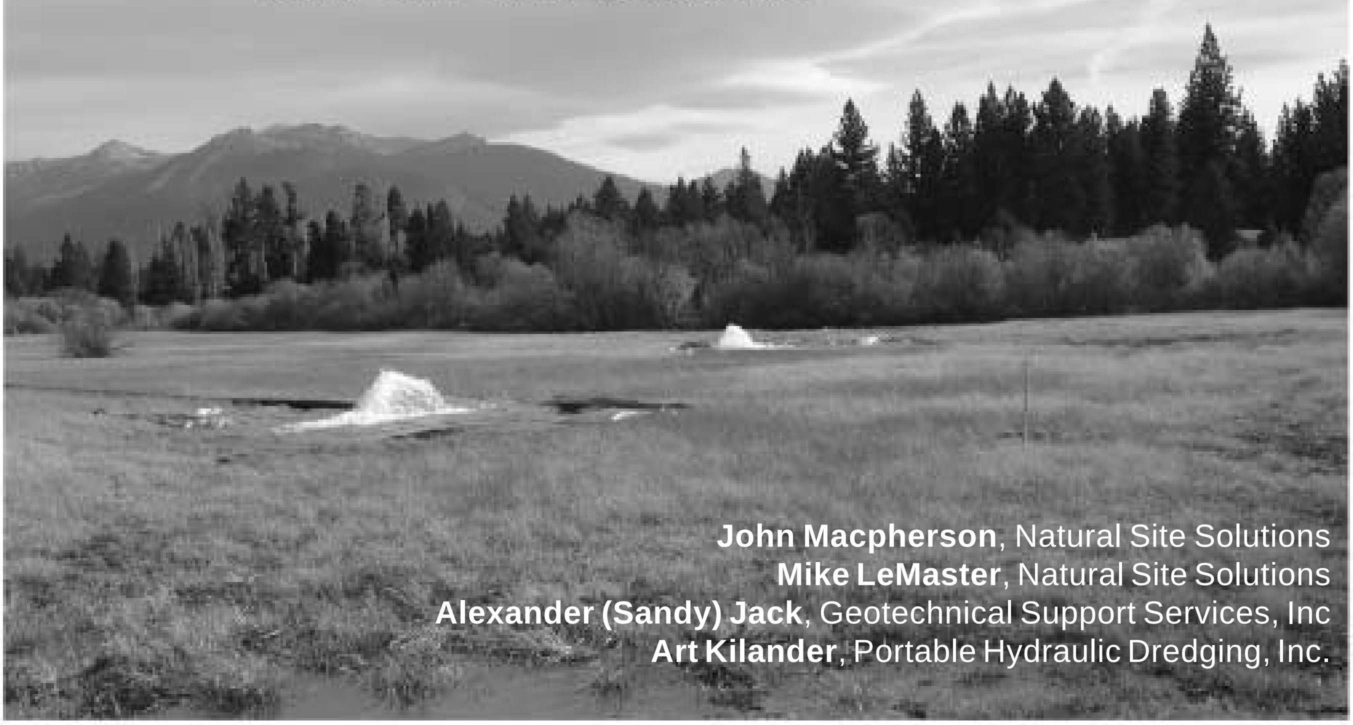
Dredging & Water Quality

Tahoe Key Marina Project Review

South Lake Tahoe, California



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Discharge of treated dredged water into the marsh for infiltration

Introduction

Modern dredging faces many challenges ranging from sediment contamination and sediment disposal to seasonal prohibitions due to sensitive aquatic species.

One of the latest issues, however, is related to the discharge of sediment-contaminated (turbid) water back into the waterways that are being dredged.

Simple settling and/or filtration are not always capable of purifying water to the degree required under county, state and federal water quality regulations.

Some dredgers have experimented with industrial water treatment chemicals with mixed results but increasingly the environmental community is hesitant to approve the use of these chemicals because of their potential toxicity and persistence.

This article takes a close look at the environmental politics and technology of the first dredging project to use a biodegradable extract from shellfish shells as a natural water settling aid.

The Project

In early November of 2002, **Art Kilander**, owner of Portable Hydraulic Dredging, Inc., received authorization to begin dredging the access channel to the **Tahoe Keys Marina** owned by **Ray Carreau** in South Lake Tahoe, California (CA) *(see cover)*.

Dredging was over due in order to ensure safe access to the marina by emergency craft, pleasure boats and larger vessels wanting entry.

The project consisted of cutterhead suction dredging approximately 7,900 yd^3 of sediment from the east channel with a shore-side series of settling ponds for sediment dewatering and water clarification.

The clarified water was to be discharged to the Tahoe Keys Marina harbor behind a sediment curtain. Early in the project, however, it became evident that natural settling would not produce water clean enough to meet the discharge standards imposed by the regulatory agencies for thisproject. The project was stopped before it had begun.

Permitting the Project

Application for the dredging permits was initiated in May of 2002, with the work planned for early September. Partly because Lake Tahoe is such a rigorously regulated water body and partly due to the sheer number of environmental regulatory agencies involved, the permitting process bogged down.

In effect, the most stringent environmental water quality standards in the modern world were butting heads with the traditional and pragmatic industry of dredging.

What makes this project unique is that a solution was developed that satisfied all of the stakeholders involved.

The following agencies participated in this collaborative effort:

* **California Regional Water Quality Control Board**, Lahontan Region (Lahontan);

* **Tahoe Regional Planning Agency**

Dredged water entering primary settling pond – cleaner recirculation water in foreground

(TRPA);
* **California Department of Fish and Game**;
*** California State Lands;**
* **Army Corps of Engineers Sacramento District**.

By late September it began to look like permitting this project would take longer than anyone predicted and the approach of winter was rapidly closing the work window.

At this point, **Alexander *Sandy* Jack** of **Geotechnical Support Services**, Zephyr Cove, Nevada (NV) was contracted to expedite permitting.

Sandy's first action was to contact local, state and federal government agencies including **Eldorado County Sheriff,** Fish and Game and the **US Coast Guard**. The unexpected delay in permitting was explained in context with the immediate need to deepen the harbor channel to accommodate agency patrol boats and rescue craft.

These agencies then prepared letters asking the lead permitting authority, the TRPA to expedite their review and permit process.

After two weeks of review, the TRPA agreed to permit the project so long as the water discharged was as clean or cleaner than the water in the harbor itself (about 3 NTU).

Unfortunately this standard was not considered achievable by any known technology. It would require treating dredged water containing up to 20% solids at 5,000 gal. per min. (gpm) and producing water nearly as clean as tap

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South Lake Tahoe Marina Full-Scale Water Treatment Test

TIME (NOV. 4TH 2002)	POND 1 TURBIDITY	PH	POND 2 TURBIDITY	PH
1140 Start of test	950 NTU	7.40 pH	750 NTU	7.32 pH
1240	500 NTU	7.37 pH	400 NTU	7.31 pH
1340	100 NTU	7.31 pH	75 NTU	7.30 pH
1440	120 NTU	7.24 pH	140 NTU	7.33 pH
1540	90 NTU	7.30 pH	180 NTU	7.02 pH
1620	67 NTU	7.28 pH	170 NTU	7.14 pH
2100	26 NTU	7.17 pH	20 NTU	7.22 pH
0800 (Nov. 5th 2002)	8 NTU	7.41 pH	8 NTU	7.23 pH

water. Another option was necessary.

Eventually a plan was devised allowing the discharge of the water onto an adjacent dry marsh (owned by the **Tahoe Conservancy**) with a maximum turbidity limit of 20 NTU, a nitrogen limit of 0.5 mg/l and a phosphorus limit of 0.1 mg/l.

In addition, marsh soil percolation tests had to be performed to insure that the water would truly infiltrate and not flow overland into the **Upper Truckee River** (a protected river comprising the eastern boundary of the marsh).

The percolation tests indicated an adequate infiltration capacity and the project was on track when another problem became apparent.

In spite of over 2.0M gal. of retention capacity in the settling ponds, the water from the dredging operation had turbidity measuring in the hundreds of NTU – far from the mandated 20 NTU required for discharge.

Water Treatment Proposed

At this point Art Kilander, Ray Carreau (marina owner), and Sandy Jack consulted with **Natural Site Solutions** of Redmond Washington (WA), (distributor of the **chitosan** *Storm-Klear Gel-Floc™* product) and prepared a plan to treat the turbid water with a natural extract from shellfish shells called chitosan (ky-toe-san).

The chitosan is commercially available in a passive dosing gel material sewn into a segmented fabric *sock* (trade name *Gel-Floc*) which is placed in the flow of water where it slowly dissolves acting as a natural settling aid.

Chitosan *Gel-Floc* was proposed for use because unlike polyacrylamides, polyamines, aluminum and iron-based coagulants, chitosan has a low toxicity, contains no industrial contaminants and is 100% biodegradable. Chitosan has been used for years as a filtration aid in commercial aquariums achieving the extreme water clarity required of professional aquarium exhibits.

Next, with tentative approval from the TRPA, bench-scale and full-scale tests were performed to demonstratethe effectiveness of the proposed treatment process.

The bench test consisted of a simple comparative *jar* test with 1.0 gal. of turbid water from *Pond 1* (three ponds in series were used to settle the water) treated with chitosan and 1.0 gal. left untreated as a control.

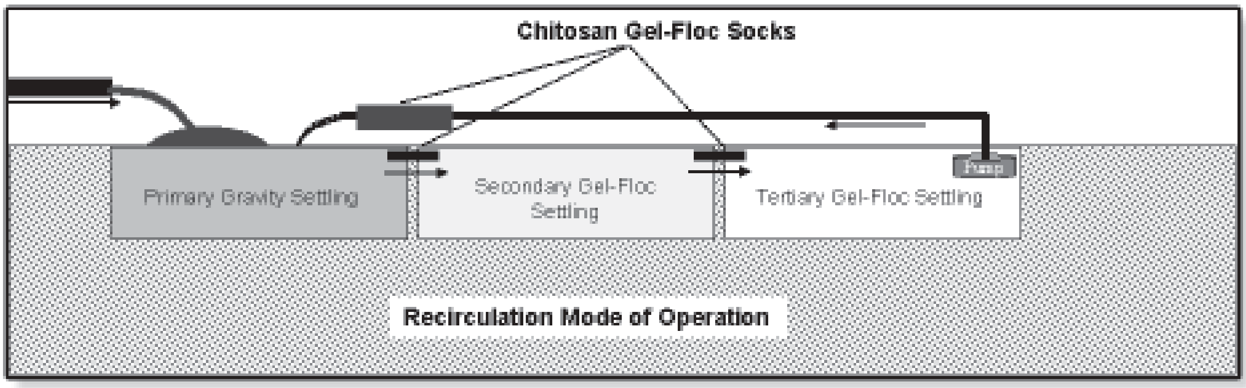
The treated sample was reduced in turbidity from 960 NTU to 11 NTU with two hours settling time. The pH and conductivity of the treated sample varied only slightly and remained well within discharge standards.

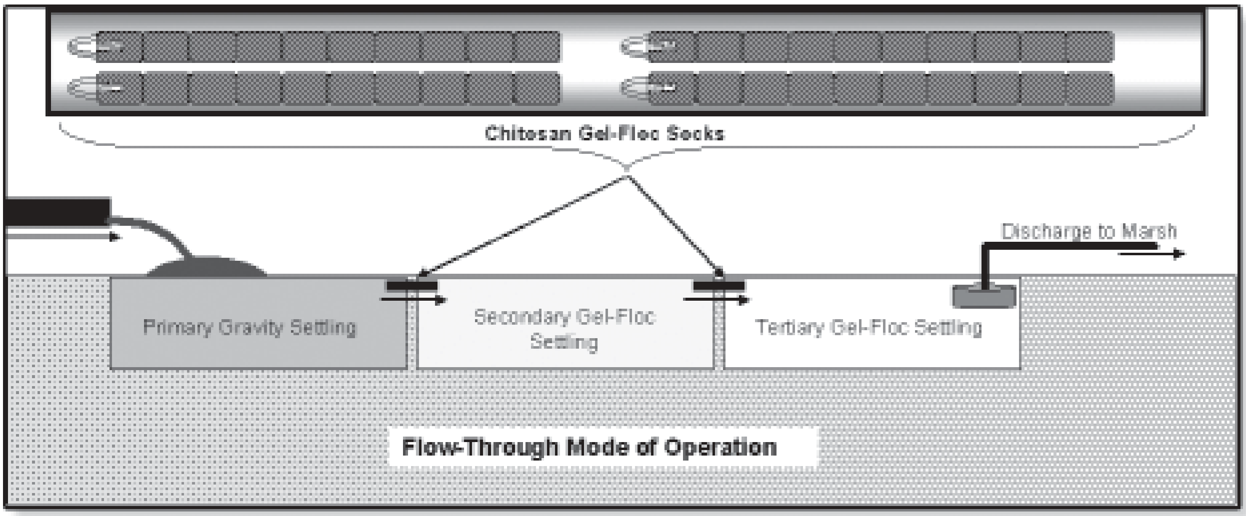
The full-scale test involved recirculating the turbid water in the pond system with eight chitosan *Gel-Floc* socks placed in the flow.

The pump flow rate was approx. 2,000 gpm and pumping continued until complete flocculation of the water was observed.

The turbidity in *Pond 1* was reduced from 950 NTU to 8 NTU and *Pond 2* was reduced from 750 NTU to 8 NTU over the test period. The table below shows the turbidity reductions as measured over time.

These results clearly demonstrated the viability of using chitosan as a





natural settling aid. Based on the full-scale test results, plans were made to implement the treatment process.

The Treatment System

As mentioned above, a total of three ponds (in series) were constructed with a holding capacity of approximately 2 .0M gal. *(see system schematic)*.

The dredging flow rate was estimated at 4,500 – 5,000 gpm making the detention (settling) time about seven hrs. The chitosan was placed in the system in several different configurations while attempting to optimize settling.

Ultimately, the *Gel-Floc* socks were placed in the 2,000 gpm recirculation flow which helped treat the incoming dredge water. Chitosan was also placed in the pipes connecting *Pond 1* to *Pond 2* and *Pond 2* to *Pond 3.*

The system was operated in the flow-through mode *(as seen above)* as long as discharge water quality standards were being achieved.If the discharge water approached 20 NTU the system was shutdown and it was put into the recirculation mode to introduce more chitosan.

Then all three ponds were allowed to settle until the water was less than 20 NTU after which it was discharged and the system was returned to the flow-through mode.

Results

The use of chitosan as a natural settling aid on this dredging project was considered extremely successful.

Water with turbidity levels of 1,000 NTU and greater was consistently reduced to below 20 NTU meeting the state discharge water quality standard for discharge into the marsh. In addition to turbidity, nitrogen and phosphorus were also monitored and reduced significantly. The pH was tracked and did not change significantly as a result of the treatment. *(See photo pg. 8)*

Monitoring stations were established upstream and downstream of the infiltration marsh to demonstrate that the discharge had no impact on surface water. The upstream sample location was in the Upper Truckee River (up-gradient of the marsh) and was monitored for total nitrogen, nitrate, nitrite, total Kjeldahl nitrogen, total phosphorus and turbidity. Samples were collected every 12 hrs.

The downstream sample location was also in the Upper Truckee River (down-gradient of the marsh) and samples were tested for the same parameters at the same intervals.

In addition, the discharge to the marsh was also sampled at two-hour intervals (when discharging) and tested for the above parameters. The test data are presented in the table below. The turbidity of the incoming dredge water varied significantly over the project but was typically over 1,000 NTU. With an average discharge water turbidity of 17 NTU,

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the reduction in turbidity was over 98 percent. The pH, conductivity and temperature were not significantly changed by the addition of chitosan. Data on nitrogen and phosphorus reductions were also very encouraging but were not available at the time of publication.

the type used in municipal wastewater treatment systems. Also, more attention should be directed to optimizing the mixing of the chitosan with the incoming dirty water.

The efficiency of chitosan as a natural settling aid is directly related to how thoroughly it is mixed with turbid

Treated Dredge Water Quality Tahoe Keys Marina Dredge Project

DISCHARGE DATE	TURBIDITY[1] (NTU)			PH (SU)			CONDUCTIVITY (uS/CM)			TEMP (^{0}F)		
	Low	Avg.	High	Low	Avg.	High	Low	Avg.	High	Low	Avg.	High
11/06/02	15	18.2	22	7.12	7.54	7.87	44	80	90	44	45.7	47.6
11/11/02	8.6	13	20	7.07	7.33	7.51	68	80.4	93	39.4	45.2	53.9
11/12/02	9.3	18.1	70	7.08	7.31	7.50	102	121	136	42.9	46.3	52
11/15/02	17	18.1	19	7.2	7.38	7.63	136	150	160	38.8	40.9	43.1
11/19/02	17	19.3	22.1	7.34	7.45	7.65	122	131	141	36.3	40.8	43.3
11/20/02	12	14.7	19	7.18	7.28	7.38	122	128	137	38.7	43.9	47.1

1. The turbidity of untreated dredge water entering Pond 1 was typically over 1,000 NTU.

Discussion

Because this was the first dredging project to be permitted in Lake Tahoe using chitosan-enhanced settling, it took significantly more time than normal to get the environmental regulatory agencies to agree with the plan and set water quality discharge limitations. The next dredging project to propose this same process will likely proceed through the permitting process much more rapidly.

And, as more experience is gained through experimentation and trial and error, it is expected that higher flow rates can be treated with even better results.

Lessons learned during the project include:

* Protect the sides of the excavated ponds with plastic to prevent wind-driven waves from eroding sediment and causing higher turbidity levels;

* Design the ponds so that the water from one pond must overflow a weir to get to the next pond (ensuring the cleanest water possible);

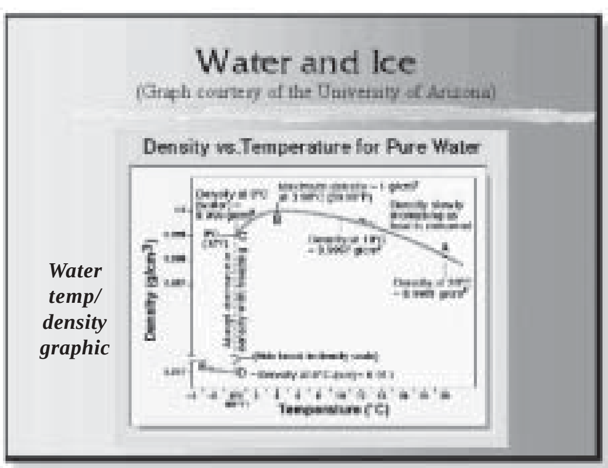
* The chitosan Gel-Floc worked well but it took a lot of system modification and labor. Future projects must develop more direct dosing methods.

One of the biggest drawbacks to this system was periodically switching from operating in the flow-through mode to the recirculation mode – because of excess turbidity.

This was caused primarily by under-dosing the water and can be easily corrected by using a more direct dosing system such as a dry-auger feed and pre mixing system –

water. Complete mixing results in cleaner water and a lower dose rate of chitosan.

Another important consideration in any treatment system depending on gravity settling for the removal of suspended sediment, is temperature. As seen in the graph below, the density of water increases as the temperature drops. The maximum density of water occurs at 3.98^o C (39.16^o F) which is problematic because, as water density increases, the apparent density of the suspended sediment is reduced. Simply stated, sediment settles more slowly as the water temperature approaches 3.98^o C.



Water temp/ density graphic

This phenomenon had a pronounced negative effect on the settling rate of sediment during the project as winter temperatures dropped and the water in the ponds began to freeze.

The project ended short of its goal in fact, because the cold water in the ponds would not clarify enough to meet the discharge turbidity standard.

Future projects should anticipate this potential problem and either avoid working in cold weather or find a way to overcome the water density problem by using pressure sand filters or gravity sand filters for particle removal.

Conclusions

Two important lessons were learned during the course of this project. First, dredging projects in environmentally

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Treated dredge water in pond.
Dredge water (10 NTU) after addition of the natural settling aid, chitosan (mfg. by Vanson HalosSource).

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Dredge rig in the snow

sensitive, recreation areas must start the permitting process well in advance of the scheduled work. Don't be afraid to ask for help from other agencies with a vested interest in the dredging project.

A comprehensive *water management* plan must be prepared to explain in detail how water will be managed, treated and discharged – including a monitoring plan. This plan then needs to be clearly communicated to all stakeholders, not just the lead environmental agency.

Ultimately the dredging community faces an even broader challenge to educate the public and change the misguided notion that dredging is destructive and dangerous to the environment.

And second, this project simply would not have been allowed to proceed without the use of the natural settling aid, chitosan. It was the addition of chitosan that caused the rapid and complete settling of the suspended sediment, nitrogen and phosphorous.

While chitosan has been used routinely to settle dirty construction stormwater, this is the first time it has been used to settle dredge water and the results were dramatic though not without a few hitches. Much work is yet to be done in optimizing dosing and mixing systems but the first dredging project to use a natural sediment settling aid is now behind us and as Sandy Jack commented, "Flocculants [settling aids] that are environmentally sound are the wave of the future." *(See ad on pg. 11)* ❍