RECLAMATION

Managing Water in the West

Trashrack Cleaning Alternatives for Parker Dam Powerplant Forebay Inlet Trashrack Structure

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Executive Summary

Five types of trashrack cleaning systems were identified and evaluated for potential use to clean the forebay inlet trashrack structure at Parker Dam. Two system types were identified as most appropriate and likely to be successful and cost-effective for this application: a hydraulic backhoe-style raking machine traveling on deck-mounted rails that cleans the trashracks with an upward scraping motion, and a cable-style raking machine traveling on an overhead monorail that cleans the trashracks by pushing debris downward and then gripping it for removal from the water. Peer-reviewed construction cost estimates for one backhoe-style system and two cable-style systems were generated. Differences in estimated construction cost for all three systems were negligible, with all costing $3.7 million, assuming award within one year. Contract award in two or three years would raise estimated construction costs to $3.9 and $4.1 million, respectively. The cost similarity of the options suggests that system selection should consider other factors.

Background

Parker Dam (Figure 1), constructed from 1934-1938, is a concrete thick-arch dam impounding Lake Havasu on the Colorado River below Havasu City, Arizona. The dam has a hydraulic height of 80 ft. Parker Powerplant (completed 1942) is located near the right abutment with rated generation capacity of 120 MW, provided by four Francis-type turbines. Flows to the powerplant pass through a forebay inlet trashrack structure into an excavated forebay channel, and then through penstock intakes equipped with individual trashracks. None of the existing trashracks have provisions for regular cleaning.

Figure 1. — Parker Dam and Powerplant.

Quagga Mussel Effects at Parker Dam

The spread of non-native mussels in the Colorado River system is rapidly changing debris handling needs at hydraulic structures and water intakes. Parker Dam has been heavily infested by quagga mussels since 2007 (see http://www.usbr.gov/lc/region/programs/quagga/parker.html). Quagga mussels can cause simple blockage of water intakes and trashracks as they attach to these structures. In addition, mussels are filter feeders, consuming phytoplankton, zooplankton, and algae, which increases water clarity. This leads to increased aquatic weed growth. As a result of expected increases in weed growth in Lake Havasu and upstream waters, a need is anticipated in the near future for automated cleaning of the trashrack structure at the entrance to the Parker Powerplant Forebay.

Figure 2 shows aquatic debris that has recently accumulated upstream from water intakes on the Central Arizona Project (CAP). Similar thick mats of aquatic weeds, algae, and aquatic grasses are expected at Parker Dam in the future. Large rafts of debris are now present in the Bill Williams River arm, but have not yet moved down to Parker Dam.

Figure 2. — Example accumulations of aquatic plants at CAP water intakes.

Trashrack Cleaning Alternatives

Study Objective

To address the future debris problem, this report evaluates alternative trashrack cleaning systems that could be installed at the forebay inlet trashrack structure. We believe the most effective debris removal can be accomplished at this location, where flow velocities are relatively low in comparison to the penstock intakes. Also, velocities at the forebay inlet trashracks will probably be low enough to allow some colonization of those racks. A rack cleaning solution for

the forebay inlet would hopefully address the need for both plant debris removal and some cleaning of mussels from the racks.

Study Approach

For this study, generic trashrack cleaning system types were identified and the characteristics of each type were evaluated with respect to the site-specific needs. Two types of trashrack cleaning systems were identified as feasible alternatives, and appraisal-level cost estimates (Appendix II) for specific designs were developed. Manufacturers of trashrack cleaning equipment were consulted, and their input was used in the development of the cost estimates. Appendix III contains the detailed information obtained from the manufacturers.

Existing Trashrack Structure Description

Figures 3 and 4 show photos of the existing trashrack structure. Drawings included in Appendix IV show the details of the trashrack structure, trashracks, and associated guides and other metalwork.

- Forebay Plan, Elevation and Sections 231-D-231
- Trashrack Structure, Plan, Elevation, and Sections 231-D-262
- Trashrack Metalwork Installation 231-D-270
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The trashrack structure is linear, 236-ft long (end pier to end pier), containing 12 bays. Each bay contains a middle metal guide and two trashrack stacks. The existing guides included a guide slot for a future rake (although no rake was ever provided). The trashracks are installed on a 0.5:1 slope (26° from vertical), with 6 racks stacked into a 62-ft long unit along the slope. The individual trashracks are each nominally about 10.25 ft long and 8.19 ft wide, except the top rack section is about 9.67 ft long. Individual trashrack sections are not pinned together, but lugs at the top of each rack section do minimize the misalignment of the stacked trashracks trash bars. There does remain the possibility for out-of-plane offsets at rack junctions. There is also a ½” gap between the trash bars at the trashrack panel junctions. Trashrack bars are ¾” thick on 6-1/16” centers, and project 3-¼” in front of the support angles and 3-½” in front of the spacer bars. A system that can provide some cleaning of the space between bars is desirable, to help control mussel colonization of the racks.

The total vertical depth of the structure is 55 ft from the deck down to the forebay invert, with a normal maximum water depth of 50 ft. Reservoir water levels fluctuate only about 5 ft throughout most years, with typical water depths being 45 to 50 ft. Maximum powerplant releases are about 18,000 ft^3/s, so typical average flow velocities approaching the forebay trashrack structure are about 2 ft/s or less. Flow is observed to concentrate somewhat toward the center of the structure, so trashrack bays near the two ends experience lower velocities and central bays experience velocities higher than the average, but flow conditions are not excessively turbulent at any location. For comparison, the average flow velocity is about 5.5 ft/s at the penstock entrance trashracks.

We anticipate cleaning needs for aquatic weeds to be intermittent. Manual initiation and control of cleaning cycles is anticipated to be the preferred mode of operation, although automatic controls may add value, since frequent periodic cleaning may help to control mussel colonization of the trashracks. A system that can dump raked debris directly into a truck for immediate disposal or off-site transport would be desirable.

Figure 3. — Deck of forebay inlet trashrack structure with existing embedded rails for future trashrack cleaning equipment. Flow is left to right.

Figure 4. — Upstream view of trashracks at inlet to Parker Dam Forebay.

Trashrack Cleaning System Alternatives

Five types of trashrack cleaning systems were identified as potentially applicable to the Parker Dam Forebay Inlet Trashrack Structure. Table 1 shows these five alternative system types and indicates the capabilities of each system type and the degree to which they meet important design requirements of the site. Each of these system types is described in more detail in Appendix I. Alternatives A and B in the table were selected for development of appraisal-level cost estimates. The backhoe style rake with extended reach away from the structure (A) probably offers the most flexibility for dealing with a variety of potential debris, while the cable style rake mounted on an overhead monorail (B) offers the advantage of a simpler installation (no reliance on deck rails) and minimal space consumed on the structure deck.

Table 1. — Design characteristics summary.

Criteria \ Design	A	B	C	D	E
	Backhoe Style Rake On Deck Rails	Cable Style Rake and Gripper on Overhead Monorail	Cable Style Rake On Deck Rails	Hydraulic Rake (Hand Rake Style) On Support Structure	Flex-Rakes
Existing Concrete Structure Acceptable	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Trashracks 26 Degrees Off Vertical OK	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Extended Reach	**Yes**	No	No	No	No
All Parts Park Above Water	**Yes**	**Yes**	**Yes**	**Yes**	No
All Electrical Parts Above Deck	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Single Rake Operation	**Yes**	**Yes**	**Yes**	**Yes**	No
Traversing Rake	**Yes**	**Yes**	**Yes**	**Yes**	No
Conveyor Free Operation	**Yes**	**Yes**	Maybe	No	No
Trashrack or Stoplog Retrieval Capability	**Yes**	No	**Yes (with optional equipment)**	No	No
American-made	Not 100%	Not 100%	Not 100%	Not 100%	**Yes**
Sole-source contracting issues	Probable	Probable	Probable	Probable	Probable

Appraisal-Level Cost Estimates

In consultation with the client, two of the rake types were chosen for development of appraisal-level quantity and construction cost estimates. The rake options selected were the backhoe style rake on rails (A) and the overhead monorail cable-style rake (B). The appraisal-level estimates developed for this study are for the purpose of comparing the rake options to each other and to facilitate planning decisions. These estimates also do not include potential costs for replacing any trashrack sections that might be in such poor condition that they would impact rake performance. The racks that are submerged continuously are reported to be in very good condition, but some top rack sections may be in poorer condition. A detailed assessment of the condition of the top trashrack sections should be performed during the detailed design of any trashrack cleaning system.

Since the appraisal-level costs are intended to be used primarily for comparison of the alternatives, electrical power availability and electrical installation costs were not included in any of the estimates. However, it should be noted that the power requirements for the two rake types are different. Depending on the manufacturer of the backhoe type rake, the motor size required may be in the range of 30-55 kW (40-75 hp). The overhead monorail cable style rake hoist motor will be in the range of 5.5-7.5 kW (7.5-10 hp). Both systems would require 480 V, 3 phase, 60 Hz electrical service.

To assist our development of cost estimates, three manufacturers were invited to provide cost estimates for consideration. These estimates generally were for the furnishing and delivery of equipment only, without installation. The Kunz estimate was stated to include installation, but provided no details. Using the provided estimates and experience from working with these specific companies and others on similar installations at other Reclamation facilities, the manufacturer's estimates were increased to account for installation costs, prime contractor costs, and other items not included by the manufacturers themselves. Costs of furnishing, delivering, and installing equipment were then increased to account for mobilization (5%), cost escalation prior to notice to proceed (4%/yr), contingencies related to design (15%) and construction (25%), and non-contract costs (33%) to obtain a final construction cost estimate.

Table 2 summarizes the cost estimate information obtained from the manufacturers and provides the approved, appraisal-level construction cost estimates for three alternative systems. For the fourth system shown, the Lakeside-MUHR Hydronic unit, an unsolicited manufacturer-provided estimate was received as this report was being completed, after the other construction cost estimates had already been finalized. That estimate is included here as additional information for client consideration, but has not been reviewed or developed to the same level of detail as the other construction cost estimates.

The table shows that the estimated construction costs of all three systems are the same *at the appraisal-design level*. Cost escalation prior to award was estimated for 1, 2, and 3 year periods, with final construction cost estimates of $3.7, $3.9, and $4.1 million. Appendix II provides the approved quantities and construction cost estimate worksheets, and Appendix III provides the information received from each manufacturer.

Two manufacturers, Lakeside-MUHR and Brackett Green, provided estimates of equipment delivery time. Lakeside-MUHR estimated 28-30 weeks for the Catronic cable-style system and 30-36 weeks for the Hydronic backhoe-style system; Brackett Green estimated 32-34 weeks for the Brackett Bosker cable-style system.

Table 2. — Cost estimate summary.

Type	Alternative	Manufacturer Cost Estimate				USBR-Approved Construction Cost Estimate (Award in 1, 2, or 3 years)[a]
		Includes		Form of estimate provided	Manufacturer Cost Estimate	
		Furnish Equipment	Install			
B	Brackett Bosker Super Duty Raking Machine	X		Estimate worksheet and drawing	$934,700	$3,700,000
						$3,900,000
						$4,100,000
A	Kunz TRCM H1000	X	X	E-mail message	$1,200,000	$3,700,000
						$3,900,000
						$4,100,000
B	Lakeside-MUHR Catronic SH-4525	X		Estimate worksheet and drawing	$1,120,000	$3,700,000
						$3,900,000
						$4,100,000
A	Lakeside-MUHR Hydronic M-4000[b]	X		Estimate worksheet and drawing	$1,650,000	—

Notes:

a) See Appendix II for detailed construction cost estimates.

b) This unsolicited manufacturer's estimate was received after construction cost estimates had been generated for all other alternatives. It is provided for client consideration, but was not fully developed as an approved construction cost estimate.

Appendix I. Alternative Trash Cleaning System Types, Descriptions, Advantages, and Disadvantages

Design A: Backhoe Style Rake on Deck Rails

This trash rake can be designed to be operated both manually by an operator and automatically without an operator. The rake looks like a rail mounted backhoe (Figure 5). The rake traverses the trashrack structure to allow cleaning the entire structure one bay at a time. The unit can pivot around a vertical axis to allow the rake to dump debris directly in a trash rail car, truck, or trailer either traveling along with the rake as it cleans or parked at one end of the structure.

Trash rake operation in Automatic Mode: At the startup signal, the trash rake travels to the first trashrack cleaning point and stops. The rake arm pivots out over the water and the arm is extended to the programmed cleaning level using hydraulics. The rake head gripper is then brought toward the structure until it contacts the rack. An adjustable pressure force is maintained between the gripper scraping bar and the racks as the rake head is raised along the rack face, cleaning the rack with an upward scraping motion. At the programmed high position, the gripper closes around the collected debris, securing it for removal. The rake then raises the debris, pivots to position the rake head over the deck, and dumps the debris into a designated dumping container. This dumping procedure may require traveling to a dumping area at the end of the structure if a trash rail car, trailer or truck does not travel with the rake as it cleans. The cleaning cycle is then repeated until each trashrack section has been cleaned. Once all the trashracks have been cleaned, the rake will return to the designated parking position.

Although several manufacturers exist, evaluation of advantages and disadvantages of this type of system is based on the KÜNZ TRCM H1000. A similar installation is at the Broadwater Power Station, Tosten Dam in Montana.

Advantages:

a. Rake can be operated automatically (automatic startup can be with a periodic clock or timer controls, pushbutton, and/or differential level controls) and manually to clean all the trashrack bays with one raking unit.
b. This unit can be purchased and assembled on site like a crane or backhoe.
c. Rake can clean both inclined and vertically mounted trashracks. The existing trashracks are 26° off of vertical.
d. Requires no conveyors. Can dump the raked debris directly into a truck or trailer moving along with the rake, or will transport the debris to where a parked trailer or dumpster is located.
e. Minimal equipment interference since there is no conveyor, the rake can be parked out of the way, and the dumpster is movable.
f. The rake can accommodate the trashrack bar spacing and depth.

g. The rake head is provided with replaceable scraper bar(s) and utilizes hydraulic controls to apply pressure against the trashrack during the cleaning process.

h. The rake, when operated in manual mode, can pick up floating debris in front of the intake. A similar model trash rake at the Broadwater Power Station (see Figure 5) was able to reach approximately 75 ft horizontally.

i. Can be provided with controls (selector switch) to allow selective cleaning of just the upper portion of the trashracks or the complete depth of trashracks.

j. The area immediately above the existing trashracks will remain accessible and uncluttered.

k. The rake head can be supplied with several optional attachments (i.e. - clamp shelf gripper, log gripper, cleaning rake).

l. The rake can be used to remove other equipment such as the trashracks or stoplogs for servicing with an optional attachment.

m. All of the rake equipment is stored out of the water.

<u>Disadvantages:</u>

a. May not be an American Made/Sole Source: Many parts are made in Austria while some parts are made in North Carolina. Although several manufacturers may be able to shop-build a similar machine, the KÜNZ TRCM H1000 may present some “sole source” concerns. The similar Lakeside/MUHR Hydronic system is also mostly German-manufactured.

b. New trash rake track rails will probably need to be furnished (old rails were specified around 1936) and the new rails will need to be specific to this trash rake’s requirements.

c. Downstream travel rail will need to project above the deck to allow holding down the rake while operating. This will reduce the available roadway width on the trashrack structure.

d. Existing trashrack structure deck loading and carrying capability will need to be evaluated. Wheel loads are transmitted to the deck-mounted rails.

e. The rake head is not usually provided with teeth that project between the trashrack bars.

f. The existing intermediate metal guides projecting upstream of the trashracks may make it more difficult to position the rake head against the trashracks during manual operation, especially near the bottom. The operator’s cab may limit visual operation.

Example Application – Power Station Broadwater

Technical Data:

Width of rake	10 ft
Screen bar pitch	12 inch
Rack inclination	87 ^{o}
Depth of cleaning	60 ft
Hoisting capacity	40 kN
Power input	30 kW

Künz America Inc., Raleigh NC 27617, Phone 919-783-8427

Customer	State of Montana
Location	Power Station Broadwater / USA
Rake Model	TRCM-H1000

Figure 5. — Künz TRCM H1000 (Backhoe Type Rake)

Design B: Cable-Style Rake and Gripper Head on Overhead Monorail

This trash rake is normally designed to operate automatically without an operator by lowering a hydraulically controlled debris gripper suspended from cables. The debris gripper travels down the trashrack face, then back up with debris held in the gripper. The trash rake can also be operated manually by pendant control. The trash rake is provided with an overhead monorail track with support columns/frames that are mounted on the trashrack structure (see Figures 6 and 7). The trash rake trolley travels along the monorail track to clean the entire structure, one trashrack section at a time. The rake transports the raked debris and dumps the debris directly into a truck, trailer or trash bin parked at one end of the structure.

Trash rake operation in Automatic Mode: At the startup signal, the trash rake trolley travels to the first trashrack cleaning point and stops. The hoist then lowers the gripper (with gripper jaws in the opened position), engaging the trashracks near the top section of the trashracks and descends to the bottom of the trashrack. As the gripper is lowered, debris is collecting within its jaws. Once the bottom limit is reached, hydraulic cylinders close the gripper jaws, securing the debris for removal. The hoist then raises the gripper and debris up to the trolley. The trolley motor is started and the trolley is moved to the designated dump area where it stops and dumps the debris. The cleaning cycle is then repeated until each trashrack section has been cleaned. Once all the trashracks have been cleaned, the rake will return to the designated park position.

Although several manufacturers exist, evaluation of advantages and disadvantages of this type of system is based on the Brackett Green USA, Inc., Brackett Bosker Super Duty Raking Machine. A similar installation is at the Headgate Rock Dam, AZ.

Advantages:

a. Rake can be operated automatically (automatic startup can be with a periodic clock or timer controls, pushbutton, and/or differential level controls) and manually to clean all the trashrack bays with one raking unit.
b. Two rakes can be operated on the same overhead beam (track), if desired. Both straight and curved overhead tracks can be supplied.
c. Requires no conveyors. Rake transports the raked debris to a debris dumping location (dumpster or parked trailer) at the end of the structure.
d. Minimal equipment interference since there is no conveyor. Even the movable dumpster may be out of the way if a curved overhead beam (track) is provided as part of the design at the end of the structure.

e. The recommended trashrack angle for operation of the Brackett Bosker Raking Machine is from 8° to 35° off of vertical. The existing trashracks are 26° off of vertical.

f. The super duty model raking machine is rated for a safe working load of 2,200 pounds (debris load). The trash rake manufacturer has other models that range from a safe working load of 550 lbs (Light Duty) up to a safe working load of 6,600 lbs (Ultra Duty).

g. The rake can accommodate the trashrack bar spacing and depth.

h. The rake head (gripper) has teeth that project within the trashrack to dislodge debris from the rack.

i. Locations for the monorail support columns are compatible with the trashrack structure. Maximum allowable span between support columns is 40 ft, and existing trashrack piers are spaced on 19.5 ft centers.

j. The area immediately above the existing trashracks will remain accessible and uncluttered.

k. Rake can be provided with controls (selector switch) to allow selective cleaning of just the upper portion of the trashracks or the complete depth of trashracks.

l. All of the rake equipment is stored out of the water.

<u>Disadvantages:</u>

a. Not American Made / Sole Source: The parent company is not American and the Brackett Bosker Raking Machine may present some “sole source” concerns. While the carriage is made in the Netherlands, the monorail and other parts are made in Texas.

b. Length of trashrack structure may require that two rakes be provided to keep up with future debris loads or to reduce the time it takes to complete one cleaning cycle of the trashrack structure.

c. When the selector switch is positioned for full depth cleaning, the rake is required to force the debris to the bottom of the trashracks before closing the gripper jaws.

d. With matted, floating debris, the rake head may not be able to push the debris down to the selected cleaning depth. A slack rope limit switch will cease the lowering motion. The gripper may then be closed, raised and the debris taken to the dump area.

e. High winds may affect the gripper position as it is being lowered (prior to contacting the trashrack).

Design B: Overhead Monorail / Cable Deployed Debris Gripper Sketches

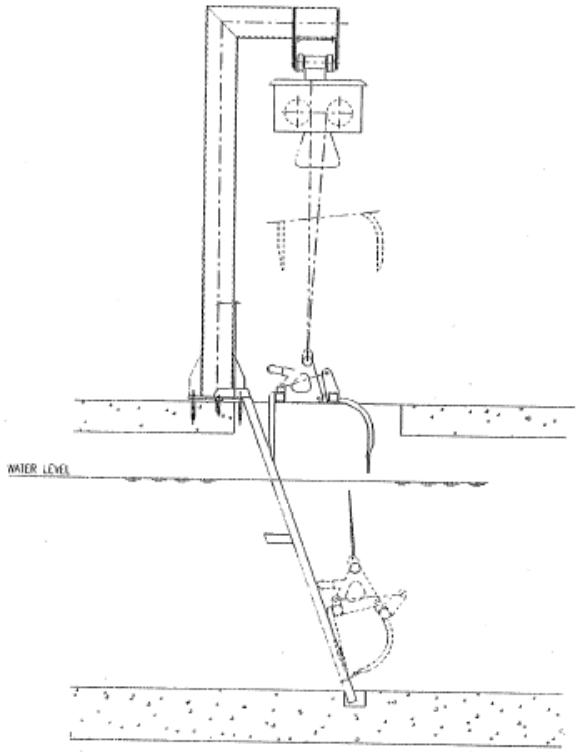

Figure 6. — Typical Brackett Bosker Raking Machine sectional view.

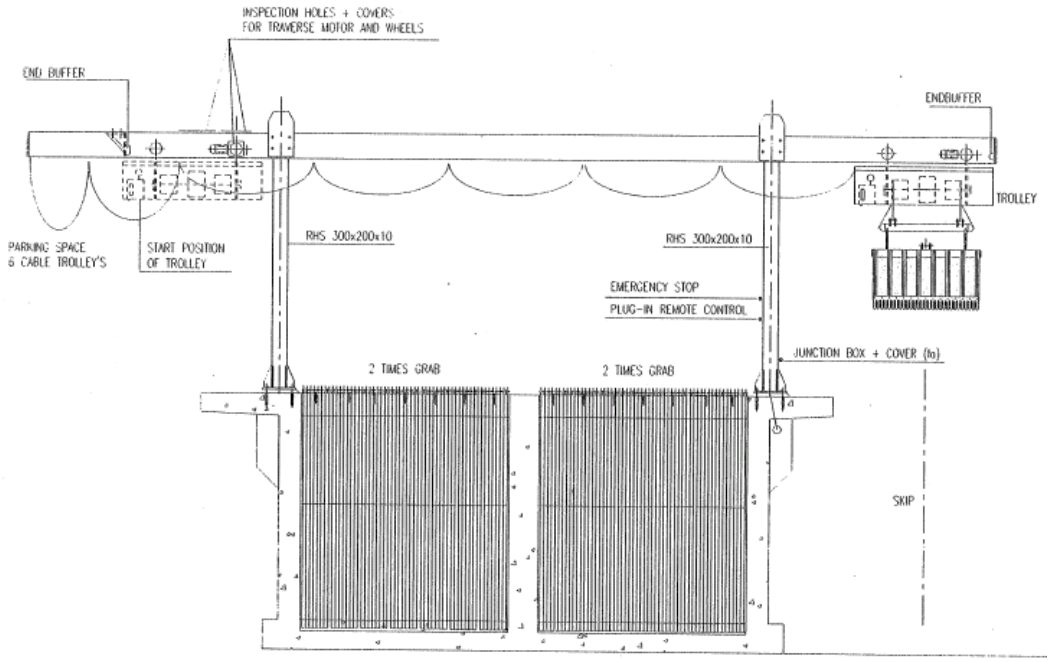

Figure 7. — Typical Brackett Bosker Raking Machine longitudinal view

Design C: Cable Style Rake on Rails

This trash rake can be designed to be operated both manually by an operator and automatically without an operator. The trash raking machine rides on deck mounted rails to traverse the structure to allow cleaning all of the trashracks, one section at a time. Cleaning is accomplished by lowering and controlling the debris gripper with cables (see Figure 8). Debris can be raked up into a trash rail car or bin that moves with the rake or into a debris conveyance (conveyor) system. Optional features can be provided as part of the trash rake (such as a jib crane hoist with grab rake, or stoplog lifter) to increase the functionality of the system. Because the trashracks end below the piers and the existing guides extend above the piers, a trashrack extension may be required above the existing trashracks to allow the debris to be raked high enough to mate with the trash rake body so it can be dumped into the conveyor(s), car or bin. Due to the length of the trashrack structure, two or more conveyors would be required. The debris is moved by the conveyors to a dumping location. An additional conveyor may be required if the debris needs to be elevated to dump into a trash bin, truck, or trailer.

Trash Rake Operation in Automatic Mode: At the startup signal, the trash rake travels to the first trashrack cleaning point and stops. The hoist then lowers the gripper (with gripper jaws in the opened position), engaging the trashracks near the top section of the trashracks and descends to the bottom of the trashrack. As the gripper is lowered, debris is collected within its jaws. Upon reaching the bottom limit, hydraulic cylinders close the gripper jaws, securing the debris for removal. The hoist then raises the gripper and debris up to the trolley. The trolley motor is started and the trolley is moved to the designated dump area where it stops and dumps the debris. The cleaning cycle is then repeated until each trashrack section has been cleaned. Once all the trashracks have been cleaned, the rake will return to the designated park position.

Although several manufacturers exist, evaluation of advantages and disadvantages of this type of system is based on the Lakeside Equipment Corporation/Muhr, Catronic Series Type SV Trash Rake. A similar installation is at Imperial Dam, AZ.

Advantages:

a. Rake can be operated automatically (automatic startup can be with a periodic clock or timer controls, pushbutton, and/or differential level controls) and manually to clean all the trashrack bays with one raking unit.
b. Requires no conveyors if rake provided with a trash rail car or bin that travels with the rake.
c. Minimal equipment interference if there is no conveyor, the rake can be parked out of the way, and the dumpster is movable.

d. The raking machine cable winch can be rated for a safe working load of 10 tons.

e. The rake can accommodate the trashrack bar spacing, angle and depth.

f. The rake head (gripper) has teeth that project within the trashrack to dislodge debris from the rack.

g. Rake can be provided with controls (selector switch) to allow selective cleaning of just the upper portion of the trashracks or the complete depth of trashracks.

h. The rake can be provided with optional features that allow removal of large debris or used to remove other equipment such as the trashracks or stoplogs for servicing.

i. All of the rake equipment is stored out of the water.

Disadvantages:

a. Not American Made / Sole Source: The main raking machine is made in Germany. Rails, superstructure, and control systems are mostly American-made.

b. When the selector switch is positioned for full depth cleaning, the rake is required to force the debris to the bottom of the trashracks before closing the gripper jaws.

c. With matted, floating debris, the rake head may not be able to push the debris down to the lowered setting. A slack rope limit switch will cease the lowering motion. The gripper may then be closed, raised and the debris taken to the dump area.

d. New trash rake track rails will probably need to be furnished (old rails were specified around 1936) and the new rails will need to be specific to this trash rake's needs.

e. Existing trashrack structure deck loading and carrying capability will need to be evaluated. Wheel loads are transmitted to the deck mounted rails.

f. The trash rake and conveyor(s) may have problems with large objects like large logs. The conveyor(s) may jam under some loading conditions.

g. A trashrack extension is required to allow raking the debris up and into the trash rail car, bin or conveyor.

h. If required, the conveyor system will reduce the available roadway width on the trashrack structure. The blockage is increased over the other options since the conveyor is positioned between the rake's rails.

i. Limited Access: The slab area immediately above the trashracks will be occupied with the trashrack extension and possibly a conveyor system. This will make access to the trashracks or a stalled rake difficult.

Design C: Cable Style Rake on Rails Photos

Traversing Type SV

Traversing Type SV with Jib Hoist

Figure 8. — Lakeside Equipment Corporation/Muhr, Catronic Series Type SV Trash Rake.

Design D: Hydraulic Rake (Hand Rake Style) with Support Structure

This hydraulically operated rake imitates the action and design of hand raking (see Figure 9). The debris is raked up the trashrack by the hydraulic rake and is dumped either onto the deck for manual removal, or into a debris conveyance system. This type of trash rake is designed to operate both automatically and manually. Manual operation is by pendant control. The rake carriage traverses the trashrack structure on a support rail system to allow cleaning the entire structure, one bay at a time. A trashrack extension will be required above the existing trashracks to allow the debris to be raked high enough so that it can be dumped into the conveyor(s). Due to the length of the trashrack structure, two or more conveyors would be required. The debris is moved by the conveyors to a dumping location. An additional conveyor may be required if the debris needs to be elevated to dump into a trash bin, truck, or trailer.

Trash Rake Operation in Automatic Mode: At the startup signal, both the rake and the conveyor are started. The trash rake then travels to the first trashrack cleaning point and stops. The rake arm is pivoted upstream and the arm extended using hydraulics. The arm then rotates back towards the trashracks until the rake head contacts the rack. An adjustable pressure force is maintained between the rake head scraping bar and the racks as the rake cleans the rack in an upwards motion. At the top of the trashrack extension the rake pulls the debris into a conveyor. The cleaning cycle is then repeated until each trashrack section has been cleaned. After all of the trashracks have been cleaned, the rake will return to the designated parking position. The conveyor(s) will continue to operate for a preset time period to ensure that all the debris has been transported out of the conveyor before shutting off.

Although several manufacturers exist, evaluation of advantages and disadvantages of this type of system is based on the Atlas Polar Company, Ltd. Hydrorake System - Model DT8300 (double boom rake). The closest similar installation is at New Waddell, AZ.

Advantages:

a. Rake can be operated automatically (automatic startup can be with a periodic clock or timer controls, pushbutton, and/or differential level controls) and manually to clean all the trashrack bays with one raking unit.
b. Multiple rakes can be operated on the same support rail system, if desired.
c. The recommended trashrack angle for operation of the Atlas Polar rake is from 3° to 30° off of vertical. The existing trashracks are 26° off of vertical.
d. The rake is rated for a safe working load of 4,000 pounds (debris load).

e. The rake's support rail system will be installed to not interfere with the installation or removal of the existing trashracks.

f. Locations for the supports are compatible with the trashrack structure (the existing trashrack piers are spaced on 19.5 ft centers).

g. Rake can be provided with controls (selector switch) to allow selective cleaning of just the upper portion of the trashracks or the complete depth of trashracks.

h. All of the rake equipment is stored out of the water.

i. The rake can accommodate the trashrack bar spacing and depth.

j. Several installations exist at Reclamation sites.

<u>Disadvantages:</u>

a. Not American Made / Sole Source: The manufacturer is not American and the Atlas Polar Hydrorake Systems, Ltd. DT8300 may present some "sole source" concerns. Shop-made units may be available from other companies.

b. The trash rake and conveyor(s) may have problems with large objects like large logs. The conveyor(s) may jam under some loading conditions.

c. The rake head is not usually provided with teeth that project between the trashrack bars.

d. The existing intermediate metal guides projecting upstream of the trashracks may make manual operation more difficult to position the rake head against the trashracks, especially near the bottom.

e. A trashrack extension and conveyor system is required to automatically transfer the debris to a dumpster or trailer parked at one end of the structure. The conveyor will reduce the available roadway width on the trashrack structure.

f. Limited Access: The slab area immediately above the trashracks will be occupied with the trashrack extension and the conveyor system. This will make access to the trashracks or a stalled rake difficult. Construction of metal walkways over the water or over the conveyor system to access the Hydrorake equipment must be considered.

Design D: Hydraulic Rake (Hand Rake Style) With Support Structure Photos

Figure 9. — Atlas Polar Company, Ltd., Model DT8300 Hydrorake.

Design E: Flex-Rake

The Flex-Rake type trash rake is manufactured by the Duperon Corporation and has side chains (Flex-Link) with scraper bars between the chains to provide a slow, continuous cleaning of the trashracks, see Figure 10. Because of the design of the Flex-Link chains, no sprockets, bearings, or tracks are required underwater. One rake would be required for each trashrack bay. Operation of the rakes are usually continuous provided with ON or OFF controls, but can also be automated. The debris is raked up the trashracks by the rake and is dumped onto a debris conveyance system. A trashrack extension would be required above the existing trashracks to allow the debris to be raked high enough so it can be dumped into the conveyor(s). Due to the length of the trashrack structure, two or more conveyors would be required. The debris is moved by the conveyors to a dumping location. An additional conveyor may be required if the debris needs to be elevated to dump into a trash bin, truck, or trailer.

Advantages:

b. The ideal angle for Flex-Rake operation is 20° to 30°. The existing trashracks are 26° off vertical.

c. The rakes can accommodate the trashrack bar spacing.

d. The scrapers are UHMW, and are usually serrated and configured to the trashrack bars.

e. Each of the rakes can lift up to 1,000 lbs of debris.

f. The Flex-Rake is normally designed to run continuously and slowly, so a control PLC would not be necessary. However, the rakes can be provided with additional controls that allow automatic operation of the rakes using cycle timers, differential level control, and remote start/stop.

g. All underwater parts are non-corrosive.

h. The Flex-Rake is American made.

Disadvantages:

a. Sole Source: The Duperon Corporation, Flex-Rake may present some “sole source” concerns. Similar shop-made units may be available from other companies.

b. A trashrack extension and conveyor system is required to automatically transfer the debris to a dumpster or trailer parked at one end of the structure. The conveyor would reduce the available roadway width on the trashrack structure.

c. Limited Access: The slab area immediately above the trashracks will be occupied with the trashrack extension and the conveyor system. This will

make access to the existing trashracks and the Flex-Rake equipment difficult.

d. Twenty four (24) individual trash rakes will be required to clean the trashracks.

e. Operation of the rakes is such that the floating debris (debris mats) would first need to be pulled down and around the bottom before it is raked up the rack.

f. Stringy material can get wrapped around the horizontal bars of the rake and make it difficult to dump the debris into the conveyor.

Design E: Flex-Rake Sketches

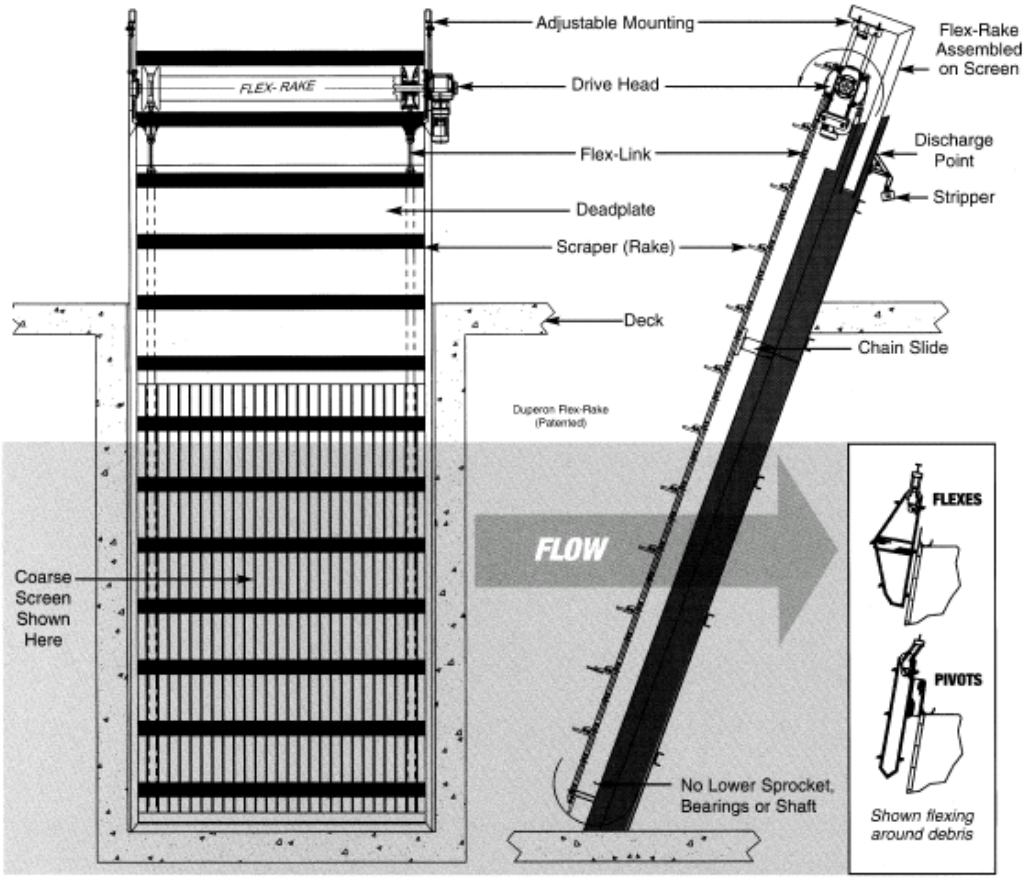

Figure 10. — Duperon Corporation Flex-Rake.

Appendix V. Contact Information for Study Participants and Representatives of Equipment Manufacturers

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