DRAFT:

Notes Regarding San Juan River Siltation Rates

by Gene Stevenson November, 2000

The closure of Glen Canyon Dam in 1963 brought about immense changes in the river dynamics of the Colorado River system. Numerous studies of stream flow and suspended sediment loads (both pre- and post-dam) have been conducted, resulting in a plethora of estimates used today by both dam advocates and adversaries. Current research in Grand Canyon concerns the lack of sediment resulting in starved beaches (Luchitta & Leopold, 1999; others), and has even brought about serious considerations of "draining Lake Powell" (Glen Canyon Institute, Glen Canyon Action Network & Sierra Club).

The dam was originally designed to contain a water reservoir of 27 million acre feet of water, or twice the annual flow of the upper Colorado River basin, and after only 35 years, the storage capacity of Lake Powell is reported to be approximately 26 million acft. Nearly one million acre feet has been lost to sedimentation. Go figure. Rivers born by snowpacks at 12,000 ft or more, rush across semi-arid to arid lands that have been assisted considerably in their rates of erosion by human involvement. The so-called "efficacy of humans as geomorphic agents" (Hooke, 1994). The conquering of the West. Think of filling the stem of a champagne glass with sand - that's the reservoir at Glen Canyon - fully one-half the total storage-able volume is in the upper 100 ft. Most discussions concern rates of sediment influx, how fast? When do we lose hydroelectric capabilities? When will the dam give way? Etc. This discussion is mostly based on observation, first hand, of a geologic process that would normally take many human lifetimes to achieve. I've seen it develop within my lifetime.

Over a period of <u>only 13 years</u> since the completion of Hoover Dam in 1935, the volume of sediments accumulated in Mead reservoir by 1948 was <u>1.426 million acft, or 101,857 acft per year</u>. The 1948-49 Lake Mead study showed that 80% (or 81,486 acft per yr) of the total suspended load entering Mead reservoir passed by the Lee's Ferry gaging station (located some 300 miles upstream) of which 30% was attributed to have been derived from the San Juan River and 70% from the main stem of the Colorado River. *Prior to closing Glen Canyon Dam in March, 1963, the average monthly total amount of suspended sediments passing the Lee's Ferry, AZ gaging station was 2.5 million tons.* The study assumed that the supply of sediment was approximately proportional to stream flow and that stream flows were considered to have been about the same for the period 1936-48. For the study period of 8.3 yr from 3/63 -7/71, 676,325 acft of sediment was estimated to have filled Powell reservoir. Actual measurements were shown to be less than this estimate, and attributed to dam closures at Flaming Gorge & Navajo & Blue Mesa in 1962. *[however, a fundamental flaw in these calculations discounted silt/sand load infilling the lower San Juan canyons from Slickhorn Gulch to Clay Hills crossing, see cross-section]*

Upper Colorado River Basin - Three major drainages supply water to Lake Powell; accounting for 96.92% of the measured outflow. Average breakdown for 1914-1965 period show:

GR @ GR,Ut =	4.427 mil ac ft,	or 35.63% of outflow
CR @ Cisco, UT =	5.662 mil ac ft,	or 45.56%
SJ @ MexHat, UT=	1.955 mil acft,	or 15.73%
TOTAL	12044 mil ac ft,	96.92%

(Therefore, SJR headwaters in SJ Mtns = 14%; *and only 1.73% from "other" tributaries?? I feel that this value is a gross under-estimation.*)

LPRP 5/1975 Gordon C. Jacoby, Jr., San Juan River Basin Surface-water Runoff based on tree-ring studies, ***upper & lower San Juan basins= 25,000 sq mi***. "There are no major tributaries nor diversions between the last gaging point on the San Juan *(at Mexican Hat, Ut)* and Lake Powell or the former confluence of the San Juan and Colorado Rivers." *[this is an incredibly boneheaded statement.]* What about seasonal flashflood potential from the following: Johns Canyon, Government Canyon, Slickhorn Gulch, Grand Gulch, Oljeto Wash , Steer Canyon, Whirlwind Draw, Rockhouse Gulch, Paiute Farms Wash, Mikes Canyon, Copper Canyon, Castle Creek, Nokai Canyon, Neskahi Canyon, Piute Canyon, Navajo Canyon, San Juan Canyon, Alcove Canyon, and Deep Canyon? ***That adds up to 19 unaccounted side canyons that are named, plus a slug of unnamed washes.***

Chinle Creek drainage of 3,300 sq mi and others = 1874 sq miles, of which Chinle adds 13,330 acft annually (1964-1973) *[and a huge sediment load]*.

Combined with upper basin = **2.256 million acft /yr.** Then a later figure of **2.166 mil acft/yr** at MexHat (?) Then **2.170 mil acft/yr** ?? *(Looks like an average of 2.2 million acft/yr)*.

From 1914-1957, the average **water flow** of the Colorado River at:

Cisco, Utah = ...	5.141 mil acft
Green River at Green River, Ut = ...	4.067 mil acft
San Juan near* Bluff, Ut = ...	2.028 mil acft.
Total = ...	11.236 million acft.

(but the suspended sediment load during same time period is respectively, 14.35, 20.8 and 37.1 percent of above total = 72.25%).

These totals (which = 72.25%), when compared to measurements at Lee's Ferry (the 80% from 1948 study), show the volume of water was mostly accounted for by summing the three stations (12.044 mil ac ft compared to 11.236 mil acft of WATER), but is significantly off when looking at sediment load (80% vs. 72.25%; where's the other 7.75% of the sediment load?).

Throughout its course below Navajo Dam, the San Juan River drops an average of more than 5 ft per mile, and as much as 14 ft per mile in the lower canyons. Historically, flows vary dramatically, from a high of 91,000 cubic feet per second (cfs) in 1911, to several occasions when it basically dried-up. (Now Lin Alder at U of Arizona estimates 200,000 cfs based on current research; from The Salt Lake Tribune, Saturday, November

25, 2000). Since the construction of Navajo Dam in the early 1960s, the highest flow has been 55,000 cfs in 1970; the last 30 years has seen flows ranging between 15,000 cfs and 150 cfs.

* When Powell Reservoir is full (at 3700 ft asl), it extends 186 miles up the Colorado arm and 75 miles up the San Juan arm, creating 1,960 miles of winding canyon shoreline, storage capacity (in 1986) of 26.2 mil ac ft, and 161,000 surface acres (Ferrari, 1988).

** From 1980 - 1987 the reservoir filled or nearly filled (above elev 3682 ft) but fluctuated 25 ft or more annually. During this period, sediments were deposited in the reservoir at relatively high elevations. From 1987 - to 1997 the level of Powell reservoir receded and vast areas of the deltas were exposed and vegetated with exotic vegetation. *This type of vegetation tends to stabilize deltas by reducing the velocity of distributary channels, which, in turn, causes more silt and clay deposition than would occur during higher flows.*

The San Juan River delivered only 13% of the water between 1964 and 1974, but it delivered close to *half of the suspended sediments*. This fact alone should have been a wake-up call to those monitoring the sediment influx into Powell reservoir. The character of the deltas of the two rivers differs because of differences in sediment load and total flow, differences in river gradient, and because of the nature of the lake confluences. (The average gradient of the Colorado River between the elevations of 3700 ft to 3550 ft is about *2.5 times greater* than the San Juan River between the same two levels, but the mean gradient of the San Juan *in the lake* is 25% greater than that of the Colorado (ie., the original "lower canyon" of the San Juan). The confluence of the Colorado arm of the lake and the river is over 20 miles up a narrow canyon with perceptible current, whereas the lake/river confluence of the San Juan is only a few miles up a narrow canyon before widening into a broad bay (fed by Piute & Neskahi washes).

* For the most part, a trip on the San Juan River from Bluff to Clay Hills is in canyons.

* The upper 100 feet of the reservoir holds 48% of its capacity.

* The reservoir depth at the dam is 560 ft high (the dam is 710 ft high), hydroelectric penstocks at 460 ft level (3490 ft asl; under current hydrologic conditions, the reservoir is filling with silt at the rate that the penstocks intakes will be silted-in within 105 years.

*** Longitudinal profiles of original river bottoms conducted by Dartmouth group since 1971 (Nothing upstream of Paiute Farms Wash; therefore these sediments from John's Canyon to Paiute Farms Wash are un-accounted for in lake sedimentation estimates).**

Aggradation of sediment accumulating at river/lake interfaces in narrow canyons (Colo and SJ). Although much of the suspended fine sediments ooze downstream, much of the coarser faction drops out further upstream thus diminishing river gradients and forming deltas.

** Plots of delta profiles show a definite break at delta crest (delta front - which is also least stable, and susceptible to turbidity flows), yet BurRec EIS states repeatedly that "the rate of growth of Lake Powell deltas is independent of dam operations" but ignores that constantly fluctuating lake levels act as a giant plunger pushing sediments ever closer to penstocks.

Deltas normally reduce river gradients ***upstream* - rivers usually don't come blowing out of a narrowly confined canyon with velocity but then rapidly reduce velocities into an equally narrow canyon, and then into a broad floodplain. So Lake Powell deltas are a definite hybrid due to human involvement. Both progradational and retrogradational processes are ongoing as lake Powell reservoir rises and falls in level. And the SJR keeps dumping silt into the champagne glass. The fluctuating lake levels act as a slow motion plunger pushing the seds closer and closer to the dam wall.

** The San Juan is a high-gradient stream with several flat-spots sprinkled across its lower course in a stair-step fashion (Paiute Farms, Copper Canyon, Nokai Canyon, Neskahi-Piute Canyon). Where it flattens is where the countryside opens up and a broadened floodplain develops; otherwise, the San Juan plunges headstrong toward the Colorado. One of the First flatspots is the stretch between Clay Hills and Paiute Farms, in southeastern Utah.

* The length of a delta exposed above the reservoir surface can change dramatically with changing lake levels. For example when lake level dropped 10 ft from 3700 to 3690 ft the length of the San Juan delta grew by more than 7 miles (reported), but 15 miles, (observed).

* From 1988 - 1995/96 the SJR changed course thru its LP delta near Paiute Farms (56 miles upstream from the mouth of the SJR) creating 25-35 ft falls where water falls over Organ Rock Shale cliffs, and effectively prevents erosion of the delta upstream, even though reservoir elevation is much lower.

* 1995 BurRec EIS - Lake Powell Deltas -- Large deltas have formed in the major tributary arms of Lake Powell - Colorado, Dirty Devil, Escalante, and San Juan Rivers, and Navajo Canyon. The shape and location of the deltas are affected by the changing water surface elevation of the reservoir. Sand and larger-size seds settle in upstream parts of the arms, forming classic ***(modified!!)*** sloping deltas, while most silt and clay deposit in deeper areas downstream (lake-bottom oozes).

* NSF Lake Powell Research Project Bulletin, number 64, June 1978, Sedimentation in Lake Powell, W. Condit, C.L. Drake, L. Mayer, and R. Spydell (Jeni M. Varady and Orson L. Anderson, editors)

* Iorns et al. (1965) presented an overview of the water resources of the UCRB for the period prior to the completion of Navajo Dam on the San Juan River and Flaming Gorge Dam on the Green River in 1962 and Glen Canyon Dam in 1963. Comparison of pre- and post-dam gauging station data shows a halving of the sediment load of the three main

rivers, but only the San Juan shows a significant decrease of the average volume of flow after 1963. Important considerations not addressed is the velocity of the streams (entrained seds are a function of the turbulence of the flow which increases with higher velocities), numerous tribs below the reservoirs/dams restore much of the natural periodicity of flow patterns, ***traction loads (not monitored in any studies due to difficulties in measuring and is also affected by stream velocity)***.

.* Operation of Glen Canyon Dam, Final Environmental Impact statement, March, 1995) US Dept of Interior, Bureau of Reclamation, p.107 "Estimates of the time required for complete reservoir sedimentation... based on 1986 survey results indicate that 868,000 ac ft of seds had been deposited below 3700 ft elevation since dam closure in March 1963. This total sediment volume represents a 3.2% decrease in total storage capacity in 23 years. And estimate it would take more than 700 years to fill completely; but 300 to 500 years to reach penstocks" *(unrealistic #'s for all sorts of reasons, but mainly the filling years have been either below normal to normal runoff years, only 1983-84 were high water years. What about the 500 year floods?, see Lin Alder estimates)* Of the 868,000 ac ft of seds, 54% in Colo River arm, 32% in San Juan arm, and 14% in remaining tribs. Slumping of cliffs considered negligible *(bullshit)*.

*** 1972 study LPRP shows SJR in downward trend in Animas/Florida drainages
The Dartmouth College part of study (C.L. Drake, principal investigator) - sed studies
source of seds, rate of seds (on macro- and micro-scales), methods of sedimentation, and character of seds. Used sonar equip & gravity core smpling.
203 miles of longitudinal Sonar reflection profiles began in July 1971 show that sedimentation occurring primarily in old river channels.

Three major sources of seds entering lake: 1) suspended seds (most important) carried by CR & SJR; 2) slumping, especially where Chinle fm outcrops; and 3) mouths of side canyons where flash flooding can bring large to small fractions (boulders & mud).

Slumping not important in terms of volume, but may affect distribution, and possibly navigational obstacles. Three major areas where Chinle outcrops; around Castle Butte along lower reaches of SJ and around the Rincon where a 60 ft thick sill formed behind which seds can accumulate.

In Cat Cyn, side cyn buildups of rubble due to flash floods, and fine seds ponded behind.

As lake level rises, similar deposits should occur further up side cyns.

Character of seds - fine grained lutites w/mixed layers of sand.Dominantly siliciclasics/ terrigenous clays but role of algae removing silica from waters, and organic content of bottom wtrs not clear (in 1971). Methods of deposition include slumping, turbidity current/density current and time of year (lake fill effects during these years).

NOTE: Altho there is a correlation of flow rates to load volumes, flash floods are not clearly understood re: the enormous amts of material in very short periods of time

Conclusions agree with stream flows, except an increasing wedge of seds from the mouth of the SJ to the dam is unclear *(GMS: SJ has a steeper gradient, thus possible subaqueous flows/turbidites?)*

* During the Summer of 2000, USGS and BLM finally realize that gauging stations along the San Juan river (and probably elsewhere), were inaccurate due to modified profiles caused by sediment infilling of stream bed, thus their flow readings were erroneously high; i.e., there's less water going down river(s) than we think, but more seds.

*San Juan River entrenchment from Farmington, NM to River mile 9 (entrance to upper canyon) is due to controlled flows from Navajo Dam, exotic vegetation, cows......

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Reference **Stevenson, Gene and Don Baars, 9/94, Paiute Falls, Lake Powell, Utah in The Canyon Echo, vol 1, 8th Ed., p.4, 5 & 13.**

HOW IT WAS

By the time the Colorado River is joined by the San Juan, it is a sizeable river with many tributaries (see map) of greater or equal size. What makes the San Juan stand out is it's position in the sequence, and it's load of sediment. For its size, it packs a huge volume of silt and mud.This is due to it picking up huge drainage basins of arid plateau country, that when they flash, can creat huge torrents of screaming red muddy waters.

Lake Powell, located in southeastern Utah, drowns a portion of the Colorado River and the lower segment of the San Juan River (Fig. 1). As overall lake level dropped from 1988 through 1994, a major waterfall formed on the lower San Juan River below the Clay Hills BLM boatramp. The waterfall had been widely publicized by river-runners, but most everyone else had either ignored its presence, or still assumed that the San Juan continued to flow quietly unimpeded into Lake Powell. Nothing could have been farther from the truth.

Certainly, one big reason to not publicize a waterfall on Lake Powell is that it is clear proof of man and bureaucracy's failed attempts to control nature. The roar of Paiute Falls speaks loudly and clearly to those who will listen - about an ecosystem that is endangered by mankinds quest for dominion. Besides creating ecological nightmares, the damming of high-gradient, silt-laden streams and rivers in the Southwest has been called a "mistake waiting to happen."

Around the world, waterfalls are usually highly regarded scenic masterpieces of nature, and what could be more appropriate than to include a year-round waterfall on beautiful Lake Powell? This lake is the result of the construction of Glen Canyon Dam, completed in 1963 and built to control the Colorado River and to alleviate flooding downstream. It was also built to provide guaranteed volumes of water to California-Nevada-Arizona, hydro-electric was thought to be a major plus as other "cash register dams" were promoted by BurRec, and of course it was built and filled unexcelled recreational opportunities for the masses who would otherwise have been deprived of the joys of spectacular Glen Canyon in its natural state.

HISTORY

As the population and development of agriculture mushroomed in southern California and southern Arizona, government survey expeditions were launched in the 1920s in the search for potential damsites along the mighty Colorado and its major tributaries so that the raging river could be "tamed" and the water impounded for "beneficial use." The Green and Colorado rivers were surveyed in 1922 in association with a San Juan River survey the same year - the Marble and Grand Canyon survey followed in 1923. The first dam - Hoover Dam - was completed the next decade in Black Canyon near Las Vegas, Nevada. Someone soon noticed that Lake Mead, the resulting reservoir, was rapidly filling with silt and sand caried down in copious amounts from the Colorado River drainage basin above. In spite of the well-advertised reasons for the necessity of a second dam upstream, Glen Canyon Dam would be required to halt the influx of sediments and the consequent early demise of the Hoover Dam engineering marvel. Certainly, a second dam, if constructed upstream in time, would mitigate the problem at Mead reservoir, and besides, who would ever miss the remote, narrow, rock-barren Glen Canyon?

The canyon "no one knew" began to be engulfed in 1963, its archaeological and scenic treasures drowned forever. It took only two decades and two back-to-back winters of record snowfall in the Rocky Mountains to fill Powell reservoir behind Glen Canyon Dam to its maximum elevation of 3,711 ft above sea level, a level only attained in June, 1984. The result was that Glen Canyon Dam overflowed and the spillways were nearly destroyed (Hannon, 1996). Lake water lapped at the foot of Big Drop Rapid in Cataract Canyon on the Colorado, Grand Gulch Rapid on the San Juan River was inundated, and powerboats could now cruise underneath the previously seldom-seen Rainbow Bridge. Hundreds of miles of drowned river canyons now clearly demonstrated the success of recreational fulfillment by hoards of powerboaters and water skiers in the otherwise inaccessible canyons. The unadvertised real reason for building the dam - the cessation of sedimentary infill of Mead reservoir - had also been successfully achieved. Or had it?

Where would all those cubic miles of sediments carried down the eroding Rocky Mountains and Colorado Plateau come to rest? Once again, Glen Canyon Dam and Powell reservoir came to the rescue. And besides, who would notice? The far reaches of the former Glen Canyon were in such desolate and fully isolated canyons that it mattered little as to their demise. The reservoir was so long, hundreds of miles long, that the lake bed would never be filled with silt; never become vast cornfields for the benefit of local Indian tribes; never crowd the storage capacity of such a marvelous engineering dynamo.

Unexpectedly, even to the water-hungry masterminds of the first half of the twentieth century, river-running came into vogue. Then people, by the tens-of-thousands, began floating the rivers of the American West. Throngs of river-runners invaded the canyons like locusts. They noticed! They saw flat water, teaming with water skiers and houseboats, where wild rivers had once been. They fought the tortuous meandering channelways through mudflats where some of the most exciting rapids had been feared and recorded by early explorers. They yearned for the marvelous spiritual experiences of Glen Canyon enjoyed by John Wesley Powell in 1869 and brought to life by the other fortunate few people, like the photo essays of Elliott Porter, or Katie Lee, or Kent Frost. They cursed the mud-drenched canyons and quagmires where boats must be retrieved at journey's end. They were not sympathetic with "the great recreational facilities" provided by the dambuilders.

THE SAN JUAN RIVER

The headwaters of the San Juan river lie in the high San Juan Mountains of southwestern Colorado, near Wolf Creek Pass. Water from the upper basin and several tributaries are temporarily stored in Navajo Reservoir, located on the Colorado - New Mexico border (Fig. 1). From Navajo dam, the San Juan River flows unimpeded across northwestern New Mexico and into southeastern Utah where it finally converges with the Colorado River near the Arizona border in what is now Powell reservoir (Fig.1).

On its course below Navajo dam, the San Juan picks up and carries enormous amounts of suspended and bottom-load sediments. For its size, the San Juan carries comparatively more sediment than any other major tributary to the Colorado River. The source of most of these sediments is from overgrazed plateau lands of the Four Corners Region. Spring runoff and late Summer rains can rapidly change the San Juan from a docile stream to a seething torrent of mud.

Today, the San Juan River is popular for nearly 15,000 combined commercial and private recreational boating enthusiasts, annually. The most scenic stretch of river is from Sand Island Recreational area west of Bluff to Clay Hills Crossing, a distance of nearly 84 miles (Fig.2). Approximately nine miles west of the Sand Island launch site, the river leaves its lazy meandering course and flows through deep limestone canyons incised into the Monument Upwarp (Fig. 3). The San Juan cuts across the structural axis of the Monument Upwarp as an incised river superimposed on the west flank of the Monument Upwarp. After being confined by a thousand-foot deep canyon for nearly 60 miles, the high gradient, silt-laden river enters the placid waters of Powell reservoir. And not surprisingly, it is there where nature is at odds with the "achievements" of man.

HISTORY OF THE LOWER SAN JUAN RIVER SILTATION RATE

The decision to build another dam above Mead reservoir was based, primarily, on the tremendous rate at which this reservoir was silting-in. After exhaustive political efforts had failed to permit construction of dams in Grand and Marble canyons, the U. S. Bureau of Reclamation constructed Glen Canyon Dam near the Utah - Arizona border (Fig. 1). Lake Powell began to fill in 1963 and power generation began in 1964. By 1980 the reservoir had filled to a sufficient height to finally test the spillways for the first time. The miscalculation (and overall lack of judgement) of the Spring runoff of 1984 nearly wiped out the spillways as the average lake level reached an elevation of 3,711 ft asl. But, the dam held and the lake level was maintained at an average high-pool elevation of 3,700 ft above sea level until the Summer of 1988. (For more, see Hannon, 1996; Bur Rec tape, Reisner?)

Moderate to dry winters from 1988 to 1996 (?), accompanied with increasing downstream demand, resulted in a low point of 3,519 ft asl in mid-1992 (confirmed by

aerial observation of lake level at RM 100.2). **By June, 1994 the lake level rose to nearly 3668 ft asl**. Current lake level is **3677 ft asl** as of 4/11/00.
This fluctuation in lake level of 192 ft (?) over the past 15 years has certainly left its mark on the upper reaches of the San Juan arm of Powell reservoir by, first completely filling it with a wedge of silt, then exposing vast silt flats grown thick with non-indigenous "exotics" (like tamarisks, tumble weed, knap weed, etc.) resulting in a major "re-routing" of the San Juan River, followed by another inundation of rising slack water as Powell reservoir once again filled to 3675' as of 11/30/00. The resulting fluctuations has created an artificial "riparian" biological community and a huge man-made flume in which fluvio-deltaic geologic and geomorphologic processes can be observed.

Just below Slickhorn Gulch (at river mile 66.7) is the first indication of lake-induced silt bars, marking the high water level of 3,711 ft asl of 1984 (actual silt line at 3715-20 ft ?sugesting river was "stacked" due to sudden change in gradient; aka suck-hole alley). For the next 16.6 miles to Clay Hills, the river now drops at a rate of only 0.42 ft per mile where it used to flow naturally at nearly 5 ft per mile. Even though the highest lake level in recent years **(1994 of 3668', and current level of 3677')** is some **32 to 23 ft lower than the boat ramp at Clay Hills**, this section of the San Juan River maintains this sluggish meandering rate. Common sense and a little arithmetic should tell us that this section should have, by now, re-established its old gradient as the lake level dropped nearly 200 ft!! Afterall, uncompacted layers of silt sand and clay was all that had filled-in the 85 feet of lost gradient. What could have held back all the silt?

ENTER WATERFALL, 1988 - 1997 (?)

Clay Hills crossing is located at the mouth of the west-plunging sandstone and limestone canyons in which the San Juan has cut for some 57 river miles upstream. Immediately below Clay Hills crossing, the countryside "opens-up" briefly, for about 5 miles, before flowing into the narrow sandstone -rimmed Glen Canyon (see map). Here, the river widened into a brief stretch of low-gradient, braided stream whereby much of its sediment load was dropped, forming a widened flood plain named Paiute Farms. At high lake levels, silt was deposited evenly across the area and extended nearly 19 miles upstream to Slickhorn Gulch. The high-gradient, silt-laden river was forced to give up its suspended and bottom-load sediments to the artificially calm waters of the lake. During the mid 1980s highstand, all low-relief topography less than3,711 ft asl was buried by lake silt, creating a rather uniform profile of the lake bottom. As the river's gradient was reduced by the silting-in process, the river's energy slowed dramatically such that the sluggish and aimless meandering currents lost their way across the man-made delta, dividing into numerous distributary channels only inches deep.

As the lake level began to lower in 1988, the river currents shifted slightly to the north to cross the delta, flowing across the buried red rock cliffs.(see photo- lake seds, bedrock, waterfall). The river current became trapped in the deltaic lake silt as the lake level continued to drop, and cut downward to the buried bedrock, forming a "surprise" rapid by year's end. By late 1990, "Paiute Falls Rapid" as it had become known to us river guides, had become a formidable obstacle, such that no one but the foolish attempted running it. With continued lowering of Powell reservoir, the rapid matured into a sheer waterfall that became a curiosity to many, and an embarrassment to the dambuilders and lake enthusiasts. The U.S. Dept. of Fish and Game were certainly aware of it, as fish migration from lake to river environments were now severed.

For at least a six year period (1989-1995), an unrunnable waterfall blocked navigation 2.2 miles below Clay Hills boat landing. Although short-lived, this was the biggest "rapid" on any so-called navigable stretch of river in North America, and no one knew about it. News of the waterfall still remained a local curiosity until **1993**, when I finally managed to get a Salt Lake City television news crew to helicopter out to the brink of the falls and see for themselves. They were impressed. I was interviewed, and when asked how this problem could be prevented, I replied ***"don't build dams on high-gradient silt-laden streams without having a solution for the cubic miles of sediments that will accumulate."*** The news piece aired at 5:00 pm the following afternoon, and was supposed to air in more detail on the 10:00 pm "late" news. It never showed. The TV station manager considered it too hot a topic, and shed unsatisfactory information on a much beloved Utah recreation site. Bur Rec representatives I contacted during these years were either uninterested to discuss the situation, or claimed ignorance that the waterfall was a rumor - it didn't exist. In the meantime, two clueless boaters from Farmington, NM went over the falls; they were rescued but their boat was never recovered. *The NPS finally erected a warning sign at the Clay Hills ramp in 1995, after the near fatal accident*.

During this entire five year period, the top of the falls was only 9 ft lower than the 1984 high lake level of 3,711 ft asl. The base of the waterfall was some 26 to 35 ft lower (depending on the lake level). The original course of the river flowed past a series of low-relief ledges of red rock (Organ Rock Shale of Permian age) along the right-hand (north) valley wall, and headed almost directly southward toward Paiute Farms. Following the highwater years of 1983-84, a Navajo-operated marina, complete with concrete ramp, had been constructed at this uppermost reach of Lake Powell, and alongside the drowned mouth of Paiute wash, a dry wash. The life of the Paiute Farms Marina was very short, as it was immediately plagued with encroaching silt problems as lake levels in the late 1980s fell. We river runners enjoyed it those years, making a take out pleasant, what with paved landings, and ice cream in the store. **But a late summer flash flood in 1990** sealed the marina's fate, as the shallow embayment was completely filled in by this one, rather average, and predictable flash down Paiute wash.

Trapped in the new channel, astride the exhumed rock ledge, the waterfall formed a temporary nickpoint, or perched base level of erosion. Lake sediments trapped in the 19 miles of canyon above the waterfall had been artificially suspended in the system at a level that ranged annually some 25 to 50 ft above the 1994 base level of Lake Powell. The seasonal fluctuation combined with the overall lowering of the lake had accelerated the formation of yet another delta complex downstream of that held up by Paiute Falls. By the fall of 1994, nearly 40 miles of the San Juan river corridor had been silted-in with downstream progradation of the delta continuing today.

1994 course - almost breached the falls
by 1996/97 - lake level rose, inundated and covered the falls - the BurRec was saved.
1998- once again river trips took out at Paiute landing (now re-claimed) no more concrete ramp; no more ice cream.
1999- unstable delta front sediments and multitudes of narrow distributaries make crossing the delta front very dangerous.
2000- no data; waiting on runoff

CONCLUSION

Even though the siltation rate was a major factor in the construction of another dam upstream of Hoover Dam, when Glen Canyon Dam was built there was no apparent consideration given to the huge volume of silt that would be deposited at the lake/river interface on the Colorado and San Juan Rivers. No consideration whatsoever was given to the sediment-starved beaches that would develop downstream in Marble and Grand canyons. Least studied were the marinas located at the upper reaches of the lake; those necessary for the recreational objectives of the project; those that would be progressively silted-out such that continuous abandonment would be the only viable solution. Obviously, no consideration was given to drastically altered stream courses, the safety hazards that would result, nor of major ecologic damage that must necessarily follow.