3
PACIFIC OCEAN TRIBUTARIES	4	4	0	0	3
CUYAMA RIVER	2	2	0	0	1
SANTA MARIA RIVER TOTAL	5	5	0	0	0
	316	**310**	**6**	**97**	**50**

1.5. STREAMBED ALTERATION PROGRAM

The Streambed Alteration program is based on state legislation enacted in 1965 following hearings on the effects of gravel mining on spawning habitat of salmon and steelhead. The program applies to any state or local agency, public utility, or person, who proposes an activity that will substantially change the channel bed or bank of any river or stream or use materials from a streambed. The program requires that project proponents notify CDFG before beginning the activity, but does not grant Fish and Game permitting authority. Instead, notification leads to a negotiated agreement between the proponent and CDFG. A streambed alteration agreement is only required if CDFG determines that the proposed activity may substantially adversely affect fish or wildlife resources. CDFG can propose measures that are necessary to protect the fish and wildlife resources that are impacted by the proposed activity. If these measures are unacceptable to the project proponent, an arbitration panel may be requested, to resolve their disagreement with CDFG.

In 1990, due to an increase in the number of mining operations, to an increased volume of aggregate extracted, and to a lingering drought in Region 1, CDFG, began requesting pre- and post-monitoring data from operations extracting more than 5,000 cubic yards. CDFG was concerned that without such data, it could not assess direct and cumulative effects of aggregate mining on fish and wildlife. In 1991, the California Resources Agency and CDFG entered into a memorandum of understanding (MOU) with the mining operators on the Mad River in Humboldt County. The MOU proposed to establish a Scientific Review and Design Committee (SDRC) comprised of members from the scientific community qualified in hydrology, and fluvial geomorphology. The committee would review commercial instream mining projects that submitted Streambed Alteration notifications. In 1993, CDFG developed and adopted monitoring guidelines and standards for use by coastal instream mining operators in Region 1; these guidelines would help CDFG evaluate the Streambed Alteration notifications. In 1995, Humboldt County retained the MOU’s scientific team with a name change to County of Humboldt Extraction Review Team (CHERT), to conduct annual reviews of all commercial aggregate extraction operations throughout the their jurisdiction. CDFG continues to utilize the findings of CHERT in its annual evaluations of instream aggregate mining operations. However, CDFG has not entered into any other MOU for instream aggregate mining in other counties, nor retained the services of a similar scientific team.

Local government agencies have sole authority in determining which land uses are appropriate on private land. They establish where commercial aggregate extraction, can be located and the volume to be mined. Until the 1999 Mendocino court decision, the CDFG’s ability to affect instream aggregate extraction under its Streambed Alteration Program was limited. Now CDFG can require that potential damage caused by allowable land uses such as commercial mining be avoided, or mitigated, to less than significant under CEQA. Following the 1999 Mendocino decision CDFG significantly revised its Streambed Alteration Program. CDFG now assumes lead agency status under CEQA, for any project, either in whole or part, that has not previously complied with CEQA. Commercial aggregate production includes extraction and reclamation as well as the processing of aggregate products.

If an aggregate mining operation began its operations after 1975 when SMARA was enacted, it would have received a CUP for its mining and reclamation activities. Since 1990, all commercial aggregate extraction operations, even those that are nonconforming or vested, were required to have a reclamation plan approved by the local lead agency, and receive a CUP for reclamation. Note: these projects that were nonconforming or vested would not have received a CUP for their extraction activities. When CDFG enters into a streambed alteration agreement, it is now required to determine if the proposed activity, in whole or part, has already complied with CEQA. Consequently, for CDFG to comply with CEQA before it enters into a SAA, it must determine that the entire project (both mining and reclamation) has been reviewed under CEQA. If CDFG finds that some aspect of the project has not be reviewed under CEQA, it assumes lead agency status and initiates compliance action, before entering into a Streambed Alteration Agreement.

1.6. CALIFORNIA COASTAL ACT

The California Coastal Act (CCA) of 1976 requires a coastal development permit for any development, such as commercial aggregate mining, in the coastal zone (PRC Section 30600 (a)). The coastal zone can extend to the first major ridgeline paralleling the sea or five miles inland which ever is less; specific zone locations are recorded in each local land use jurisdiction's Coastal Plan. For example, from the Smith River south to the confluence of the Eel and Van Duzen Rivers, the coastal zone is approximately the area to the west of Highway 101. A coastal development is defined as a development, which requires a site on, or adjacent to, the sea, in order to operate (PRC Section 30101.3). In the CCA "development" includes grading, removing, dredging, mining, or extraction of any materials (PRC Section 30106).

The California Coastal Commission's (CCC) implements the CCA. Their interpretation of the CCA has allowed commercial aggregate mining in river environments in the coastal zone. The CCA allows dredging in these environments, but it is only permitted where there is no feasible less-environmentally-damaging alternative, and where feasible mitigation measures have been provided to minimize adverse environmental effects (PRC Section 30233 (a)). The CCA states that "environmentally sensitive habitat areas" shall be protected against any significant disruption of habitat values, and only uses dependent on those resources shall be allowed within such areas (PRC Section 30240). Further, the CCA specifically prohibits mineral extraction in "environmentally sensitive areas" (PRC Section 30233 (a) (6)). An environmentally sensitive area is any area in which plant or animal life or their habitats are rare or especially valuable because of their special nature or role in an ecosystem, and which could be easily disturbed or degraded by human activities and developments (PRC Section 30107.5). The CCA does not define "rare" but issuance of a Coastal Development Permit must comply with CEQA, which does define "rare". A rare species is one that is likely to become endangered within the foreseeable future throughout a significant portion of its range and may be considered "threatened" as that term is used in the Federal Endangered Species Act (CEQA Guidelines Section 15308 (b)(2)(B)). The CCC identifies riparian habitat as "environmentally sensitive areas", but does not specifically mention aquatic environments such as the active channels of rivers in the coastal zone. However, federally listed species such as chinook salmon, coho salmon and steelhead are present in many central and northern coastal estuaries and river environments in the coastal zone. If these federally listed species are present in California's estuarine and riverine habitats, these habitats by federal definition are critical habitat (Section 3(5)(A) of the ESA). Critical habitat was designated to include all river reaches accessible to listed salmon or steelhead within the range of the ESUs listed. Accessible reaches are those within the historical range of the ESUs that can still be occupied by any life stage of salmon or steelhead. Inaccessible reaches are those above longstanding, naturally impassible barriers (Federal Register vol. 64, no. 86, May 5, 1999, F.R. vol. 65, no. 32, February 16, 2000). NMFS also includes riparian zones as part of its designation of critical habitat, specifically defined as the "area adjacent to a stream that provides the following functions: shade, sediment transport, nutrient or chemical regulation, streambank stability, and input of large woody debris or organic matter" (Federal Register vol. 65, no. 32, February 16, 2000).

Specifically, in the Central California Coast Coho Salmon ESU, critical habitat is designated to include all river reaches and estuarine areas accessible to listed chinook salmon between Punta Gorda and San Lorenzo River (F.R. vol. 64, no. 86, May 5, 1999); Southern Oregon Northern California Coho Salmon ESU, between Mattole River and Elk River in Oregon (F.R. vol. 64, no. 86, May 5, 1999); Northern California Coastal Steelhead ESU; California Coastal chinook salmon ESU, from Redwood Creek (Humboldt County) to the Russian River (F.R. vol. 65, no. 32, February 16, 2000); and for Central California Coast steelhead from Russian River to and including Aptos Creek (F.R. vol. 65, no. 32, February 16, 2000).

The CCA also contains provisions to maintain biological productivity and quality of coastal waters, streams, wetlands, and estuaries, and, where feasible, to restore them through, minimizing adverse effects and alterations of natural streams from development (PRC Section 30231). The CCA also states that dredging in existing estuaries and wetlands shall maintain or enhance the functional capacity of the wetland or estuary (PRC Section 30233 (c)). Post 1976 developments such as aggregate mining operations shall be located where they will not have significant adverse effects, either individually or cumulatively, on coastal resources (PRC Section 30250(a)).

The CCC has not ruled whether federally designated critical habitat in the coastal zone is defined as an "environmentally sensitive area" when federally listed salmonids are present. The CCA prohibits mineral extraction in "environmentally sensitive areas" (PRC Section 30233 (a) (6)). At this time, twelve commercial aggregate mining operations are within the coastal zone; three operations are in Del Norte County on the lower Smith River, and nine are in Humboldt County on the lower Eel River below the confluence with the Van Duzen River. According to the CCC, Coastal Development Permits (CDP) have not been obtained by all commercial aggregate mining operations in the coastal zone. When issuing a CDP for commercial aggregate mining in Del Norte and Humboldt Counties, the CCC limits the volume of extraction to an amount equal to annual replenishment. The CCC, also as a condition of operation in its CDPs, requires annual reporting to, and approval from, the Executive Director, prior to commencement of commercial aggregate extraction.

1.7. CLEAN WATER ACT

The Army Corps of Engineers (ACOE) is responsible for administering Section 404 of the Clean Water Act (CWA), which regulates the discharge of dredged or fill materials into the navigable waters of the United States. The CWA's definition of "discharge" is the "addition of any pollutant to navigable waters". In 1993, the ACOE issued a regulation defining the term "discharge of dredged material," to mean "any addition of dredged material into, including any redeposit of dredged material within, the waters of the U.S." In 1997, the ACOE was successfully challenged in Federal District Court in Washington, D.C. by the American Mining Congress, who claimed that the ACOE had exceeded its authority under the Act by regulating fallback or incidental fill from dredging. In 1998, the U.S. District of Columbia Circuit Court of Appeals agreed with the earlier decision; that is, it found that the ACOE had exceeded its authority (National Mining Association v. U.S.A.C.O.E., et al., 1998). With this 1997 ruling (known as the "Tulloch ruling"), the ACOE's ability to regulate commercial aggregate mining (dredging) below ordinary high water is now limited to reclamation (grading) of mined surfaces and fill placed for low water crossings. The ACOE no longer has authority to regulate "fall back" of materials as a result of aggregate extraction or dredging, but only fill below the ordinary high water in waters of the U.S. The ACOE in the San Francisco District has accepted the stage of "bankfull" discharge to define the footprint of the area inundated by ordinary high water. The ACOE and U.S. Environmental Protection Agency (EPA) propose to close a "loophole" in the regulations that was opened by the Appellate Court's affirmation of the Tulloch ruling. This ruling allows dredging in waters of the U.S., the ACOE and EPA now propose a new rule that would establish a rebuttal presumption that is based on the nature of the equipment and type of dredge activities such as instream mining that produce "more than incidental fallback". Such dredging results in a discharge of dredged material that would be subject to regulation and environmental review, by the ACOE, under Section 404 of the CWA.

While there are related Federal statutes such as the National Environmental Policy Act (NEPA) and ESA, these acts cannot extend the ACOE's jurisdiction under the CWA, nor do they enable ACOE to enforce NEPA or ESA protection/mitigation measures, beyond the ACOE's jurisdictional limits. Presently, if side casting of aggregate occurs during extraction, it is called temporary ("incidental") fill, and the San Francisco District of the ACOE has ruled that it will not regulate that activity if the fill material is ultimately moved above the ordinary high water mark. In recent years, the ACOE in Humboldt and Del Norte Counties has utilized an administrative process known as a "Letter of Permission" (LOP) to streamline issuing Section 404 permits on a regional basis for commercial aggregate extraction. The ACOE in Humboldt County has utilized the LOP process depending on annual review and concurrence of CHERT. The ACOE issued Individual Permits in other counties of northern and central coastal California for commercial instream aggregate mining.

1.8. PUBLIC TRUST DOCTRINE

The rudiments of the Public Trust concept are:

- the Pubic Trust is common law;
- it is state not federal law;
- it is property law;
- it is a public property right (Smith 1999).

The Public Trust is "an affirmation of the duty of the state to protect the people's common heritage in streams, lakes, marshlands and tidelands, surrendering that right of protection only in rare cases when the abandonment of that right is consistent with the purposes of the trust" (National Audubon Society v. Superior Court (33 Cal.3d 1983)). According to Jan S. Stevens, former State of California, Deputy Attorney General "the trust reflects an understanding of the ancient concept that navigable waters, their beds and their banks, should be enjoyed by all people because they are too important to be reserved for private use."

The Public Trust Doctrine (PTD) is not a legislative statute, or a regulation administered by an agency. The PTD in United States is common law, derived from the Judiciary, and is one of the most important and far-reaching doctrines of American property law (Slade, 1990). Generally speaking, public trust lands, are those lands below navigable waters at the time of statehood (1850 in the case of California), with the upper boundary being the ordinary high water mark (OHW). Under the PTD, the states of Washington and Oregon each retained ownership of all non-tidal navigable waters below the OHW marks. Any commercial instream aggregate mining occurring in the active channel, is therefore regulated only by the state, because the active channel is within the state owned lands. In Washington and Oregon, local land use authorities regulate commercial aggregate mining, but only above OHW.

California also holds ownership interest in all non-tidal navigable waters. But in 1913, the California' Supreme Court (People v. California Fish Co., 166 Cal. 576) held that California had retained its interest only below the ordinary low water mark; it still retained an easement up to OHW. California still retains ownership of land subject to the ebb and flow of tides up to OHW. Each year, the area below the ordinary low water can be located within the active channel. However, the boundaries for the area inundated under ordinary low water, have not been defined either geomorphically or hydrologically. Further, the area beneath ordinary low water is subject to change annually during the high flow season.

Presently, in California, instream mining is typically conducted by "skimming" the exposed bed of the active channel, and the State Lands Commission has not yet determined whether this is state owned land. Therefore, unlike Washington or Oregon most instream aggregate mining in California, occurs on private lands, and is subject to local, not state, land use regulations. However, if lands below the OHW mark on navigable non-tidal waters, are privately owned, and were conveyed to the state in 1850, then these private lands are still subject to publicly held property rights expressed as an easement under the PTD. A state can convey the ownership interest below the ordinary high water into private ownership, but it cannot convey the public's rights into private interest, nor can the state abdicate its trust responsibilities in these lands (Slade, 1990). State and local land use authorities must protect the public's rights held under the Public Trust Doctrine by exercising their legislative functions, such as adopting general plans and laws like as California Coastal Act of 1976. When asserting the Public's Trust property rights on lands beneath the OHW in navigable waters, the state is not "taking" a private property right.

1.9. PRESENT REGULATORY STANDARDS

This section summarizes present regulatory standards as they apply to commercial aggregate mining in California, Oregon, and Washington. Local lead agencies from Monterey County to Del Norte County were contacted, to determine if commercial aggregate extraction operations were active in their jurisdictions. In addition, the California Coastal Commission, California Department of Fish and Game, Division of Mines and Geology, State Lands Commission, Caltrans, as well as the Hoopa and Yurok Tribes, were contacted. State and Tribal mining laws, local mining ordinances, mine/reclamation standards, conditions of operation, programmatic environmental impact reports, and aggregate management plans were reviewed. Yolo and Ventura Counties, though not in central or northern coastal California, were also contacted because they had developed comprehensive aggregate management and monitoring plans (although, perhaps in response to development and adoption of these plans, commercial instream aggregate is no longer extracted in their jurisdiction). Published literature was reviewed; "gray literature" such as environmental impact reports, negative declarations, reclamation plans, aggregate management plans and monitoring programs were also reviewed. Further, to gain a more comprehensive perspective on current regulations and standards affecting commercial instream aggregate extraction, the following Washington and Oregon State resources agencies were contacted:

- Washington Department of Natural Resources
- Washington Department of Fish and Wildlife
- Oregon Division of State Lands
- Oregon Department of Geology and Mineral Industries
- Oregon Department of Fish and Wildlife

Counties in central and northern coastal California that reported currently operating <u>commercial</u> instream aggregate extraction were:

- Del Norte County. Smith River, Hunter Creek (a tributary to the Klamath River), and the Klamath River.
- Siskiyou County. Kidder Creek, (a tributary to Scott River), is planned for extraction in the near future.
- Humboldt County. Eel River, Larabee Creek (a tributary to the Eel River), South Fork Eel River, Van Duzen River, Mad River, North Fork Mattole River and Trinity River, Redwood Creek is planned for extraction in the near future.
- Mendocino County. Garcia and Russian rivers.
- Sonoma County. Russian and Gualala rivers.
- San Benito County. upper Pajaro River
- Monterey County. Arroyo Seco

Local land use planning staff reported no active <u>commercial</u> instream mines in Trinity, Marin, Napa, San Francisco, San Mateo, Santa Clara, or Santa Cruz Counties.

Standards and/or conditions of operation are common to many CUPs, ordinances, and state statutes. Conditions addressing the timing, location, vertical offset, horizontal setback, and slope were most often included in permits for commercial aggregate extraction. Local land use authorities and state regulatory agencies addressed the management of commercial aggregate extraction similarly. A summary of common elements is provided below.

<u>Timing</u>

Instream aggregate extraction is an activity limited by seasonal runoff. After reviewing existing stream alteration or mining regulations from southern Oregon to the central California coast, we found the instream mining period varies, from north to south, as does runoff. The commencement of the instream mining season is tied to declining water stage following spring runoff, until a sufficient portion of the channel bed is exposed. The mining season ends in the fall, when the risk of inundating the mined surface area increases.

Life histories for each anadromous salmonid have evolved in response to a basin's hydrology, and they vary from north to south, and species to species. In coastal California there are

- four anadromous salmonid species present in rivers north of the Eel River;
- three species present from the Mattole River to the Russian River;
- two species present south to Santa Cruz; and
- only steelhead present south of Santa Cruz.

The Oregon Department of Fish & Wildlife has established July 15th to September 30th as the period for instream mining in its southwest coastal region river systems, which support coho salmon, chinook salmon and steelhead. The California Department of Fish and Game also limits the instream mining period from June 1st to October 15th. Local land use authorities also impose limits on the period of operation. The windows of operation vary, increasing from north to south. The following summarizes operating seasons in coastal southern Oregon and northern California.

Southern Oregon --July 15th to September 30th.

Del Norte County ---July 1st to October 15th.

Humboldt County--- June 1st to October 15th.

Mendocino County --- June 15th to October 15th.

Sonoma County ---June 1st to November 1st.

Anadromous salmonids are susceptible to physical disturbance or degraded water quality during all freshwater life stages, including incubation and emergence. Juvenile and adult upriver migrations are sensitive life stages, which could be interrupted or impaired by physical disturbances in the active channel. To use biological parameters for establishing instream mining periods, sensitive life stages must be identified, for each listed species. Potentially damaging mining activity should be avoided during that time frame.

However, in coastal California, state or local authorities generally set instream mining periods between spring runoff and storm induced fall runoff; these periods are not synchronized to migration periods of listed anadromous salmonids. For example, on the Mad River in Humboldt County, peak smolt outmigration occurs from May (coho salmon), mid-June (chinook salmon), through July (steelhead), and peak adult migration can begin in mid-July (summer steelhead), November (chinook salmon), mid-December (coho salmon), through February (winter steelhead). If the Mad River instream mining period was based on avoiding peak periods of migration, mining would begin on August 1st and cease at the end of October. It begins on June 1st presently.

Location

The upper reach of a bar often provides extensive rearing habitat for emergent fry and juvenile anadromous salmonids. A prevalent permit condition restricts mining the upstream end of gravel bars. Retaining the morphology of the bar, down to its widest point, is now a common operating condition required by state regulatory agencies in Washington and Oregon. In California, Sonoma and Mendocino Counties require new mining operations to limit excavation to the lower two-thirds of a bar, and in Del Norte County, mining is limited to below the upper 100 feet of a bar. Humboldt County's surface mining and reclamation ordinance does not have a standard bar excavation limit, although the annual reviews by CHERT require that mining avoid the upstream end of bars.

Vertical Offset

Local land use authorities and state regulatory agencies recognize that to avoid river braiding and bed degradation, the entire volume of a gravel bar above the low flow water surface should not be removed. Vertical offset is one way to limit the volume of gravel excavated from a bar, and retain low flow channel confinement. A specified vertical offset above the low water surface functions as a baseline elevation or "redline" at time of extraction. However, a universal vertical offset standard does not exist. In central and northern coastal California, existing County and State aggregate mining management documents require either a one-foot vertical offset or none at all. Oregon has no uniform standard, and in Washington, the required vertical offset is two feet.

Figure 2. Excavation location and cross bar slope standards.

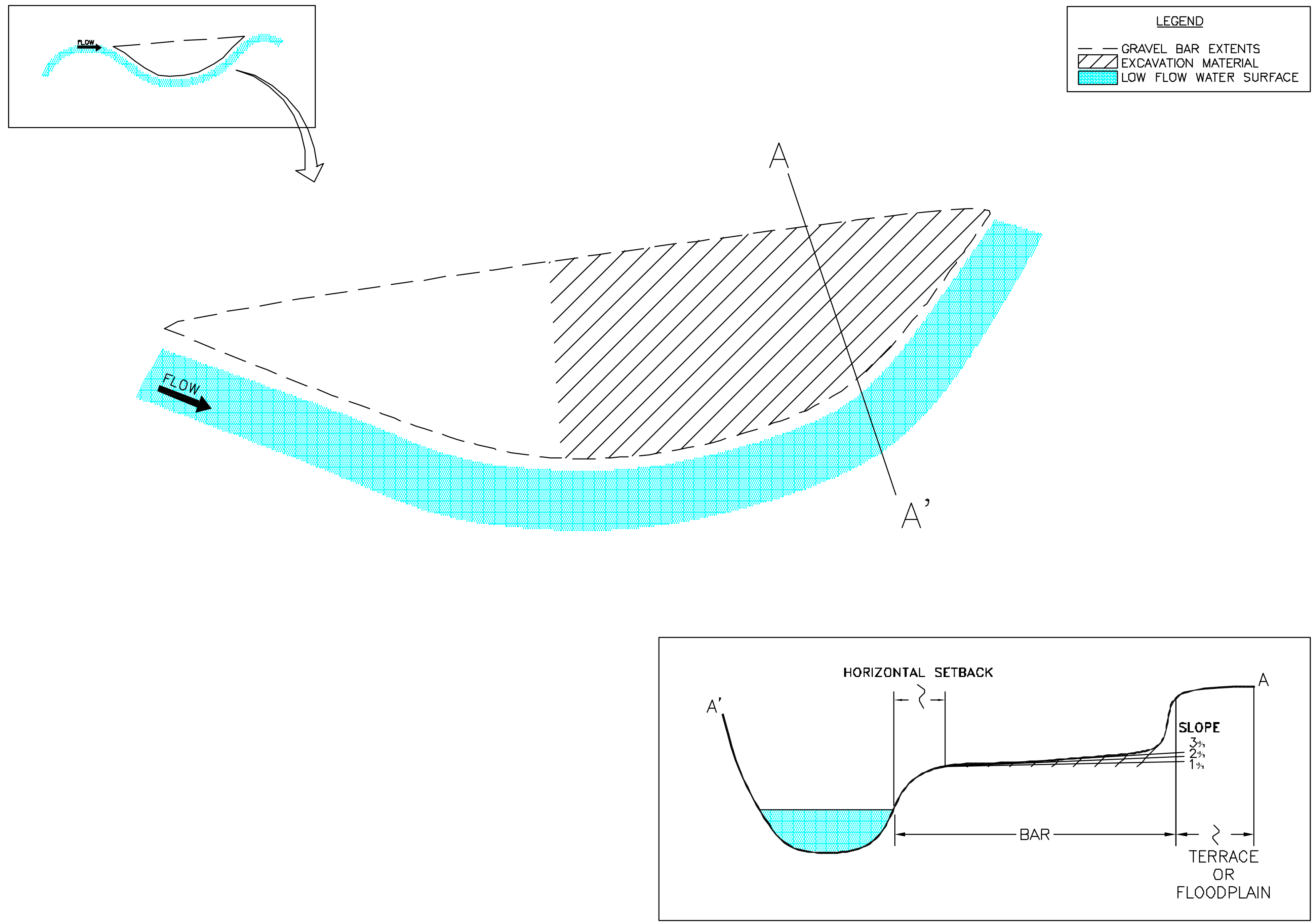


FIGURE 2.
EXCAVATION LOCATION & CROSS BAR SLOPE STANDARDS

McBain & Trush 2000

8/21/00

Horizontal Setbacks

Horizontal setbacks in addition to vertical offsets often define the boundary of excavation areas. Horizontal setbacks, where aggregate extraction is prohibited, are required along the water's edge and along the streambanks. Establishing a horizontal setback between the water's edge and the extraction area creates a buffer along the low flow channel. At low flow, the wetted channel margin provides rearing habitat for emergent fry and juvenile anadromous salmonids. A vertical offset establishes a setback from the low water's edge, but may not adequately protect the edge-water rearing habitat in the lower half of a bar, where the greatest relief occurs. However, a horizontal setback from the low water's edge, below the widest point of a bar, will typically achieve greater setback from the water's edge.

Establishing a horizontal setback is also common between the extraction area and the streambanks, which usually support riparian habitat. Riparian vegetation on stream banks and bar surfaces is an important feature in river environments. A horizontal setback from the outer channel bank limits extraction impacts to streambanks and their riparian vegetation. The horizontal setback for riparian areas can be tied to either channel bank height, vegetative drip line, channel width, or fixed horizontal distance. Only Sonoma County has a specific mining standard, that requires a thirty-foot horizontal setback (or 2.5 times the height of the bank, whichever is greater), from the outer bank to protect streambanks and their riparian vegetation on the Russian River. In previously issued CUPs, Humboldt County, also employs a standard that restricts mining from areas that support at least 1/16th of an acre of riparian vegetation, one inch diameter or larger at breast height (DBH).

In Del Norte County, the California Coastal Commission (CCC) prohibits extraction on the Smith River within fifty feet of the low water edge (in the coastal zone). However, in Humboldt County on the Eel River, the CCC requires both a one-foot vertical offset and six-foot horizontal setback from the low water's edge. A general condition of operation commonly contained in CUPs issued by Humboldt County is to prohibit mining within 20' of the low water's edge. In its 1997 Russian River Aggregate Management Plan, Mendocino County states, that the horizontal setback to delineate extraction boundaries should be measured on June 15th.

Figure 3. Typical setback standards.

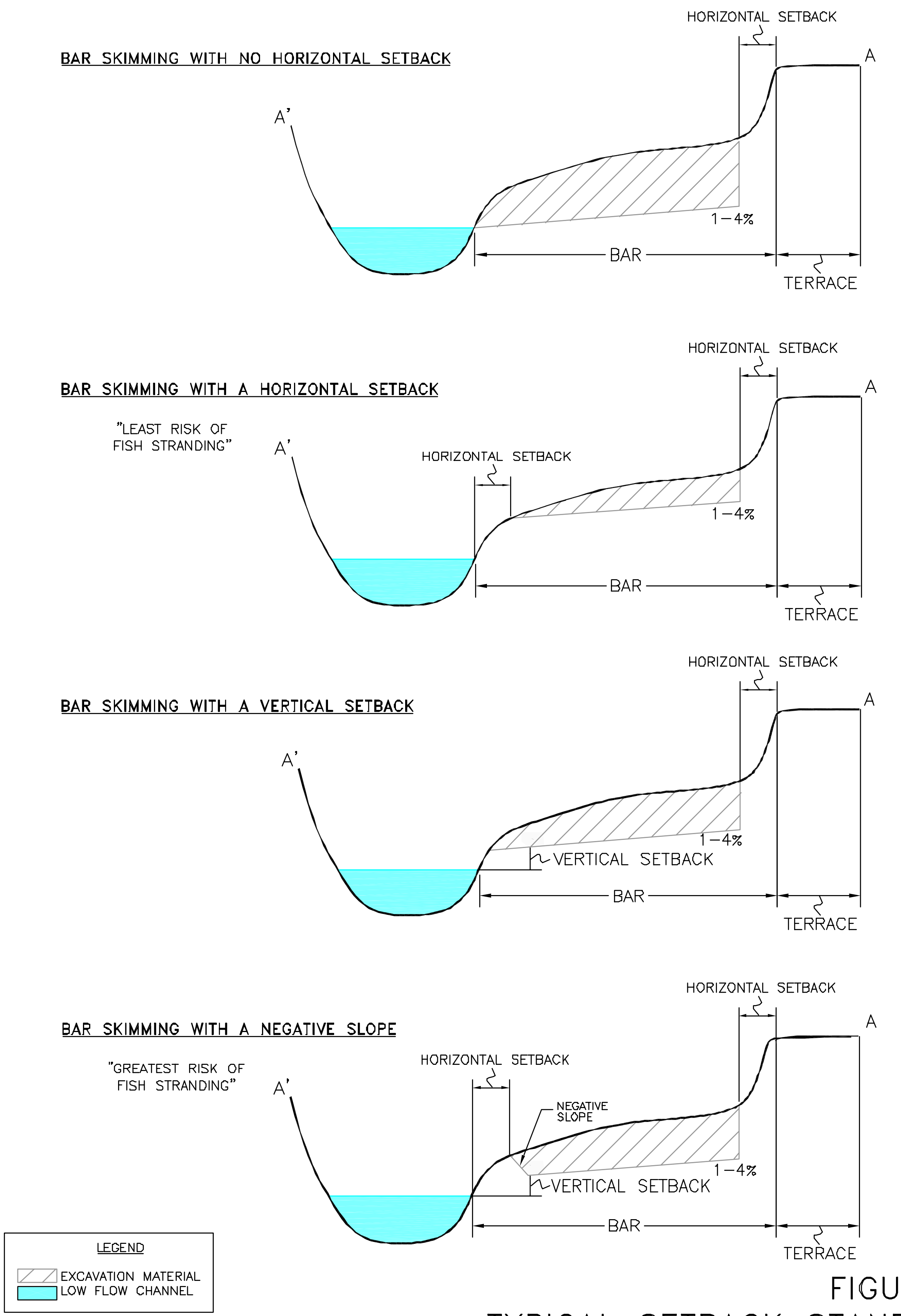


FIGURE 3.
TYPICAL SETBACK STANDARDS

McBain & Trush 2000

8/29/00

Horizontal setback standards, at the low water edge, do not establish whether the elevation of the boundary defined by the horizontal setback, is the base elevation below which excavation is not allowed. Without first establishing the setback boundary at a base elevation, a horizontal setback could result in excavation creating a negative slope that leaves a depressed bar interior surrounded by an elevated berm (Figure 3). The horizontal setback itself then becomes a berm, and if fall storm water levels rise and recede (which is often the case), adult and juvenile fish could become stranded in isolated ponds in the interior depression. To prevent fish stranding, the head and toe of the bar could be breached, so the berm is not contiguous, but the elevated berm could cause channel braiding during high flows. To avoid these impacts, the horizontal setback boundary should become the base elevation below which extraction cannot occur.

<u>Slope</u>

A specific grade, or a post-extraction cross bar slope, required by state resource agencies in Washington and Oregon is 2%, measured from the water's edge; in coastal California, the cross bar slope ranges from 1% to 2%, measured from the water's edge. According to commercial aggregate mine operators, their ability to excavate to a 1% or 2% slope is limited due to their equipment and the survey control they employ. The cross bar slope of a "reclaimed" mine surface is required by regulatory agencies to provide for drainage of the bar surface and prevent surface depressions which can cause stranding of anadromous salmonids. Requiring a minimum cross bar slope is an important standard in preventing the capture of juvenile salmonids. One study by Monk (1989) found a significant trend, depending on cross bar slope, of stranding of juvenile chinook salmon, with a greater incidence of stranding on slopes equal to or less than 2%.

CDFG is concerned with fish stranding, and during the drought of 1987 through 1992, they required cross bar slopes of at least 3% in extracted areas. CDFG, in its Streambed Alteration Agreements, has since revised this condition of operation, to allow extraction down to a 1% slope, in response to the commercial aggregate extraction industry's complaint that limiting extraction to a 3% slope reduced the volume available for them to mine.

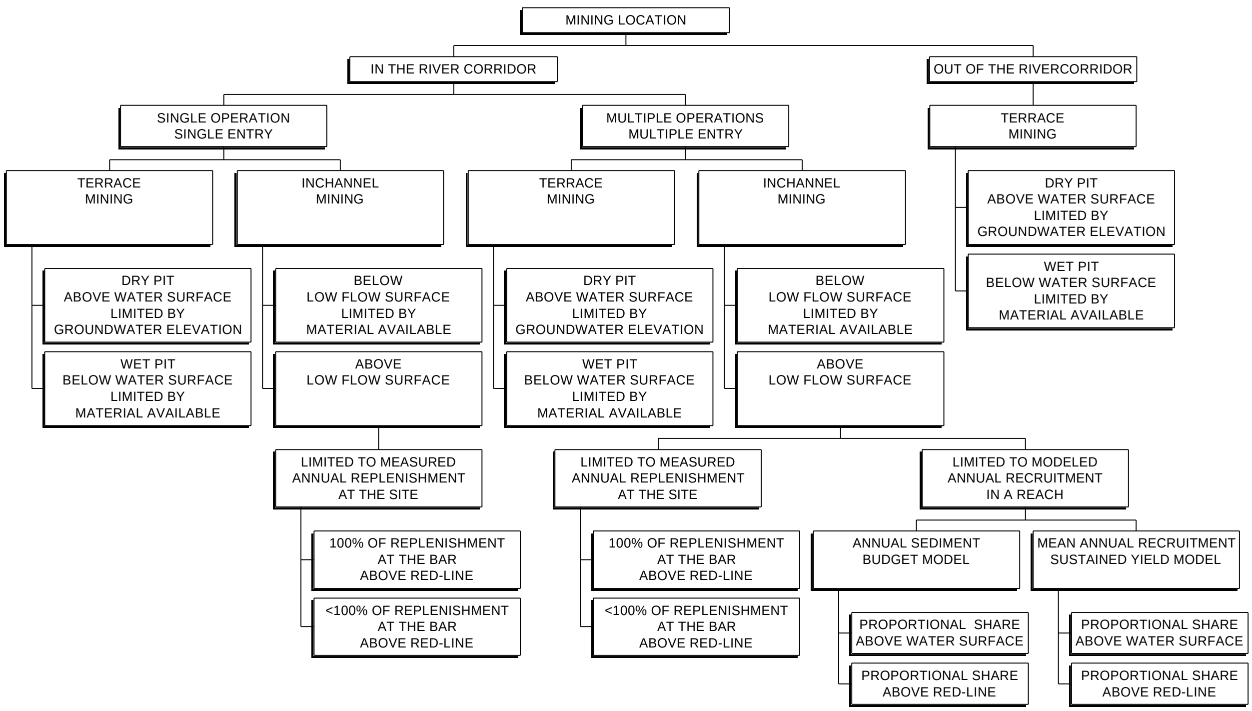
<u>Management</u>

Throughout central and northern California, Oregon, and Washington, local land use authorities, resource agencies and the public, often confuse or use interchangeably the terms "replenishment" and "recruitment" when discussing commercial aggregate mining management strategies. The two terms can be distinguished to help avoid confusion.

Recruitment: the volume of bedload passing a specific point on a river over the course of a single high flow season.

Replenishment: the net change in bed material volume (stored sediment) that occurs on a river reach over the course of a single high flow season.

Figure 4. Commercial aggregate extraction management strategies currently practiced in central and northern California.



The primary extraction management strategy in Washington, Oregon and California is to measure annual replenishment at the extraction site, and to limit the volume mined to that replenished annually. This prevents bed degradation (a net lowering of the channel cross section and thalweg). The management goal associated with replenishment, most often cited by land use and regulatory agencies, to avoid cumulative effects and to allow degraded beds to aggrade by limiting extraction to less than the total replenished at the site. However, a review of existing state and local regulations and literature found that extracting up to the volume replenished was the normal practice, which prevents aggradation. Additionally, we found no standard identifying any specific percentage less than 100% of replenishment necessary to mitigate mining impacts. The implications of using replenishment as a management strategy are discussed in detail in Chapter 3.

The most common practice for determining replenishment volumes is to measure the net change in bed material volume over the channel bed surface resulting from the first year of excavation. The post extraction surface elevation would essentially function as a “red-line” for administrative purposes. Local or state regulatory extraction standards often include horizontal and vertical setbacks and minimum cross bar slopes for reclaimed mined areas. An alternative management strategy to the measure of annual replenishment, used in Sonoma (S.Co, 1994) and Mendocino (PWA, 1997) Counties, is based on development of a sediment budget to estimate annual recruitment (the volume of bedload passing a specific point on a river over the course of a single high flow season). Similar to replenishment, this approach allows extracting 100% or less of the estimated annual recruitment above an administrative redline or the water surface. Another management practice currently in use only in Humboldt County on the Mad River, is modeling the long term mean annual recruitment (MAR) or sustained yield estimate as defined in this document (discussed in detail in Chapter 3). Sustained yield is the volume of gravel mined without causing changes to river morphology or mean bed elevation. A MAR estimate can be developed for a variety of spatial scales, from the individual bar, to a reach, or to an entire river system. The risk to river beneficial uses varies directly with the percentage of MAR extracted.

There are eight commercial instream aggregate mining sites on the Mad River. Humboldt County has approved instream aggregate mining permits for the Mad River that total 752,000 cu.yds per year; substantially greater than the maximum estimated MAR volume of 200,000 cu.yds. The goal of Humboldt County's sustained yield extraction management strategy on the Mad River is to mitigate cumulative effects of multiple aggregate extraction operations on the riverine environment. Over the more than five years in which sustained yield management has been attempted on the Mad River, the reach immediately below most instream mining has not aggraded despite numerous flood events. However, during the first five years of practicing sustained yield management on the Mad River, the extraction volume ultimately approved was often higher than the maximum MAR estimate of 200,000 cu.yds.

1.10. REGULATORY UNCERTAINTY

In California, local governments have the primary responsibility for the planning and regulation of land uses on private lands. As quoted earlier, local government land use planning chooses particular uses for the land, while state or federal environmental regulation does not mandate particular uses; it does require environmental damage to be limited. Numerous state and federal resource agencies also administer regulations and policies, which can limit the effects from land use such as instream aggregate mining, in order to protect those resources under their jurisdiction.

As previously noted, the authority to regulate land uses, such as commercial aggregate extraction, is determined by ownership of the land. In Washington or Oregon, ownership of its navigable rivers up to the ordinary high water mark still resides with the state. In California, ownership below ordinary high water (OHW), can be privately or publicly held. Again, in Washington and Oregon, the state is the sole authority regulating land uses below the OHW. While in California, regulation of land use on these lands is primarily done by the county. In Washington and Oregon, because the state, as sovereign, holds ownership of the land below the OHW, there are no legal non-conforming uses or vested rights for uses such as commercial instream aggregate extraction. However, in California, land above the ordinary low water (below OHW) of non-tidal navigable waters can be privately owned, and as discussed previously, commercial instream aggregate extraction that pre-dates local land use and state resource legislation, has been recognized as a legal nonconforming use, or as having a vested right to continue its activities. In California, local legislative bodies such as the County prepare and adopt a general plan, which contains land use policies; these policies are then implemented via land use ordinances. But general plan policies and land use ordinances can only affect new projects, not operations that legally existed prior to the adoption of new land use regulations.

In California, in any given county, several different regulatory statuses can be defined for commercial aggregate mining operations:

1. a nonconforming land use (pre-date the general plan-zoning ordinance),

2. a recognized vested right to mine (pre-date SMARA of 1975),

3. a recognized vested right to mine (pre-date CCA of 1976),

4. a CUP, and/or CDP and approval of their reclamation plan, dated prior to 1993 (pre-date amendments to SMARA, CCR Section 3500, "Reclamation Regulations"),

5. new operations which comply with the new reclamation regulations in SMARA (post-date 1993).

In Humboldt County for example, the regulation of commercial instream aggregate extraction is particularly complex, because many commercial instream aggregate mining operations have recognized vested rights. Two PEIRs (Eel & Van Duzen Rivers (H.Co, 1992), and Mad River (H.Co, 1993)) have been prepared that cover almost all the commercial aggregate extraction in the County (approximately 21 sites). Both PEIRs identified significant adverse cumulative effects from extraction; specifically, degradation of river channels. Both PEIRs proposed measures to mitigate these significant adverse cumulative effects from extraction. As discussed previously, the primary mitigation measure provided in the 1992 PEIR for the lower Eel and Van Duzen rivers was the development of a "River Management Plan". However, eight years later as mining has continued with new operations coming on line, a plan has yet to be offered. It may now be problematic for Humboldt County to require compliance with this mitigation measure when 70% of the operations discussed in the 1992 PEIR were previously fully permitted. Any compliance by the majority of these operations with this mitigation measure (River Management Plan) would be voluntary. Similarly, compliance with mitigation measures provided in the 1994 PEIR on the Mad River are also voluntary, as all of the commercial mining operations that were operating on the Mad River in 1994, (that already had use permits, if not vested rights and approved reclamation plans). In the 1994 Mad River PEIR, the primary mitigation measure provided the establishment of a Scientific Design and Review Team appointed by the County. In 1996, as discussed earlier, Humboldt County renamed their former scientific review team as the County of Humboldt Extraction Review Team (CHERT), whose function is to annually review all proposed mining plans and provide the County, as well as CDFG and ACOE, with its recommendations.

Since 1996, CDFG and ACOE, have incorporated CHERT (a County advisory body) review as a condition of operation in their respective permits. However, CDFG and ACOE are not required to utilize CHERT, nor are they bound by its recommendations. Whether the ACOE or CDFG continue to utilize the services of this advisory body in the future is uncertain. Since 1999, CDFG in response to a finding of the Mendocino Superior Court (EPIC v. CDFG) is now complying with CEQA when issuing a SAA. CDFG must determine before entering into a SAA with an existing commercial instream mining operation whether it has previously complied with CEQA. If CDFG determines that a project's previous CEQA compliance is in-sufficient due to changing environmental or project conditions, it would assume lead agency status and supplement the earlier CEQA document. CDFG could impose mitigation measures with its SAA to avoid or reduce potential significant impacts from a project. Since 1999, CDFG in Region 1, within Humboldt County has required conformance with CHERT's recommendations as a CEQA mitigation measure.

The County, as local land use authority and lead agency under SMARA and CEQA, has not developed a clear planning or regulatory mechanism requiring preparation of comprehensive aggregate management plans to address previously identified significant adverse environmental impacts. Given salmon and steelhead's federal listing and the designation of their critical habitat, descriptions and goals delineated in previously-approved reclamation plans (regarding rehabilitation of stream channels and banks as required under PRC Section 2772 (c)(8)(B)), are no longer adequate. The County, could make a finding that previous environmental setting descriptions contained in initial studies, Negative Declaration or EIR, are inadequate because of the recent listings of chinook salmon, coho salmon and steelhead and designation of their critical habitat which includes areas where commercial aggregate is being mined.

In California, there is often regulatory uncertainty as to which agency should take the lead in addressing commercial aggregate extraction within river corridors. In conducting assessments, developing mitigation measures, or preparing monitoring plans local land use authorities (lead agency) often defer to state or federal agencies. These other agencies are usually California Department of Conservation-Division of Mines and Geology, California Department of Fish and Game, California Coastal Commission, and State Lands Commission, or federal agencies such as the Army Corps of Engineers, National Marine Fisheries Service and United States Fish and Wildlife Service. But as stated earlier, commercial aggregate extraction is a land use for which the County is the primary authority, whereas the mandate of these other agencies is the protection of a natural resource. The mandate of these state or federal agencies is not to regulate a land use, but rather to regulate impacts to the natural resource under their jurisdiction; such as water quality, fisheries, habitat, coastal resources, the public's trust rights, or federally listed species and their designated critical habitat.

After 1993, when the ACOE expanded its jurisdiction under the CWA, some counties (as in Humboldt Co.), which have long established that commercial instream mining is an allowable land use, began relying on the ACOE to take the lead to regulate commercial instream aggregate mining under Section 404 jurisdiction. Commercial instream aggregate extraction operators rely on the ACOE for a federal nexus to comply with the federal ESA through Section 7 consultation rather than individually under Section 10 incidental take agreements. However, since the 1998 Federal Appellate Court decision (Tulloch ruling), it is not certain whether the ACOE has jurisdiction sufficient to cover all instream extraction activities. Many coastal counties in California want the state to pursue an agreement with NMFS to address incidental take from land uses such as commercial aggregate extraction. But again, this would shift the responsibility (given under California's Constitution to regulate land use such as commercial aggregate extraction) from local authorities, back to the state or federal governments.

Regulation of commercial aggregate mining inside the river corridor is complex. Aggregate mining within the river corridor creates direct, indirect, and cumulative effects on rivers and salmonids as discussed in detail in Chapter 2. The commercial aggregate extraction industry has long complained about burdensome regulations. However, it is important to emphasize, that there is only one surface mine-reclamation law in California; the purpose for other multiple state and federal resource laws is not to regulate land use such as commercial aggregate mining per se, but to avoid or minimize impacts that such uses have on natural resources. Commercial aggregate extraction outside of the river corridor would only involve the local land use authority. A more unified and simpler approach to regulating aggregate extraction could both diminish the compliance burden of mine operators as well as ensure better protection of salmonids and their habitats.

1.11. INSTITUTIONAL REMEDIES

The abundance of chinook salmon, coho salmon, and steelhead in central and northern coastal California has declined, resulting in their federal listing as threatened. As discussed earlier local governments through their land use decisions have allowed uses like commercial instream or terrace mining to occur in riverine environments. Given the listing of these species local governments should re-assess the validity of these previous land use decisions, and others uses which have contributed to the degradation of environments on which the survival of these federally listed species depend. The ineffectiveness of existing state and federal environmental regulatory mechanisms to protect these species from the effects of commercial instream mining as well as other land uses has contributed to this decline. This section will explore resource regulations and institutional remedies applicable to improving the effectiveness of existing land use for the protection of federally listed anadromous salmonids and their critical habitat.

The salmon and steelhead fisheries of California and the river corridors that support their freshwater life stages are public trust resources. Yet, these resources are still declining, even threatened with extinction. Why? In light of the Secretary of Commerce's determination of the effectiveness of existing regulations to protect these species from the effect of deleterious land uses, it would appear that the Public Trust Doctrine is not being adequately applied by the state and local governments. The Public Trust Doctrine obligates state and local legislative bodies as Trustor, to protect publics trust resources. Both local and state legislative bodies, through their legislative actions, can enact policies and laws that require better environmental protection. Local lead agencies and state resource agencies must mitigate any harm to trust resources to the extent feasible through their regulatory decisions. The public trust doctrine provides the rationale to say no, when warranted, to development projects such as commercial aggregate extraction that have the potential to adversely affect the river corridor or salmon and steelhead fisheries. Prior allocation decisions, in the case of recognizing vested rights or in the issuance of conditional use permits, do not shield against the Public Trust Doctrine. All these vested rights or previous allocations by permit are vulnerable to litigation to force compliance with the Doctrine. Enforcing the Doctrine through legislation or regulation does not create a regulatory taking, as the Doctrine pre-empts local or state legislative actions. The administration and application of state resource statutes should protect and exercise the state's Public Trust obligations and responsibilities. In California, land use is determined at the local level, therefore, it is through the adoption of appropriate general plan policies and zoning or use ordinances that counties can protect our trust resources. The Public Trust Doctrine needs to be applied through General Plan polices and land use ordinances to become a living Doctrine; protection of the public rights must be made a more effective part of California's local government decision-making and state environmental regulatory programs.

Local Land Use Authorities

Local land use authorities enact and enforce planning, zoning, and land use laws. The land use element and map of the general plan identify and describe the location of principally permitted uses for each land use district. Alluvial deposits can occur within or outside a river corridor. Commercial aggregate extraction outside of the river corridor may have little or no effect on the riverine environment, on federally listed salmon and steelhead, or on their habitat.

Local land use authorities can amend the land use element of their general plan to provide either a new land use district, designated “River Corridor”, or create a sub-district “River Corridor Zone” (RCZ) under the natural resource district, akin to Timber Production Zones. The boundaries of the RCZ would occur at the demarcation of the river corridor for each river and stream in its jurisdiction, as described in Chapter 3. The land use element and the zoning ordinance could also be amended to identify those land uses that would be principally or conditionally permitted in the RCZ: specifically, only those land uses compatible with protecting and maintaining public trust resources, including salmon and steelhead fisheries and their habitat. Again, existing land uses in the new RMZ not identified as allowable (Chapter 3 mining activities not recommended in the river corridor) in the amended general plan, would become nonconforming uses and would therefore be phased out over a reasonable period of time. Local land use authorities have the authority to eliminate any use not compatible with the protection of trust resources under the Public Trust Doctrine.

New general plan policies within the conservation element are needed to provide decisionmakers with guidance that will protect trust resources. Some policies to consider are those that will require:

1. protection of all riparian vegetation,

2. cessation of all aggregate extraction when degradation threatens existing infrastructure such as bridges, levees, or public facilities,

3. all aggregate extraction activities within the RCZ to have a Conditional Use Permit,

4. all aggregate extraction in the RCZ be managed on a sustainable basis; that cumulative extraction of aggregate in a river basin adhere to an appropriate percentage of mean annual recruitment as delineated in Chapter 3,

5. preparation of a management plan for those areas of the RCZ where any commercial operations are permitted,

6. special protection measures from all allowable uses in areas federally designated critical habitat (Federal Register vol. 64, no. 86, May 5, 1999, and F.R. vol. 65, no. 32, February 16, 2000).

Local land use authorities could adopt a more comprehensive surface mining and reclamation ordinance than the minimum required under the SMARA. In order to assess and mitigate adverse cumulative impacts from aggregate mining within a river basin, existing local surface mining and reclamation ordinances should eliminate the present exemptions for operations under

1 acre, or 1000 cubic yards in volume, and require a CUP for any aggregate mining in the RCZ. As a means to protect trust resources, local land use authorities could apply the new 1993 reclamation standards (CCR Sections 3700 et.al.) and incorporate the standards described in Chapter 3, into all aggregate mine operations in the RCZ.

All commercial aggregate mining operations tiered to a PEIR that define mitigation measures which have not been implemented (such as in Humboldt County on the lower Eel and Van Duzen rivers), or that have not been successful in mitigation, could be suspended until the lead agency action is brought into compliance with CEQA.

Any EIR prepared for a local lead agency is required to comply with CEQA's provision to conduct an analysis of feasible alternatives. A review of the alternative discussion, in many of the existing EIRs for commercial aggregate extraction, was deficient in analyzing project alternatives because the underlying articulation of the purpose of the project was constrained. CEQA requires that a project's objectives and its underlying purpose be clearly described (CCR Section 15124 (d)). An accurate description of the project's purpose is necessary to facilitate an analysis of alternatives. In the case of commercial aggregate mining operations, their underlying purpose is to provide aggregate products to the community. Most EIR's reviewed describe project objectives and purpose which unnecessarily limit the alternative analysis to property owned by the applicant, or to other alternatives within the river corridor. Off-site locations are dismissed outright. CEQA establishes a duty for public agencies to avoid or minimize environmental damage where feasible (CCR Section 15021 (a)). To decide which alternative satisfies a project's underlying purpose to provide aggregate products, alternate site locations, which avoid significant impacts, must be assessed. Lead Agencies could reassess the alternative analysis in existing EIRs to bring their actions in compliance with CEQA.

<u>California Department of Fish and Game</u>

The public's rights under the Public Trust Doctrine are senior to any other property right. CDFG has an obligation under the Doctrine to exercise continual supervision and diligence in protecting the public's rights and resources through the application of its regulations. CDFG's Streambed Alteration Agreement (SAA) is not a discretionary permit. Rather, it is a negotiated agreement. CDFG, can refuse to enter into a SAA in waters of the state where federally listed salmonids are present, may be in the future, or where habitat critical to their continued survival exists. CDFG cannot be forced or arbitrated into an agreement that does not protect the public's rights under the Doctrine. When CDFG enters into a SAA with a commercial instream mining operation, it has essentially made the finding that such an activity adversely affects fish and wildlife resources. Further, in entering into this agreement, CDFG has also implied a second finding: the activity authorized by the Agreement is being mitigated to avoid or offset adverse effects to fish and wildlife. CDFG could decline to enter into such agreements when facts have not been provided to support the second finding. Further CDFG could require a monitoring plan, as discussed in Chapter 3, to document not only compliance but success of the mitigation measures in all its Agreements with commercial instream aggregate mining.

CDFG, in conformance with a 1999 court decision (EPIC v. CDFG, Mendocino Superior Court, 1999), cannot enter into a Streambed Alteration Agreement for any project not reviewed under CEQA. Before entering into a streambed alteration agreement, CDFG could assume lead agency responsibilities under CEQA for any portion of instream aggregate mining activity that is not covered under existing CEQA document or findings. Instream mining activities (not to be confused with reclamation plans) for an operation that has recognized vested rights have not been subject to review and disclosure under CEQA. In the case of operations with vested rights, CDFG could assume lead agency position to comply with CEQA for the extraction project; specifically, conducting an alternative analysis that selects the most environmentally superior alternative which satisfies the project's purpose to provide aggregate products to the community. CDFG could also assess the adequacy of CEQA documents which a proposed project is tiered to, such as a PEIR, to assure all mitigation measures have been implemented and significant impacts have been reduced to less than the threshold identified in the PEIR. CDFG could assume lead agency position on any proposed project tiered to any document that does not comply with CEQA. To assist in project review, CDFG could retain a team of scientists which would review Streambed Alteration Notifications, advise the department on possible impacts, and then recommend appropriate mitigation measures to protect trust resources.

Lastly, CDFG can petition the California Fish and Game Commission to list those anadromous salmonid species now federally listed in California under the California Endangered Species Act and prepare recovery plans for these species.

California Coastal Commission

The only development activities permitted in the coastal zone are those that need to be sited on or adjacent to the sea (PRC Section 30101.3). In California, deposits of alluvium (aggregate) occur outside and inside river corridors as well as in or outside the coastal zone. Commercial aggregate mining is a development activity throughout California that occurs wherever deposits of alluvium reside near a market. However, the coastal zone is a protected area, spatially limited to the immediate area near the sea, generally extending inland 1,000 yards to five miles in significant coastal areas (PRC Section 30103). Commercial aggregate extraction is certainly not dependent upon, or limited to, a coastal zone site. For the period of 1991 to 1993, Trinity Associates identified the locations of instream aggregate mine sites in central and northern coastal California; of the 118 sites in Humboldt County, only 9 were in the coastal zone. Providing commercial aggregate products to communities in coastal California is not dependent on extraction of aggregate, in the coastal zone. The California Coastal Commission (CCC), under the California Coastal Act (CCA), could prohibit commercial instream mining in the coastal zone unless a finding can be made that 'a given' site is the only source of aggregate available.

The CCA in the coastal zone specifically prohibits mineral extraction in "environmentally sensitive areas" (PRC Section 30233 (a)(6)) described as those areas where rare animal life or their habitats occur, and which could be easily disturbed or degraded by human activities (PRC Section 30107.5). A rare animal as defined in the CEQA Guidelines (Section 15380(b)(2)(B)) is equivalent to a federally listed threatened species. There are at least two areas in the coastal zone where instream commercial mining operations have received Coastal Development Permits; 3 sites on the Smith River and 9 sites on the Eel River. Both rivers have been federally designated as critical habitat and support salmon and steelhead species listed as threatened. Both meet the criteria necessary to be designated environmentally sensitive areas as described in the CCA. The CCC could determine that both river corridors be treated as environmentally sensitive areas under the Coastal Act, and prohibit mineral extraction therein. The Public Trust Doctrine provides the legal mandate to the CCC to require environmental protection of coastal resources including river corridors and the fisheries they support.

State Lands Commission

Unlike Washington and Oregon, California only retained fee title interest of non-tidal navigable waters up to the OLW. The OLW, each year, will be located between the banks of the active channel. The substrate which forms the bed of the active channel becomes mobile during OHW, therefore the location of the OLW is subject to re-location each year. Without a boundary determination from the State Lands Commission (SLC), private property interests, and local and state lead agencies, have used the lowest wetted channel to define the state's fee title interest. Because the bed of the active channel is mobile, the state's fee title interest is likewise as mobile; from year to year the footprint occupied by the OLW will shift. The SLC could codify the boundaries of the OLW to be the bed of the river between the banks of the active channel.

The SLC is also a land use authority on sovereign lands owned by the state, such as the area occupied by OLW, and could be the primary land use authority in this area. If the state determined that its ownership in the non-tidal navigable waters was the bed of the river between the banks of the active channel, there would no longer be any non-conforming or vested rights possible for commercial instream mining operations. The state's role as sovereign of such lands pre-dates any subsequent private land use; as such " regulatory takings" is not an issue. With the state having a fee title interest in the active channel bed, the SLC could then begin to manage land use and protect the public's rights under the Doctrine.

1.12. SUMMARY

California does not need more laws regulating commercial mining. More effective application of existing laws and regulations will significantly reduce the deleterious effects of commercial mining on riverine environments.

During this study, reports from local land use authorities and state regulatory agencies in all three states indicated a definite trend of commercial aggregate extraction re-locating from instream mining via bar skimming to off-channel pit (terrace) excavation. Recently, in California, such shifts have occurred in Ventura County on the Santa Clara River and on Cache Creek in Yolo County. Before commercial aggregate extraction shifted to terrace mining, both counties had adopted comprehensive aggregate management and monitoring plans. On regulated rivers in California, particularly in the Central Valley, this trend generally occurred in the early seventies after the last large dams were constructed. Sonoma County experienced this shift, starting in the early eighties, in the middle reach of the Russian River.

The greatest concentration of commercial instream aggregate mining and the two largest cumulative extraction volumes of aggregate under permit on the west coast of the United States are in Humboldt County, on the lower Eel River, and the Mad River. Two other locations found to have relatively high concentrations of large volume commercial instream aggregate mining were on the Smith River in Del Norte County, and the Alexander Valley reach of the Russian River in Sonoma County. The greatest concentration and volume of commercial aggregate mining in central and northern California's coastal zone also occurs on the lower Smith and Eel rivers.

Instream aggregate mining has the potential to cause an adverse effect on salmonid habitat (Chapter 2). In California, application of existing land use law and environmental regulation affecting instream aggregate mining as well as other land uses has failed to prevent the decline of the state's anadromous salmonid populations. The federal listing of chinook salmon, coho salmon and steelhead trout, and the designation of their critical habitat, introduces a new regulatory mechanism, the Federal Endangered Species Act, that has the authority to regulate the taking or adverse modification of federally listed species or their critical habitat from instream mining in California. Successful recovery of these species in California may depend on the National Marine Fisheries Service (NMFS) encouraging more effective application and enforcement of existing land use decisions and regulatory mechanisms by local land use authorities, and state or federal resource agencies. NMFS could request the appropriate local and state authorities in California enact long term institutional remedies, that first address appropriate land use in the river corridor, and second increase the effectiveness of existing resource regulation. A more effective application of existing laws, in keeping with local governments' and the states' obligations under the public trust doctrine, would substantially advance the protection and recovery of federally listed anadromous salmonids and their habitat.

"The salmon problem is of human and institutional origin; remedies, if they are to be found, must entail human, institutional change." and *"There are no easy answers to the salmon problem. Rehabilitating the salmon will take decades, incur direct costs in the billions of dollars, and require substantial realignments of property rights and government institutions"* National Research Council, 1996.

2. REVIEW OF EFFECTS OF INSTREAM MINING ON FLUVIAL GEOMORPHOLOGY, RIPARIAN HABITAT AND AQUATIC BIOTA

2.1 INTRODUCTION

This section summarizes literature addressing the realized and potential effects of instream mining on physical channel conditions (fluvial geomorphology, channel and riparian habitat) and aquatic biota. The literature on effects of instream mining can be broadly categorized as: 1) that which focuses primarily on alterations of the physical character of streams and rivers (geomorphology) from mining (primarily targeting effects on infrastructure, such as bridges, pipeline crossings, and levees), 2) that links habitat quality and quantity and biological effects with geomorphic alterations, and 3) that which directly measures biological effects (e.g., inventories of biota for comparisons of species abundance and diversity at mined sites before and after mining or comparisons of mined and unmined sites, or a combination of the two). Our present ability to measure changes in the environment and elucidate cause-and-effect relationships through hypothesis testing typically diminishes from the former to the latter (physical geomorphic/habitat responses are generally easier to quantify than biological responses). Consequently, most literature addresses effects of instream mining from case studies rather than applying statistical analyses within the context of hypothesis testing for cause-and-effect.

To relate the impacts described in this chapter to extraction strategies described in Chapter 3, each impact is assigned an alphanumeric code, with the letter “B” indicating biological effects and the letter “P” indicating physical effects (on channel geomorphology, habitat, hydrology, or hydraulics). Some of the studies that focussed primarily on impacts to biota included observations of or inferences about physical impacts, and vice versa. Thus, physical and biological impacts and their codes are included in both sections. Moreover, many impacts documented in the literature occur in association with others, being either caused by or causing others, in a cascade of interrelated impacts. Consequently, discussions of specific impacts include mention of other related impacts that may be discussed in more detail elsewhere in this chapter.

2.2 EFFECTS OF INSTREAM MINING ON AQUATIC BIOTA

Perhaps the most rigorous study of the biological effects of instream mining can be found in Brown et al., (1998). They conducted a controlled experiment on three Ozark Mountain gravel bed streams, with data collection upstream from mining sites (reference), within mining sites (on-site effects), and downstream from mining sites (off-site effects). Data collection focused on fish and benthic macroinvertebrates, but also included data collection on stream morphology, turbidity, biofilm, benthic particulate organic matter (BPOM), and low flow sediment dynamics on a subset of sampling sites.

They found that:

- Bankfull channel widths were significantly increased at mining sites and for at least one kilometer downstream from each site (**P14**).
- Distances between riffles were significantly increased, resulting in fewer pools in downstream reaches, causing the percentage of riffle area to decrease from 9% to 1% (**P3**).
- Turbidity was significantly higher in mining sites and downstream reaches while mining was occurring than in upstream reference reaches (**P4**).
- Biomass and densities of both large and small invertebrates were higher at reference reaches that at mine sites and downstream reaches (**B2**).
- Total fish densities in pools were higher in reference reaches than in mine sites and downstream reaches (**B5**).
- Mean densities of game fish were higher in reference reaches than in mine sites and downstream reaches (**B12**).
- Silt-sensitive fish species were less abundant in mined reaches than in reference reaches (**B5**).

The authors concluded that:

> “Environmental degradation [from mining] extended far beyond the boundaries of the immediate gravel mining areas.”
>
> “Downstream [from gravel mining] areas had too little gravel bedload to maintain normal stream channel structure because gravel was intercepted at the mines.”
>
> “Silt travels long distances downstream as a plume of turbidity while gravel is being removed. During floods, turbidity is likely to be higher than normal for even longer distances downstream due to the higher flow rate and increased entrainment of sediments as a result of channel deformation.”
>
> “Gravel mining from stream channels seems to create an irreconcilable multiple-use conflict among the various users of gravel bed stream resources. Removing gravel from gravel bed streams impairs the use of them for several other purposes, not the least of which is sport fishing, and the impairment is not avoidable or reparable.”

Pauley et al., (1989) conducted another biologically oriented study on effects of bar skimming ("scalping") in the Puyallup River drainage in western Washington State. They conducted pre- and post-skimming observations of channel morphological conditions, salmonid habitat, benthic macroinvertebrates species composition and abundance, survival of salmonid eggs in artificial incubation chambers, and juvenile salmonid fish distributions at several previously mined sites as well as similar observations at non-mined control sites. Although their study was of short duration and their sample size was insufficient for statistical testing for some effects, the authors drew several inferences described below:

- The percentage of channel width composed of gravel bar surface decreased due to bar skimming, decreasing channel confinement and, consequently, widening and shallowing of the low flow channel (**P14, P18**). Shallowing of flow depths over riffles created barriers to upstream-migrating adult salmonids (**B6**).

- Several side channels on skimmed bars were obliterated, either by direct removal during mining or by channel planform changes during subsequent high flows (**P9, P15**). About 70% of all juvenile coho found during summer surveys had been found in pools within these side channels prior to mining, and therefore had to relocate (**B7**).

- Loss of side channel macrohabitat probably forced relocation of juvenile salmonids to "unsuitable or less desirable macrohabitat" (**B7**) where survivability probably would be lower due to: 1) less cover for escaping predation, 2) higher summer water temperatures, 3) lower food availability, and 4) diminished overwintering habitat and refuge from high flow velocities.

- Skimming caused formation of secondary channels and caused the main channel to flow across the previously skimmed surfaced as a shallow riffle-glide at several mined ("treatment") sites (**P17**). Unlike side channels, which are typically lined with riparian vegetation and provide complex habitat with abundant cover structure, the secondary channels offered little habitat for juvenile salmonids. Main channel habitat was also reduced due to flow divergence into multiple channels and destabilized by lateral migration onto the previously skimmed surface (**P15**).

- Channel bed scour was increased in riffles adjacent to skimmed bars, resulting in the loss of artificial egg incubation chambers (**B9**). It was determined that "gravel scalping leads to river channel instability at the top of the scalped bar" (Pauley et al.,, 1989, p. 128) (**P15**). It follows that the probability of scouring of natural redds would also be increased due to proximity to bar skimming.

In another study (Woodward-Clyde Consultants, 1980), effects of skimming and pit excavation on aquatic biota were documented in Alaskan streams and rivers by comparing mined areas with unmined areas upstream. The study was conducted on 25 mined sites from 2 to 20 years following extraction. Study sites included a range of channel types (straight, meandering, sinuous, braided, and split), each with a unique response to the type of mining performed (although meandering and sinuous channels responded similarly). Skimming increased braiding (formation of multiple channels (**P17**)) on all channel types except braided rivers (where they already existed as part of the channel's natural planform). Braiding was associated with:

- Decreased depth and velocities as flow spread out over a wider area (**P10, B6**). Consequent reductions in flow depth and velocity encouraged deposition of fine sediment (**P7**) and caused higher summer temperatures (**P5**) and lower dissolved oxygen levels (**P6**).
- Reduced habitat quality by changing to a less productive (finer) substrate size (**P8**).
- Impaired water quality for aquatic macroinvertebrates. Altered temperature regimes (**P5**) caused shifts in emergence periods of aquatic insects and lower diversity of macroinvertebrate assemblages (**B1, B3**).
- Reductions in diversity and numbers of fish stocks, including Arctic char, coho and Chinook salmon (**B4, B5**).
- Loss of low flow channel confinement (**P18**) led to migration blockages (**B6**) during low flow periods due to shallower water depths over riffles and occasional drying up of surface flow in mined reaches (**P21**).

Depending on site-specific conditions, near-channel pits created overwintering refugia for salmonids, but these same pits offered poor rearing habitat compared to naturally formed main-channel habitat pools. Additionally, entrapment of fish occurred where a surface flow connection to the main channel was either not provided during extraction or was subsequently obliterated by river channel changes (**B11**). Direct removal of bank and instream cover in pools (**P2**) was also associated with reduced population densities of both Arctic char and Arctic grayling (**B5**). Although some of the sites were examined up to two decades following mining, residual effects of mining persisted. While most sites exhibited some recovery to pre-mining conditions following cessation of mining (mine closure), continual mining would be expected to maintain chronic channel and habitat instability and prevent recovery of habitat and dependent biota.

2.3 EFFECTS OF INSTREAM MINING ON FLUVIAL GEOMORPHOLOGY AND HABITAT

Unlike studies documenting effects on aquatic biota, there is considerable literature on effects of instream gravel mining on fluvial geomorphology and riparian habitat. The following lists the primary categories of effects of instream mining on river geomorphology and resultant inferred effects on habitat and biological functions. Descriptions of causal mechanisms are provided along with references to published literature. Seldom is a river channel subjected to just one of the effects listed below; mining effects nearly always occur as an interrelated suite of effects including two or more of those listed below.

Decoupling Channel from its Floodplain (Gravel Mining as Flood Control) (P19)

A flood is defined as "any relatively high streamflow, which overtops the natural or artificial banks in any extended portion of a stream" (Amer. Geol. Inst., 1962). Flooding occurs when the water surface elevation exceeds the elevation of the top of the bankfull channel. The magnitude of such a flood is commonly accepted to be any discharge greater than the bankfull flow (typically of 1.5- to 2-years recurrence interval for natural channels (Dunne and Leopold, 1978)).

Diminishing the frequency, magnitude, or duration of flooding, by either flow regulation, levee construction, artificial channelization, or channel enlargement from instream mining, decouples the channel from its floodplain (**P19**), and can be thought of as an unnatural disturbance visited upon the natural geomorphic/hydrologic regime of riparian ecosystems (Bayley, 1995; Swanson et al.,, 1998). The importance of overbank flooding to riparian ecosystems is becoming more widely recognized and reported in the literature. Overbank flooding delivers water, large woody debris, and nutrient-rich sediment to the floodplain. This process allows for establishment and vigorous growth and succession of riparian vegetation, which plays important roles for fluvial geomorphic processes and formation and maintenance of both terrestrial riparian and aquatic habitats (Hughes, 1997; Kondolf and Wilcock, 1996; Whiting, 1998).

Overbank flooding is necessary for maintaining a natural large woody debris (LWD) "turnover rate" via episodic entrainment and deposition of LWD stored on floodplains and exchange of LWD between the channel and the floodplain. LWD and riparian vegetation contribute to hydraulic diversity on floodplain surfaces during floods, allowing habitat diversity to endure well after floods recede. Deposition of fine sediment in the lee of LWD pieces or accumulations on floodplains creates conditions for vegetation colonization, particularly when associated with a scour hole creating a seedbed near the water table. Also, LWD imparts a degree of protection from scour as vegetation grows and gradually becomes more resistant to scour independent of LWD (Hughes, 1997).

Critical life stages of species dependent on seasonal wetlands (invertebrates, amphibians) would be adversely affected by reduced inundation of off-channel wetlands from artificially limiting flooding. In addition, in areas where soil moisture and groundwater recharge depends, at least in part, on contributions from infiltration of overbank water, soil moisture and groundwater levels may be lowered by limiting flooding (**P20**). This could result in die-off of riparian vegetation due to inadequate soil moisture (Hughes, 1997).

Instream mining can affect overbank flooding as either an unintended effect or one that is done deliberately to reduce flooding. It is commonly argued that instream mining is necessary to control flooding, although this is rarely accompanied by an analysis of sufficient rigor (e.g., hydraulic modeling) to confidently evaluate any potential effects on flood heights. Kondolf (1994a) describes cases where aggrading rivers have been mined to successfully control flooding and reduce the risks of channel avulsion, but cautions that resulting incision (**P13**) may undermine flood control levees, thus negating benefits from reduced flood heights. He also points out that rapidly aggrading rivers are the exception rather than the rule, resulting in extremely limited cases where application of gravel mining as a flood control measure could be effective.

Where gravel mining enlarges the channel cross section, the volume of water the channel may contain is increased. While channel enlargement from instream mining has, in some cases, been used successfully to reduce flooding impacts on developed floodplains (Collins, 1993; Kondolf, 1994a), ecological impacts are typically undervalued or ignored altogether. In other instances, channel enlargement by mining may fail to reduce flooding due to lack of recognition of hydraulic properties of floods. At a downstream hydraulic control, such as a channel constriction or local base level, the potential for lowering of floodwater heights by mining upstream would be limited or non-existent (Collins, 1993; Collins, 1997). Channel enlargement caused by mining in this case would only increase channel storage capacity by a relatively small volume (compared to total floodwater volume), but would not increase floodwater conveyance because the downstream constriction controls the rate of flow and the water surface elevation rather than the channel at the mining site.

In a case where mining were indeed able to lower local floodwater heights by creating additional *effective* flow area, such lowering would only be realized in the immediate area of mining unless mining occurs to a degree where the geomorphic responses (channel incision (**P13**) and subsequent widening through increased bank erosion (**P14**)) propagate upstream and downstream of the mined area(s). Overbank water coming into the site from upstream would have to be somehow drawn down into the enlarged channel within the mined area. This might not occur where natural levees are present or where secondary channels exist within the floodplain. In these cases, some portion of the floodwater would bypass the enlarged channel. Alternatively, where upstream overbank flows might be drawn into the enlarged channel, it must flow across streambanks, initiating headward erosion of streambanks and gully erosion of the floodplain.

Any flood control benefits derived from instream mining would be temporary and could be lost or diminished during the most critical times. The greatest volume of bedload transport occurs during large floods, precisely when potential benefits of reduced floodwater heights are most critical to human developments on floodplains. Mined bars have greater bedload trap efficiency than adjacent unmined bars (Collins and Dunne, 1990). Consequently, channel enlargement from mining and any reduction in floodwater heights is likely to be offset either partially or completely due to this preferential deposition of bed material on previously mined bars over the course of a single large flood event. The degree to which this happens depends on the supply of bedload relative to the magnitude and duration of the flood.

As with discontinuous flood control levees, containment of floods within a mining-enlarged channel segment would exacerbate downstream flooding. Floodplains allow temporary storage of floodwaters, a process important for attenuating flood effects downstream. Loss of this floodplain storage capacity would alter the flood routing characteristics of the floodway by accelerating the transfer of floodwater to downstream areas, thus elevating peak flood discharge and water surface elevations.

Floodplains are areas of significant deposition of a portion of the fine sediment load carried by rivers at flood stage. Kleiss (1996) found that an average of 14% of the Cache River's (Arkansas) suspended sediment load entering a 49-km reach of the river bounded by a well vegetated floodplain was deposited on the floodplain. Containment of flooding within the channel would cause this sediment to remain in the river, changing substrate sizes (**P8**) and perhaps filling in critical side channel and estuarine habitats with fine sediment (**P7**): this fine sediment may have otherwise deposited on floodplains and enhanced riparian vegetation colonization and growth. Estuarine habitats on the Pacific coast have been demonstrated to be crucial for rearing of juvenile salmonids, physiologically preparing them for the transition from freshwater to the ocean. Where estuary rearing functions have been impaired by reduced habitat volume and/or loss of habitat diversity, studies (as in Redwood Creek in Humboldt County, northern California; Hofstra and Sacklin, 1987) have shown it to be a major bottleneck in the life histories of salmonids. Reductions in tidal prisms by sediment deposition and/or shifts to finer substrate sizes, both potential effects of artificially limiting flooding by instream gravel mining, would impair the ecological functioning of estuarine environments.

To summarize, gravel mining's utility as a flood control measure cannot be taken as a given. Clearly stated flood management goals must first be quantified, justified, and incorporated into the regulatory framework. This must be accompanied by rigorous hydraulic analyses to evaluate the potential for gravel mining to be used effectively in flood risk management and in locating and designing mining to achieve the desired effect. Moreover, reduction of flood risks to facilitate human occupation of flood prone areas must be weighed against the risks posed to riparian ecosystems from reducing the magnitude, frequency, and duration of flooding necessary for maintaining riparian ecosystem function and integrity and avoiding downstream cumulative effects from instream mining.

Retardation or Prevention of Riparian Vegetation Colonization and Succession (P11)

Riparian vegetation typically occupies areas immediately outside the active channel (the channel area subject to gravel scour and deposition on a relatively frequent basis), but within the meander belt (zone of contemporary and historical channel migration, similar in geographical extent to total floodplain width). Infrequent, large floods typically cause channel migration within the meander belt, eroding some riparian vegetation areas while leaving others intact. During relatively inactive periods between large floods, vegetation colonization and succession proceeds with minimal disturbance from floods ("recruitment" periods). This natural disturbance regime is essential for creating and maintaining a dynamic mosaic of riparian vegetation communities important for maintaining the health of riparian ecosystems (Hughes, 1997; Swanson et al.,, 1998).

Instream gravel mining imposes an artificial disturbance regime within the riparian corridor that reduces or eliminates windows of successful riparian vegetation recruitment (**P11**). Where mining is an ongoing activity, the disturbance is chronic and riparian succession and maturation is inhibited or prevented, at least on the mined surfaces and nearby areas where indirect geomorphic responses to mining occur (e.g., areas of accelerated bank erosion and/or braiding). Because much of the erosional resistance at flood stage in alluvial rivers is derived from riparian vegetation, long-term channel stability may be reduced by lost riparian recruitment (**P14, P15, P16**). The degree to which this occurs depends on: 1) the type of mining (bar skimming, pit excavation, etc.), 2) the volume and/or areal extent of mining relative to channel size and sediment availability, 3) the type of river being mined (straight, sinuous, meandering, etc.), and 4) the location of mining within the river's planform.

Most regulatory mining programs attempt to avoid impacts to riparian vegetation simply by limiting the removal of existing riparian vegetation, requiring vegetation of significant size to be either avoided or transplanted to nearby areas. This strategy, while limiting disturbances to existing vegetation, fails to allow natural colonization and succession on disturbed surfaces. It attempts to maintain the status quo by ignoring the dynamism necessary for healthy riparian vegetation communities. The long-term effects of such a strategy would tend to be relatively minor where mining is a one-time occurrence or where a single isolated, relatively small site is mined on a recurring basis. However, where there is a high concentration of sites along a river reach and/or where mining takes place annually on a recurring basis, effects can be chronic, pervasive, and dramatic, keeping riparian vegetation communities in a constant state of disturbance without intervening recovery periods.

Healthy alluvial channels migrate across their floodplains through time, and riparian colonization and succession follows this migration. Bar skimming operations should also migrate, following the zone of frequent scour and deposition where high quality aggregate can be obtained without disturbing existing riparian vegetation. However, skimming operations tend to enlarge in areal extent through time as the riverward boundary moves with migration, but the landward boundary remains fixed (see Fig. 7, Chapter 3). This is an unanticipated result of the regulatory approach that only limits damage to existing vegetation, but fails over time by increasing the extent of unvegetated bar surfaces left behind as channels migrate.

When combined with other land uses that remove riparian vegetation, instream mining strategies that fail to allow for riparian colonization and succession will create riparian corridors offering reduced habitat for both terrestrial and aquatic species and will be increasingly unstable during high flows.

<u>Channel Planform (Lateral) Destabilization (P15)</u>

Meander cutoff occurs naturally when a river bend migrates laterally and increases its amplitude to the point where a geomorphic threshold is crossed and overbank flows incise across the cutoff and create a new main channel across the inside of the bend. This process is most typical of low gradient (slope < 0.002), unconfined rivers, while steeper rivers tend more towards avulsion or braiding. Over time following meander cutoff, the adjacent planform of the channel adjusts to accommodate the new bend location, reforming a somewhat regularly-spaced sequence of bends of similar amplitude and wavelength and leaving abandoned channel segments as oxbow lakes or side channels that support a variety of riparian ecosystem functions (Klingeman, 1987). This represents a form of channel planform instability (lateral migration) that erodes some banks while building new ones. Following large floods causing widespread erosion and/or deposition, sinuous and meandering channels can become temporarily braided during the subsequent recovery period. While braided, a larger portion of the channel becomes active (subject to scour and deposition on a more frequent basis) and channelbed disturbances (scour and deposition) increase in both frequency and areal extent.

As mentioned earlier, bar skimming and pit excavation on the floodplain can lead to either braiding (**P17**) or meander cutoff (**I15**), especially in meandering and sinuous channels. Pits located on the insides of meander bends have the potential to create cutoff channels under certain conditions, especially when the pit is large and/or deep relative to the bend on which it is located (Collins and Dunne, 1990; Norman et al., 1998; Woodward-Clyde Consultants, 1980). While this process occurs naturally on some rivers, it can be initiated on rivers in response to pit mining where it may not occur naturally and may be accelerated on rivers already prone to meander cutoff.

Channel widening through bank erosion (**P14**) is also a commonly reported lateral instability resulting from gravel mining in excess of replenishment. Harvey and Schumm (1987) document over a ten-fold increase in channel width of Dry Creek, tributary to the Russian River, California, due to excessive mining in both Dry Creek and in the Russian River, the degradation of which lowered the base level for Dry Creek.

Channel braiding, meander cutoff, and widening (and the destabilization of channel pattern that follows) can disrupt benthic macroinvertebrate communities by altering the timing of emergence during larval stages and ultimately reduce populations and species diversity (Woodward-Clyde Consultants, 1980). Flow divergence into multiple channels upon braiding can also increase deposition of fine sediment, resulting in a poorer substrate size for many aquatic organisms. It can also cause shallowing of flow depths (**P10**), leading to increased summer water temperatures (**P5**), lower dissolved oxygen levels (**P6**), low flow migration barriers (**B6**), and possible drying up of the surface flow during low flow periods (**P21**) (Pauley et al., 1989; Woodward-Clyde Consultants, 1980). Widening causes direct loss of riparian vegetation and increases exposure of the channel to solar warming.

If this was a relatively short-term condition, as in the case of a properly functioning (dynamically stable) river channel, affected species could recover relatively quickly. Were the destablilization to occur in a discrete area of the river channel, as would be the case where a single mine site is located within a relatively large reach of a river, there would be stable areas nearby providing refugia. However, where multiple mining operations are concentrated within a river reach and/or where those operations take place on a recurring basis, channel destabilization and subsequent effects on aquatic biota tend to be both widespread and chronic.

Rivers in their natural condition can be assumed to support aquatic ecosystems adapted to their characteristic geomorphic conditions and flow and sediment transport regimes. When a river's planform becomes destabilized, by natural or human-induced changes, a shift towards some other channel type occurs. The shift tends to be more temporary where the disturbance is natural, and more chronic where human-induced disturbance is a recurring influence on channel form, such as mining the same site or series of proximal sites year after year. Native aquatic biota is usually not well adapted to the new channel type. Long term sustainability depends on recovery of the stream environment to the pre-disturbance condition soon enough to allow species to rebound and the availability of suitable refugia nearby during the interim.

Channel Incision (Vertical Instability) (P12)

Mining can also cause vertical instability in channels, a process whereby the channelbed incises into underlying alluvium as a result of gravel mining volumes approaching or exceeding recruitment (gravel supplied from upstream sources). Numerous cases of channelbed degradation leading to infrastructure damage are documented in California and elsewhere (Avila-Crossett, 1998; Bull, 1974; Collins and Dunne, 1989; Collins and Dunne, 1990; Dunne et al., 1981; Harvey and Schumm, 1987; Kondolf, 1993; Kondolf and Swanson, 1993; County of Humboldt, 1993; Macdonald, 1988; Sandecki, 1989; Sandecki, 1997). Because environmental effects of gravel mining are typically given lower standing by society relative to threats to infrastructure, their appearance in the literature is not nearly as common. However, as Pauley et al. (1989) demonstrate, riffles may be subjected to accelerated scour following bar skimming, thereby washing out redds that might be present and reducing benthic macroinvertebrate abundance and species diversity. Off-site redd wash-out would also result from reach-scale channel incision caused by extracting greater volumes than recruited (**B9**).

Incision often accelerates bank erosion (**P14**) as both natural (tree roots, LWD, emergent vegetation, boulders, etc.) and engineered features (rip-rap, etc.) that strengthened banks from erosion become suspended above the new bed elevation (Lagasse et al., 1980). Bank erosion rates increase as the river seeks to restore its sediment balance by making up the gravel deficit created by mining by adding bank materials to its bedload (the “hungry water” phenomenon) (Kondolf, 1994a; Kondolf, 1995). This process can be explained, at least in part, by confinement of higher magnitude flows (greater than bankfull) within the incised channel, which elevates erosion stresses against the banks, leading to greatly accelerated bank erosion rates (Collins and Dunne, 1990). Incised channels typically undergo chronic arroyo-style bank cutting as the stream seeks to re-establish lost channel features (bars, floodplains) within the narrower confines (Harvey and Schumm, 1987).

As mentioned earlier, channel incision may also lower riparian groundwater tables (**P20**) and soil moisture levels, resulting in die-off of riparian vegetation and increased pumping costs for groundwater users (Philip Williams and Assoc., 1997).

Bed degradation in a main channel lowers the geomorphic “base level” for tributaries, leading to degradation in the lower reaches of affected tributaries through knickpoint migration (Harvey and Schumm, 1987), even though the tributaries themselves may be unmined. As with main channels, threats to bridges and other infrastructure (bank revetments, etc.) would result from tributary incision. Steepening of tributary gradients, an intermediate (but potentially long term) response to main channel lowering during headward erosion in the tributary, makes upstream migration more difficult for fish and can prevent access to important spawning and rearing areas, especially if natural and artificial grade control structures (bedrock, LWD, and culverts, sills, respectively) create hydraulic drops too large to be negotiated by fish.

Tributary incision can also increase bank erosion by the same mechanisms described above that occur in main channels (Harvey and Schumm, 1987). As with main channel bed degradation, benthic macroinvertebrate communities can be disrupted (**B1, B2, B3**) and valuable fish habitat can be lost if pools are converted to riffles or runs (**P1, P2**) and structural habitat elements (LWD, boulders, etc.) are washed away or become stranded above the lowered bed and wetted channel, reducing pool complexity and abundance of instream LWD (**P2, P12**).

River Channel Avulsion and Pit Capture (P15)

Floodplain and terrace mining, while not usually considered instream mining, has the potential to become instream in cases where pit off-channel extraction is carried out close to the active channel and where excavation depths exceed the depth of the adjacent channel. Numerous cases of pit capture (an unnatural form of river avulsion) are reported in the literature (Bull, 1974; Collins and Dunne, 1990; Kondolf, 1994a; Kondolf, 1997; Philip Williams and Assoc., 1997; Sandecki, 1989; Vick, 1995). When a dike separating the river from an off-channel pit is breached during a high flow event, channel adjustments are rapid and dramatic. These typically include incision of the channel upstream from the breach and erosion of an outflow channel through the levee at the lower end of the pit. Instances of multiple pit capture, where the breaching of one upstream pit leads to the successive capture of other adjacent pits downstream, have been documented (Bull, 1974). Water is temporarily impounded in the pits and virtually all coarse sediment carried by the river, including that scoured during the ensuing incision process, is deposited in the pit (McBain and Trush, 2000). This leads to incision below the point of flow re-entry to the channel due to sediment starvation. Impoundment of flow in pits can trap aquatic wildlife, including fish (**B11**), and lead to die-off due to lack of suitable habitat and food sources (**P1, P2, P3**).

In many cases, dikes are repaired and flow is once again routed back into the river channel. However, geomorphic effects of avulsion may persist in the channel for a period of years or decades. Moreover, the risk of repeated pit capture remains for the life of the pit, although it can be lessened somewhat (but not eliminated entirely) by engineering works such as bank revetments and channel re-alignment.

Loss of Low Flow Channel Confinement (P18)

Adjacent bars and banks substantially higher than the water surface provide confinement of the low flow channel. A confined channel is important for fish because successful migration (both upstream and downstream) depends on adequate water depth and attractant flow velocities. It is also important for bedload transport. Bar skimming reduces this confinement by lowering the relative height of the adjacent bar.

Most mining regulatory programs require skim elevations to be some distance above (one to two feet, most often), or at least no lower than the summer water surface elevation during extraction. While this prevents streamflow from spreading out across skimmed areas while flow remains low, a moderate increase in flow would cause water to overtop the skim area and spread out over a wide area. When this occurs, the potential for stranding of migrating fish (**B11**) is increased to a level inversely proportional to the elevation of the skim above the low water surface.

Loss of confinement can also affect water quality in two ways. Where skimming lowers the bar to below the low flow water surface, the flow spreads out over a wider area, becomes shallower and slower and more subject to warming from solar insolation and increased water surface area in contact with warmer air (**P5**). Increased water temperatures also cause lowering of dissolved oxygen levels (**P6**) (Pauley et al., 1989). In addition, turbidity levels may be increased in the early part of the rainy season as flow inundates and mobilizes suspendable sediment (silt and clay sized particles) from the skimmed surface (**P4**).

Loss of Pools (P1)

A well-confined low flow channel is characteristic of most channel types, except in braided channels. This confinement creates hydraulic conditions at high flow that form and maintain deep pools at the outsides of bends, where secondary currents converge to scour out sediment to depths below the average thalweg elevation. These pools provide important holding habitat for adult and juvenile salmonids. They serve as resting and holding areas for migrating juveniles and adults, and as hiding and feeding areas for juveniles.

As described earlier, bar skimming can scour riffle crests (**P3**), which function hydraulically as controls for the pool immediately upstream. When riffles scour, the controlling elevation for the pool is lowered, thereby diminishing pool volume, or eliminating the pool altogether (**P1**). Sufficient scour of the riffle may cause a shift from pool to run or glide. In rivers where pools are limiting, loss of any pools can impact adult and juvenile salmonids.

Alterations of Substrate Size (P8)

Rivers are composed of a variety of sediment sizes, ranging from silt and sand to gravel. Stability of alluvial rivers depends on armoring of bars with relatively coarse gravel material (Lagasse et al.,, 1980). Bar skimming removes the natural armor layer capping bars in alluvial rivers, thus it directly alters the size distribution of bed materials on the skimmed surface by exposing finer sediments beneath the armor layer within the skimmed area. Where several skimming sites are concentrated within a river reach, removal of numerous patches of the armor layer at skimmed sites has the potential to alter the size distribution of bed material along extensive segments of a river by selectively removing the coarser portions, making it finer and more likely to be transported during lower (more frequent) flows. A decrease in surficial gravel size by skimming the armor layer lowers the bar surface's resistance to scour when inundated, leading to braiding on the bar's surface (**P17**). Lagasse et al., (1980) show an association between gravel mining and an 88% reduction of gravel-sized bed materials in a 200-mile reach of the Mississippi River, and a doubling of braided ("divided flow") reaches. They state:

> "The documented decrease in bed material size, in general, and loss the armor layer, in particular, can be considered contributing factors to the increase in

> divided flows, deeper revetment [rip-rap] toe scour, and the tendency toward a wider, shallower cross section. Divided flow reaches create a less efficient channel for navigation, flood control, and sediment transport with a resulting increase in maintenance requirements (**P22**)."

Clearly, reductions in bed material sizes from instream mining triggers other responses in channel morphology and engineering works; these are discussed in more detail in other parts of this section.

Skimming enhances deposition of fine sediments on previously mined surfaces (**P7**) (Pauley et al., 1989; Woodward-Clyde Consultants, 1980) and may cause part of the river's fine sediment load to deposit and be temporarily stored within the river rather than be transported out of the system (to the ocean or a larger trunk stream). Fining of substrate size has been linked with several effects on aquatic biota, such as reduced benthic macroinvertebrate species abundance and diversity (**B2, B3**), poorer hiding and foraging habitat for juvenile salmonids (**P2, P3**), and higher egg mortality in salmonid redds (**B8**) (Pauley et al., 1989; Woodward-Clyde Consultants, 1980).

In other cases, instream mining can coarsen bed materials due to the "hungry water phenomenon (**P8**), akin to bed coarsening below dams which interrupt the flow of sediment to downstream areas (Kondolf, 1993). This process likely prevails on riffles within the low flow channel. Although opposite tendencies of bed fining and coarsening might lead one to conclude that the net effect on substrate size would be minimal, coarsening of riffles could occur at the same time and immediately adjacent to bar surfaces undergoing fining. In any case, alterations to substrate sizes to which aquatic biota are adapted would be expected to compromise habitat quality and quantity, and decrease species abundance and diversity.

<u>Loss of Large Woody Debris (I12)</u>

As discussed above, decoupling the active channel from its floodplain (**P19**) may result from excessive instream mining, causing loss of floodplain-stored LWD from the LWD budget of the river (**P12**). As discussed earlier with respect to increased bank erosion, enlargement of the channel by mining could cause high flows that would otherwise overtop the river's banks to be contained within the river channel thereby increasing velocities and boundary shear stresses. Increased hydraulic forces would increase LWD mobility and cause a net loss of LWD as the instream portion is washed away and not replaced by exchange with floodplain LWD. When combined with direct removal of LWD by humans (discussed later), habitat diversity within the wetted and active channel diminishes.

<u>Lowered Groundwater Table in Riparian Zones (I20)</u>

Channel incision is a commonly reported effect of instream gravel mining where the volume mined exceeds that necessary for maintaining bed elevations within, upstream from, and downstream from mining operations (**P13**). Where the predominant channel response is incision (bed degradation or lowering), floodplain soil moisture and groundwater tables can also be lowered by increasing the hydraulic gradient from the floodplain water table to the river channel, leading to more rapid summer drawdown of the water table in riparian areas. Resultant reductions in summer soil moisture and water table elevations can cause desiccation and die-off of riparian vegetation stands (**P11**). Hughes (1997) has shown a strong dependency of floodplain vegetation species composition on elevation relative to the channel and water table.

Where channel incision lowers the water table, floodplain surfaces are effectively elevated relative to the water table, reducing access to water in the capillary fringe just above the water table and decreasing survivability of riparian vegetation during times of moisture stress. This is especially likely in floodplains underlain by coarser sediments (gravel, sand), where moisture retention capacity is low compared to fine materials (silt, clay) and where hydraulic conductivity is high, facilitating rapid reductions in dry-season groundwater levels following incision. Kondolf (1994a) discusses several cases in California where documented lowering of the alluvial groundwater table caused significant mortality to surrounding riparian vegetation.

<u>Destabilization of Infrastructure Leading to Channel Disturbances During Reconstruction Activities (P22)</u>

Bed degradation and/or bank erosion (**P13, P14**) commonly precipitate engineering fixes to bridges, bank revetments, municipal water collection facilities, etc. (Avila-Crossett, 1998). Construction activities for repairing threatened or damaged infrastructure, by necessity, require disturbances to the river channel such as grading for staging areas and construction of access roads and settling ponds. Some projects cannot be completed in a single low flow season, so the disturbance is renewed for one or more additional seasons following the commencement of work. While such disturbances and their effects are typically localized in extent and limited in duration, they may add to and combine with other unnatural disturbances to river ecosystems.

<u>Increased Need for Bank Revetment to Reduce Bank Erosion (P23)</u>

As mentioned earlier, mining in excess of gravel re-supply may increase bank erosion. This can lead to damage of existing bank revetments, requiring them to be rebuilt (**P22**). It can also lead to extension of existing revetments upstream or downstream, or construction of completely new bank revetments where infrastructure or property damage has occurred or is likely to occur (Avila-Crossett, 1998). Although the damage to riparian ecosystems from levees and bank revetments is becoming increasingly recognized, society generally preserves its traditional view that protecting property subject to damage from bank erosion is more important than maintaining riparian ecosystem integrity. Consequently, the tendency still exists to increase, rather than decrease, bank revetments along rivers. To the extent that gravel mining increases bank erosion, it also increases the tendency to further reduce riparian ecosystem integrity by indirectly causing construction of new bank revetments.

Increased Vehicular Access to Riverbed and Floodplain (P24)

Facilities related to gravel mining, such as haul roads, provide and attract vehicular access to river channels. Activities associated with vehicular access commonly include LWD cutting/removal and off-road vehicle (ORV) disturbances to bar surfaces. Effects of ORV use include destruction of existing vegetation and prevention of early successional willow communities from becoming established (Richter, 1992). Other potentially damaging activities may include poaching of fish and deer, trash dumping, noise from vehicles, recreational firearm use, and removal of LWD for firewood or lumber. In Humboldt County, California, removal of LWD for firewood or lumber is a common practice that reduces instream and floodplain LWD and the habitat it creates for fish and other riparian species. While gravel mining facilities do not provide the only river access points, they contribute to the overall impacts of vehicular access to riparian zones on rivers.

2.4 SUMMARY

Realized and potential effects on riparian zones from instream gravel mining can range from relatively minor and short-lived to dramatic, pervasive, and chronic. Mining effects are rarely isolated in time or space. For example, river incision due to mining in excess of sediment supply (the most common of geomorphic effects appearing in the scientific literature): 1) decouples the channel from its floodplain, 2) lowers the riparian water table, 3) results in increased bank erosion, braiding, meander cutoff and channel widening, and 4) may precipitate channelization and/or construction of new bank revetments. Some effects discussed in this section, even if considered alone, represent substantial and persistent alterations to channel geomorphology, riparian habitat, and biota, while others are less so. However, relatively minor effects can combine synergistically.

In the broader sense, cumulative effects from instream mining must also be considered in relation to effects from other land uses, such as timber harvest. Elevated sediment yields from timber harvest have the potential to be partially offset by instream gravel removal, but the problem is more complex than simply removing an equivalent volume. Issues such as time delays, particle attrition, localized gravel depletion and resultant habitat loss, and maintenance of viable habitat during the recovery period must be considered if an objective is to manage gravel extraction for accelerating channel/habitat recovery from management-related sedimentation. Additionally, some instream effects from gravel extraction are similar to those from elevated coarse sediment yield, such as braiding and increased bank erosion. Consequently, the potential for synergistic cumulative effects between management-related sedimentation and instream mining must also be evaluated in situations where gravel mining is being considered as a means to mitigate channel sedimentation.

Most contemporary instream mining avoids wetted channel features during the low flow season (mining season), and probably minimizes direct, immediate, and localized effects to most aquatic habitat and organisms. This is frequently offered in environmental documents as a sufficient means to avoid impacts, and probably accomplishes impact avoidance of most of the potential direct, immediate, and localized effects of instream mining. However, some potential effects of instream mining at a single site can be delayed, distributed offsite, and combine with effects from nearby mining sites or other river influences (i.e., cumulative effects). Cumulative effects are the most difficult to predict, measure, and mitigate. Only with careful, informed management and strong regulatory controls that address localized, immediate effects and reach-scale mining-related cumulative effects can instream gravel mining be conducted without excessively compromising salmonid habitat.

3. EXTRACTION TECHNIQUES, STRATEGIES AND ASSOCIATED IMPACTS

3.1. INTRODUCTION

In this chapter, we describe approaches to determine zones in a river corridor potentially affected by instream mining, and develop a range of possible extraction strategies tailored to several generalized river situations and gravel mining management objectives. Recognizing that each mining reach has a unique combination of opportunities and constraints, and these may change through time, the strategies should assist in the review process, narrowing the universe of possibilities and providing a “first cut” method for evaluating the potential for adverse cumulative effects from new or existing gravel operations.

Our primary objectives were twofold. The first was to describe a tier of extraction strategies that spanned a wide range of annual extraction volumes expressed as a percentage of the mean annual recruitment (MAR, explained below). The second objective was to identify relative potential impacts to habitat and suggest monitoring requirements for each extraction strategy. These two objectives are compensatory: greater annual extraction, no matter how accomplished, generally produces more habitat impacts, and consequently requires more comprehensive monitoring and adaptive management.

Anadromous salmonid habitat is not simply confined to the bankfull channel or commonly flooded areas, but depends on the entire river corridor. Only by excluding gravel extraction from the river corridor can mining impacts to salmonid habitat be eliminated. Therefore, minimization of potential impacts is the best that can be expected if extraction is to continue within the river corridor. The annual volume and area extracted, the location of extraction, and methods of extraction all contribute to potential cumulative impacts. Recommended extraction strategies, therefore, must be tailored to specific site characteristics, the anticipated extraction volumes and methodologies, as well as potential, reachwide cumulative impacts. In turn, each extraction strategy impacts habitat differently. Some may be appropriate for headwater streams, generating only minor habitat disturbance, but inappropriate in large mainstem rivers. Therefore, no single extraction strategy completely meets all ecological or commercial expectations.

3.2. MEAN ANNUAL RECRUITMENT (MAR) AS AN EXTRACTION STRATEGY

While the volume of gravel transported (“recruited”) past a specific point on a river within a specific time period is unpredictable and can vary tremendously from year-to-year, the long term annual average volume provides an essential tool for managing cumulative effects from gravel extraction. We call this value the “mean annual recruitment”, or MAR. It can be estimated by several techniques that vary in accuracy. Generalized methods are briefly described below in order of increasing accuracy (for a more thorough discussion, see Collins and Dunne, 1990):

Regional sediment yield: this method applies an estimate of regional sediment yield (usually expressed in tons per unit area per year) to a local area within the region. Unless the regional value is expressed in terms of bedload (as opposed to total or suspended load), the method requires conversion (by using an assumed ratio of bedload to total or suspended load). In addition, within-region geologic variability can confound the estimate for the subject area, as can scale differences (the ratio of suspended to bedload typically increases with basin size).

Within-basin sediment yield: this method transposes unit sediment yields from an area within the subject basin (where it has been established from detailed sediment budget studies) to another point within the basin, usually by simply scaling to basin size. As with regional estimates, conversions may be necessary depending of the nature of the yield estimate used, although geologic variability may be lower. Scale differences may also apply, but probably to a lesser degree than with regional yields.

Reach-level conversions: this method uses measured suspended sediment transport relations for a certain reach and applies a conversion factor (the ratio of bedload to suspended load) to estimate bedload yield, assuming a long term gaging record is available. Accuracy of the estimate depends on the accuracy of the conversion factor used, with the most accurate results derived at locations that actually have overlapping bedload and suspended load measurements. Commonly used conversions assume bedload is between 5 and 10% of suspended load, with 20% a typical upper limit.

Sediment budget: a sediment budget relies on both sediment yield estimates (discussed above) and long-term historical topographic and other information (e.g., topographic maps, cross sections, bridge construction drawings, historical photos, etc.). Where available, sediment accumulation rates behind dams and/or actual measurements of sediment transport substantially improve accuracy. This method is preferred if sufficient data are available because it is the most comprehensive method and allows crosschecking of results to evaluate accuracy (Collins and Dunne, 1990; County of Humboldt, 1993).

Using MAR as a basis for determining appropriate extraction strategies is a robust method for ensuring or evaluating sustainability. Although different terms are used to describe this recruitment-based approach, it has been used to develop sustainable extraction strategies in a number of locations in the western US (Collins and Dunne, 1990; Collins, 1992; County of Humboldt, 1993). It applies the basic concept of the river continuum in avoiding cumulative effects by ensuring that extraction volumes remain low enough to leave sufficient gravel in the river to maintain channel integrity (alluvial structure). Risk (to bridges, salmonid habitat, and other issues dependent on alluvial structural integrity) will generally increase with an increasing percentage of MAR extracted. Other strategies, such as those based on replenishment (gravel accumulation in a reach) or “redlines”, require judgement calls on exceedingly uncertain target conditions, require intensive monitoring, and tend to keep rivers in a state of impacted habitat by failing to accommodate the natural geomorphic variability necessary to support healthy river ecosystems. Figures 5 through 7 depict graphically the primary extraction strategies discussed in the chapter.

What is an "Appropriate" Extraction Strategy?

An appropriate aggregate extraction strategy must maintain and recover habitat to promote species recovery. In this chapter, we present a range of approaches to extracting gravel that vary in the degree to which they balance environmental and commercial goals. They range from low risk to very high risk of cumulative effects from instream gravel mining. Good salmonid habitat requires complex channel morphology with abundant instream cover and vigorous, complex riparian vegetation assemblages. Habitat maintenance and recovery require a sustainable aggregate extraction strategy that only harvests a fraction of the MAR when averaged over many years. These requirements can be combined as:

> *An appropriate extraction strategy prescribes annual extraction averaging less than the mean annual recruitment in such a manner as to preserve, maintain, and recover a complex three-dimensional channel morphology within the immediate area of mining, as well as to prevent cumulative effects over the entire potentially affected river reach.*

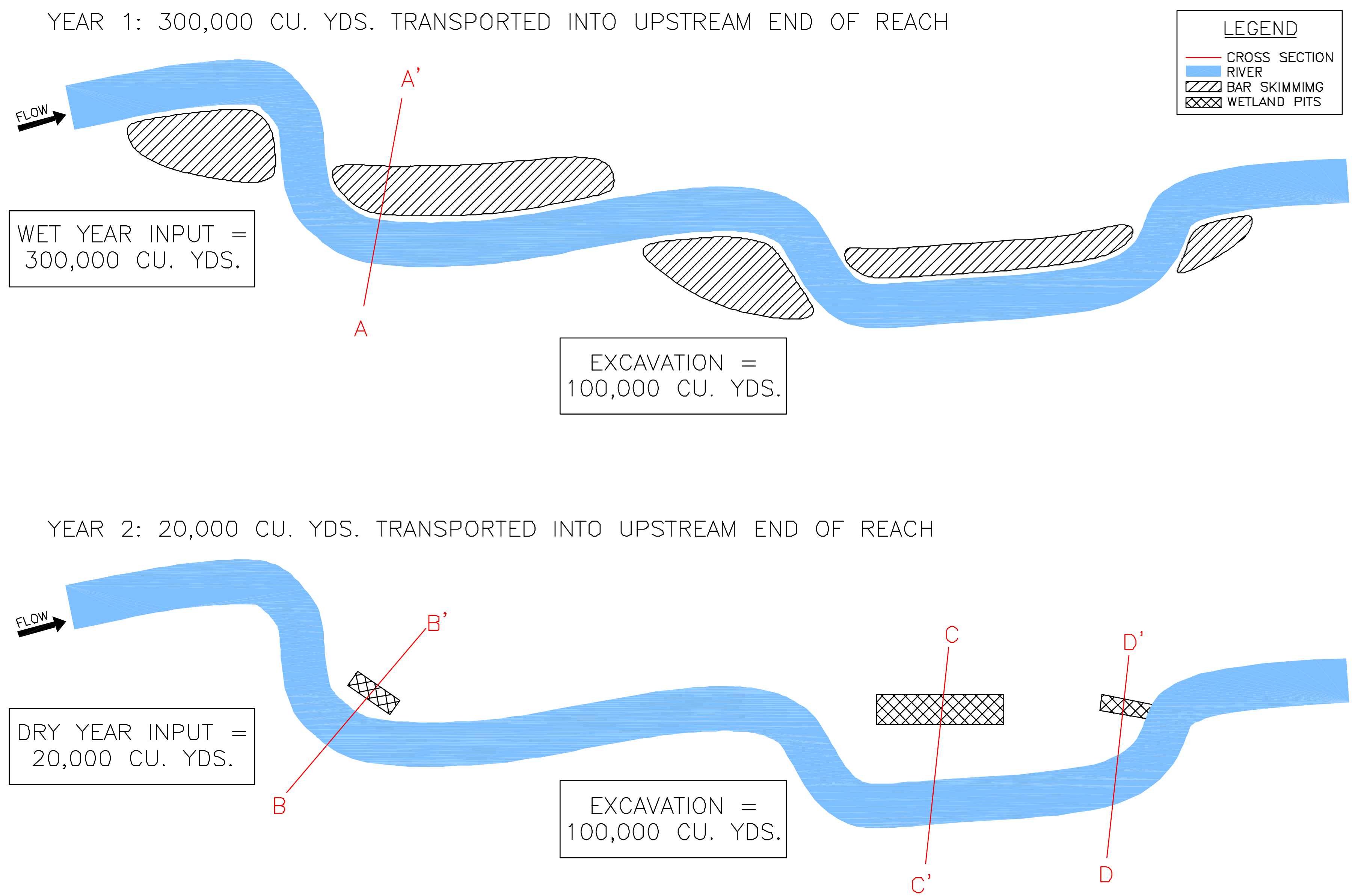


FIGURE 5.

MEAN ANNUAL RECRUITMENT (MAR) STRATEGY AT TWO POINTS IN TIME

ASSUMING A LONG TERM AVERAGE ANNUAL SEDIMENT INPUT = 100,000 CU. YDS.

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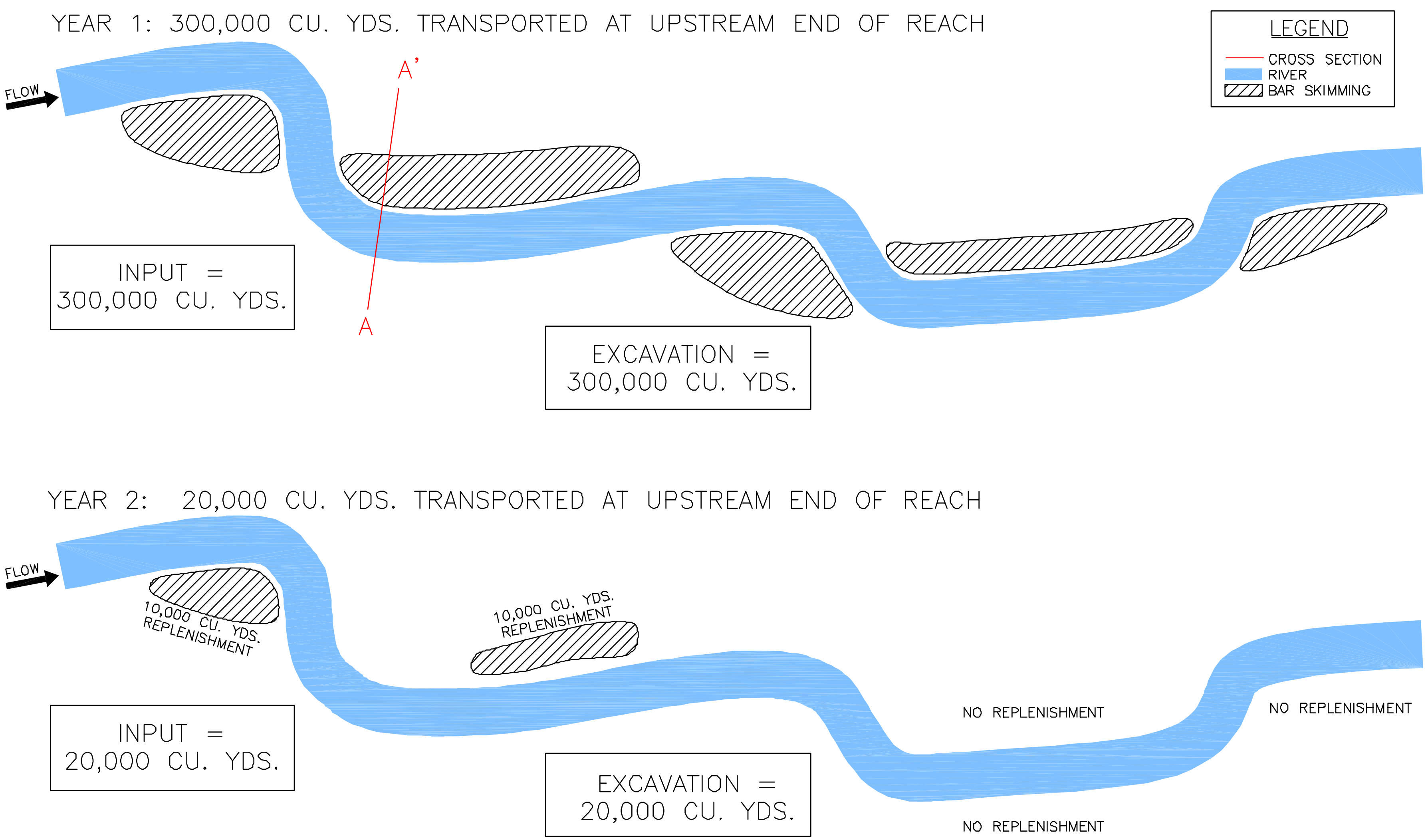

FIGURE 6.
ANNUAL REPLENISHMENT STRATEGY AT TWO POINTS IN TIME
BASED ON ANNUAL NET STORAGE INCREASE ON MINED BARS
ASSUMING A LONG TERM AVERAGE ANNUAL SEDIMENT INPUT = 100,000 CU. YDS.

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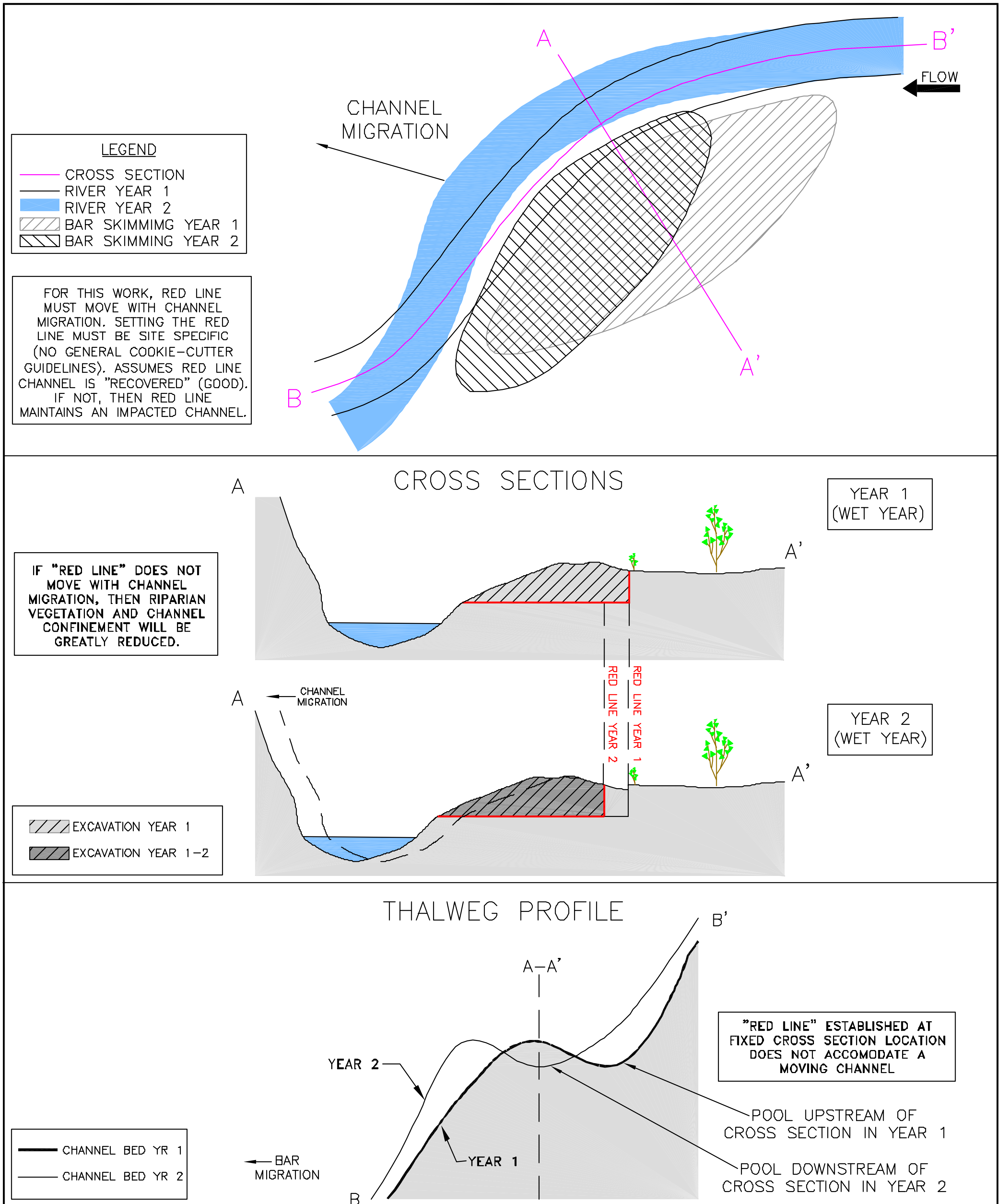

FIGURE 7.
ANNUAL REPLENISHMENT (RED LINE) STRATEGY

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Most contemporary mainstem channels bear little resemblance to their historic counterparts. Cumulative effects from multiple sources have greatly simplified mainstem channel complexity (see Chapter 2). Therefore, a policy that maintains the status quo condones continued habitat impacts for most northern California rivers. Extraction strategies that only maintain contemporary, impacted channel morphologies, and therefore do not protect and recover habitat, were not considered “appropriate” in our definition.

To the extent that instream mining has contributed to the problem, salmonid habitat maintenance and recovery require a sustainable aggregate extraction strategy; one that only harvests a fraction of MAR annually. More gravel exiting the reach than is deposited in the reach causes channel incision, widening, and loss of channel habitat “infrastructure” (low flow channel and bar morphology, riparian vegetation), and thus cannot maintain habitat. Therefore, the extraction modifier “appropriate” also explicitly requires sustainability. One issue will center on whether extraction of the annual replenishment (specific to each mining season) is permissible or if averaged annual extraction (a moving, multi-year average) also is permissible. In low water years, the latter would allow extraction in excess of that year’s replenishment (as has occurred on the Mad River) but would provide a less variable rate of annual extraction. While short-term (annual) sustainability may be desirable ecologically, longer-term sustainability may be more desirable commercially.

Long-term sustainability is necessary of an appropriate extraction strategy. Gravel companies need as much predictability as possible to forecast revenues and meet demand. If no extraction is allowed in a dry year with little or no bar replenishment, companies will be forced to seek other nearby sources in or near the river corridor (e.g., unmined gravel bars). This would surely extend potential cumulative effects riverwide. The challenge, therefore, will be to allow short-term over-extraction (exceeding recruitment in 1 or 2 sequential low flow years, analogous to incurring a short-term dept in one’s personal finances) without jeopardizing longer-term habitat recovery or maintenance (extracting less than annual recruitment for a few years to pay off the sediment debt).

Salmonid habitat protection requires scientific justification and political/regulatory recognition and support of refugia. An important component of any extraction strategy, therefore, is to delineate where not to extract. These refugia may be within, upstream, and/or downstream of a presently mined reach. An extensive alcove on the downstream edge of a forced meander bend may warrant no future extraction of that bend’s inside point bar to preserve this potentially important juvenile salmonid habitat feature (depending on the relative importance of the feature as local refuge). At a larger spatial and temporal scale, mining operations should not be allowed to restrict future channel migration, e.g., by excavating corridor pits (addressed below). Habitat is often mobile, episodically rejuvenated by a migrating channel (e.g., alcoves on alluvial channel bends). Therefore, to a large degree, a migrating channel is needed to maintain habitat.

Physical complexity, the underpinning of habitat, requires a channel infrastructure of migrating floodplains, multiple terraces, and diverse riparian stands. Rebuilding this complex infrastructure, while sustaining economically viable extraction, is the primary challenge. This can be done, but only at a compromise. Even if all extraction operations were delegated outside the contemporary river migration zone (but inside the river corridor), recovery would still be constrained. Narrowing of the migration zone, ubiquitous large wood removal, urban encroachment, and imbalanced coarse sediment loads will continue constraining recovery. What will recovered rivers, given these constraints, look like? We do not know exactly, but we do not expect complete habitat recovery relative to pristine conditions. The backdrop of pervasive cumulative effects is too great. Each river will achieve its unique channel morphology if allowed (and probably rather quickly) within this backdrop; this future, more complex channel morphology should improve habitat and assist in species recovery.

Setting Spatial Boundaries

Effects of mining may extend well beyond the limits of gravel extraction sites, both upstream and downstream as well as laterally (see Chapter 2). For successful implementation, extraction strategies need clearly defined boundaries. Longitudinal boundaries along a river are needed for delineating the “designated mining reach” within which cumulative effects on channel responses and riparian habitat and biota could be expected. Lateral (outward from the channel) boundaries are also needed to delineate zones where different mining methods are appropriate, and where different types and durations of impacts are expected. We propose the following methods for delineating these boundaries.

Defining Lateral Boundaries

Figure 8 shows a typical large alluvial river with several zones comprising the river corridor that influence the extraction strategies. Figure 9 shows these zones displayed as a cross section across the river corridor. The zones correspond to distinct fluvial surfaces that decrease in frequency of hydrologic and geomorphic activity with increasing distance outward from the channel. Because of the strong interdependence between hydrologic/geomorphic processes and mining effects, delineation by this approach provides a robust method for evaluating extraction strategies. The zones delineated in Figures 8 and 9 are described as follows:

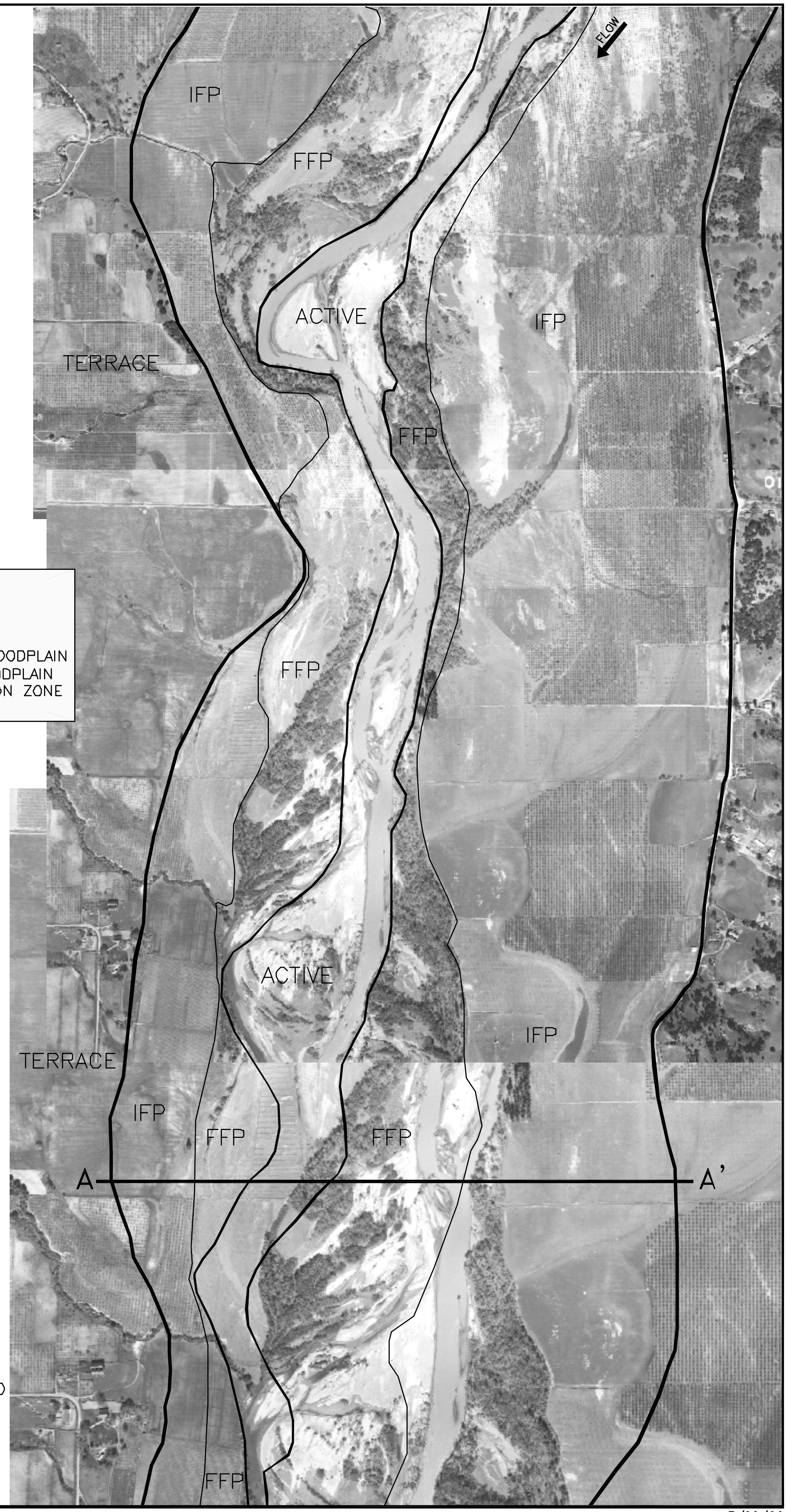
Active Channel: The active channel (AC, Fig. 8) resides within the floodplain and usually comprises a portion of the bankfull channel and roughly corresponds to “ordinary high water (OHW). It is the common zone of active bedload transport and deposition and includes unvegetated bars where skimming usually takes place. Skimming is generally confined to the active channel. Active channel mine areas, such as skimmed bars, have a relatively high probability of replenishment in any given year.

Frequent and Infrequent Floodplains: Floodplains are alluvial surfaces adjacent to the bankfull channel and are inundated by the 2-year or greater floods. Floodplains can be subdivided into zones that reflect various frequencies of inundation, such as the frequent floodplain (FFP, Fig. 8) and the infrequent floodplain (IFP, Fig. 8). We distinguish the FFP as the surface inundated by the 1- to 10-year flood and the IFP as that inundated by the 10-yr to the 100-yr flood. While finer distinctions are possible (i.e., 50-year floodplain), these provide sufficient resolution for the extraction strategies described below. Probability of replenishment of mining areas, in general, correlates with inundation frequency. Thus the higher up a mine area is on the floodplain, the lower probability of replenishment.

Terraces: Typically one or more sets of terraces (abandoned floodplains, Amer. Geol. Inst., 1976) are located outward from a river's floodplain. Low terraces may be very infrequently inundated by extreme floods (e.g., 500-year), but are not commonly considered part of the floodplain. They may, however, be geomorphically active, i.e., subject to erosion in locations where the outside of a channel bend is immediately adjacent to a terrace (TMZ, Fig. 8). Because of their greater vertical and/or horizontal distance from the active channel, terraces mining pits have low or no probability of replenishment (i.e., not sustainable), and therefore must be considered permanent features on the landscape that eliminate most other future land uses.

FIGURE 8.
1940 AIRPHOTO OF AN ALLUVIAL RIVER

SHOWING LATERAL ZONES WITHIN THE RIVER CORRIDOR



LEGEND

TERRACE = ABANDONED FLOODPLAIN
IFP = INFREQUENT (10-YR TO 100-YR) FLOODPLAIN
FFP = FREQUENT (1.1-YR TO 10-YR) FLOODPLAIN
INCLUDES CMZ = CHANNEL MIGRATION ZONE
ACTIVE = ACTIVELY SCOURED CHANNEL

NORTH

1600 800 0 1600

SCALE: 1 IN = 1600 FT

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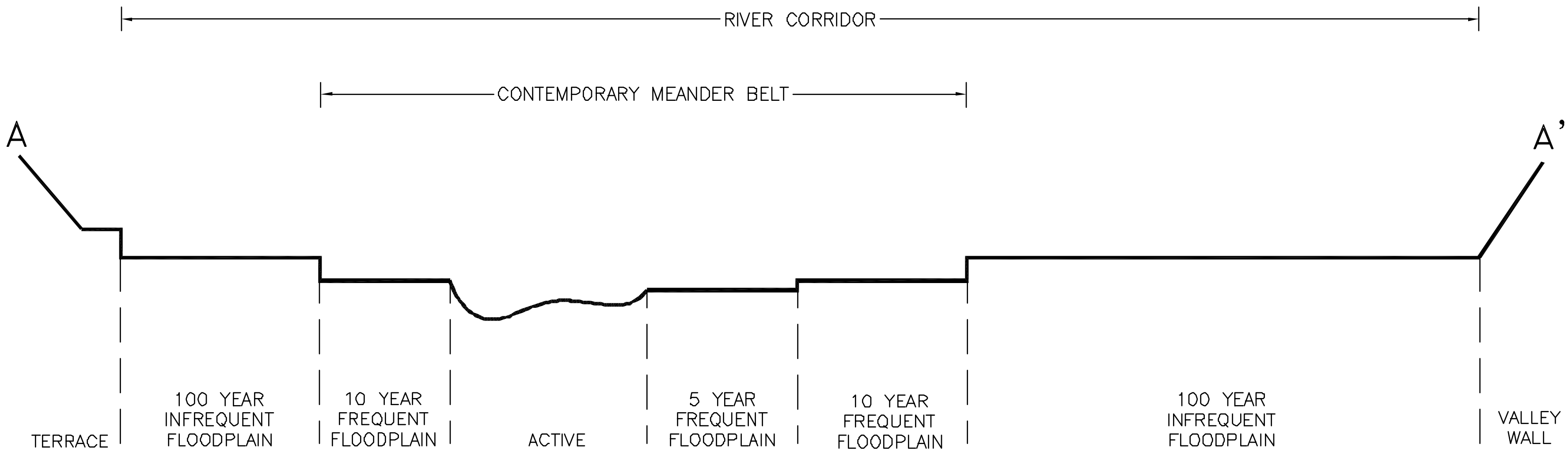

FIGURE 9.
EXAMPLE CROSS SECTION OF AN ALLUVIAL RIVER
SHOWING LATERAL ZONES WITHIN THE RIVER CORRIDOR

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Contemporary meander belt: This is the geomorphic zone of active channel migration and contains existing and recently abandoned channel meanders. It is located within the river corridor and exhibits features indicative of former channel positions (oxbow lakes, meander scars, curvilinear riparian vegetation strands). The contemporary (relatively shorter-term) meander belt is comprised of the active channel, the floodplain (or a portion thereof), and terraces subject to lateral channel erosion (TMZ, Fig. 8).

Floodway: This includes all areas within the 100-year floodplain (AC, FFP, IFP) and corresponds to the regulatory (e.g., FEMA) definition, so long as the latter has been delineated with sufficient resolution and accuracy.

River corridor: The river corridor encompasses this contemporary meander belt as well as higher elevation floodplain surfaces (outside the contemporary meander belt) that generally extend no higher than the 100-yr flood elevation and often only up to the 50-yr flood elevation (roughly equivalent to twice the maximum 2-year flood depth, Rosgen, 1996). It also includes areas outside the contemporary meander belt (part of the long-term meander belt) that, unless obscured by land use, bear evidence of channel meandering decades to hundreds or thousands of years before the present. The river corridor is typically bounded by hillslopes or high, uplifted terraces well above the floodway. Table 3 shows the relationship between hydrologic, geomorphic, and operational zones used in this chapter.

Hydrologic Zones	Geomorphic Zones	Existing, Historic Operational Zones	Recommended Operational Zones
“Ordinary High Water” Channel (approx.)	Active Channel	Bar Skimming, Alcoves	Bar Skimming, Alcoves
Frequent (2- to 10-year) Floodplain	Contemporary Meander Belt	Wetland Pits (few), Diked “Permanent” Pits Prone to River Capture (many)	Wetland Pits
Infrequent (10- to 100-year) Floodplain	Long-term Meander Belt		No Mining
Abandoned Floodplain	Uplifted Pleistocene Terraces	Upland Pits	Upland Pits

Table 3. Comparison of hydrologic, geomorphic, and operational zones within the river corridor.

No simple guideline can definitively outline river corridor boundaries in all situations. Where broad floodplain surfaces extend for miles beyond the active or bankfull channel (unlike that shown in Figs. 8 and 9), a method is needed to constrain the river corridor within practical limits. Corridor width could be based on a set of geomorphic and hydrologic criteria that are relatively easy to apply and capture the zone of present and likely future channel migration, such as at least doubling the average width of the contemporary meander belt.

A different approach is usually needed for regulated rivers. Dams typically regulate both flow and sediment transport downstream such that the scale of the river is much smaller than pre-dam conditions. This reduction in scale may be to the point where the post-dam river corridor often extends no higher than the pre-dam meanderbelt, or for highly regulated rivers, extends no higher than the pre-dam floodplain. The pre-dam floodplain often becomes the 50-yr to 100-yr terrace through flow regulation. The meanderbelt is often eliminated entirely and the active channel narrowed significantly. Pit mining in many California regulated rivers is occurring up to their former (but narrowed) active channels, extracted to depths well below the rivers' thalweg elevations, and separated from the active channel by only ineffective dikes. The Tuolumne River is a good example (Vick, 1995; McBain and Trush, 2000). This ongoing legacy of gravel extraction has created extremely few options (all expensive) for recovering salmonid habitat. If mining is occurring or already permitted within the river corridor of a regulated river, extraction should be allowed no deeper than a channel's contemporary floodplain elevation and outside the anticipated long-term meander belt. Any deeper poses a long-term risk to habitat maintenance and recovery.

When a regulated river's annual flow and coarse sediment regime is significantly reduced, the river's ability to migrate consequently diminishes. The pre-dam meander belt width in a highly regulated river is a minimum approximation of the post-dam river corridor width needed for habitat maintenance and recovery under the regulated flow regime.

Defining Longitudinal Boundaries

The anticipated upstream and downstream limits of cumulative effects due to aggregate extraction should be used to define the longitudinal boundaries of what we refer to as the designated mining reach. As discussed in Chapter 2, mining effects on habitat and aquatic biota can propagate for long distances upstream and downstream, depending on the type and intensity of mine operations in a localized mining reach. However, defining the affected reach may not be easy. In mined reaches near the coast, such as the lower Mad and Eel rivers, the ocean is the logical downstream terminus. For other situations, however, such as the South Fork Eel River, the downstream limit of cumulative effects is not as apparent.

As a gravel particle is transported downstream, friction with other particles grinds down the particle to a smaller size ("particle attrition"). Consequently, a cobble extracted from the South Fork Eel River at Garberville is not a cobble "lost" to the Eel River below the Van Duzen River confluence because much if not all the cobble's mass may be converted to sand through particle attrition by the time it reaches Scotia. This greatly affects how we consider cumulative effects. The gravel operation at Garberville would not have a cumulative effect on cobble supply for other operations below Scotia, but the same Garberville operation could be affecting sand supply below Scotia. What then would be the downstream limit of potential cumulative effects for the Garberville operation? The simple answer would be the estuary or ocean, but the more complex reality is how to manage (and allocate) sediment budgets for various sized particles over a > 3100 mi^2 basin as the Eel River. Should the sand (but not the cobble and gravel) extracted at Garberville be subtracted from the estimated MAR for operations below Scotia? Probably not, but the spatial scale must still be resolved by an objective, scientifically valid protocol that assesses the available information. For example, one would want to consider the reduction of coarse sediment load from mining at the upstream location, particle attrition between the two sites, additions of coarse sediment from tributaries in the intervening reach and attrition of those loads, coarse sediment sinks in the intervening reach, time delays, and perhaps other physical phenomena. Clearly, this is a complex problem that is not well addressed with tools (e.g., sediment transport models) presently available.

Despite substantial analytical challenges, the case described above is relatively simple in that it only considers a single channel. However, most situations involve multiple stream channels and gravel extraction operations. The contribution of gravel (or lack thereof) and habitat effects from mining in a tributary affects not just the tributary, but also the trunk stream into which it flows. For example, should the lower Van Duzen River be considered part of the same cumulative effects as the mainstem Eel River from Scotia to the estuary? Perhaps a minimum downstream limit should be, other than to the ocean or estuary, the downstream-most tributary (or watershed area) that cumulatively replenishes the gravel extracted upstream. This approach makes geomorphic sense, but requires reasonably accurate estimates of the contributions of all coarse sediment sources and evaluation of other operations along relatively long mainstem river reaches and tributaries.

Upstream effects are also well documented in the literature (see Chapter 2), but are typically not as extensive. Nonetheless, the designated mining reach must include the river for some distance upstream of mined sites, and the distance would be proportional to the size of the river (primarily determining sediment supply) relative to the average annual rate of extraction. A local geomorphic base level (provided by lithologic or engineered controls on channel downcutting through knickpoint migration) located upstream from a mining area would, in most cases, provide an upstream limit to the mining effects. Lacking this, mining-induced channel incision through upstream knickpoint migration would have to be either: 1) determined by topographic (channel cross section) information, if available, or 2) estimated from case studies in similar reaches.

Regulated rivers are possibly more complex, depending on the extent of flow and coarse sediment regulation. For example, on a highly regulated river, gravel extraction would not be sustainable downstream from the dam until a point is reached where coarse sediment influxes compensate for dam losses. Below that point, instream gravel mining might be sustainable. Using bedload models on regulated rivers requires special attention, as several model assumptions can be seriously violated (for example, the assumption of unlimited bedload supply).

3.3. HISTORIC AND CONTEMPORARY GRAVEL EXTRACTION METHODS

A variety of methods have been used through the years to extract gravel from river corridors in California. Several of those described below have been either nearly or fully abandoned as their impacts on river ecosystems and human infrastructure have become more apparent. The primary methods of gravel extraction conducted within river channels since the middle 1900s have been:

1. Excavating pits spanning the entire channel width, sometimes to elevations well below the river's thalweg.

2. Excavating pits occupying most of the active channel width to below the groundwater table elevation, while leaving or constructing a berm separating the low-flow channel from the pit.

3. Excavating a deep, curvilinear trench adjacent to the low-flow channel but separated from the low flow channel by a residual berm,

4. Skimming bar surfaces adjacent to the low-flow channel down to the elevation of the groundwater table.

5. Skimming bar surfaces to elevations above the groundwater table at various slope gradients, sloping toward the low-flow channel edge (cross channel) or downstream.

6. Excavating a "wetland" pit to elevations below the groundwater table on the insides of meander bends on low terrace surfaces and set back some distance from the low flow or active channel.

7. Excavating "alcoves" connected to the low flow channel near the downstream ends of bars.

8. Excavating permanent or semi-permanent pits into older fluvial deposits on infrequent floodplains or terraces.

Several types of heavy equipment have been used to extract gravel, depending on the type of excavation. Dragline cranes were best suited to excavation of pits, which were dug to below the water surface over large areas. Skimming is usually accomplished with scrapers, bulldozers, or front-end loaders. Trenching is accomplished using large a large backhoe or excavator.

To our knowledge, only the last four methods have been used recently, and only 5-7 are recommended in this report. Figure 10 depicts contemporary gravel extraction methods. While some contemporary extraction methods are less harmful to riverine resources than others, there is still much room for scientifically guided experimentation with new methods that might further limit the impacts of instream gravel mining. For example, radial trenches on point bars (D. Rosgen, pers. comm., 1999) may provide a means to conduct gravel extraction while avoiding or minimizing some of the effects of bar skimming. This type of extraction, if properly designed and constrained, would better preserve the coarse armor layer on the bar surface as well as low flow channel confinement. However, salmonid stranding risk could increase if trenches do not drain to allow juveniles to escape from them. Careful planning, design, and experimentation should precede wholesale application of new techniques.

Brief descriptions of extraction types and associated impacts are given below (see Chapter 2 for a more detailed discussion of impacts. The reader is also referred to Collins and Dunne (1990) for additional discussion of effects of instream mining methods, impacts, and assessment methods.

Pits within the bankfull channel (1 and 2, above): Pits within or immediately adjacent to the low flow (which is within the bankfull channel) channel which are excavated to depths below the thalweg elevation likely had the most profound and immediate effects on channel processes and form, and thus riparian and aquatic habitat. This configuration creates a large basin that causes abrupt decreases in water velocity, similar to a reservoir behind a dam considered in the short term. When flows sufficient to transport sediment from upstream reaches occur, they very efficiently trap virtually all bedload transported, leading to channel incision downstream due to the interruption of sediment supply. They continue to starve downstream reaches of gravel until deposition in the pit restores sufficient bed elevation to allow transport past the pit to downstream reaches.

In addition to trapping bedload sediment that is transported from upstream reaches, pits within the active channel can cause rapid scour of the bed through upstream migration of the knickpoint created by the upstream lip of the pit. A knickpoint may migrate a long distance upstream of a deep pit, depending on river slope, sediment supply, flood magnitude, and other factors. Channel bed scour may also occur downstream of the pit. Pit excavations can be sufficiently large, numerous and near each other to propagate past one extraction site and reach up to and combine with bed scour migrating downstream from another. This can lead to incision over a very long reach of river well beyond the extraction areas. Rapid bed scour presents an immediate danger to nearby bridges, levees, and other facilities having foundations within the active channel. It also adversely affects aquatic habitat (discussed in Chapter 2) by altering hydraulic geometry and destabilizing riffles and other bedforms.

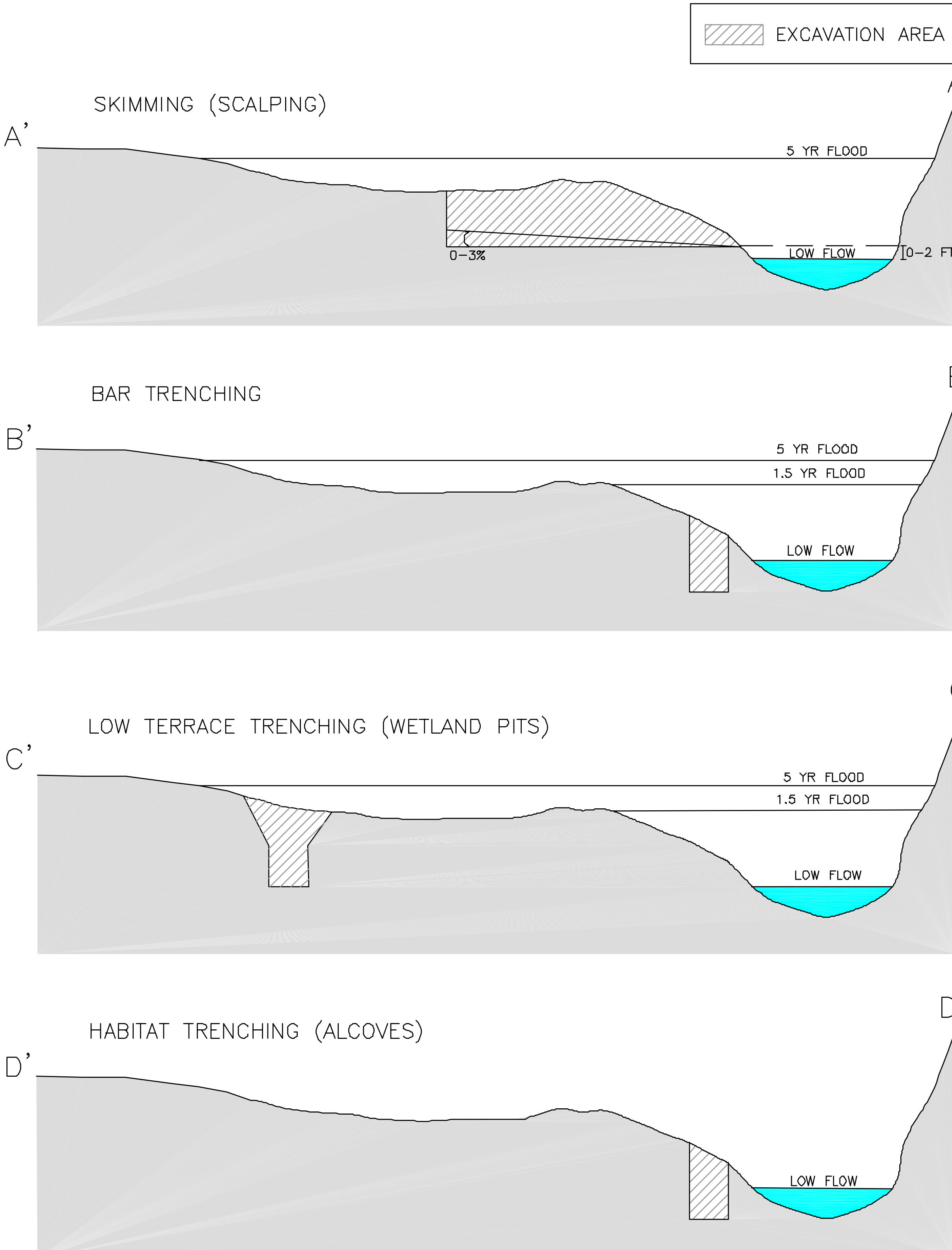

FIGURE 10.
DIAGRAMS OF CONTEMPORARY
GRAVEL EXCAVATION METHODS
(SEE FIGURE 5 FOR PLANVIEW)

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As pits refill with new sediment, a channel morphology is created which is discontinuous with adjacent channel bedforms. During the intermediate stages of refilling, transitional bedforms such as mid-channel bars may be deposited, or a lateral or point bar may develop which is out of phase with similar features up- and downstream of the pit, triggering planform adjustments beyond the extraction area.

Trenches within the active channel (3, above): Trenches were commonly dug just inside the low-flow channel on meander bends and were sometimes intended to realign the channel. Being near the low flow channel, they readily capture the thalweg even during low to moderate stormflows. This artificially shortens channel length, decreasing radius of curvature and increasing slope of the thalweg. Consequently, the channel is temporarily destabilized as it adjusts to the new conditions, and planform adjustments and thalweg lowering can be expected upstream of and downstream from the trench.

Trenching adjacent to the low-flow channel likely has effects similar to those from pits. They very efficiently trap bedload and promote bed scour, even in low-flow years. Trenches tend to capture the thalweg, thereby realigning segments of the river and producing a geomorphically discontinuous planform. Incomplete capture of the low flow channel results in multiple channels (also known as braiding or divided flow). Trenches excavated on the inner margin of a meander bend (away from the low-flow channel) and sufficiently close to the head of the bar increase the risk of a meander cutoff during a high flow event. Radial trenches on the downstream half of the bar is a new technique (D. Rosgen, pers. comm., 1999) that would better preserve the coarse surface layer of the bed surface and reduce risk of channel capture, but would also reduce sediment routing downstream and would encourage salmonid stranding during flood recession limbs.

Bar skimming (4 and 5, above): Bar skimming down to the groundwater elevation on a level, planar surface virtually eliminates the beneficial confining effect, which bars have on the inner channel. As with trenching and pit excavation, this method of gravel extraction can result in bed scour, braiding, channel realignment, and may prevent riparian vegetation regeneration. A more appropriate method of bar skimming, and that most common today, leaves sufficient vertical offset of the skim floor above the low flow water surface to preserve some low flow channel confinement. Additionally, cross-channel or downstream-oriented skim floor slopes (1-3%) help provide for drainage following inundation by post-mining flow events and thus reduce potential fish stranding. This is the most common type of extraction occurring today and is depicted in Figure 10.

Off-channel ("wetland") pits (6, above) on the frequent floodplain: Creation of wetland pits as a method of providing commercial aggregate during periods of very low recruitment has been used successfully in Humboldt County and perhaps elsewhere. On the Mad River during the 1992 and 1993 extraction seasons, several wetland pits were excavated on high bar/low terrace surfaces that were inundated about once every five years on average. The rationale for selecting this type of feature was that it would be sufficiently removed from the active channel in low to moderate flow years to have little effect on channel morphology or sediment transport, but with the occurrence of flows of about 10-year recurrence interval or greater, they would refill with commercial aggregate.

These pits were up to several acres in size and were located downstream from the upper end of the bar to avoid the risk of knickpoint migration causing development of a meander cutoff. Designs incorporated features to enhance their value as short-term riparian habitat. Pit bottom depths were below the groundwater table and side slopes were very gentle (as low as 10%) so that a spectrum of terrestrial, emergent, and aquatic plants could colonize the pit margins. The planform of the pits was designed to follow existing vegetation patterns, resulting in an irregular shape bounded by existing vegetation. Woody debris was placed in some to provide complexity and resting places for birds and amphibians. The first several years following excavation, winter storms were relatively small, and the Mad River wetland pits became fringed with abundant wetland plants species and wildlife species were observed to be using them. Subsequently, following several wetter flow years, nearly all of the pits refilled with gravel as expected.

Wetland pits located on frequent floodplains (depicted in Fig. 10) provide a relatively low impact means of providing for commercial gravel extraction through times of low recruitment while offering off-channel wetland habitat in the interim. It must be stressed, however, that there is a limit to the extent to which these pits may be utilized without creating a reach-wide sediment deficit or elevating the risk of meander cutoff.

Alcoves (7, above): Frequently, a scallop-shaped pool is found at the downstream end of a meander bend and downstream of the crossover point. This feature is most likely formed as overbank flow re-enters the main channel during floods and is coincident with a pool in the main channel. At low flow, water in alcoves can be cooler than main channel water in coastal streams, thus providing thermal refuge for fish during the warmest times of the year. Direct observation has shown preferred use this of habitat on the South Fork Eel and Mad rivers, Humboldt County. The source of this cooler water is probably emergent groundwater flowing through alluvium beneath the bar’s surface. Gravel extraction can be configured to mimic alcoves on bars where none presently exist. This was done on the Mad River in 1994, and juvenile fish were observed utilizing the feature shortly after excavation. As with wetland pits, alcove excavations can provide a modest volume of gravel for commercial purposes while also providing aquatic habitat that may be lacking. Risks of fluvial geomorphic impacts are expected to be low assuming alcoves size and placement replicate similar naturally occurring alcoves nearby.

Terrace pits (8, above): Terrace pits are not normally considered instream mining, but many examples exist in California (Tuolumne, Merced and Russian rivers) and elsewhere of a pit capturing the river where the two are separated by narrow dikes. Terrace pits commonly are excavated to well below the adjacent river’s thalweg elevation, a condition that exacerbates the consequences of pit capture. In addition, they are virtually permanent features on the landscape, prevent channel migration, and severely limit future land use options due to the formidable expense of filling (reclaiming) them.

3.4. SITE-SPECIFIC CRITERIA FOR MINIMIZING IMPACTS

Many criteria presently used to minimize habitat impact at mining sites are based on professional judgement and have been reasonably successful. In this section, we list these criteria as they exist today.

Skimming Design Criteria

1. A curvilinear bench skim along the outside of point bars (Fig. 2) provides a good replenishment configuration without preventing riparian colonization;

2. Skim widths need to be constrained to avoid braiding (divided flow) by being no wider than about half the unvegetated bar width (Fig. 2);

3. Skim floors should provide for drainage following inundation (either directly toward the low flow channel, in a downstream direction, or somewhere in between; Fig. 3) to reduce salmonid stranding potential;

4. A vertical offset should be provided that retains some degree of low flow channel confinement (Fig. 3);

5. The upper one-third of a bar should be left unmined to preserve some degree of high flow confinement of flows entering the bend and discouraging braiding (Fig. 2).

6. Disturbance to existing riparian vegetation stands and areas of potential natural riparian recruitment should be avoided, limiting skimming to areas of frequent bedload movement.

7. Skim areas should move as the channel migrates (and not expand) to maintain natural riparian regeneration processes.

Wetland Pit Design Considerations

1 Gentle (10:1) side slopes should be provided around the outer edges of pits, with deeper areas in the interior to increase volumes (see Appendix A);

2 Pits should not disturb existing riparian vegetation, but rather conform to existing openings in riparian vegetation;

3 Pits should be avoided near the upstream ends of bars to avoid elevating the risk of meander cutoff;

4 Total pit area on a bar should not exceed about 10% of the bar’s surface area to avoid elevating the risk of meander cutoff.

Extraction Method Refinements

Although historical methods that had the most dramatic and immediate negative effects on channel geomorphology and habitat have, for the most, been abandoned (with the exception of stream-adjacent terrace pits separated by ineffective dikes), there is still much room for improvement of existing methods (primarily skimming and wetland pits). Refinement of design criteria is a subject desperately needing research attention. For example, the availability of an objective, hydraulically and biologically meaningful method to determine the minimum vertical offset necessary for preserving low flow channel confinement would improve skim designs relative to maintenance of habitat. Present methods use one foot above the low flow water surface as a minimum for all river situations, but there are at least two problems with this design criterion: 1) intuitively, the vertical offset should be scaled to river size and perhaps other geomorphic/hydraulic and biological characteristics, and 2) flow varies substantially from year–to-year and even through a single mining season. As an example of a biologically-based approach, if maintaining channel confinement for fall adult salmonid migration is an objective, channel criteria that confine river flows that initiate fish migration could be incorporated into skim designs through hydraulic analyses. Lacking such quantitative analyses, a commonly observed feature termed the “silt band” located on bar margins adjacent to the low flow channel (probably a signature of an algal bloom during the late-winter, early spring freshet) has provided a reference datum for achieving hydraulic consistency of skim vertical offsets through a mined reach, and appears to provide adequate confinement for adult salmonids to successfully migrate.

The following presents issues we feel need to be addressed, through experimentation in the field or in the laboratory through physical modeling, to provide much needed refinements to extraction designs:

1. A meander bend’s radius of curvature may be important relative to bar stability potential mining impacts;

2. A central pit with no downstream or upstream outlet (or one or more radial trenches) with the top and bottom of bar left undisturbed could reduce some bar impacts from skimming (D. Rosgen, pers. comm., 1999). However, risks of fish stranding may be higher than other methods because of the lack of an outlet to the main channel;

3. How should we deal with continued skimming on bars already highly impacted (i.e., bars that are braided with high width/depth ratios);

4. Identify environmental settings where skimming should not be done;

5. How high up on the bar can skimming be done while still preserving sufficient alluvial structure and allowing for vegetation regeneration (active channel only)?

6. A protocol that guarantees skim boundaries shift with migrating bars;

7. What should be exceedence probability of a biologically-relevant flow (say, a flow that commonly initiates salmonid migrations) that just begins to inundate a skim floor; this could be a method for objectively and flow-independently determining vertical offsets for rivers of different sizes (discussed above).

8. Pits higher up should require more elaborate design criteria as temporary wetlands because they will be there longer before being replenished;

9. Old oxbows should be studied for their viability to be excavated/enlarged as wetland pits;

10. Design criteria should be developed to minimize adult salmon entrapment in wetland pits;

11. Design criteria should be developed for setting maximum river corridor pit depths (no lower than nearby thalweg elevation).

3.5. EXTRACTION STRATEGIES

Methods for extracting gravel fall into two broad categories: excavate a pit or skim the surface of a bar. The extraction strategies described below apply one or both techniques to different areas of a river corridor at varying intensities. Sustainable extraction can be managed within the contemporary meander belt using bar skimming and/or pit excavation, but not higher into the river corridor zones (infrequent floodplains, terraces). Terms used in describing the strategies refer to the definitions of lateral boundaries given earlier and the graphical depictions in Figure 8 and 9.

The following extraction strategies are tiered from least to most intrusive on the river ecosystem. The mean annual recruitment (MAR) approach is incorporated into all recommended strategies as the safest and most manageable means to maintain and recover salmonid habitat (see section 3.2.1). We used increments of 25% of MAR to separate out extraction strategies by level of risk. While these breaks are admittedly arbitrary, they serve as a starting point for considering impacts and are meant to be refined through monitoring and adaptive management.

Viable extraction strategies

A. Extraction Only on Frequent Floodplain (FFP) at <25% MAR

This strategy would limit extraction to the frequent (2- to 10-year) floodplain (FFP) only and exclude it from adjacent surfaces (the active channel (AC) and higher infrequent floodplain (IFP) surfaces). It would be limited to wetland pits, including both new pits as well as enlargement of existing wetlands, such as oxbow ponds. Annual volumes could vary depending on market demand, but must have a cumulative multi-year ceiling determined as a percentage of MAR to prevent over-extraction during a series of low recruitment years (the sum of wetland pit excavation volume not replenished should not exceed two times the MAR). This strategy would not support a long-term average annual extraction volume greater than 25% of MAR, and probably a significantly lower annual average percentage. Replenishment of wetland pits would be expected with the occurrence of a 15-year or greater flood, as was seen on the Mad River in the mid-1990s. This strategy would cause limited immediate impacts to the existing woody riparian community (unless pits are carefully located to avoid areas of woody vegetation), but the ecological tradeoffs of not extracting in the AC and creation of short-term riparian wetland habitat may be worthwhile.

B. Active Channel Bar Skimming at <25% MAR

This strategy limits mining to skimming bars within the active channel (AC) and annually limits the volume to no more than 25% MAR. It retains sufficient gravel in the channel to preserve (or restore, as the case may be) alluvial structure within the mined reach and minimizes gravel deprivation for downstream reaches. Accompanying this strategy should be controls (through zoning or some other means) on the number of bars mined; mining would need to be constrained to repetitive mining on no more than half the bars in a mined reach to minimize effects on channel meander pattern and habitat. Because alternate bars provide the structure in alluvial rivers, removal of more than half the bars would likely lead to loss of nearly all channel morphology structure for maintaining viable salmonid habitat.

C. Frequent Floodplain/Active Channel with Multi-year Extraction at <25% MAR

This strategy combines A and B, with the restrictions provided in each, and provides flexibility in where mining can be done from year-to-year to respond to annual variations in recruitment. This strategy has the potential to extract more than 25% MAR annually over a multi-year period. For example, in wetter years skimming will comprise the 25% MAR whereas in dry years, wetland pit excavations will occur. AC skimming could extract 25% MAR while nearby wetland pits within the FFP have not been replenished, so long as the multi-year average rate of extraction does not exceed 25% MAR summed for those years.

D. Active Channel Bar Skimming at 25% to 50% MAR

This skimming strategy provides less bedload to downstream reaches than those mentioned above, and consequently, has moderate potential of causing some channel degradation. It may be the first of our ranked strategies where recovery will be slow. Determining an appropriate fixed percentage within the 25-50% range is critical, requiring scientific analyses up front (e.g., an accurate reach-specific estimate of MAR). It also requires considerable geomorphic monitoring as well as controls (zoning, etc.) to preserve some bars as unmined throughout the river corridor.

E. Active Channel/Frequent Floodplain Annual Extraction at 25% to 50% MAR

This strategy (as with C) essentially combines A and D (above), alternating between the FFP (wetland pits; A) in the lean years, and bar skimming in the AC during normal to wet years, but is less conservative in annual volumes extracted. Some bars must be left unmined to provide habitat within a mining reach containing multiple areas or operations. As with E, this strategy has moderate potential for channel and habitat degradation, but alternating between the active channel and the frequent floodplain will moderate these effects.

F. Active Channel Bar Skimming at 50% to 75% MAR

This skimming strategy provides a minimum volume of bedload to downstream reaches and, consequently, has high potential (probably the certainty) of causing channel incision ~~degradation~~. Habitat recovery from the effects of gravel mining will likely be very slow. Determining an appropriate fixed percentage within the 50-75% range is critical, requiring rigorous scientific analyses up front (e.g., a sediment budget and historical analysis similar to that used in the Mad River PEIR (Lehre and others, 1993)) . It also requires considerable geomorphic monitoring (discussed later) as well as regulatory controls to preserve some bars as unmined to provide interspersed habitat throughout the river corridor.

G. Active Channel/Frequent Floodplain Extraction at 50% to 75% MAR

As with E, this strategy combines A and D, alternating between the FFP (wetland pits) in the lean years, and bar skimming in the active channel during normal to wet years, but is less conservative in terms of annual volumes. As with F, it has high potential (probably the certainty) of causing channel degradation and habitat recovery will likely be very slow, but impacts will be moderated somewhat by alternating between the FFP and AC. A rigorous determination of MAR is critical and some bars must be left unmined to preserve interspersed habitat throughout the river corridor.

H. Active Channel/Frequent Floodplain Annual Extraction Up To 100% MAR

This is the least conservative of the recommended strategies based on MAR and is what has been applied on the Mad River since 1992. It greatly restricts potential for channel recovery and ignores potential downstream impacts. However, if sufficiently insulated from political pressures, the 100% MAR can truly be used as a ceiling, rather than a target, so that annual extraction does not impair replenishment potential in the next year and does not jeopardize the very slow recovery anticipated with this strategy. Offsite (especially downstream) areas must be carefully monitored for cumulative effects and, to have any chance of being effective, mitigation must be swift to remedy offsite impacts when they are first detected through monitoring.

<u>Extraction Strategies Not Recommended</u>

<u>Three-dimensional Redline</u>: This strategy attempts to define a minimum ("redline") channel morphology (i.e., 3-dimensional redline) within a mining reach, with the condition that no mining occurs below this redline. Consequently, this strategy is a variation of the replenishment-based approach (as opposed to the MAR approach), where all gravel that is deposited within a mined site is considered available for extraction. Because redlines are usually set at channel conditions that exist at the time of adoption, it is an approach that maintains existing, usually adversely impacted channel and habitat conditions and actively prevents recovery. It has been an issue of contention in recent years, with proponents arguing that it has the advantage of providing a quantitative morphological or habitat "redline" below which no mining would be allowed. Skeptics note that the approach is flawed because science lacks the understanding required to determine objective, ecologically defensible redlines and the approach would require relatively expensive, sophisticated annual monitoring and evaluation. We consider the approach scientifically indefensible and with only the appearance of being easily managed. Moreover, there would be a relatively high chance of the occurrence of a year or string of years where no mining could be allowed (baseline transgressed). To avoid this, proponents seek to incorporate provisions to allow variance about (below) the redline, further increasing the risk derived from and inappropriate redline determination. Thus, we consider this to be a shortsighted approach that has only the appearance of maintaining or restoring habitat by imposing a human-conceived redline morphology with great risk for abuse.

<u>Two-dimensional Redline</u>: This strategy is similar, but less sophisticated than the 3-D strategy, above. It poses even more risk because it only considers the safety of bridges and other structures as worthy of protection and it relies only on the selected cross sections in the river for setting a redline and evaluating annual river conditions. Because pools and riffles migrate downstream through time, the redline cross sections may erroneously indicate aggradation or degradation as bedforms move through the monitoring reach. In addition, planform changes that might indicate mining impacts (e.g., channel widening, divided flow, etc.; Chapter 2) would not be considered in evaluation of 2-D redline targets.

Structural Redline Extraction: As with the two above, this strategy uses a minimum elevations to evaluate the potential for mining, but would rely solely on cross sections at man-made structures, triggering no mining or restricted mining if the redline is transgressed. Many regulators find the approach appealing because it simplifies decision-making and requires only minor monitoring. However, in reality, it will be extremely difficult to manage. For example, if the redline is transgressed, would downstream operators in the reach be allowed to continue mining considering that the problem most likely originated from over-mining upstream? Additionally, a decision would have to be made as to how rigidly to apply the redline (i.e., recognizing the normal year-to-year fluctuations in riverbed elevations, would some variance below the redline be allowed before mining is curtailed?).

Market Driven Extraction: This strategy lets the market for aggregate determine where and how much gravel is extracted, with rivers nearest to the end uses being favored. While market conditions will always be a factor in mining programs, this strategy ignores all other issues and is a common historic strategy leading to pervasive, persistent damage to rivers near rapidly developing areas. It ignores considerations for maintenance or recovery of riparian and aquatic habitat and dependent species. Given improvements in both the understanding and awareness of effects of gravel mining on riparian ecosystems, not to mention on bridges and other structures, a return to this approach is unlikely to occur in the future.

Infrequent Floodplain Pits: This is the only extraction strategy outside the contemporary river migration zone but still within the river corridor. The strategy is not sustainable and adds constraints to recovery because the pits extend below the thalweg elevation, and the dikes surrounding near-river pits must be maintained in perpetuity unless pits are reclaimed at great expense. Moreover, pits can easily proliferate into the situation found on the Tuolumne and Russian rivers, severely limiting both riparian ecosystem health and recovery and adjacent land use options. History has shown that such pits tend to proliferate following damming: the floodplain and meanderbelt essentially become the same, then pits are excavated into the old meanderbelt. This greatly inhibits future restoration, as witnessed on the Tuolumne River. It is important to dispel a common myth held by many in the regulatory arena that this strategy would not affect salmonid habitat recovery. Preventing development of new situations such as those on the Tuolumne and Russian rivers requires agency recognition of the negative impacts of such pits on salmonid habitat and major regulatory commitment.

3.6. APPLYING APPROPRIATE EXTRACTION STRATEGIES

The objective of this document is to inform NMFS on the potential and probable impacts of riverine gravel extraction on listed salmonid species within the central and northern coastal ESU. As previously discussed, the only way to eliminate direct and cumulative impacts of gravel extraction is to eliminate it from the river corridor and obtain aggregates from Pleistocene terraces or hard-rock quarries. Complete relocation of aggregate extraction from the migration zone has been recommended by previous studies (e.g., Kondolf, 1993). Typical present-day aggregate extraction in California occurs within the migration zone but outside of the bankfull channel (e.g., large “off-channel” pits within the 100-yr floodway). As described in Chapter 2, these “off-channel” pits are only off-channel for a short time, and are eventually connected to the river and negatively impact listed species and habitat. Because the scale of these pits is so large, cumulatively they are more damaging to the river corridor, listed species, and habitat in the long term. Additionally, maintenance and restoration of off-channel pits, once they become connected to the river, are very expensive. Therefore, our primary recommendation is that instream extraction within the active channel (AC) and/or the frequent (10-yr) floodplain (FFP) is a preferable extraction strategy, but only if:

1. extraction volumes in the reach are less than recruitment volumes into the reach from upstream (<100% MAR),
2. extraction methods are used that avoid refugia habitat and riparian vegetation,
3. it provides for natural riparian regeneration on areas within the contemporary meander belt,
4. it provides for woody debris recruitment into the channel,
5. a scientifically-based monitoring and adaptive management program in implemented, and
6. the river’s flow is not substantially regulated by upstream dams and diversions.

If all these are not conducted together, gravel extraction should be relocated outside of the contemporary meander belt to either Pleistocene terraces or hard rock quarries to ensure that listed species and their habitat are not adversely impacted.

Assuming that gravel extraction within the migration zone will continue for the foreseeable future, we draw upon Chapter 2 that summarizes impacts of gravel extraction discussed in the literature. This literature identifies impacts not only on salmonids, but also on channel morphology, channel processes, riparian vegetation, and non-salmonid aquatic organisms. Our task of describing impacts to listed species is problematic because many impacts are indirect and cumulative. For example, over-extraction may not directly harm a listed species, but subsequent channel degradation, bank instability, addition of rip-rap, loss of riparian regeneration will have negative long-term negative impacts. Confounding this complexity is that the impacts of gravel extraction depend on several other important factors, primary among them is the volume of extraction compared to the volume of coarse sediment supplied to the reach, and the spatial extent and location of extraction.

We attempted to organize this complexity in impacts to facilitate understanding and to provide NMFS with a logical procedure to evaluate individual and cumulative gravel extraction plans. Gravel extraction in the central and northern coastal ESU ranges from numerous large commercial gravel operators extracting large volumes annually on lower alluvial rivers (e.g., Eel, Mad, and Russian rivers) to small landowners infrequently extracting small volumes on tributary and headwater streams. Relative scale is perhaps the most important criteria for assessing cumulative impacts. For example, a single operation extracting 5,000 yd^3 annually on the lower Klamath River will have far smaller potential cumulative impacts than ten operators extracting 5,000 yd^3 on the Garcia River. These complexities make it difficult to develop specific extraction recommendations for each possible scenario. Therefore, we have organized the extraction management section as general guidance to potential and probable impacts. In the following sections, we describe in more detail the spatial and scale considerations in this decision making process, then provide a review guidance flowchart and impact matrices to aid NMFS in evaluating existing and future gravel extraction activities.

Spatial, scale, and life-history considerations

Spatial and scale considerations are summarized as "where does the extraction occur within the river valley, and how much gravel is extracted from the river compared to the amount delivered by the watershed". These factors will greatly influence whether impacts will occur, and to what degree. Life history considerations address if and how extraction interferes with critical stages of a listed species life history.

Life history considerations

Extraction in an area that does not currently have a listed or candidate species, or does not support habitat for a listed species, or would not have indirect impacts to habitats or listed/candidate species downstream of the extraction site should have no impact on a listed/candidate species. For those situations where extraction does occur in an area inhabited by a listed species or contain habitat, then the degree of potential impact would vary depending on what kind of habitat was present, and how the listed species used that habitat. For example, impacts of skimming a point bar on lower alluvial rivers will be considerably different than extracting a point bar in the headwaters of the river.

The life history of listed/candidate species requires different habitats at different times of the year. For example, reaches near estuaries may be used for juvenile rearing in the spring and summer months, be migration corridors for adults in the fall, and be sparingly used in summer by adults. In contrast, the headwater portions of the rivers may provide juvenile rearing habitat year round, and provide spawning habitat in the fall and winter months. Therefore, hypotheses of potential gravel extraction impacts will be different depending on where and when mining occurs.

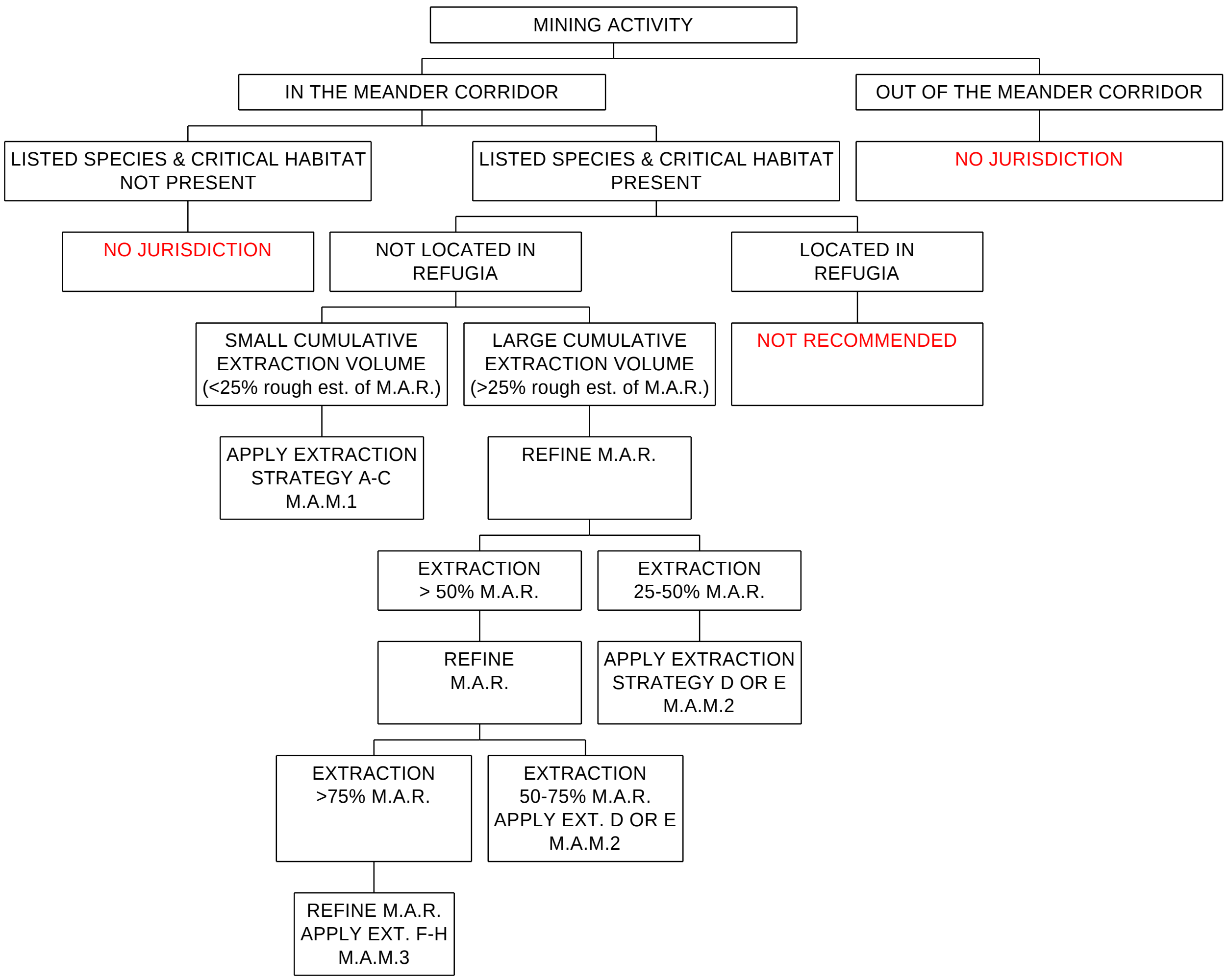
Scale of Stream

The size of the stream influences where and how much can be mined and the potential impacts on listed species. Large rivers will have a variety of alluvial deposits (bars, floodplains, and terrace areas within the migration zone (TMZ, Fig. 8)), while smaller rivers will be limited to exposed point bars for the most part because of the lack of wide alluvial surfaces outside of the bankfull surfaces. The frequency and intensity of extraction are much greater on larger rivers than small, since the use is different (e.g., commercial versus road maintenance). A drainage area threshold of 50 mi^2 generally discriminates between small and large rivers and separates Rosgen (1996) 'B' and 'C' channel types, whose primary morphological differences are in alluvial storage, floodplain presence or extent, and floodway confinement.

Project Screening

Figure 11 (review guidance flowchart) provides a coarse-level screen to evaluate how closely present or proposed annual extraction volumes in a designated mining reach approach recruitment. Where the total extraction is low compared to MAR, a rigorous sediment budget (see Collins and Dunne, 1990) is likely not required. Alternatively, an option is to use a unit coarse sediment yield estimate (yd^3/mi^2/year) as a rough estimate of MAR for any given location of operation(s). If the total annual extraction for that reach by that operator or group of operators is less than 25% of the rough estimate of MAR (Strategies A-C), then mining would only be constrained by site-specific mining design criteria (e.g., vertical buffers, no disturbance to head of bar, etc.) that minimize impacts to listed species and habitat and no further analyses to refine MAR would be necessary. If more than 25%, then it is recommended that NMFS require a more rigorous coarse sediment yield evaluation, monitoring, and adaptive management program. A gravel management plan would be necessary for Strategies F-G because of the elevated risk to salmonid habitat, and the more comprehensive river management plan would be necessary for Strategy H, which poses the greatest risks to salmonid habitat. Figure 11 also shows monitoring/adaptive management protocols recommended for each extraction strategy.

Figure 11. Gravel extraction review guidance flow chart



3.7. MONITORING AND ADAPTIVE MANAGEMENT PROGRAMS

Although a well-conceived monitoring and adaptive management program can be used to refine extraction strategies and techniques, due to the backdrop of many cumulative effects, demonstration of biological recovery directly attributable to improved extraction strategies with scientific certainty may not be possible. The need to acknowledge and deal directly with scientific uncertainty has been a major theme in resource management in the last decade. Many scientists and managers now realize that:

1. Ecological management actions are experiments and should be treated as such;

2. Management decisions must be made despite scientific uncertainty;

3. Areas with the greatest scientific uncertainty and biological implications should be prioritized within future monitoring programs; and

4. A "hardwired" feedback loop from monitoring to management must be in place to insure that management improves with time rather than preserving the status quo.

The latter represents a perspective embodied in the widely advocated approach of adaptive management (e.g., Holling, 1978). Whether acknowledged or not, resource managers are implementing "adaptive management" in every resource management decision. However, a structured adaptive management program adds more rigor to simply trial and error decision making by replacing it with hypothesis testing and predictive management. Impacts of gravel extraction discussed in Chapter 2 offer initial hypotheses on future gravel extraction impacts. To be of greatest use in adaptive management, effectiveness monitoring should be designed to test these hypotheses, giving priority to those having the greatest impact to listed species and their habitat.

County of Humboldt Extraction Review Team (CHERT) is a functioning adaptive management program tailored specifically to gravel extraction in Humboldt County. It is unique in that a team of river scientists conducts annual reviews of mining and river conditions. By contrast, the typical situation only involves scientists (if at all) in the preparation of environmental and/or management documents. In recent years, however, programs similar to that used in Humboldt County are being considered in other locations in California.

Monitoring is crucial for evaluating compliance and impacts and providing information essential for adaptive management. Too often, monitoring plans designed by regulatory agencies include expensive data collection (particularly some types of biological monitoring) incapable of furthering adaptive management. When (or if) this is realized, the investment of both time and money in ill-conceived data collection understandably causes gravel operators funding the program to argue for wringing something meaningful from the data (which may be impossible) or for cessation of data collection altogether. Consequently, ill-conceived monitoring programs are more than just costly accumulations of meaningless data; they can force erroneous conclusions on the effects of mining and lead to unnecessary or even harmful adaptations in management.

Another failure of some monitoring programs is that there is no structured data review and analysis component with a "hardwired" feedback loop to adaptive management. Too often, data are simply filed, with little or no review for adequacy, no analysis for spatial or temporal trends, and no attempt to glean insights for altering site-specific gravel extraction practices or reach-wide strategies. An effective, cost-efficient monitoring and adaptive management program explicitly requires a schedule for data review, analysis, and development of any needed alterations to practices and strategies. While this may add to the cost of such a program (by funding data review, analysis, and the adaptive management process), it ensures that there will be a return on monitoring investments and may ultimately lower program costs by reducing the level of uncertainty associated with outstanding questions so that they may be dropped (or more effectively addressed) as subjects of ongoing debate and/or management concern (e.g., how far upstream and downstream are geomorphic effects from a mining area propagating?).

It is recommended that NMFS, in consultation with other regulatory agencies and using guidelines in this report, specify the monitoring/adaptive management protocols and reporting procedures tailored to expected types and levels of impacts. Monitoring and adaptive management protocols should be scaled to the expected potential and/or documented impacts of management. For example, the level of effort for monitoring gravel extraction by single operator on a large river should be much less than that for multiple operators on a small river. Where extraction volumes are low relative to recruitment (MAR), cumulative effects will likely be minimal and monitoring can be relatively simple and inexpensive. A few on-site and near site channel cross sections and air or high oblique photos could suffice for physical monitoring, and biological monitoring could consist simply of periodic (once every five years or so) air photo-based mapping of riparian vegetation. Adaptive management might only be required where monitoring signals off-site effects.

Where the probability of cumulative mining effects is high (e.g., where reach-wide annual extraction is high relative to MAR), monitoring should be more intensive and extensive and should be accompanied by a scientifically guided adaptive management protocol. Adaptive management should expand (relative to low MAR extraction situations) to routinely provide independent scientific review, additional data collection, and more extensive reporting and coordination among agencies and other stakeholders. In this section, we provide guidelines for scaling a monitoring and adaptive management program to the anticipated level of impacts from various extraction strategies.

Compliance and Effectiveness Physical Monitoring

The two primary objectives of monitoring are to document compliance (with terms and conditions of mining plans, laws, etc.) and to evaluate channel and habitat response to mining over various time scales to inform adaptive management. Data collection will vary depending on the objective, but many types of data collection can serve both purposes.

Compliance Monitoring

Monitoring for compliance would take the form of collection and review of operator-provided information and field reconnaissance to determine how well the approved conditions of operation were met after completion of extraction for the season. Conditions of operation include such things as:

1. The post-extraction topography of mining areas (comparison of pre- and post-extraction cross sections or DTMs) to document extraction volumes, vertical offsets, horizontal boundaries, skim floor slopes, drainage impediments, depressions);

2. Conformance with mining permit conditions related to ancillary activities (haul roads, temporary water crossings, stockpiles, etc.)

3. Adequacy and timeliness of documentation (quality and completeness of survey products, air photos, replenishment and extraction volumes computations); and

4. Performance of any required mitigation (vegetation avoidance or transplanting, large woody debris redistribution on skimmed areas, etc.).

To our knowledge, most contemporary compliance monitoring focuses primarily on the latter three. They require the least scientific knowledge and expertise and can typically be performed by agency staff. Local experts in river science are rarely involved in compliance monitoring (with the Humboldt County program being the most notable exception), but their involvement is crucial to the process.

Effectiveness Monitoring

Effectiveness monitoring is far more complex and elusive than compliance monitoring due to the complex web of multiple causes and effects and time lags operating in river systems. However, if we first frame the issue properly and elucidate well-conceived, attainable objectives, the chances of conducting cost-efficient effectiveness monitoring increase dramatically. Effectiveness monitoring must refine the extraction strategies and techniques to minimize impacts to habitat (which, ideally would be zero impacts, but realistically will be something greater than zero if instream mining is to continue). This can be rephrased as adaptive management. From clearly-stated objectives, specific questions deserving attention through applied research (i.e., focused, short-term, hypothesis-driven monitoring) can be stated, such as:

1. Does a particular extraction technique encourage rapid replenishment and do different techniques do better job over narrow high flow range, for example, extraction of a mid-bar “wedge” may replenish at relatively low winter flows and not jeopardize bar stability (D. Rosgen, pers. comm., 1999)?

2. Does a particular extraction technique preserve biological and/or habitat integrity of the site? Integrity can include woody debris input resulting from channel migration, riparian regeneration on floodplain surfaces, and/or the coarse bed surface layer important for salmonid fry rearing habitat, among others.

3. Does a particular extraction strategy eliminate or substantially reduce reach-wide cumulative effects? Most cumulative effects include channel downcutting, loss of riparian vegetation, loss of channel confinement (and increased braiding), and channel instability. These impacts are not limited strictly to the extraction site, but can be propagated to adjacent reaches.

4. Are monitoring techniques robust enough to segregate extraction related impacts from other sources (natural floods, other watershed land uses)?

On large rivers with multiple operations, monitoring should include site-specific impacts, but also focus on reach-wide and cumulative impacts. Site specific monitoring should be tailored to document local changes and dovetail into the reach-wide monitoring program. Site-specific monitoring protocols must be scaled to river size; for example, on large alluvial rivers, cross section spacing can be much greater and benchmarking must be farther from the channel than on small rivers because the contemporary channel migration zone is much wider. Monitoring for large-scale potential impacts includes:

1. Trends in channel grade, channel confinement, and channel migration;

2. Riparian vegetation recruitment;

3. Changes in large woody debris recruitment and storage; and

4. Changes in habitat quantity and complexity resulting from extraction.

Some of this broader-scale monitoring is subject to the economy of scale. All operators might contribute to funding mutually beneficial products, including: air photos for the entire reach, improved recruitment estimates, integrated analysis of all data for the reach, and implementing the adaptive management program.

<u>Biological Monitoring</u>

Biological monitoring, as used here, includes both direct monitoring of biota as well as physical monitoring of habitat. We are skeptical of requiring fish and amphibian monitoring as part of any effectiveness monitoring plan unless designed explicitly to provide meaningful, accurate feedback to adaptive management through hypothesis testing. For example, the periodic inventory of adult salmonids in Humboldt County required by the Army Corps cannot be related to gravel extraction practices because there are no provisions for linking to various extraction strategies or methods, nor are there provisions to distinguish gravel extraction effects from the host of other sources of cumulative effects (LWD removal, channelization, riparian vegetation removal, etc.). It is not designed to explicitly test a mining impact-related hypothesis. Such a monitoring program is ill-conceived and potentially dangerous in that: 1) a “no impact” conclusion could be made when real impacts from mining are occurring, but not detected, or 2) an “impact” conclusion could be made when the real culprit could be some other influence on biota. In the first case, mining practices that could be improved would not be, while in the second case, practices that were relatively benign might be modified in ways that might worsen their effect on biota.

However, with revisions to the Army Corps monitoring plan for Humboldt County, fish and amphibian data collection could be designed to answer specific questions and be less expensive, such as horizontal or vertical setback distances necessary for protecting nearshore habitat used by nocturnal amphibians (this, of course, would require nighttime observations that are not presently required). The narrow bar skimming setbacks required by the Army Corps (6 ft horizontal and 1 ft vertical) are not based on applied research or effectiveness monitoring, thus they have no biological justification. Simple, field-based experiments can be performed in one or two seasons to determine what setback dimensions are biologically defensible. Thereafter, amphibian monitoring might be scaled back or dropped altogether, with only compliance monitoring of post-mining bar configuration to ensure consistency with the approved, biologically justified setback requirements. Monitoring to evaluate setbacks for anadromous salmonids requires a thorough analysis of how their life history potentially intersects with differing extraction setbacks. Using examples from Chapter 2, vertical setbacks provide flow confinement during adult migrational periods, and horizontal offsets preserve channel margin habitat for fry and juvenile rearing.

Fish stranding has been another recurring concern. We think this may be an issue worthy of study in frequently flooded wetland pits, but is likely not a major issue for skimmed bar surfaces that provide sufficient vertical offset from the low flow channel and/or a cross-channel slope. Wetland pits could be constructed to minimize adult stranding provided careful thought and perhaps some experimentation are applied. For example, analyzing the hydraulic geometry of a bar and local hydrology could help locate wetlands in areas where inundation duration and frequency is low (minimizing stranding), but would still eventually fill with sediment during infrequent large floods. Recovery of complex channel morphology probably will result in greater fish stranding on topographically diverse bar surfaces. Frequent pieces of large LWD accumulating on bar surfaces, or scour pools becoming isolated from the main channel flow along complex backwater side-channels, may occasionally trap juveniles or adults, but the tradeoff in terms of overall better habitat will likely more than offset stranding mortality. For example, survivability may be increased by using wetland pits as high velocity refugia and prime feeding habitat, thereby increasing growth rates.

Chronic loss of channel complexity is the most difficult cumulative effect to document, yet may be the most significant impact to anadromous fish habitat (consequently, we include it here under biological monitoring). The difficulty arises from our inability to reasonably define a desired condition or devise reliable measures of complexity. What was the channel complexity before cumulative watershed impacts and how do you measure it? Moreover, what is a realistic goal given that we cannot go back in time? Availability of complex holding pools and sufficient flow depths for migration over riffles is often limiting factors for adult salmonids during low flows. Thus, effectiveness monitoring that refines extraction techniques to promote (or at least not compromise) complex pools and sufficient low-flow depths over riffles would be beneficial.

The most straightforward approach might be to monitor measures of complexity on non-skimmed bars just upstream of skimmed bars, then contrast channel complexities. Alternate bars should be the basic sampling units as opposed to arbitrary distances upstream and downstream of extraction areas. Morphological complexity of alternate bars must be mapped three-dimensionally; cross sections do not provide the necessary resolution. Habitat can be mapped for a few selected flow magnitudes throughout skimmed and unskimmed alternate bars. Mapped habitat types can be tallied to evaluate skimming effects. This approach assumes enough unskimmed bars exist and that these bars operate somewhat independently of the skimmed bars. Sufficient time would be necessary to subject a range of management prescriptions to similar flow regimes.

Surface particle size distribution of the channelbed is another potentially important habitat-related variable to monitor. However, specific hypotheses (or expectations) must direct the data collection and analysis. If chronic skimming is affecting bar stability, should we expect a finer surface layer on skimmed bars following replenishment (existing research would indicate so, see Chapter 2)? Hypothesis testing should focus on how much difference would be important and identify the unit of measure (e.g., D_{50} of surface particles, ratio of surface to subsurface particle size, etc.).

Bar stability also affects biological productivity and diversity (Chapter 2). Less stable bars may have a higher turnover of bed material, increasing the magnitude and frequency of benthic disruption. If these "unstable" bars annually returned to approximately their original shape (from the year before), equilibrium (at least geomorphic) can be preserved. However, equilibrium assumes equally compensating scour and fill at all discharges. If the flood peak threshold for mobility of the skimmed bar is lower than that for an unskimmed bar, the skimmed bar could scour but not receive sufficient (compensating) replenishment from unskimmed bars farther upstream in normal and drier water years. Therefore, a complicating factor will be the uncontrolled sequence of various magnitudes and durations of flood flows. As with biologically significant particle sizes (above), hypothesis testing should focus on how much difference would be important and the unit of measure (e.g., scour and fill depths, etc.).

Beyond periodic riparian mapping, biological monitoring needs to be explicitly re-oriented toward hypothesis testing, an approach that is distinctly different from monitoring for compliance or long-term effects on channel morphology. Valid hypothesis testing requires cause (extraction) and effect (biological response) to be directly evaluated. Without this, many nagging questions on mining impacts will either never get answered, or worse, will be erroneously answered by ill-conceived, misdirected monitoring. Investment in monitoring will have been wasted.

Tiered Monitoring and Adaptive Management

The following briefly describes a number of adaptive management and monitoring "packages" tiered to various extraction strategies or levels of anticipated impacts from mining. They complement the extraction strategies: as anticipated risks of cumulative effects and/or uncertainty associated with a particular extraction strategy increases, the intensity and geographical extent of monitoring and the degree of scientific involvement in adaptive management must increase. The packages are meant as general guides, but may need tailoring to accommodate variations in local conditions (e.g., presence of refugia or special life history requirements may create a need for customized or more intensive monitoring). In addition, hypothesis testing (discussed above) is not specifically included in the three packages below, but rather should be conducted as focused, short-term applied research aimed toward resolving outstanding questions related to mining techniques and strategies.

The following defines terms describing monitoring and adaptive management protocols.

Designated Mining Reach (DMR): as described earlier, the longitudinal extent of a river that, considering the magnitude of extraction versus the size of the river, would be expected to exhibit cumulative effects from mining. Includes mine sites (several of which may exist near each other) and upstream/downstream areas likely to experience off-site effects.

Extraction Area: a zone of contiguous extraction. Multiple extraction areas may exist at a single mining operation.

Monitoring Cross Sections: these are permanent cross sections spaced at longitudinal distance intervals approximately proportional to the bankfull width (consequently, scaled to river size; the proportion to be determined by the extraction strategy, with replenishment-type strategies requiring closer spacing), placed normal to the direction of high flow, and extending slightly beyond the contemporary channel migration zone. They are primarily used for long-term monitoring, but may also assist with compliance monitoring where they happen to intersect extraction areas. Spacing and orientation should be coordinated where multiple mining sites exist within a mining reach. Alternatively, digital terrain models (DTM) can be used to document annual topographic changes in the channel bed. Elevations should be tied to NAVD or some other datum in local use; horizontal survey control should also be provided.

Extraction Cross Sections: non-permanent cross sections surveyed only across the area of extraction in any given year, oriented normal to the long axis of the extraction area. These are surveyed both before and after mining and allow accurate mining volume calculation. Spacing should allow accurate calculation of extraction volume, with a minimum of three per extraction area at a minimum 200-foot spacing. Elevations should be tied to NAVD or another datum in local use; horizontal survey control should also be provided.

Air Photos: vertical air photos obtained from aircraft that provide continuous coverage of the designated mining reach with contact prints at a scale no smaller than 1:10,000 for large rivers, and no smaller than 1:6,000 for small to medium rivers. For large operations or reaches with multiple operations, both pre- and post mining air photos are necessary each year for pre-project planning and post-project compliance documentation. Complete coverage of the designated mining reach need only be provided for post-mining (pre-mining photos need only cover mining sites since their primary use is in planning annual extractions).

Oblique Photos: ground-based photos, obtained from a promontory, that may be used to adequately document mine site conditions in lieu of air photos at small scale, remote (from other operations) mining sites to minimize expenses, providing vertical air photos are provided periodically (once every 5 years) to provide a mapping base for riparian vegetation.

Replenishment Volume: calculation of the volume of replenishment within a designated mining reach by comparison of successive digital terrain models (DTMs) or closely-spaced cross sections taken in the fall (at the end of the mining season) with those taken the following spring (following the winter recruitment period). Extraction cross sections could also be resurveyed to refine the replenishment calculation.

Monitoring and Adaptive Management (MAM) Packages

MAM Package 1: Small operations with low potential impacts should have a simple, inexpensive monitoring/adaptive management program that simply confirms there is minor or no impact. This package provides the least intensive monitoring option, designed for reach-wide mining operations that extract only a small percentage of MAR (<25%; Extraction Strategies A-C). Monitoring would consist of: 1) annual surveys of monitoring cross sections, spaced at intervals equal to two-times bankfull width with at least three per meander bend and extend at least one bend upstream and downstream of the site (additional monitoring cross sections should provided at bridges and other infrastructure within the designated mining reach), 2) extraction cross sections, and 3) air photos covering the designated mining reach. Ground-based oblique photos may be sufficient for small, remote operations. Periodic (every 5 years) air photo-based mapping of riparian vegetation associations would also be required. This protocol would require only infrequent (once every five years or so, with a high-flow trigger) review of monitoring data and could be conducted by agency staff with appropriate scientific expertise.

MAM Package 2: Multiple small operators or a single large operator on a reach (extracting 25-50% of MAR; Extraction Strategies D-E) will require greater scientific and regulatory oversight, and a larger monitoring and adaptive management program will be needed because the potential impacts will be much greater. This package provides an intermediate level of monitoring that would be required of locations where reach-wide mining extracts an intermediate percentage of MAR (25-50%; Extraction Strategies D and E). It requires closer spacing of monitoring cross sections than Package 1 (no farther apart than bankfull width) and additional biological monitoring (riparian mapping and salmonid habitat mapping on mined and unmined bars once every 5 years) is necessary to provide sufficient resolution for: 1) evaluating the anticipated cumulative effects on habitat and channel morphology, and 2) informing adaptive management which, for these strategies, could play a large role. Monitoring information should be reviewed by agency staff annually and reviewed by an independent panel of scientists once every five years.

MAM Package 3: A more elaborate adaptive management program involving greater scientific and regulatory oversight will be required as extraction exceeds 50% (Extraction Strategies F-H) because of both on-site and off-site cumulative effects. This is the most intensive and extensive monitoring and adaptive management package, and is recommended for the higher risk extraction strategies. The designated mining reach would be the longest of any extraction strategies, as cumulative effects are anticipated to extend for long distance up- and downstream from mining operations. Due to the large area of the river needed to support these strategies (length and width), digital terrain modeling (DTM) might be a necessary supplement to cross sections for adequately documenting both channel and habitat responses, and for evaluating the potential for and suitable locations of mining on an annual basis. Air photo-based and ground-based surveys would be necessary to obtain complete topographic coverage of the exposed and wetted channel. Habitat mapping and evaluation of complexity should be assessed frequently (annually to once every five years, depending on local circumstances, e.g., presence of refugia) and compared to a standard or reference reach developed for the specific river. Monitoring information should be scientifically reviewed each year; scientific review of annual extraction plans should be included each spring with alterations and refinements based on longer and shorter-term trends as well as careful consideration of site-specific conditions (refugia, riparian recruitment potential, vertical offset, etc.).

While monitoring approaches are briefly summarized here, details of specific methods and standards for data collection and presentation can be found elsewhere. The most comprehensive sources for this information are: 1) Humboldt County monitoring specifications included in the California Department of Fish and Game's (CDFG) monitoring guidelines (contained in a May 9, 1995, memo from Richard Elliot, Regional Manager, Region 1), 2) the 1996 Letter of Permission (LOP 96-1) issued by the Army Corps, 3) the 1996 Interim Monitoring and Adaptive Management Program issued by the Humboldt County Department of Public Works, and 4) the 1993 "Draft Instream Mining Monitoring Program" issued, but not adopted by the California Department of Conservation, Office of Mine Reclamation.

3.8. GENERAL GUIDANCE FOR IMPACT EVALUATION

In this section, we collapse and consolidate the contents of previous sections on mining impacts, extraction strategies, monitoring, and adaptive management to provide general guidance for avoiding impacts to salmonids and their habitat from instream mining. We doubt any impact assessment of gravel extraction can quantify a customary definition of “take” (see NMFS Harm Rule for a discussion of the relationship between habitat and incidental take of a species). Too many other impacts besides mining have contributed to chronic habitat loss and simplification. Any management strategy based solely on take assessment, in the customary sense, to regulate extraction is unlikely to succeed and could degrade or further degrade habitat. Sustainability, the cornerstone of our recommended strategies, requires annual extraction less than mean annual recruitment. This is the single-most important management decision affecting salmonid habitat. Poor site-specific mining design criteria or practices may create local habitat degradation, but mining in excess of MAR has much greater consequence.

Alternatively, protection of listed salmonid species is best pursued by regulating extraction strategies and site-specific mining design criteria that minimize habitat disruption by allowing the river to transport and store sediment, water, and wood in a manner that approximates a natural disturbance regime. As stated throughout this chapter, constraining annual mining volumes to a fraction of mean annual recruitment (MAR) balances this goal with the need for commercial extraction in a way that protects listed salmonid species and avoids or minimizes intensive reviews and scientifically indefensible criteria characteristic of other approaches (e.g., redline methods). Figure 11 provides a review guidance flow chart to assist decision makers through a logical process of initially evaluating and selecting an appropriate extraction strategy and monitoring/adaptive management package.

Table 4 lists the biological and physical potential impacts (and codes) to salmonids, their food sources, and their habitat shown to be triggered by instream gravel mining in the extensive body of literature reviewed in Chapter 2. It links with an impact matrix (Table 5) that organizes impact codes into groups of probable impacts associated with the suite of gravel extraction strategies discussed in this chapter. Impacts are assigned relative severity ratings from “1” (mild) to “5” (severe). The severity ratings assume that site-specific “best management” practices are followed. For example, bar skimming in the active channel (AC) that uses a sufficient cross-channel slope and vertical offset from the low flow channel would rated as “1” (mild) for fish trapping potential where a low percentage of MAR (<25%) is extracted. This strategy would likely leave a high proportion of bars unmined within the mining reach. However, even with use of best management practices (cross-channel slope, vertical offset, etc.), strategies that extract a higher percentage of MAR would have more severe potential impacts due to the greater number of bars that would be skimmed in the mining reach, thus increasing the “exposure level” of migrating fish to skimmed bars. The same progression of potential impact severity would be associated with wetland pits.

BIOLOGICAL IMPACTS	CODE
Altered life histories of benthic macroinvertebrates	B1
Reduced biomass and/or densities of benthic macroinvertebrates	B2
Reduced species diversity of benthic macroinvertebrates	B3
Reduced salmonid species diversity	B4
Reduced fish numbers and/or densities	B5
Creation of migration barriers	B6
Shifts in fish habitat use	B7
Diminished salmonid egg survival in stable redds	B8
Redd wash-out	B9
Direct mortality from channel de-watering	B10
Fish trapping and/or stranding	B11
Increased densities of non-salmonid fish species	B12
Increased predation of salmonids	B13
PHYSICAL (HABITAT) IMPACTS	**CODE**
Reduced pool habitat volume	P1
Reduced pool habitat complexity	P2
Loss of riffle habitat	P3
Increased turbidity	P4
Altered stream temperature regime	P5
Lowered dissolved oxygen	P6
Fine sediment deposition on substrate surface	P7
Altered substrate particle size	P8
Loss of side channel habitat	P9
Altered channel hydraulics	P10
Suppression of riparian vegetation recruitment	P11
Loss of large woody debris	P12
Channel Incision	P13
Channel widening (bank erosion)	P14
Channel planform destabilization	P15
Channel avulsion	P16
Divided flow (braiding)	P17
Reduced low-flow channel confinement	P18
Decoupling of floodplain from channel	P19
Lowered groundwater table	P20
De-watering of low-flow channel	P21
Channel disturbance from repair of engineered structures	P22
Channel disturbance from construction of new levees and/or bank revetments	P23
Increased recreational vehicle access	P24

Table 4. Biological and physical (habitat) impacts from instream mining and codes (from Chapter 2).

Extraction Strategy	**Biological Impacts**	**Physical (habitat) Impacts**	**Monitoring/ Adaptive Management (MAM) Package**	**Anticipated Salmonid Habitat Protection/Recovery And Other Considerations**
A (FFP,	B7(1); B11(1)	P11(1)	1	Protects intact channel habitat, no impedance to recovery of impacted channel habitat (impacts limited to FFP wetland pits)
B (AC <25% MAR)	B1-3(1); B7(1); B11(1)	P4(2); P7(2); P8(2); P11(2); P10(2); P17(2); P18(2); P24(1)	1	Provides good to moderate protection of intact channel habitat, promotes moderate recovery of impacted channel habitat (impacts limited to AC bar skimming)
C (AC/FFP <25%	B7(1); B11(1)	P4(1); P7(1); P8(1) P10(1); P11(1);	1	Protects intact channel habitat and promotes relatively fast recovery of impacted channel habitat (impacts alternate between AC and FFP)
D (AC	B1-13(2)	P1-24(3)	2	Provides moderate protection of intact channel habitat, promotes slow to moderate recovery of impacted channel habitat (some bars in the mining reach must be designated as “off limits”
E (AC/FFP 25-50%	B1-13(1)		2	Provides moderate to good protection of intact channel habitat, promotes moderate recovery of impacted channel habitat (impacts alternate between AC and FFP)
F (AC	B1-13(4)	P1-24(4)	3	Habitat protection difficult (requires frequent scientific oversight) and recovery of impacted channel habitat very slow; some bars in the mining reach must be designated as “off limits”
G (AC/FFP 50-75%	B1-13(3)	P1-24(3)	3	Habitat protection difficult (requires frequent scientific oversight), slow recovery of impacted channel habitat (impacts alternate between AC and FFP); Aggregate Management Plan needed
H (AC/FFP 75-100%	B1-13(5)	P1-24(5)	3	Habitat protection and/or recovery precluded or extremely slow at best; some bars in the mining reach must be designated as “off limits” to skimming to serve as refugia; River

Table 5. Guidance matrix for evaluating/avoiding biological (B) and physical (P) impacts from gravel mining. Impact codes are derived from Table 4 and are assigned severity ratings of 1 (mild) to 5 (severe). Impact avoidance is generally anticipated to be relatively easy to achieve for extraction strategies A-C, moderately difficult for D-E, difficult for F-G, and extremely difficult for extraction strategy H.

The impact matrix may be used to conduct preliminary cumulative impact evaluations and initially select an extraction strategy to avoid cumulative effects. It also provides general guidance on setting the level of monitoring and adaptive management appropriate to the various extraction strategies. Refining cumulative impact avoidance strategies, monitoring requirements, and adaptive management protocols would follow from these guidance tools by considering unique local circumstances and tailoring as needed.

For extraction strategies not recommended (discussed earlier), potential impacts would likely include all those described in Chapter 2 and could range from mild to severe, depending on the appropriateness of "redlines" or baselines established or market demand, as the case may be. In the case of redlines, existing programs that we are aware of (e.g., Russian River) select an arbitrary baseline as the condition of the river at the time such criteria are adopted. In virtually every river that has historically been and continues to be heavily mined, changes in channel form significantly impair salmonid habitat quantity and quality. Consequently, 1) criteria that maintain such a condition do not protect or recover habitat, and likely aggravates impacts to habitat, 2) virtually all the impacts discussed in Chapter 2 would commonly occur in such rivers, and 3) the severity of those impacts would be high.

3.9. SUMMARY

Cumulative effects from mining are inextricably linked with effects from a host of other activities. Despite this complexity, management of gravel extraction can, with reasonable certainty, minimize the cumulative effects associated with instream gravel mining by adopting a sustainable management strategy. Central to this approach is the need to determine the sustainable yield. Alluvial rivers are formed by the interaction of water and sediment supplied by the watershed. Just as removing a large portion of a river's water causes significant impacts to channel form and habitat quality, removing a large portion of a river's coarse sediment load will also impact channel form and habitat quality. Sediment must route through mined reaches to continue creating and maintaining alluvial channel structure, aquatic habitat, terrestrial habitat, and riparian vegetation within the reach and in downstream reaches. Clearly, extracting all coarse sediment supplied to a mining reach will result in channel downcutting and loss of channel structure both at the mining reach and downstream. Sustainable extraction river-wide, therefore, must be below 100% of the MAR. Unfortunately, the literature summarized in Chapter 2 only assesses impacts associated with extraction over 100% MAR, and does not assess various levels of MAR extraction between 0 and 100%. Therefore, based on the need for an substantial volume of coarse sediment to route through the extraction reach, professional judgment, and our own observations on the Mad River, we recommend that average annual extraction should not exceed 75% of MAR in salmonid-bearing rivers and streams. This recommendation assumes that the MAR estimate is reasonably accurate (i.e., a variety of rigorous, scientifically sound methods are used to estimate MAR). This annual average extraction less than 75% MAR (as in extraction strategies A through H) could require being substantially lower depending on local circumstances. Extracting greater than 75% of MAR would greatly increase the risks of channel incision and loss of channel form in downstream reaches, thus elevating the risk of negatively impacting salmonid habitat.

In the absence of an accurate estimate of MAR (e.g., MAR is estimated using a single unit sediment yield estimate from a nearby river ("X" tons/mi^2/year), then we believe that extraction should not exceed 25% of this rough MAR estimate until a more rigorous estimate is investigated and peer reviewed by qualified expert geomorphologists. If this MAR estimating process is accompanied by an effective monitoring and adaptive management program, a higher sustainable percentage of MAR can be refined through time while managing risks concurrently. This recommendation defines the acceptable level of risk to imperiled species. Although choices will never be easy, they must be made utilizing a decision-making framework that considers economic objectives, but prioritizes ecological needs.

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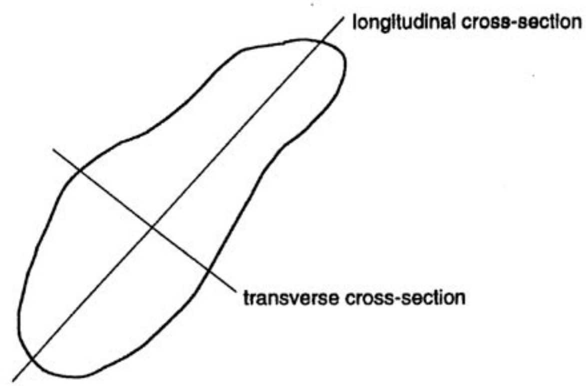
APPENDIX A

GENERAL SPECIFICATIONS FOR WETLAND PITS

Plan view of a pit



Longitudinal cross-section

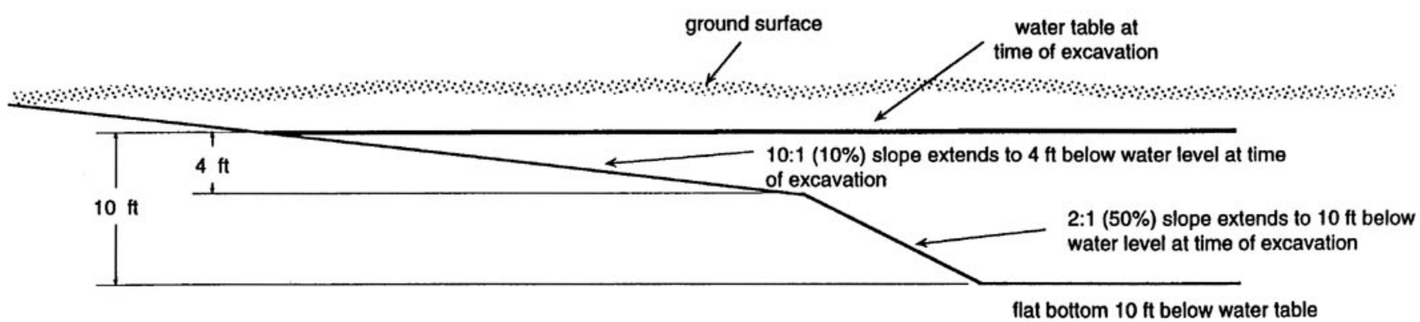


diagram shows upstream end of pit only; downstream end is identical, symmetric around midpoint of pit

GENERAL SPECIFICATIONS FOR WETLAND PITS (cont.)

Transverse cross-section

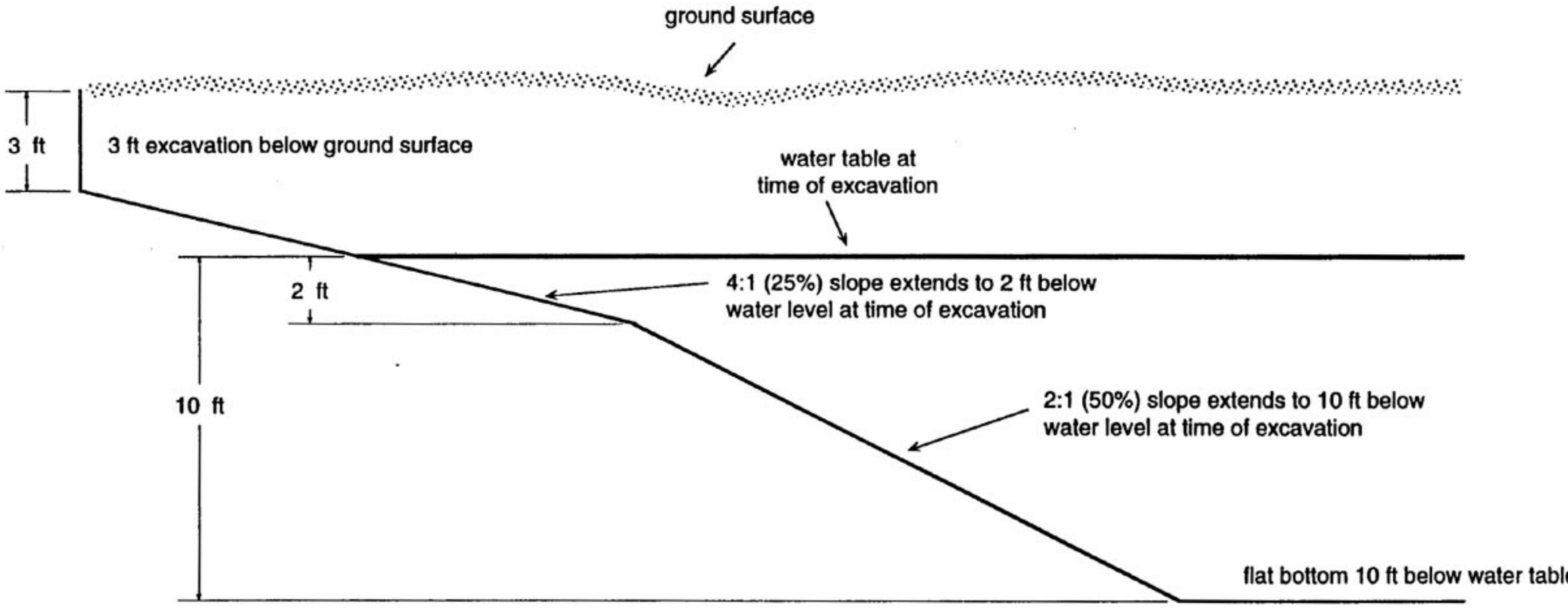
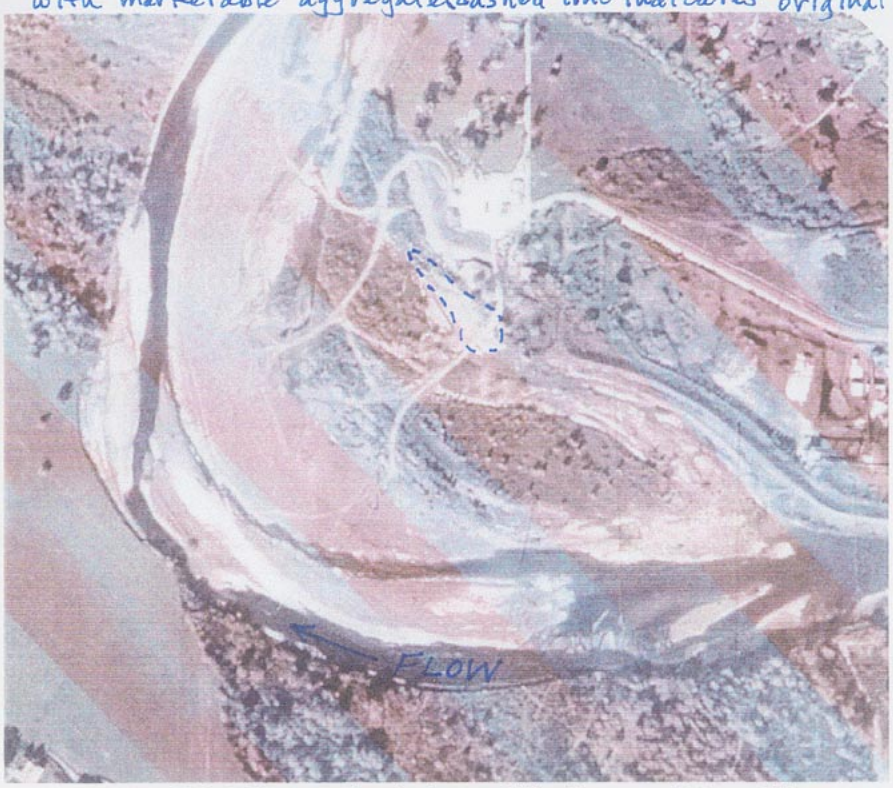


diagram shows left-hand side of pit only; right-hand side is identical, symmetric around centerline of pit

1996 photo of Blue Lake Bar wetland pit excavated in 1993 and enlarged in 1994. Pit has partially re-filled with marketable aggregate (dashed line indicates original pit boundary).



1997 photo of Mad River wetland pit area following complete re-filling