TECHNICAL SERVICE CENTER
DENVER, COLORADO

GENERAL PROPOSAL FOR A COMPREHENSIVE SEDIMENT TRANSPORT AND GEOMORPHIC STUDY OF THE YAKIMA BASIN

YAKIMA AND KITTITAS COUNTIES, WASHINGTON

US Department of the Interior
Bureau of Reclamation

DRAFT PROPOSAL-JANUARY 5, 2004

U.S. Department of the Interior
Mission Statement

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian tribes and our commitments to island communities.

Mission of the Bureau of Reclamation

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

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INTRODUCTION

This proposal discusses sediment transport and geomorphic aspects within the context of reclamation of gravel mining ponds that lie within the 100-year floodplain of the Yakima River, Yakima and Kittitas Counties, Washington. Floodplain mining of sand and gravel for aggregate has resulted in many abandoned ponds adjacent to the river. The mining has forced the construction of dikes and levees to discourage avulsion of the river into the ponds. The dikes and levees severely limit essential habitat in the preexisting outboard floodplain, essential to both fish and wildlife (Norman et al., 1998). For the purpose of this report, levees refer to structures parallel to the river intended to contain water within the main channel while dikes are structures built to prevent river flows from entering a specific area, such as a gravel pond. Side channels and oxbow lakes have historically provided habitat for juvenile salmon, steelhead and resident cutthroat trout. These important habitat features are currently cut off from the main channel. A basin-wide sediment transport and geomorphic study performed by the Bureau of Reclamation's (Reclamation) Technical services Center (TSC) will form a scientific and engineering basis from which sound decisions can be made regarding the rehabilitation of the Yakima River.

Within the Yakima River floodplain, there are many opportunities to develop highly productive wetlands and off-channel habitat for salmonid fish species (Norman, 1998), many of which are listed as either threatened or endangered. It may be possible to restore lost habitat by allowing the river to reclaim selected gravel ponds through planned and carefully monitored levee or dike breaches. In some locations this will involve the setback of existing levees. Because many portions of the Yakima River have historically consisted of multithread channels, strategic breaches of existing dikes into gravel ponds could mimic the historical planform and allow the river to occupy portions of the floodplain that it otherwise might occupy in the absence of mining. By properly engineering these breaches, potential disasters can be avoided when the river enters a gravel pit during high flows, which has happened on several occasions on the Yakima River in the past. These unplanned avulsions have occurred because the ponds are separated from the river by easily eroded gravel dikes (Dunne and Leopold, 1978, Norman, 1998), many of which are constructed of river alluvium and are therefore more easily mobilized. A study performed by Dunne and Leopold (1978) after a 10-year flood on the Yakima River indicated that the river is capable of moving boulders 0.6m (2 ft) in diameter.

A literature search revealed very little information detailing planned or engineered breaching of levees or dikes into floodplain gravel ponds, which likely indicates that only a few projects or perhaps no project of this type has previously been performed. With proper analysis and understanding, the feasibility of the proposed efforts can be judged. Until a thorough sediment transport and geomorphic study has been performed, the probability of success remains in question. One of the most important factors determining the success of this project will be a sufficient sediment load transported by the river.

If the analysis shows this project is feasible and the proposed actions are carried out, the project will allow riparian zones to once again function properly, providing a healthy ecosystem to support fish and wildlife. This will also benefit residents of the Yakima Basin by improving the protection of nearby infrastructure and agriculture through increased protection from flood damage. Widening the river corridor increases the effectiveness of levees through a decrease in water surface elevations and channel velocities. The Yakima Basin water users have benefited

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from a vast network of reservoirs, canals, drains, pumping plants and power facilities for approximately 100 years (Pfaff, 2001), making it one of the most productive agricultural regions in the nation (Duvall, 1987). It is possible to maintain a healthy aquatic system for human benefit and that of fish and wildlife.

Recent initiatives by Reclamation's Pacific Northwest and Mid-Pacific Regions, in conjunction with many local and private organizations, Native American tribes, and state and federal agencies, have placed special emphasis on balanced fisheries maintenance, water development and restoration programs. The Yakima River Basin Project plays an instrumental role in reestablishing the salmon and steelhead fishery. Reclamation, along with other federal, state and local agencies, has funded state-of-the-art fish passage facilities at 20 water diversion sites in the Yakima Basin (Duvall, 1987). In order to take full advantage of this $53 million (Duvall, 1987) effort, salmonid habitat throughout the basin needs to be rehabilitated to the extent possible to insure the future survivability of the species. The Yakima River Basin Water Enhancement Project has been tasked with identifying alternatives for improving instream flows on the Yakima River and major tributaries to enhance and maintain aquatic habitat and to improve the efficiency of fish passage and screening efforts (Duvall, 1987). These efforts by Reclamation set a precedent for continued efforts in maintaining and rehabilitating the river system for fisheries.

SITE DESCRIPTION

The headwaters of the Yakima River are located on the eastern slope of the Cascade Mountains below Snoqualmie Pass. The river flows in a southeasterly direction for 216 miles from heavily forested areas at the headwaters through arid regions in the Yakima Valley before entering the Columbia River near Richland, WA (Figure 1). The basin covers an area of 6,200 mi^2 and produces approximately 5,600 ft^3/s of unregulated mean annual runoff and about 3,600 ft^3/s of regulated annual mean runoff (Mastin and Vaccaro, 2002). Five reservoirs store water in the basin for irrigation projects.

East of the Cascade crest, floodplain gravel mines are located almost exclusively on the Yakima River and its tributaries (Figure 2). These include 140 ponds on the Yakima River, 4 on the Naches River, 1 on the Tieton River and 1 on Wenas Creek (Baker et al., 2003). The majority of floodplain gravel mining has occurred since the 1950's.

TECHNICAL SERVICES CENTER (TSC)

Reclamation's Technical Services Center (TSC) is capable of providing expert technical support covering a wide range of river and water related issues. The TSC possesses an experienced, multidisciplinary team of engineers and scientists capable of analyzing difficult situations. The TSC operates as a business and uses a billable rate structure to fully recover costs. We are available to work with Federal and non-Federal clientele. The Sedimentation and River Hydraulics Group and Flood Hydrology Group specialize in river hydraulics, sedimentation, computer modeling and geomorphology. We are staffed with professionals who possess advanced degrees, extensive experience and professional registrations.

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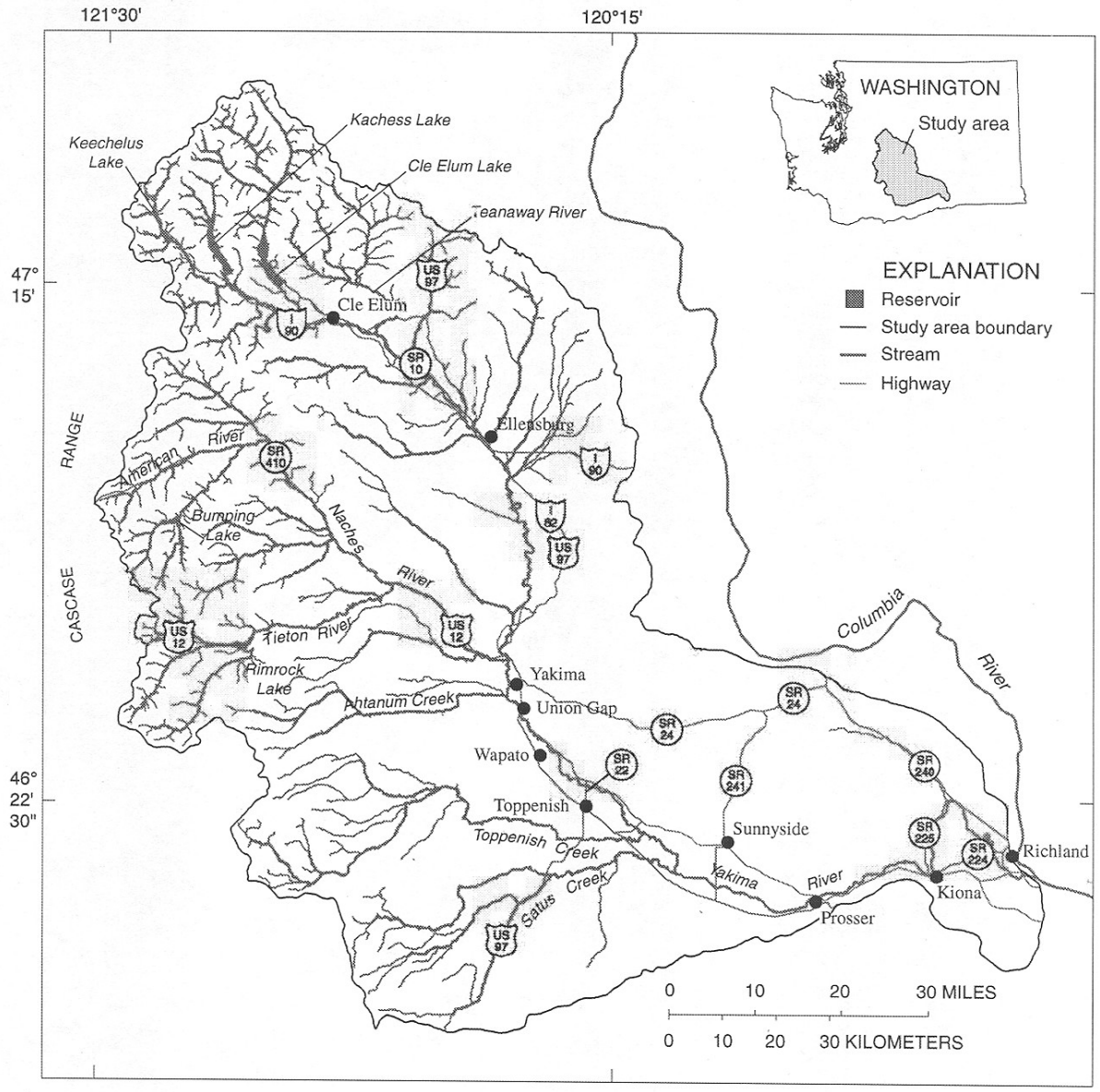

Figure 1: Location map of the Yakima Basin (from Mastin and Vaccaro, 2002).

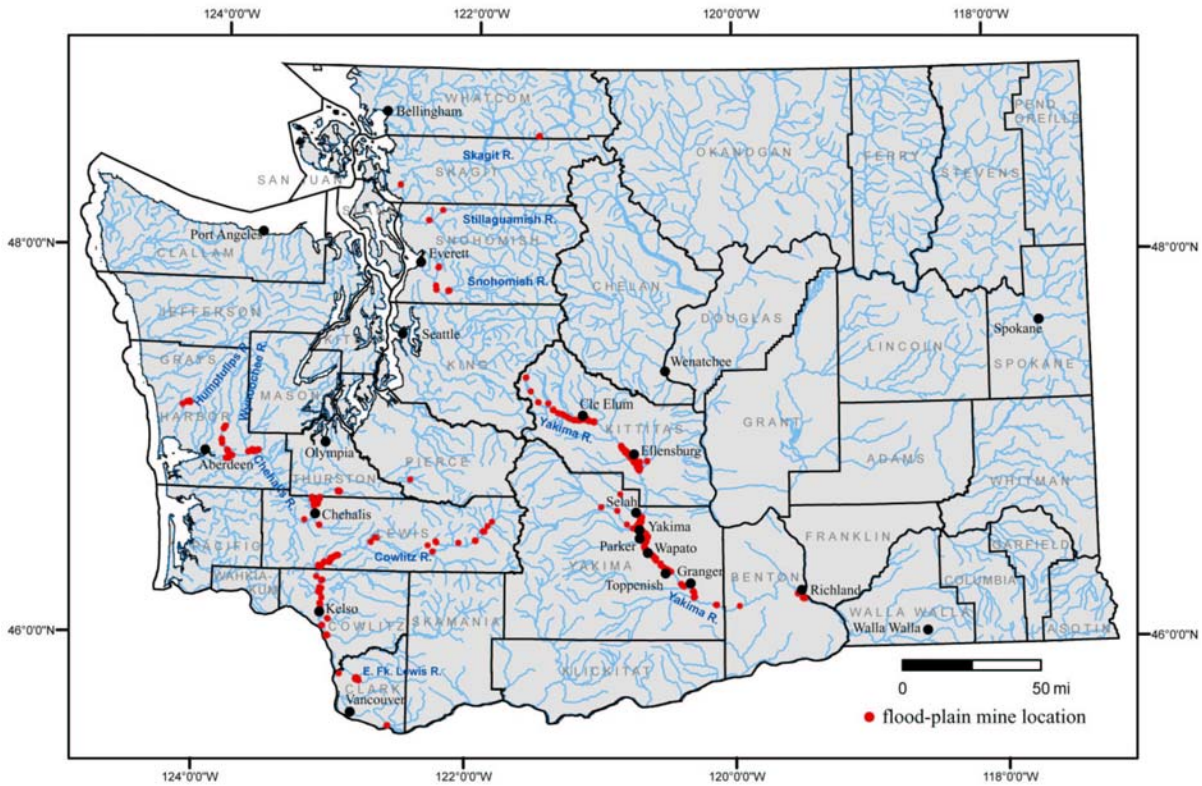

Figure 2: Map showing locations of gravel pits located within the 100-year floodplain (from Baker et al., 2003). There is good potential for reclaiming floodplain gravel mines along the Yakima River.

CHANNEL AVULSION INTO FLOODPLAIN GRAVEL PITS

A major concern with gravel pits in the floodplain is the risk of unplanned channel avulsion during high flows. This has happened along the Yakima River at Parker, Union Gap and Selah Gap (Norman et al., 1998) among others. The severity of unintended channel avulsion varies depending on location (e.g. surrounding infrastructure, size and depth of pond, upstream sediment supply, etc.). If the levee or dike is breached and the river flows into a deep pit, considered here to be significantly deeper than the main channel, nearby infrastructure (bridges, levees, roads, railroads, irrigation structures, water and wastewater treatment facilities) could be at risk due to lateral and vertical instability of the main channel. Incision can result upstream from a migrating nick point and downstream from sediment starvation (Kondolf, 1998). Figure 3 shows a schematic diagram of this process. Following severe degradation of the river, exposure of buried pipelines and water supply facilities is also likely to occur (Parsons et al., 1994). Severe channel incision may also result in degradation of tributaries and a lowering of the ground water table, which is likely to further disconnect the floodplain from the river and cut off access to existing side channels. It could take many decades or longer before the river might recover from such an event, if ever. A few brief examples of river channels that have breached levees and flowed into floodplain gravel ponds during high flows follow.

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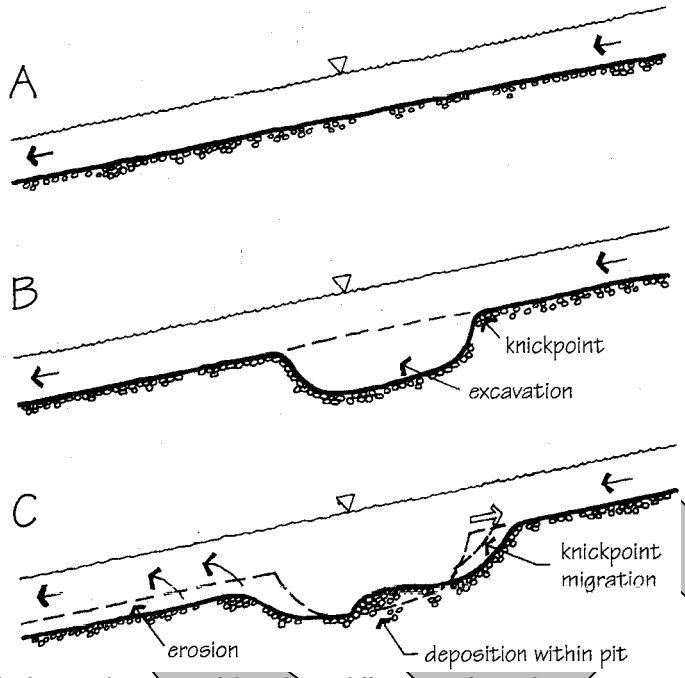

Figure 3: River profile showing the process of degradation following avulsion of a river into a gravel pit. Degradation of the river can be possible upstream, downstream or both, as shown here (from Norman et al., 1998).

COLORADO RIVER NEAR GRAND JUNCTION, COLORADO

Following flood events in 1983 and 1984, the Colorado River near Grand Junction avulsed into floodplain gravel ponds. Figure 4 shows aerial photos taken in 1976 and 1997of the Colorado River in the vicinity of the avulsion. The position of the channel in cross section A-A' in the 1997 photo is approximately 1000 feet south of its position in the 1976 photo. Cross section B-B' shows a channel shift of approximately 720 feet to the north. In addition, the channel has adjusted from a multithread planform to a single channel following the avulsion. Cross section C-C' shows the most dramatic change in the river. In the 1976 aerial photo the river is confined to a single channel approximately 250 feet wide and is flowing against the bluff. Following the flood events of 1983 and 1984, the river shifted northward into the gravel pits visible in the 1976 aerial photo. The 1997 aerial photo shows a multithread channel located more than 900 feet north of its former position (Klinger, 2002).

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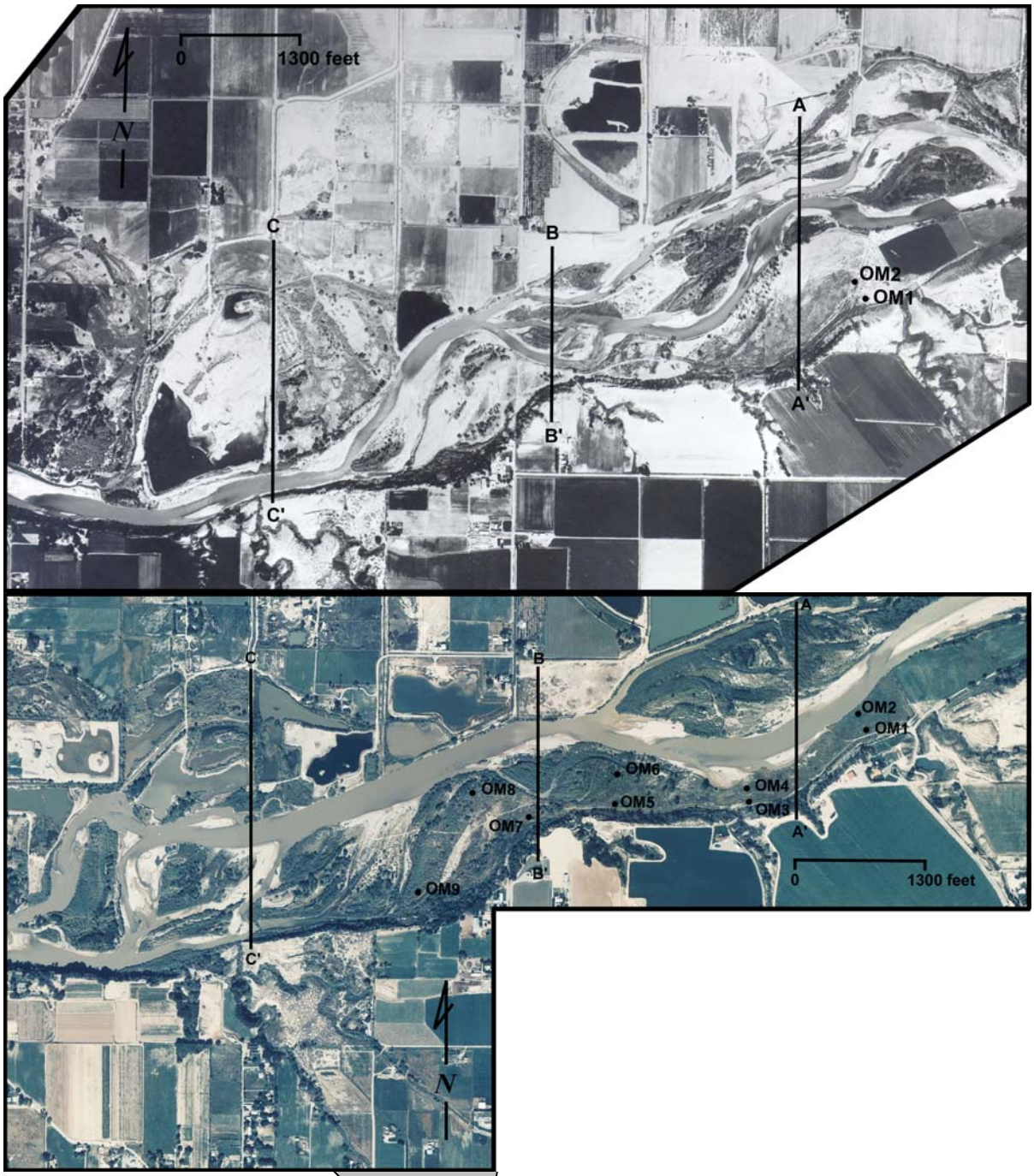

Figure 4: Diagram showing the planform change following a channel avulsion into a gravel pit on the Colorado River near Grand Junction, CO. The top aerial photo was taken in 1976 and the bottom aerial photo was taken in 1997. Note the large gravel pit to the left of cross section C. In 1982 the channel avulsed into this gravel pit, completely changing the course of the river. Flow is from right to left on the photos. (from Klinger, 2002).

YAKIMA RIVER AT PARKER, WASHINGTON

During a flood in February, 1996, the Yakima River avulsed through gravel pits near Parker on the south side of Union Gap. The flood breached the dikes that separate the river from the ponds in two locations. These avulsions were not repaired following the flood and the river currently has a braided, meandering course through the ponds. The depths of these ponds was

not greater than 10 feet, hence no severe degradation of the river resulted from this avulsion. No negative side affects have been recorded at this site, however, no monitoring has taken place (Norman et al., 1998).

YAKIMA RIVER AT SELAH GAP, WASHINGTON

During the same flood in 1996, the Yakima River avulsed into approximately 250 acres of gravel ponds at Selah Gap. This avulsion caused 6 to 8 feet of channel incision immediately upstream of the point of avulsion. This nick point was observed migrating upstream as evidenced by a standing wave (Norman et al., 1998). Repairs to the dike were made following the flood but not before 300,000 yd^3 of gravel was scoured from the riverbed and deposited in the gravel ponds to depth of 6 feet over a 33 acre area (Norman et al., 1998). To put this volume of sediment into perspective, Dunne and Leopold (1978) estimate that the total annual sediment yield of the Yakima River near Yakima is approximately 250,000 yd^3.

EAST FORK LEWIS RIVER NEAR LA CENTER, WASHINGTON

The East Fork of the Lewis River avulsed into floodplain gravel pits during floods in 1995 and 1996. The results of these avulsions include 10 feet of channel incision, increased bank erosion and abandonment of 4,900 feet of channel where salmon and steelhead had previously spawned. It is estimated that 2,000,000 yd^3 of sediment will be required to refill the seven acre ponds through which the river now flows (Norman et al., 1998).

It may be possible to prevent unintended channel avulsion of the Yakima River into gravel ponds by setting back levees and properly engineering strategic breaches of remaining dikes or levees at carefully selected locations. With a proactive approach to gravel pit reclamation based on engineering and science, there will be a greater assurance of avoiding future unintended channel avulsions and their potentially negative side affects. Furthermore, proper habitat can be regained through appropriate efforts to allow the river to reclaim floodplain areas lost to levee construction and gravel mining. The engineering should be coordinated with many interested parties, including Reclamation, U. S. Army Corps of Engineers, WDOT, Yakama Nation, State and Federal biological and ecological experts as well as local county and city planners.

PROJECT GOALS

There are two primary goals for incorporating existing gravel pits into the normal flow of the river and setting back levees, which fall under a common goal of restoring the natural geomorphic process critical in maintaining ecological functions. From a fish and wildlife perspective, habitat will potentially be greatly improved with levee setback through restored floodplain interaction and improved riparian zones. Existing gravel ponds that are incorporated into the river will improve channel complexity, thereby creating improved habitat for native fishes.

From an infrastructure perspective, channel stability will be improved through strategic breaches of dikes or levees, addressing what could likely be inevitable in the future. Setting back levees reduces the possibility for flood damage by lowering water surface elevations and channel velocities. Gravel pits that are too deep or otherwise not feasible to be incorporated into the main river channel should be examined for desired operability and stability for protection against future flood damage.

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An important goal is to allow the Yakima River to perform the work of transporting sediment and achieving its own stability regarding width, depth, slope and planform. This will be done under supervised conditions through planning and monitoring. The stable condition can be predicted to a certain degree, which will provide important information regarding levee construction, sediment transport, channel migration and gravel pond rehabilitation. Degradation of the river will not likely be acceptable due to channel instability and the proximity of infrastructure and a potential lowering of the water table. It may be necessary to provide channel slope stability in the form of grade control structures in the vicinity of the planned breaches. Other engineering structures may be recommended such as stream barbs, weirs and log jams to control velocity and erosion potential.

GENRAL PLAN FOR BASIN-WIDE GRAVEL PIT RECLAMATION

To maximize efficiency and provide a flexible step-wise approach, the geomorphic analysis and sediment transport studies should be divided into sections or reaches. This effort could begin with the headwaters of the Yakima Basin, through Easton and Cle Elum. The downstream boundary can be determined at a later date, perhaps in the vicinity of Thorp to include the Gladmar and I-90 ponds. Following a study in this location, specific sites feasible to be reclaimed should be reviewed from all perspectives for feasibility of incorporating the gravel ponds into the normal flow of the river and whether or not existing levees, if any, will need to be setback. Following the sediment transport and geomorphic study, a specific design for reclamation of the pond(s) can take place, such as strategic breaching of dikes and levees and placement of grade control and bank protection if needed.

Because the rehabilitation of a gravel pond is likely to create instability in the locality of the project, it will probably be necessary to limit in-stream work to short reaches, reworking one location at a time within a given reach of influence. Many concurrent efforts within a short reach may create the potential for widespread instability.

It is likely that the reclamation of these sites may take many years before anticipated results are realized. This will depend on discharges and sediment transport rates as well as site-specific conditions such as pond size and depth and floodplain elevations. Although it may take more time, allowing the river to attain its own stability is likely to provide more desirable results as opposed to constructing a heavily engineered channel. This option is also less costly to maintain.

RESEARCH

Very little background information on incorporating floodplain gravel pits into the normal flow of the river is available. The literature collected to this point does not specifically address breaching levees or dikes to provide river access to floodplain gravel pits. A vast majority of available information related to gravel mining discusses rehabilitation of river channels following in-stream mining or bar scalping (e.g. Graham Mathews and Associates, 2003; Brown et al., 1998; Lowe, 1999; Collins and Dunne, 1990) or addresses only a single downstream connection to the river (Norman, 1998). It appears that strategic breaches to allow normal river flow into floodplain gravel pits have not been performed to any great extent. Critical information can be

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gained from documented unplanned avulsions on the Yakima and other rivers (e.g. Parker ponds). This data often does not include surveys before and after the avulsion, however reasonable estimates are often made regarding depth of incision and volumes eroded from the channel and banks following avulsions into gravel pits. Frank Schnitzer from Oregon State University may be able to provide a report detailing a recent channel avulsion on the Clackamas River. In this case, a hydrographic study was performed not long before a channel avulsion occurred. The study team may benefit greatly from site visits to locations where avulsions into gravel ponds have occurred. The Terrace Heights site has been identified as having achieved near pre-mining conditions following avulsion into the pit (Yakima River Floodplain Mining Impact Team, 2003). A gravel pond reclamation site on the Wynoochee River may also provide information relevant to gravel pond reclamation efforts on the Yakima River. Grays Harbor College has monitored this reclaimed site (from a biological perspective) since 1989 (Norman, 1998) and a site visit, accompanied by a person knowledgeable of the site and it's history, could be scheduled.

GEOMORPHOLOGY AND SEDIMENT TRANSPORT

Before work can begin to incorporate floodplain gravel ponds into the normal flow of the river, a geomorphic study of the Yakima Basin should be performed. A geomorphic study will document the alluvial history of the Yakima River and form a context for current sediment transport conditions. It will also provide information regarding geologic controls to vertical and lateral migration of the river as well as surfaces that are likely to be inundated by various flood discharges. The geomorphic study will also indicate the natural pattern of the river predating mining efforts with the aid of historical aerial photographs and maps, providing a channel migration zone. Volumes of alluvium that are available for transport by the river will be determined.

The transport of sediment through reaches of the Yakima River to be rehabilitated is a very important factor in predicting the success of the project and also needs to be studied prior to decisions regarding strategic breaches. Calculating and predicting sediment transport is an inexact science because no comprehensive theory exists regarding the initiation of motion and subsequent transport of sediment particles. Numerous sediment transport formulae are available, most based largely on empirical data. The results of these formulae often vary by an order of magnitude. Results can be narrowed to determine representative values based on measured quantities and physical observations made in the field related to a geomorphic study. Past surveys also provide information with which to verify sediment transport models.

Specific data will need to be collected for a sediment transport analysis, including the bathymetry of the river and the pond(s) to be reclaimed. Floodplain topography will also be necessary. The existing 2000 LiDAR for the Yakima River is expected to be sufficient in the near future however as time passes, LiDAR or photogrammetry will likely have to be updated. There may also be a need for supplemental photogrammetry in some reaches. Sediment samples will be required, from both the riverbed and banks. It may be necessary to measure bedload transport at selected locations in order to verify sediment transport calculations. A determination of flood frequency and flow duration will also be required for sediment transport calculations, both in the Yakima River and tributaries contributing significant sediment loads. The sediment transport analysis will likely be evaluated using an average annual hydrograph, providing annual sediment loads.

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The calculation of an effective discharge may prove useful in order to determine the flows required to effectively transport sediment. The effective discharge is the flow at which the greatest amount of sediment is transported over a long period of time. This flow usually has a return period of approximately 1.5 years, however this is dependant on regional characteristics and flow regulation. The effective discharge can be used in determining stable channel geometry and, if it is feasible to do so, controlled releases of the effective discharge from dams may aid in the recovery of the river system following modification.

Some of the information gained through investigation of the upstream portion of the basin will be applicable to reaches downstream. The sediment load determined in the upstream reaches and tributaries can be used as input when determining sediment loads in downstream reaches during subsequent phases of the study. Breaching techniques, bank stabilization methods, engineered structures and pilot channels that are successfully incorporated in early phases of the study can be used as a model for subsequent efforts.

SITE SELECTION

Following a geomorphic and sediment transport analysis, it will be necessary to identify and prioritize specific sites to be reclaimed. This selection should be based on input from the involved disciplines including planning, ecology, biology, geomorphology and engineering. Many sites have already been identified as potential prime habitat in the Floodplain Mining Impact Study (Yakima River Floodplain Mining Impact Team, 2003). The most important consideration should be the potential for negative impacts to the ecosystem and existing infrastructure. It may be discovered that some sites pose a greater threat to unplanned avulsions, in which case those sites may need to be reclaimed earlier in the project if feasible to do so. Should it be determined that avulsions are to be prevented at a specific site and no breaching will be planned, the ability of the dikes or levees to withstand floods should be investigated.

In some locations of the river, gravel ponds may be located far enough from the river that it may be more prudent to simply setback the levee or levees and allow the river to migrate through the floodplain, with possible capture of the pond in the future.

DETERMINE IN-FILL POTENTIAL

Baker et al. (2003) published an inventory of gravel pits in Washington, including pond size, depth and excavated volume. This information will need to be verified through a bathymetric survey to be certain of the depth and volume of the ponds to be reclaimed. Results from the geomorphic and sediment transport analysis will be used to predict of the ability of the Yakima River to fill gravel pits that are to be incorporated into the river. These analyses will predict whether or not the volume of sediment transported by the Yakima River will support the required volumes to bring the elevation of the ponds to elevations similar to the channel bed. Information from the geomorphic study will be needed to determine available upstream sediment. The sediment transport analysis will predict volumes and sizes of gravel transported through the system and to the specific site being reclaimed. It is possible that portions of the available upstream sediment will not be mobilized by frequent flows. Armoring of the riverbed may prevent the erosion of bed material, with the exception of large flows, leaving only incoming sediment and sediment eroded from banks available for transport through the armored reach. If large amounts of sediment will be required to fill in a gravel pond and

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much of the upstream reach is armored, the channel is likely to become vertically unstable because the sediment required to fill the gravel pond will be taken from the bed and banks in the nearby upstream portion of the river.

A very important consideration for sediment transport on the Yakima River is whether sediment can pass existing irrigation diversions throughout the basin. If this can not be accomplished, sediment upstream of the diversion can not be considered for use in filling the gravel pits.

In addition to sediment transported to a site from upstream reaches, sediment from existing dikes or levees that are to be deconstructed may provide fill for nearby gravel ponds. If a dike or levee is breached with the intent of creating normal river flow through the pond, natural erosion of the dike material may help to fill the pond. Structures may need to be constructed to encourage beneficial erosion of the dike or levee material. If a dike is not expected to erode through natural processes or will not deposit the material in the desired locations, the material can be relocated to areas where it will be expected to provide the greatest benefit.

Another potential source for supplying sediment to the river is the accumulated sediment in the Yakima River near Interstate 82 at Union Gap. Sediment has accumulated at this location, presumably due to a downstream dam and may pose a future threat to the nearby interstate and railroad. This option will have to be studied for potential benefits and negative impacts before a decision can be made about removing gravel at this site. This may be a costly alternative, depending on the transport distance and regulations for in-stream sediment removal.

RIVER CHANNEL STABILITY

The objective of the engineering for the reclamation of gravel pits and levee widening project is for the river to eventually attain a state of dynamic equilibrium. This is defined as a river that is stable regarding width, depth and slope. Minor adjustments are made by the river to maintain equilibrium with changing discharge. These minor adjustments include localized changes to width, depth and slope, which may come about with relatively small changes in planform. When a river is stable, the product of sediment discharge and median sediment diameter is in proportion to the product of water discharge and slope (Lane, 1955). Quantification of this process can be accomplished using stable channel design methods and Yang's theory of minimum unit stream power (Yang, 1986).

Pre-modification channel characteristics can be obtained from historical aerial photographs and relatively undisturbed reaches. Channel properties such as length, width, sinuosity and braid patterns can be determined and will be an indicator of the geometry the river will likely work toward.

In some cases, it may be more prudent to provide connectivity at to an existing gravel pit while maintaining the integrity of the dikes or levees separating the gravel pit from the river. This may be the case for larger and deeper gravel pits. These pits can be hydraulically connected at the downstream end of the pit, leaving the remaining levee in tact. Some of the gravel ponds in the Yakima Basin are already connected in such a fashion. By connecting the river at the downstream end, avulsion is less likely (Norman et al., 1996) due to decreased velocities at the opening. A large benefit to the stability of the dikes and levees can be realized with a downstream connection. A study by Schnitzer et al. (1999) following major flooding in Oregon

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in 1996 found that gravel pits where floodwaters backed into the gravel pond before the river over-topped the levees generally received the least amount of damage. This happened because the hydrostatic pressure applied to the back-side of the levee was equal to that on the river-side of the levee.

There could be a drawback to connecting the gravel pond to the river at only one location. When this is done, velocities in the pond are negligible and pond temperatures may be elevated from those in the stream. This condition has the potential to create habitat for undesirable or introduced species that have access to the main channel of the river.

In order to achieve stability of the river it may be necessary to place engineered structures in and around the reworked portions of the river. These structures may include; large woody debris to decrease channel velocities near banks and discourage their erosion, grade control structures upstream of a planned avulsion to maintain the slope of the river and prevent headcutting, stream barbs or weirs to direct higher velocity flow in a desired direction and bank protection. Whether or not these measures will need to be taken will depend on site conditions. Some of these engineered structures can be removed once they have achieved the intended result.

A two-dimensional (2-D) numerical model can be utilized for predicting local hydraulic conditions following the breaching of dikes or levees. This information will help to determine locations of bank erosion, scour and deposition.

MONITORING

It will be important to monitor the activities mentioned in this proposal. These works should be monitored from an engineering standpoint for stability and damage from flooding. Permanent bench marks can be placed at strategic locations marking cross section end-points and regular surveys of the cross section should be planned. The surveys will document changes in the channel and should be compared to projections made in the study. It may also be necessary to obtain a longitudinal surveys of the channel in the reaches affected by engineering works. Should the river begin to behave in an unpredicted or adverse manner, corrective actions should be taken to reverse the problem. Repeating aerial photographs is an effective and inexpensive way to also document channel changes.

The newly created habitat should also be monitored for efficacy from a biological and ecological perspective. Currently the Weyco-Brisco ponds on the Wynoochee River are the only gravel pit lakes monitored for off-channel habitat (Norman, 1998). The monitoring plan for the Weyco-Brisco ponds should be examined and perhaps used as a model for monitoring gravel pits in the Yakima Basin.

The monitoring efforts can be performed by government agencies (local, state and federal), tribes, academia and industry (Norman, 1998). The monitoring plan will help to insure the effectiveness of the work performed and will provide feedback for subsequent efforts.

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OTHER CONSIDERATIONS

LEVEE SETBACK

Many of the gravel pits in the Yakima Valley lie outside of existing flood control levees. Because of recent land acquisitions, possible future acquisitions and the potential widening of State Route 24 in Yakima, opportunities may now exist to widen the river corridor by setting back existing levees. Such action may decrease the risks associated with channel avulsions into gravel pits (planned or unplanned) because lateral movement of the river will not be as likely to interfere with infrastructure. Levee setback can also create conditions for increased riparian habitat and channel-floodplain interaction as well as expanded opportunities for the Yakima Greenway. The potential of flood damage will be decreased with wider levees and improved river hydraulics following the proposed actions.

Because many of the levees were likely constructed by the U.S. Army Corps of Engineers, it will be necessary to work with them for proper permitting, design and construction of new levees along portions of the Yakima River. If it is determined that the levees are to be reconstructed to provide a wider river corridor, actions to reclaim gravel ponds in that vicinity should be coordinated with the construction of the new levees. If it is known that breaches are planned within a reach to be considered for levee setback, this will have to be taken into consideration for the design of the new levees.

RESERVOIR MANAGEMENT FOR FAVORABLE FLOWS

It may be possible to coordinate and manage river flows through favorable releases from the five Reclamation dams in the Yakima Basin. Controlled releases of the effective discharge could accelerate the recovery of the system following in-stream work. The sooner the gravel ponds are filled to an elevation similar to the original channel elevation, the sooner a stable channel might be expected to form.

VEGETATION OF RECLAIMED AREAS

Areas where avulsions are expected to take place may need to be revegetated due to clearing during mining activities. The Yakima River Basin Water Enhancement Project (YRBWEP) has been involved in efforts to eradicate noxious or invasive species on Reclamation owned property. This effort should be expanded to include planting of native species where necessary. The newly planted vegetation will improve habitat for wildlife and help to reinforce banks adjacent to newly formed channels.

NEXT STEP

The Technical Services Center will provide sound engineering and scientific studies for efforts related to the reclamation of floodplain gravel ponds. It will be the role of local and State agencies, including YRBWEP and Reclamation's Upper Columbia Area Office (UCAO), to implement recommendations and strategies set forth in reports generated by the TSC. The levee owners, local agencies and U.S. Army Corps of Engineers should be responsible for efforts related to levee setback and design. Bank stabilization efforts, pilot channel construction,

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placement of large woody debris and other engineered structures can be contracted with local labor.

At this time there is insufficient knowledge of a set plan regarding studies for the reclamation of gravel ponds in the Yakima Basin to determine a financial budget and time estimates. Stakeholders in this project should provide comment on this proposal so that local input is provided. Following local input, this proposal can be finalized by the TSC and submitted to Yakima County. When an agreement is reached on a study plan, the TSC may need to perform further analysis in order to create a detailed scope of work and provide a financial budget and time line for the first phase of the project.

It will be necessary for local stakeholders to determine funding sources for the proposed study or series of studies. There may be many sources for financial contributions to this effort. Contributions to this project by state and local agencies, other than financial, may come as in-kind services. This could include, but is not limited to, processing sediment samples collected by the study team, ground surveys before and after modifications, monitoring efforts and photogrammetry.

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