HISTORICAL CASE STUDY

Early EDDY Pump Testing

EDDY Pump Dredging Demonstration at Cresta Reservoir

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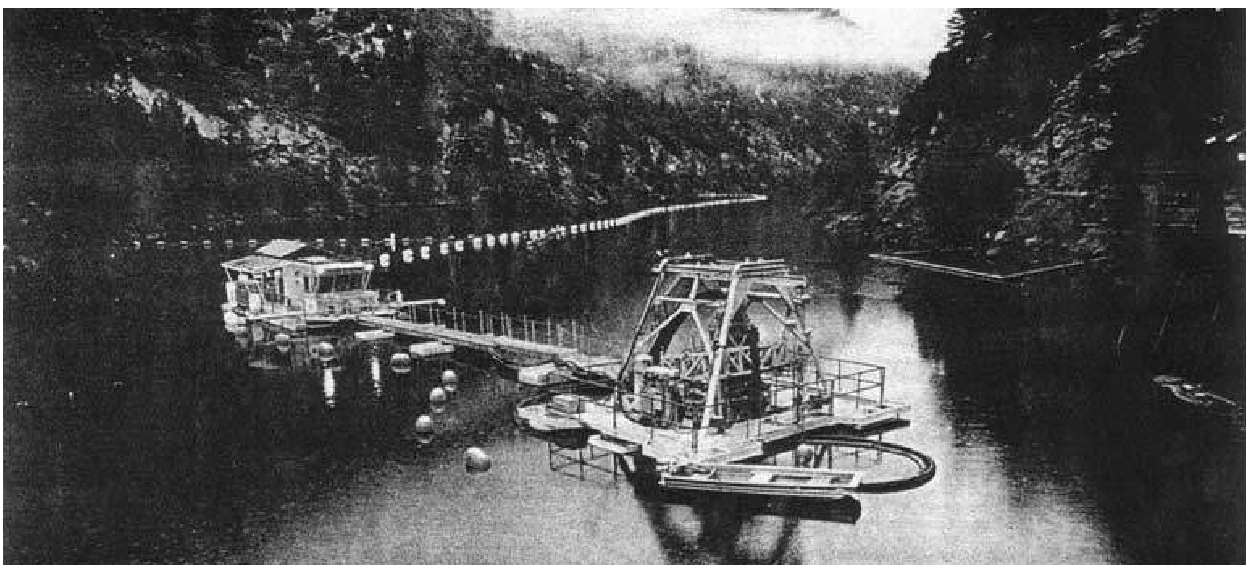
A demonstration test of a new environmentally friendly slurry dredging technology using the "EDDY Pump," a patented vortex slurry pump, was performed in 1994 at Cresta Reservoir in northern California to verify its performance capabilities and to determine the potential environmental impacts of proposed dredging. The reservoir, located on the North Fork Feather River in Plumas County, has accumulated approximately 2.3 million cubic meters of sediment, filling almost half its total capacity since it was placed in service in 1949. The sediments jeopardize the reliable operation of the dam and the 70,000 kW Cresta Powerhouse by obstructing reservoir outlets, The owner has conducted a number of comprehensive studies investigating sediment management alternatives for the reservoir since the mid-1980s.

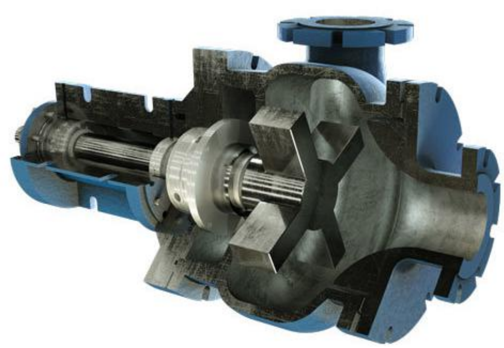


For the EDDY Pump demonstration, approximately 7,833 cubic meters of sandy sediment deposits near Cresta Dam were dredged and returned to the reservoir bottom 600 meters upstream. Turbidity, suspended solids, dissolved oxygen, flow, the density of the slurry, and production rate were monitored. It was concluded that the dredge performance exceeded the manufacturer's production specifications and easily complied with restrictive water quality standards. Slurry densities greater than 70 percent solids by weight were sustained, while peaks over 90 percent were achieved. Production rates of over 230 cubic meters per hour were observed. The maximum turbidity of the discharge plume was only 12 Nephelometric Turbidity Units (NTU) over ambient.

Background

Since 1984, the owner of Cresta Reservoir has evaluated a number of methods to address sediment problems there. and at the similar Rock Creek Reservoir located upstream. Clamshell and hydraulic suction dredging with sediment disposal by truck, rail or slurry pipeline to distant landfill sites were considered. All of these options involve potential environmental impacts which could adversely affect the aquatic and terrestrial ecology of concern to the regulatory agencies. The owner's present plan calls for limited dredging at the dams followed by controlled passage of sediments downstream during flood flows. For production dredging, the Regional Water Quality Control Board (RWQCB) proposed the upper limit for turbidity at 25 NTU above the background level and limited total suspended solids (TSS) to 80 mg/1 regardless of the background level. The owner, concerned that conventional dredging equipment would be unable to meet these restrictive · standards, identified the EDDY Pump dredging technology as an alternative that might both meet the environmental standards and economically dredge large volumes of sediment. (Han·ison, 1995)

The novel EDDY Pump is a physically simple machine that belies its advanced hydrodynamic design and performance. The pump consists of a rotor in a volute with a suction nozzle and discharge outlet. Pumps for dredging service are constructed of high-strength, abrasion-resistant alloy steels. The only moving parts are the rotor and its shaft. Rotary power may be applied by electric or hydraulic motors, or by mechanical shafts from diesel or other engines. Typical operating speeds are in the range of 1000 to 2000 RPM. The rotor, located inside the volute opposite the suction nozzle, imparts rotation to the column of water in the volute and suction tube, creating a vortex that draws-in water and solids much in the same manner as a tornado lifts objects. The high energy vortex also serves to loosen sediments or other solids, allowing them to be entrained in the flow. This feature permits slurry formation with very high



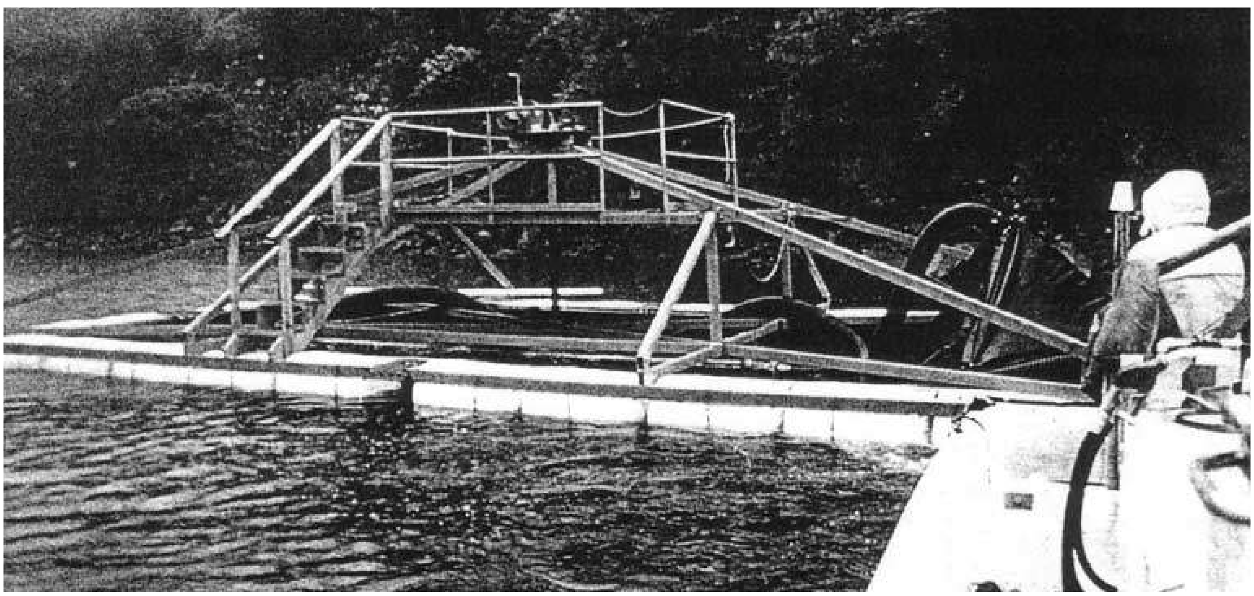
solids concentrations without the need of water jets or cutter heads. The rotor is out of the flow-stream so that gravel and even cobbles can pass readily through the pump and be discharged without impinging on the rotor. The pump also readily passes rags, vegetation and woody debris that would jam other types of pumps. The pumps are custom manufactured by EDDY Pump Corporation in sizes (discharge diameter) from 0 .1 0 meters to 0.36 meter for a variety of applications in addition to dredging.

The new EDDY Pump technology promised: 1) little or no turbidity or resuspension at the dredge suction, 2) ability to dredge to the full depth of the reservoirs, 3) ability to handle a wide range of materials from clay to cobbles and organic debris, 4) ability to transport sediments as high-density slurry, and minimal effluent to be treated at the disposal site. In addition, the high density of the slurry suggested the feasibility of depositing the slurry underwater without excessive re-suspension, with the potential for saving the reservoir owner millions of dollars compared to landfill disposal.

To verify the feasibility of EDDY Pump dredging and in-reservoir deposition, the owner entered an agreement with "PB-MK Consultants and Engineers," an affiliate of the EDDY Pump Corporation, to perform project study. a full-scale demonstration of the technology at Cresta Reservoir. The demonstration called for approximately 7,646 cubic meters to be dredged near the dam and redeposited on the reservoir bottom 610 meters upstream. Environmental parameters of turbidity, suspended solids, and dissolved oxygen was to be monitored in addition to dredge performance. The RWQCB imposed the same restrictive limitations on water quality for the demonstration as it had proposed for production dredging.

Dredge Description

An innovative new dredge was designed and constructed by PB-MK for the demonstration. The dredge was constructed in modules for trucking to the job site as non-permit loads. · This was important for access to Cresta Reservoir as several highway tunnels restricted clearances. The modular design permitted the dredge to be assembled efficiently without re-welding of major components. A crane was required to place the major sub-assemblies into the water due to the steep banks and shallow water near the shore at the mobilization area, which precluded skidding or rolling the assemblies into the reservoir. Otherwise, the only large equipment needed for mobilization was a fork-lift.



The dredges main barge platform supporting the power and control cabin modules, and the pumping platform from which the dredge pump and drive motor were suspended. The two platforms were connected by a boom with a pivot connection at the main platform. An EDDY Pump with 0.254-meter diameter discharge driven by a variable speed submersible 224 kW electric motor was the heart of the system. Main electrical power was supplied by a 500 kW diesel generator. Pump speed control was achieved by varying the power frequency using a solid-state frequency driver. A 7.6 cubic meter/minute diesel-driven flushing water pump was mounted on the main platform and operated in standby mode to guard against pipeline plugs in the event of a malfunction. A flexible pump discharge hose, approximately 60 meters in length, was run from the pump platform through the boom and under the main platform on a system of rollers, allowing the pump to be raised and lowered as necessary. The equipment was set-up to dredge up to 30 meters deep. Electric drives were used for most powered equipment to minimize any chance of oil spills.

An induction type flow meter and a nuclear densitometer were mounted on a small instrument barge at the end of the discharge hose behind the main platform to monitor flow and density. Other instrumentation included an underwater video camera to observe the · dredge suction area, side scan sonar, continuous reading turbidimeters, power demand meters and position indicators. An on-board computer assisted with system control computed the production rate and recorded production and water quality data.

A 0.254-meter diameter high-density polyethylene pipeline 550 meters long with thermal-welded joints was extended from the instrument barge to the discharge platform. Floats were strapped to the pipeline at 4.5-meter intervals. At the end of the pipeline, a floating platform was designed to suspend a sediment curtain and to support a ported diffuser within the curtain. For the discharge distance of 610 meters, no booster pumps were required. If needed for longer pipelines, an · EDDY Pump could also serve as an efficient booster pump

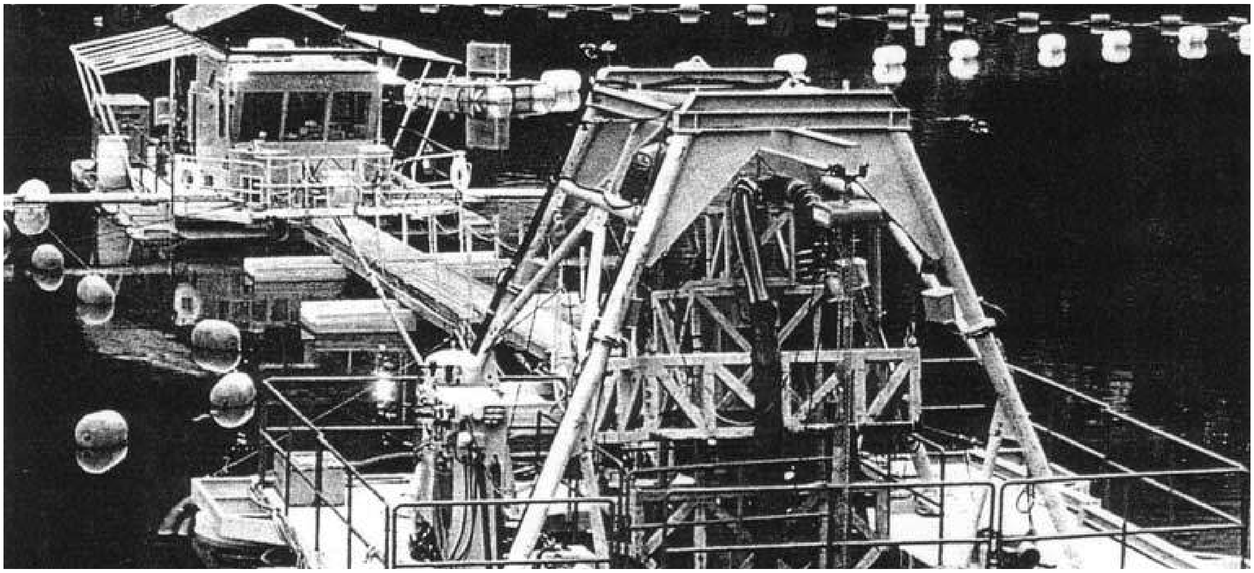
Unfortunately, the design of the discharge sediment curtain proved unsuccessful and the curtain was removed for most of the demonstration following initial start-up. Even so, the water quality parameters remained well within the agency requirements. It is believed by the authors that an improved curtain design could have achieved even lower levels of turbidity and TSS, and may be necessary for finer grained sediments than were encountered at Cresta Reservoir.

Dredge Operation

In operation, the main platform was positioned by winch lines at each comer tied off to onshore anchor points and the dam. In open waters, marine anchors would be used. A joy stick control for the anchor line winches allowed the operator to move the main platform in any direction.

While the main platform was held fixed, the pumping platform was swung slowly about the pivot joint by winch controls through an arc of up to 2.1 radians (120 degrees).

The pump was raised or lowered to dredging depth by four winch lines, one attached to each comer of the pump support frame. By varying the length of the suspender cables independently, the pump and suction nozzle were angled to optimize suction efficiency. The ability to control. the nozzle attitude and location on all three axes allowed material to be dredged with surgical precision compared to other dredging methods. In addition, the pump was mounted on trunnions •. in its support frame so it could be articulated back and forth by a pneumatic ram at the same time it was swung through the arc to dredge a 2.4-meter wide swath. After each swing, the dredge was repositioned for the next pass.



Demonstration Results

The physical performance of the dredge exceeded expectations. Slurry densities greater than 70 percent solids by weight were sustained, while peaks over 90 percent were achieved. Sustained production rates of over 230 cubic meters per hour were observed. In one 6.5-hour long test run, approximately 1681 cubic meters were dredged. The material dredged was predominately medium to fine sand with aD-50 of 0.5 mm. Quantities of sunken driftwood and organic debris were observed by the underwater video camera to be pumped through the system without clogging. In several instances, large pieces of wood and chunks of concrete were observed to be sucked into the pump and discharged through the pipeline. Depths of 15 meters were dl'edged with no problem. Deeper dredging, to the 30-meter design capability, was not attempted because the resulting excavation volume would have exceeded the volume approved by the US Army Corps of Engineers' permit. The dredging demonstration was stopped when the cumulative volume reached 7,833 cubic meters.

TABLE 1- SELECTED DREDGING PRODUCTION DATA (PG&E, 1995)

Date	Dredging Time - Hours	% of Operating Time Dredging	Total Cubic Meters	Dredging Rate Meters p/Hour
12/14/94	6.5	87	1479	228
12/16/94	6.5	100	1681	258
12/19/94	5.5	76	1263	229
12/20/94	4.25	81	1154	271
12/21/94	2.25	50	462	205

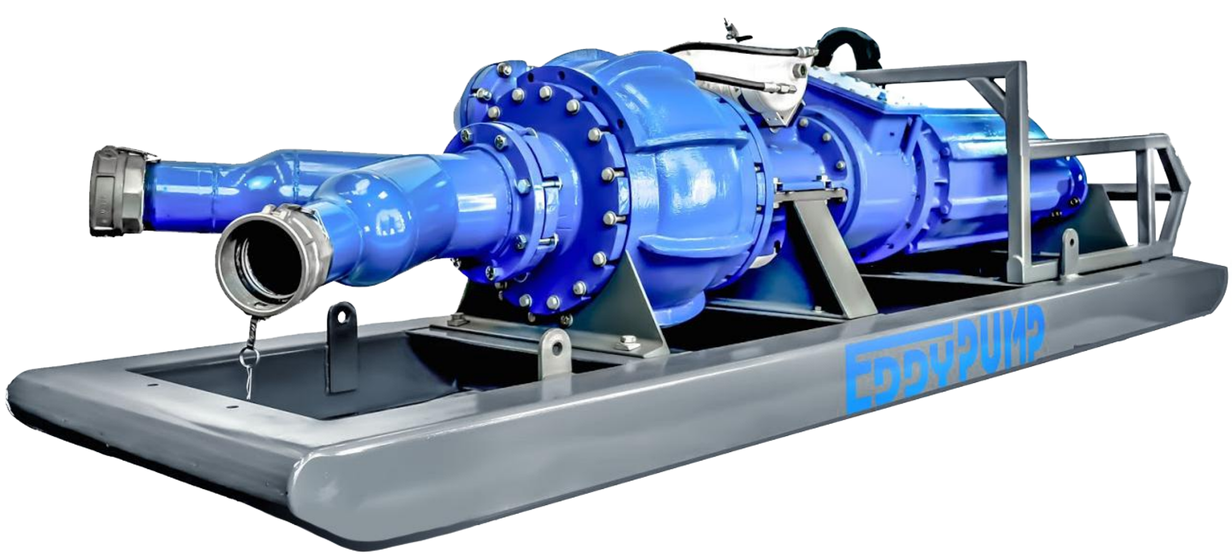
Turbidity, TSS, and dissolved oxygen (DO) were measured at the upstream control station, near the dredge suction, in the plume downstream of the discharge, and at the compliance station established at the power tunnel intake. On average, turbidity around the pump intake. exceeded background levels by only 1.2 NTU. At no time did turbidity or suspended solids concentrations measured at the intake structure compliance station approach the limits set by the agencies. The maximum turbidity increase was 1.9 NTU and maximum suspended solids measurement was 9.0 mg/1. Downstream of the discharge platform, turbidity was far below the limits specified for the compliance station. The maximum increase over ambient was 12 NTU. Dissolved oxygen concentrations were not measurably affected by the dredging. (Creek, PG&E, 1995)

TABLE 2- SELECTED TURBIDITY & TSS DATA (Creek, PG&E, 1995)

Date	Outflow CMS	Trub. (NTU)	TSS (mg/1)	Turb. (NTU)	TSS (mg/1)	Turb. (NTU)	Turb. (NTU)
12/14/94	105	0.8	1.0	1.9	4.0	2.4	10.5
12/16/94	76	0.6	1.5	2.0	4.0	1.5	5.1
12/19/94	92	0.5	2.0	2.4	8.0	0.7	2.2
12/20/94	N/A	0.4	1.0	1.1	2.5	1.4	N/A
12/21/94	N/A	0.5	2.0	1.0	9.0	1.4	N/A

NEW DREDGE

A second generation dredge is now under construction that will improve upon the prototype dredge used for the Cresta demonstration. Portability and rapid mobilization capability are primary features of the new design.



EDDY PUMP CORPORATION

Conclusions

- EDDY Pump slurry suction dredging provides an environmentally superior dredging methods to meet strict water quality standards.
- Very little turbidity or re-suspension of sediments occmTed at the suction head.
- The EDDY Pump is capable of high production rates. Comparable to much larger conventional suction dredges.
- The EDDY Pump dredge is capable of passing large volumes of woody debris and other foreign material in sediments without clogging.
- High slurry density minimizes the volume of effluent to be treated and disposed of upland deposition of sediments.
- The capability of the technology to pump dense slurries long distances provides a pipeline alternative for transporting sediment to distant disposal sites.
- Following solution of initial start-up problems, the prototype dredge proved capable of sustained reliable operation.
- The discharge of sediment slurry into the water column resulted in low levels of turbidity and TSS, well within the limits of stringent water quality standards, without the use of a sediment containment curtain.

REFERENCES

- Creek, Korbin D. and Timothy H.Sagraves, (1995), “EDDY Pump Dredging: Does It Produce Water Quality Impacts?,” ASCE Waterpower '95 Conference, p. 2246-2252
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