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Draft Report
Ball Mountain Sedimentation Study

Ball Mountain Lake
Jamaica, Vermont

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US Army Corps
of Engineers
New England Division

DRAFT REPORT
BALL MOUNTAIN SEDIMENTATION STUDY
JAMAICA, VERMONT
CORPS OF ENGINEERS, NEW ENGLAND DIVISION

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INTRODUCTION

The Corps of Engineers Ball Mountain Lake project is situated on the West River in the town of Jamaica, Vermont. Together with Townshend Lake, a total of 87,350 acre feet of flood storage is provided to the communities downstream, including the city of Brattleboro. The location of the project is shown on Plate 1. At the time its construction was completed, Ball Mountain Dam was operated with a dry bed; no pool was kept behind the dam for a majority of the year. The exception was a 25 foot pool that was maintained in winter in order to keep the flood gates from freezing. During dry bed operation, small amounts of sediment routinely passed through the dam. In 1966, an experimental pool to depth of 65 feet was implemented to allow sediment to settle out and prevent it from harming trout habitat areas below the dam. Secondary benefits of that measure were enhancement of both the aesthetics of the area and recreational potential at and below the project. Later, the 65 foot pool was made a permanent part of Ball Mountain operations, along with the 25 foot winter pool, although other seasonal fluctuations, such as those due to storm events and planned recreational releases, still took place.

The areas upstream of the project are very mountainous, causing the West River and its tributaries to exhibit flashy characteristics. Significant increases to the pool level at the dam can be experienced in a very short time. Maintaining a specific pool level at Ball Mountain Lake through manual operation of the gates is, therefore, a very difficult task.

The Connecticut River Atlantic Salmon Restoration Program, a joint effort between New England states and Federal agencies, was established to reintroduce the Atlantic Salmon to Connecticut River and its tributaries, including the West River. In response, an automated system for the operation of the center gate at Ball Mountain Dam was installed in 1993. Its purpose is to provide automatic regulation of a 25 foot pool during the smolt migration period from May 1st to June 15th. In addition to the automated gate at Ball Mountain Dam, construction of a fish trap at the nearby Townshend Dam was completed in 1993. The fish trap provides a necessary link to the West River above Ball Mountain Lake, allowing adult salmon caught in the impoundment to be transported upstream of the two dams.

Over time, a large volume of alluvial sediments accumulated behind the dam. Problems were encountered with the automated gate during the first year of operation, and malfunctions twice caused the pool level to be lowered inadvertently below 25 feet, allowing some of the sediment to be released downstream. In 1995, the valve in the line feeding the float well in the dam's gate tower began leaking. This condition meant that the water level in the float well was lower than that of the pool, and the automated gate could not be used because it depends on sensors located in the float well to determine pool level. During the interim, manual operation of the gates, an error in the estimation of inflow caused the pool to drop overnight below the 25 foot stage. As a consequence, a large quantity of sediment was released downstream. The float well valve has since been repaired, but there remains a risk that debris could block the float well or damage the valve.

The recent sediment releases have unfortunately produced adverse environmental consequences. The impacts to water quality in the West River at those times likely caused fish kills and reduced the quality of attractive reproductive habitat for aquatic life.

The purpose of this study is to develop and evaluate alternatives intended to reduce the likelihood that any further sediment releases from Ball Mountain Dam will occur. Alternative measures under consideration will be evaluated for engineering feasibility, constructability, environmental impacts and cost. Based on the information presented herein, the Operations Directorate of New England Division will seek to implement one of the several proposed plans.

STUDY PURPOSE AND SCOPE

This study was initiated to investigate a number of alternative measures to reduce the chances of accidental discharges of sediment through the Ball Mountain Dam. The merits of each of the alternatives will be examined with respect to engineering feasibility , impacts to environmental resources, and cost. Implementation of any alternative, or combination of alternatives is subject to the recommendation of the Corps of Engineers New England Division Operations Directorate, as well as approval of its Fiscal Year 1998 budget initiatives at the Headquarters in Washington D.C.

PHYSICAL CHARACTERISTICS AND SETTING

Ball Mountain Dam is located on the West River in the Town of Jamaica, about three river miles above Jamaica Village. It has been an important part of the Corps of Engineers flood control network in the Connecticut River Basin since its completion in 1961. The dam is located on the West River about 9.5 miles upstream of the Corps' Townshend Lake flood control project and 29 miles upstream of the Connecticut River confluence. The dam is a 915 foot long rolled earth and rockfill embankment with a maximum height of 265 feet. Outlet works consist of a gated intake structure and a 864 feet long 13'6" diameter discharge conduit through the dam. Its spillway crest is at elevation 1017.0 feet.

From mid June through early October, a 65-foot deep conservation pool is normally maintained at the project. The pool has a maximum depth of 65 feet, a surface area of 75 acres, and extends about 9000 feet upstream of the dam. The elevation of the 65 foot pool is 870.5 feet. During the fall, winter, and early spring the pool is lowered to minimize ice damage along the

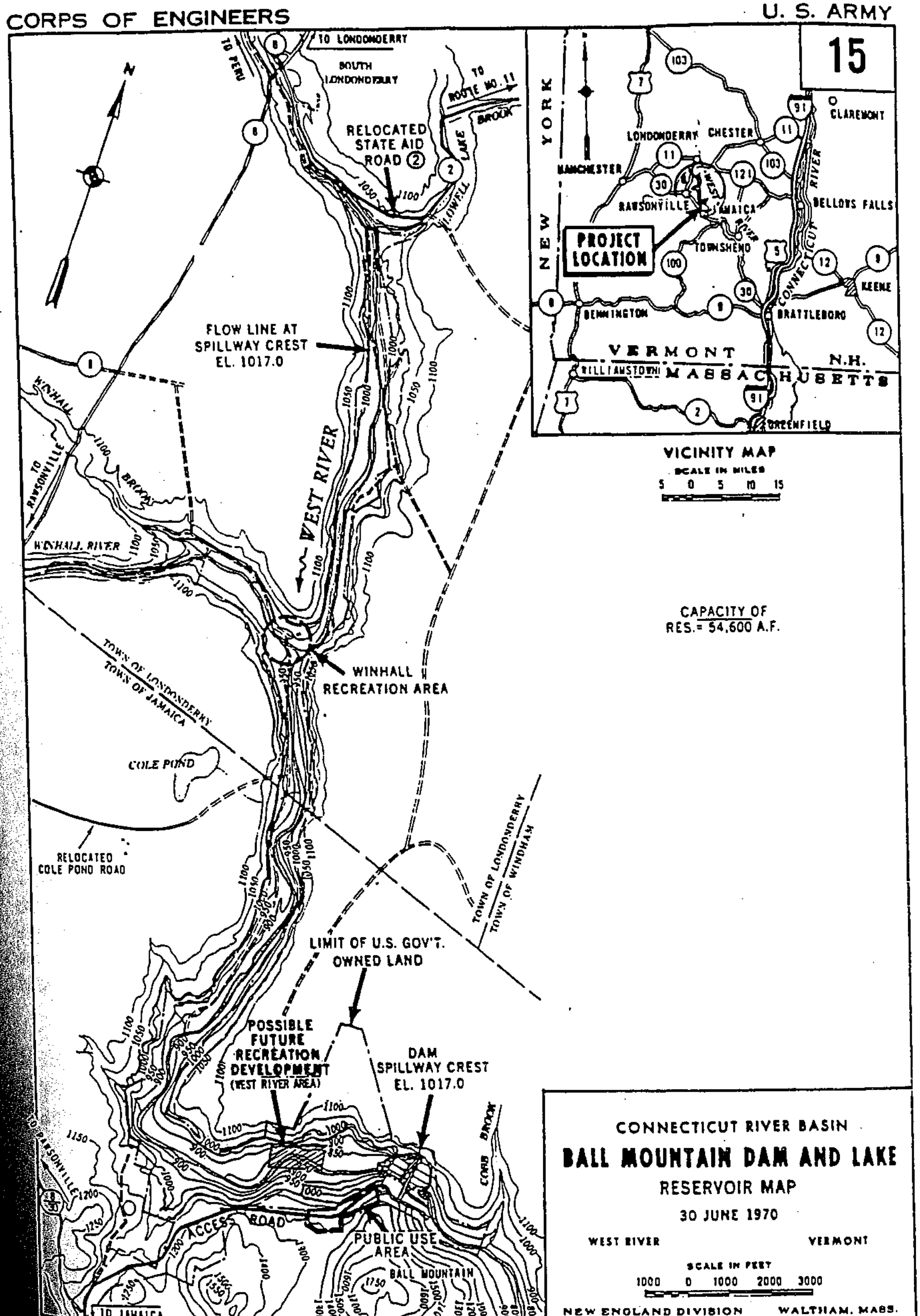

Plate 1 Project Map

shore. In recent years the winter pool elevation typically ranges between 35 and 50 feet. Since 1992, the pool has been lowered to 25 feet from the last weekend in April until about June 15 to enhance downstream migration of Atlantic salmon smolts.

During flood control operations the reservoir has a maximum surface are of 819 acres and extends up to 6.5 miles upstream along the West River and Winhall Brook. The reservoir has been operated for flood control purposes on numerous occasions, but storage has rarely exceeded 50 percent of capacity. Full capacity was reached only once, during the flood of April, 1987.

Other Facilities present include a large public campground near the confluence of Winhall Brook and the West River and hiking trails. In total, the project lands encompass 1227 acres.

The river basin has a length of about 38 miles, and a maximum width of 18 miles. The total basin area is 423 square miles, of which 172 square miles are upstream of Ball Mountain Lake. Topography in the basin is hilly with elevations ranging from 200 feet NGVD at the mouth of the West River, to 3500 feet at several points on the watershed divide. There are few natural lakes in the region. The basin is primarily forested and undeveloped. Agricultural land is scarce in the watershed, and is confined almost entirely to floodplain areas along the West River and its tributaries. The portion of the watershed near the dam is best characterized as "flashy". Significant increases to the pool level at the dam can be experienced in a very short time.

WATER AND SEDIMENT QUALITY

Water Quality - Water quality in the West River is rated as class "B" by the Vermont Legislature. Class "B" waters are suitable for bathing, recreation, and irrigation, provide good fish and wildlife habitat, have good aesthetic value, and are acceptable for use in public water supply (with filtration and disinfection). Water quality in the West River is generally good, and usually meets these standards.

The West River and its tributaries are further designated as Type I and Type II waters. Which particular sections are of the river are Type I or II, however, has not been specified. By definition, Type I waters sustain natural reproducing populations of salmonids, have dissolved oxygen levels of not less than 7 mg/l at and near spawning areas, and at least 6 mg/l at all other areas. Type II waters contain mixed populations of brook trout, brown trout and smallmouth bass, and shall not contain less than 6 mg/l dissolved oxygen at all times.

Ball Mountain Lake water quality was investigated in a series of studies conducted between 1974 and 1986. Based on nutrient levels (phosphorus and nitrogen) and chlorophyll a levels (a measure of phytoplankton abundance) the impoundment is classified as borderline oligotrophic/mesotrophic.

Temperature profile data from deepwater stations near the dam indicate that the impoundment exhibits weak to moderate thermal stratification in the summer. Stratification is most pronounced on calm sunny days, but can be broken up by wind action at night, or on cool, cloudy days. When stratification is well developed, bottom waters can be 10 to 15°F cooler than surface waters. Water temperature near the bottom of the impoundment ranges from about 55 to 70°F in June through August.

Coldwater discharges from Ball Mountain Lake may moderate West River stream temperature during the summer. The Vermont Fish and Game Department observed that releases from the impoundment reduced the temperature of tailrace waters by an average of 10°F in 1966. West River water temperature data collected by the Corps from 1971 through 1982 indicates that median temperature about 2 miles downstream of the dam is 5°F cooler than upstream of the impoundment. Not enough information is available, however, to definitely attribute the difference to cold water releases from Ball Mountain Lake.

Dissolved oxygen levels in surface waters are generally above 6 mg/l. Thermal stratification results in somewhat depressed dissolved oxygen levels in hypolimnetic (bottom) waters, but anoxic conditions have not been observed. pH ranges between about 5.5 and 7.

Average suspended solid level at several stations in the West River upstream of Townshend Dam between June and October of 1993 was 3.3 mg/l; n = 80. The maximum reported level was 32 ppm. Based on visual observations, much higher suspended sediment levels likely occur during heavy runoff events, with Winhall Brook a major contributor. Although the reservoir clearly acts as a settling basin to trap suspended solids, no studies have documented the effect of the impoundment on downstream suspended sediment solid levels.

Sediment Quality - Little sediment quality data is available for the reservoir. A composite sample collected from the top 4" of sediment near the edge of the 25 foot pool was composed of mostly silt and clay with some sand. Ball Mountain Lake sediments have not been tested for contaminants. Given the undeveloped nature of the watershed, however, it is very unlikely that the sediments contain contaminate levels which would adversely effect aquatic life or necessitate special dredged material disposal measures.

<u>ENVIRONMENTAL RESOURCES</u>

Biological Resources

Fish - Ball Mountain Lake supports a limited warmwater fishery. Species likely to be present include fallfish, largemouth bass, white sucker, longnose sucker, yellow perch, brown bullhead, golden shiner, common shiner, and pumpkinseed sunfish. Wide seasonal variations in pool level, lack of cover, and lack of aquatic vegetation, limits development of the fishery.

The State of Vermont stocks Winhall Brook, near the West River confluence with brook trout and the West River downstream of Ball Mountain Dam (near Cobb Brook) with rainbow trout. At one time the West River near the old Pratts Bridge site and Ball Mountain Lake were also stocked with trout. A self reproducing brown trout population once occurred in the West river downstream of the dam, but in recent years no young of the year have been noted at the site by the Vermont Department of Fish and Game.

In recent years state and federal agencies have been working to restore Atlantic Salmon to the Connecticut River Basin. Efforts have focused on construction of fish passage facilities on mainstem Connecticut River dams and on intensive stocking of selected tributaries with hatchery reared fry.

The West River has been stocked with large numbers of fry since 1987 and proven to be one of the best salmon streams in the basin. Areas stocked include numerous tributary streams and sections of the mainstem West River, including the reach downstream of Ball Mountain Lake near Jamaica State Park. According to the Vermont Department of Fish and Game, fry survival and growth in this reach is usually exceptional, but was severely impacted by the sediment releases that occurred from Ball Mountain Dam in 1993. No information is yet available about the impact of the 1995 sediment release.

In 1992 the Corps constructed a fish trap at Townshend Dam to capture adult salmon returning to the river to spawn. Two adult salmon have been captured at the trap and released upstream of Townshend Dam. The Corps also modified Ball Mountain Lake operation to enhance downstream smolt migration. This involved lowering the reservoir to 25 foot during the smolt migration period (late April through mid June). Studies using radiotaged smolts indicate that lowering the pool to 25 foot allows smolts to pass Ball Mountain Lake with minimal delays and no obvious mortality. Maintaining a higher pool stage would expose the smolts to more extreme pressure changes as they pass through the outlet gates and is not recommended by the Vermont Department of Fish and Game. Proper operation of Ball Mountain Lake to facilitate downstream smolt migration is essential to success of the West River restoration program since about 50 percent of West River smolt habitat is upstream of Ball Mountain Lake.

Other Aquatic Life: Aquatic invertebrates occurring in the West River downstream of Ball Mountain Lake include caddisflies, stoneflies, aquatic dipterans, freshwater sponges, freshwater mussels, and other species. No studies of the effect of the silt releases on the invertebrate community are available. Qualitative observations made shortly after the June 1995 event, however, suggest that stream habitat was severely impacted by siltation up to 2.5 miles downstream of the dam. Rocks in riffle areas covered with silt were devoid of visible life, while, those in areas without silt supported caddisfly larvae, freshwater sponge, and other species.

Vegetation - Little wetland or submerged aquatic vegetation is present in Ball Mountain Lake near or below the normal 65 foot summer pool. Vegetation is probably lacking mainly due to the extreme seasonal fluctuations in water level (i.e. 25 ft. to 65 ft. pool stage) and to a lesser extent short term variations in water level caused by flood control storage. In some locations poor substrate (i.e. rocky soil or bedrock outcrops) and steep slopes also limit vegetative growth. The reservoir shoreline between the 65 foot stage and 80 foot stage is vegetated by grasses, other herbaceous species, and low shrubs. Above the 80-foot stage the reservoir is mostly forested.

Wildlife - Common mergansers are abundant at Ball Mountain Lake during the summer and fall. Other waterfowl such as mallards, canvasbacks, cormorants, and hooded mergansers are present but not abundant. Dabbling and diving duck populations are probably limited by lack of emergent and submerged aquatic vegetation needed to provide nesting, brooding, and foraging habitat. Large mammals likely to occur near at Ball Mountain Lake include white tailed deer, fox, fisher, mink, muskrat, otter, and black bear.

Protected Species - Several species of rare or protected freshwater mussels are known to occur in the West River. These include the brook floater, listed as threatened in Vermont, and as a U.S. Fish and Wildlife Service Category 2 "candidate species" for inclusion on the Federal list of threatened and endangered species. Several large populations of brook floater, a rare freshwater mussel, are present downstream of Townshend Dam. A small brook floater population was also present near the route 100 bridge in East Jamaica, but may have been extirpated by the 1995 sediment releases from Ball Mountain Lake.

Except for transient bald eagles, peregrine falcons, and Atlantic salmon (a U.S. Fish and Wildlife Service species of special concern), no other Federal or state protected species are known to exist either at Ball Mountain Lake. A thorough survey of the project for rare and protected plants and animals is scheduled to occur during the spring and summer of 1996

Historic and Archeological Resources

A Cultural Resource Management Study for Ball Mountain Lake was completed in 1982. This study identified two finds that could be affected by pool fluctuations. One find spot, WD-FS-3, was a large terrace, normally below the level of the summer reservoir. One bifacially worked quartzite cobble was found on the surface during a walkover of the terrace.

The second area was a small terrace at the northern edge of the summer pool (870.5 ft. MSL). Further investigations were performed at this location in 1984, as part of a proposed plan to convert the dam to produce hydroelectric power, and prehistoric site VT-WD-36 was identified. It was determined that site VT-WD-36 met the eligibility criteria for nomination to the National Register of Historic Places. A short-term monitoring program implemented by the Corps at that time did not identify any significant terrace erosion at VT-WD-36.

Social and Economic Resources

Ball Mountain Lake is located in a largely rural area of southeastern Vermont. Much of the area is forested and undeveloped. Principal towns near the project include Townshend, Jamaica, and Newfane. Brattleboro, the 8th largest city in Vermont, is located about 30 miles southeast of Townshend Lake. Several major population centers (Boston, Massachusetts; Concord, New Hampshire, Albany, New York; and Hartford, Connecticut) are within a three hour drive of the area. Vermont Route 30, parallels the West River, and provides easy access to both projects from Brattleboro.

The local economy is dependent on the forest products and tourist industries. Tourism is largely based on sight-seeing during the summer and fall, and downhill skiing during winter months. Recreational opportunities at Ball Mountain and Townshend Lakes and the nearby Jamaica State Park also draw many visitors to the area. Numerous retail shops, motels, and restaurants are present in the area, and are heavily dependent on tourism. Manufacturing, construction, and agriculture play a relatively minor role in the local economy.

Recreational facilities available at Ball Mountain Lake include the Winhall Brook campground and hiking trails. A boat ramp is present on Ball Mountain Lake but is rarely used. Popular fishing spots include the Winhall Brook and the West River near the Winhall Brook campground and the West River downstream of Ball Mountain Dam. Little fishing occurs in Ball Mountain Lake but stocked reaches of Winhall Brook and the West River near the dam are popular fishing spots for trout.

Each year the Corps provides controlled releases from Ball Mountain Lake for whitewater canoeing and kayaking. Releases typically occur during the last weekend in April and during Columbus Day weekend in October. The releases provide outstanding white water conditions between Ball Mountain and Townshend Lakes and attract hundreds of white water enthusiasts each year. Several outfitters service the event.

Potential Disposal Areas

Several potential dredged material disposal areas were identified at Ball Mountain Lake. These include three old borrow areas (J, K, and R) used during construction of the dam, a small area behind the project's existing shop building and the Ball Mountain Dam spillway channel.

Borrow Area J is a 2 acre depression located near the Ball Mountain Lake boat ramp. The site is inundated by the normal 65-ft pool but is completely exposed when the pool level drops below about 45 ft. The site was exposed during much of the summer of 1995 and was lightly vegetated with grasses, herbs, and a few low shrubs. The substrate is silty sand with numerous stone and scattered boulders.

Borrow Area K is an upland area located north of the main project access road. The site is steeply sloped for the most part, but includes a relatively level terrace that is well suited for use as a disposal site. The upper slope and terrace are vegetated with small pine and aspen. The lower slope is forested with mature maple, beech, and other hardwoods. A small stream runs along the base of the slope, about 200 feet below the terrace.

Borrow Area R is an upland area located south of the main project access road. Most of the site is upland and is steeply sloped. The site is vegetated with grasses, herbs, and scattered small trees and shrubs. Tree and shrub species noted during a February site visit include Aspen, gray birch, white pine, Eastern hemlock, white pine, and willow. Scrub-shrub and emergent wetland, totaling about 0.5 acres, is present along a drainage swale at the base of the area.

STUDY ALTERNATIVES

The following alternative measures were outlined at a meeting of the Windham Regional Commission on November 28, 1995. Some of the alternatives are structural solutions, and involve dredging, construction activity or other physical installation to the Project. Other alternatives involve changes to the way the Project is operated. Each was deemed to have some merit, and will be individually discussed under its own heading.

- **Dredge Intake Area Only -** This alternative would involve removal of sediment from the immediate vicinity of the dam's intake structure. A floating, hydraulic dredge would most likely be used. The projected volume of sediment would likely range from 1000 to 6000 cubic yards. Snags and debris are known to be located in that area, so some of the work is expected to be fairly labor intensive. Frequent maintenance dredging of the area would be necessary. A disposal site for the dredged material would need to be identified.

- **Dredge Larger Portion of Entire Pool -** This alternative calls for the removal of much greater quantities of sediment, encompassing the area between the dam's intake structure and the log boom and beyond. A floating, hydraulic dredge would most likely be used. The volume of accumulated sediment between the intake and the log boom is estimated to be 120,000 cubic yards. If dredging the entire pool, out beyond the log boom, is considered, the estimated volume of accumulated sediment to be removed is 240,000 cubic yards. Periodic maintenance dredging, the extent of which would be dependent on the initial volume of sediment removed, would be necessary following any implementation of this measure. A disposal site for the dredged material would need to be identified.

- **Draw Down Pool and Excavate Sediment -** This alternative calls for the removal of sediment, by conventional excavation, after the complete drawdown of the pool at Ball Mountain Lake. The sediment would be removed from the area between the dam's intake structure and the log boom. The total volume of accumulated sediment between the intake and the log boom is estimated to be 120,000 cubic yards. Periodic removal of additional sediment, either by dredging or future excavation, would be necessary if this measure were implemented. The extent of future maintenence would be dependent on the initial volume of sediment removed. A disposal site for the material would need to be identified.

- **Construct Intake Weir -** One possible method of protecting against loss of the pool at Ball Mountain Lake would be to construct a permanent intake weir of sufficient height to maintain a minimum 25 foot high pool level behind the dam. The intake weir would be a structure built around the intake channel in which the automated gate is located. Some dredging of the area around the intake would be necessary in order to implement this alternative. A disposal site for the dredged material would need to be identified.

- **Modify the current set of operating guidelines for the Project -** This alternative considers changes to the pool levels presently maintained behind the dam. The summer pool level is kept around 65 feet. In winter, the pool elevation is allowed to fall to a range of 40 to 50 feet. In late spring, coincident with smolt migration, the pool level is drawn down to 25 feet. The planned drawdowns also provide for both spring and fall recreational releases. The impact of changes to any of these criteria, including the possibility of reverting to dry bed operation at Ball Mountain Lake, will be investigated.

- **Modify Instrumentation -** The existing instrumentation installed at ball Mountain Dam will be evaluated. Several changes or modifications to instrumentation, based on available technology, will be investigated for potential improvements to reliability and accuracy.

- **No changes to the existing Project -** At Ball Mountain Dam, the center flood gate was fully automated in 1993. A leaking float well valve was replaced by a new valve with the capability of being "flushed out" in early October of 1995. It has been suggested that with an annual clean out of this new float well valve, and the possibility of increasing the staffing of the project to two shifts at times when a 25 foot pool is being maintained, no further physical improvements to the Project need to be made.

STUDY PARTICIPANTS AND COORDINATION

An initial meeting hosted by the Windham Regional Commission took place on September 19, 1995. Members of the Commission were joined by representatives of the U.S. Fish and Wildlife Service, the Vermont Agency for Natural Resources, the Vermont Fish and Wildlife Department, the Jamaica Planning Commission, the Connecticut River Watershed Council, the Corps of Engineers and a number of state officials. The meeting allowed the participants to share their viewpoints on the siltation problem and provide input to the strategies the Corps could pursue towards a solution.

Presentation of an outline of alternatives for this study took place on November 28, 1995, when Corps of Engineers representatives participated in a regular meeting of the Windham Regional Commission. Questions from the attendees were fielded, and a plan for further progress reporting was generated.

A second meeting was held on May _, 1996. Details of the developed study alternatives were discussed with selected representatives of the Commission.

A Public Notice of the Draft Report's availability was printed in the Brattleboro Reformer on May _, 1996. Copies of the draft report were made available through the Windham Regional Commission's office in Brattleboro and the Corps Project Office located on the access road to Ball Mountain Dam.

Corps of Engineers personnel met with members of the Windham Regional Commission's Rural Lands Committee on May _, 1996 to discuss the contents of the Draft Report. Written comments received by June 5, 1996 were incorporated into this report.

DREDGING BALL MOUNTAIN LAKE

Estimates prepared by New England Division indicate that 4100 cubic yards of sediment accumulates annually at Ball Mountain Lake. Based upon soundings taken in June, 1995, and information contained in record drawings for Ball Mountain Dam Project, a total of 120,000 cubic yards of sediment has settled in the pool area between the intake and the log boom over the twenty nine years since a permanent pool was implemented. If the entire pool is considered, the estimate of the total volume of accumulated sediment within the limits of the 65 foot pool beyond the log boom is 240,000 cubic yards. Removal of some portion of this sediment is called for by a majority of the proposed plans.

Dredging alone is not a complete solution to the problem of sediment releases. Even if all of the accumulated sediment were removed, the new sediment load associated with the next storm event could be potentially harmful to downstream habitat if the storm event was coincident with, or followed by a complete loss of the pool. Dredging would reduce the risk that the entrance to dam's float well will be blocked, and would reduce the volume of material that is available to be washed downstream. Another benefit would be to provide a settling basin capable of trapping at least some material that might be mobilized by a partial pool loss.

Because of the topography in the vicinity of Ball Mountain Lake, access for equipment capable of dredging the pool is difficult. One recent sample of material from the area between the dam and the log boom showed a combination of fine sand and silt. A likely method of removing material like this would be to employ a small floating hydraulic dredge known commercially as the "Mudcat". The Mudcat, or similar equipment, is small enough to be transported to the pool at Ball Mountain Dam. Once there , it would also have the maneuverability and extension to reach tight spots. Its output with one booster pump is reported to be 100 cubic yards per hour with fine material. The projected rate of removal of sediments using this type of equipment is 24,000 cubic yards per month.

The plan for dredging calls for removal of sediment from the intake channel and its vicinity to the greatest extent possible. Since the purpose of dredging is to control sediment movement, a basin, rather than a channel, is needed to allow settling of suspended material before it gets to the intake and becomes susceptible to being washed downstream. The best location for this basin is immediately upstream of the intake. Dredging somewhere near the middle of the pool might be an easier task, however, when the water level drops, it is the material immediately in front of the gates that is the first to go. Therefore, this is the material that is the most important to remove. The configuration of the dredged basin should be roughly concentric around the intake. This remains so for any quantity of sediment selected for removal.

The single sample of material that was available to this study did not constitute sufficient information to predict what underwater slopes would be stable. Based upon the June 1995 soundings, estimated of the prevailing underwater slopes upstream from the dam's intake show a wide variation ranging from 9:1 to 250:1. With no guarantees of stability, the most important criteria would be removal of the required volume for any project; the remaining material will adjust to naturally stable slopes.

As soon as some volume of accumulated sediment is dredged from Ball Mountain Lake, the dredged basin will begin to gradually fill in. The basin side slopes are expected to find their own angle of repose, and an average annual load of 4100 cubic yards of new sediment is expected to be added to the system. Consequently, periodic maintenance dredging will be necessary to support any study alternative for which dredging is a part. For the area between the intake and the log boom, the data presented in Table 1 suggest an interval for the maintenance dredging that corresponds to an initial volume option. The interval "Years To Fill" represents the estimated length of time for which any benefit will be realized from dredging compared to existing conditions.

For example, if a volume of 48,000 cubic yards were removed from Ball Mountain Lake according to the criteria named above, maintenance dredging of a similar magnitude would probably be required 18 years later. Periodic surveys of pool depth scheduled for the intervening years could provide indications of whether or not a shorter interval for maintenance dredging would be appropriate.

The same goals and objectives that apply to proposed dredging activities also apply to the alternative that calls for the removal of sediment, by conventional excavation, after the complete drawdown of the pool at Ball Mountain Lake.

TABLE 1 - BALL MOUNTAIN LAKE
EXPECTED DREDGING PROJECT LIFE

Percent Pool Dredged	Volume Dredged (CY)	Percent of Annual Sediment Load Captured Between Intake and Log Boom	Sediment Load Captured (CY/Year)	Years To Fill
1	1,200	10	410	2.9
5	6,000	17	700	8.6
10	12,000	25	1,030	12
20	24,000	40	1,640	15
25	30,000	47	1,930	16
30	36,000	54	2,210	16
40	48,000	65	2,670	18
50	60,000	75	3,080	19
60	72,000	83	3,400	21
70	84,000	89	3,650	23
80	96,000	93	3,810	25
90	108,000	95	3,900	28
100	120,000	100	4,100	29

DISPOSAL OPTIONS FOR DREDGED MATERIAL

A variety of possibilities exist for the disposal of sediments dredged from Ball Mountain Lake. The disposal options fall into one of three categories:

- Onsite Upland Disposal
- Onsite Disposal For Wetlands Creation
- Offsite Upland Disposal

The scope of this study and available surveys limited the number of areas considered for onsite upland disposal. Dredged material would first be partially dewatered behind a temporary berm built along the edge of the pool between the shore access road and the log boom. A six foot high berm up to 1200 feet in length and 150 feet wide could be accommodated if the level of the pool was kept at 25 feet during construction. Approximately 27,000 cubic yards of dredged material could be accommodated at any time. The dredged material would then be removed from inside the berm and trucked to the upland sites.

An upland site adjacent to the dam's paved access road known as "Borrow Area R" could conservatively accept up to 33,000 cubic yards. This is a partly hilly area, however, and some stone protection would be required on the steeper finished slope. The drainage of the area boundaries would have to be reworked if "Borrow Area R" is used.

Room for fill material exists at the base of a large embankment adjacent to the paved access road to the dam about 8/10 of a mile from the road's junction with Route 30. This area is known as "Borrow Area K". Construction of a berm at about elevation 1040 feet would be required to contain the fan of material. Vegetative cover would be planted to help stabilize the new slope. The capacity of "Borrow Area K", based on a 400 foot long section, is estimated to be 32,000 cubic yards.

A small, flat area behind the shop located on the access road to the dam can accommodate approximately 4400 cubic yards of material. This area might be more valuable to the Project if kept available for other uses, however. It should be utilized only after the capacities of the other upland areas of the project are exhausted.

The spillway channel is a rough and uneven area for which the project personnel have a maintenance responsibility. They have requested some fill to level this area and facilitate future maintenance. Up to 3400 cubic yards of compacted material would satisfy that requirement. More disposal capacity could be achieved at the spillway channel if a confinement berm or slope protection was provided along two sides of that area. The spillway lip and adjacent rock wall would provide natural confinement for the area's other two sides. If a layer of dredged material six feet thick is placed on the spillway channel, its volume would be 20,400 cubic yards.

The concept of onsite disposal for wetlands creation combines short pumping distances for a hydraulic dredge and simplified material handling with environmental enhancement. One candidate area, known as "Borrow Area J", is a naturally bowl-shaped area located at the edge of the pool just east of the end of the unpaved service road that leads to the pool from the dam's paved access road. A containment dike could be constructed across the bowl to retain dredged material. If the summer pool elevation was coordinated with the final elevation of the sediment, the area could become revegetated with wetlands species. The dike would be made of armor stone, gravel bedding and granular fill. The armor stone would have to resist the ice action experienced during fluctuations of the winter pool. The top of the dike would be broad enough to allow equipment, such as a tractor, shoreline access at pool elevations below the top of the dike.

The capacity of the proposed diked containment area would be 13,500 or 18,500 cubic yards of dredged material depending upon its finished height. The material placed inside would naturally dewater through the dike. For proposed plans where the extent of dredging is 72,000 cubic yards or more, and a permanent dike for wetlands creation is being constructed, the area of the temporary berm for dewatering could be reduced by about one half. Upon completion, the yield at "Borrow Area J" would be approximately one acre of emergent wetland. The pool level would still need to be maintained at the 25 foot level for the smolt migration period.

If a containment dike were to be built, it may be possible to use dredged material placed in elongated geotextile bags as a substitute for the granular fill. If that is feasible, then the capacity to receive dredged material for any given size of dike would be increased, and the cost of the dike would decrease. However, the unit costs for disposal associated with upland onsite disposal were consistently much less than those for onsite disposal for wetlands creation.

No opportunities were identified for offsite upland disposal. While the dredged material is expected to be very clean and provide excellent fill, none of six local contractors canvassed expressed an interest in acquiring material that had not been thoroughly dewatered. A large, temporary site for dewatering would be needed to store larger quantities of material for the extended period necessary to dewater. The Project lands at Ball Mountain Lake do not feature a large enough suitable area to efficiently accommodate those quantities of stored material for extended periods of time.

Several plans are proposed that call for a volume of dredged material to be removed in excess of the upland capacity identified onsite. In those cases, it is assumed that the remainder of the material will be hauled by truck to an approved upland disposal site not more than twenty-five miles from Ball Mountain Lake.

DREDGING PLUS CONSTRUCTION OF AN INTAKE WEIR

The construction of an intake weir around the central, automated gate at Ball Mountain Dam would be an extremely effective means of preventing the kinds of accidental sediment releases that occurred in 1993 and 1995. The proposed structure would be constructed of reinforced concrete and be similar to a weir that already exists at Townshend Dam. Its preliminary dimensions are 25 feet high, 24 feet long and 15 feet 8 inches wide, with wall thicknesses of 3 feet or 2 feet 6 inches, dependent upon their location. The weir's two longitudinal walls would each encompass an existing trash rack support, while a third support would remain in place within the weir. A splash pool for fish survivability would be sculpted at the bottom of the weir. Once the weir was in operation, the project could be operated with either a permanent 25 foot pool, or keep the pool at some higher elevation, perhaps consistent with the creation of new wetlands through disposal activities.

From the standpoint of both safety and ease of constructibility, it would be prudent to construct such a project in the relatively dry summer season. Some dredging, probably at least a volume of 6000 cubic yards, would have to be accomplished first. The cost to build an intake weir might vary considerably, depending upon the method used. If the pool is allowed to be slowly drawn all the way down, then a conventional means of construction could be used, and the cost is estimated to be $187,000. Prior dredging of the area should remove most material from around the intake; however, for any extreme drawdown, there would likely be an accompanying release of some sediment downstream. One suggestion is to schedule completion of the weir to precede a fall recreational release, with the expectation that the release would quickly flush the new sediment load out of the West River habitat below Ball Mountain Dam. Ultimately, the sediment would reach Townshend Lake.

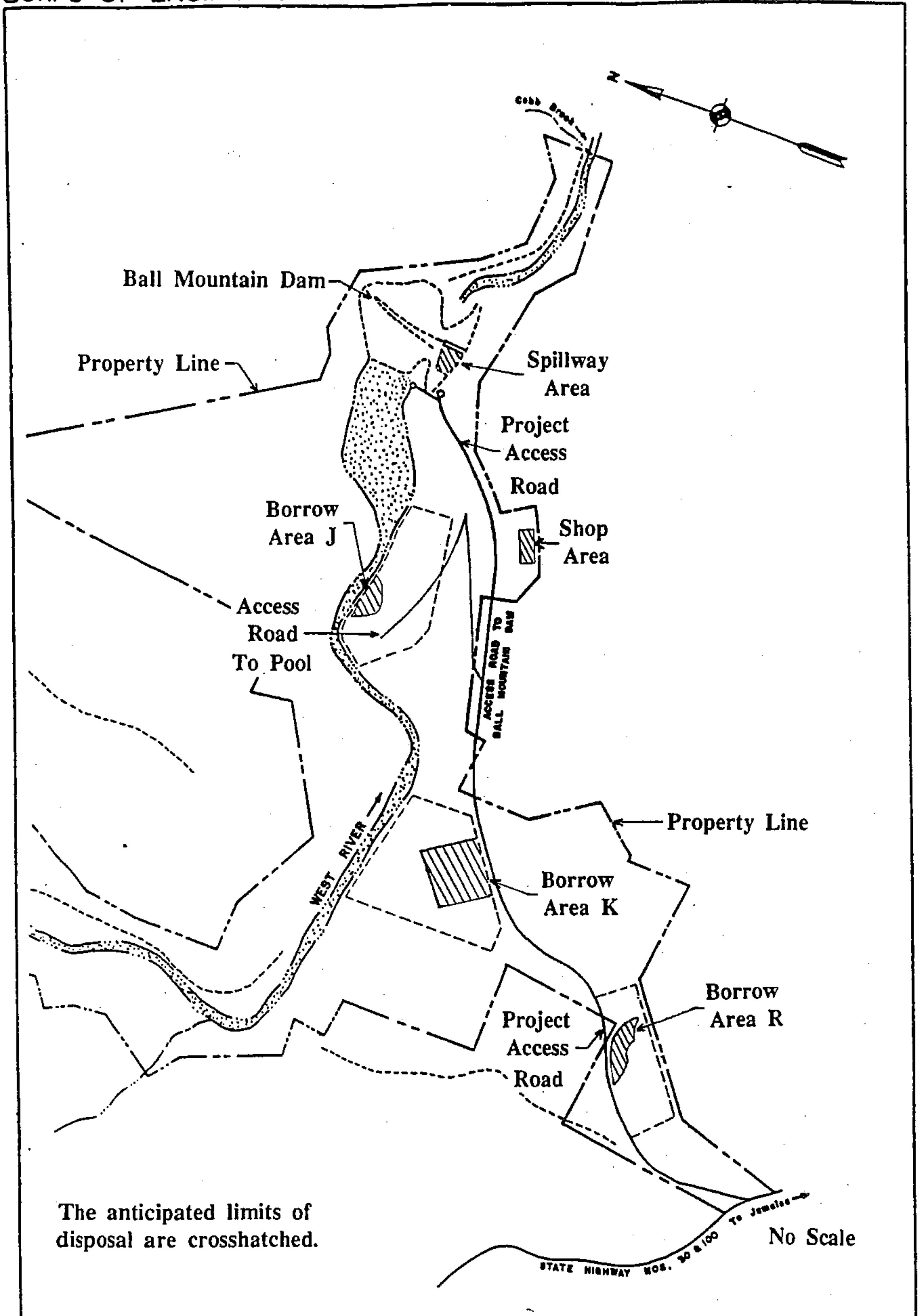

Plate 2 Location of Proposed Onsite Disposal Areas

Another approach, under consideration in the event that the pool cannot be drawn down, is to employ a temporary cofferdam built around the intake structure. The cofferdam would hold back the low pool as well as any sediment that encroached after dredging. A "bulk bag" cofferdam consisting of one cubic yard polyethylene bags filled with a sand-cement mixture is one design that may be suited to the site requirements at Ball Mountain Dam. The cofferdam would be at least eighteen feet high and some means to duct a minimum flow through the dam would be necessary. The need for a small barge equipped with a crane, along with divers to position the bags, makes the use of a cofferdam a more expensive way to construct the intake weir at an estimated $745,000.

A third scheme calls for the basic structure of the weir to be modified from cast in place reinforced concrete to precast, reinforced concrete panels to be placed between driven steel "H" piles. A structure like this could be built entirely in the wet, without a cofferdam or a significant drawdown of the pool. Sophisticated survey, a barge equipped with a drill rig and pile driver, a barge equipped with a crane, and other special preparations would be required for the operation. Construction of an intake weir using "H" piles and precast concrete panels is estimated to cost $435,000.

The idea of creating a functioning weir by placing prefabricated panels in the existing stoplog slots in front of the automated gate was investigated. The cost of the panels and their installation promised to be much less than the cost of the other proposals. At the invert of the gate tunnel, there would be sufficient space to provide a splash pool upstream of the gate. Unfortunately, there would be insufficient horizontal distance between the weir and the concrete wall of the gate tower to allow fish to fall, unimpeded, into the splash pool for flows greater than 150 cubic feet per second. A review of the flows experienced during the months of May and June in two recent years indicated a typical range of 50 to 1,050 cubic feet per second. During all but the lowest flow conditions, fish would be thrown against the wall with likely high mortalities. Further development of this idea was abandoned.

MODIFY THE CURRENT SET OF PROJECT OPERATING GUIDELINES

The differences in available flood storage offered by varying pool depths at Ball Mountain Lake between 25 feet and 65 feet is only 0.2 inches of runoff. This relatively negligible change in storage capacity has no impact on the Project's flood control capability. However, lower levels set for a permanent pool could have a negative effect on volumes available for recreational releases.

Reverting to a dry bed reservoir from spring through fall would require a significant initial dredging operation at Ball Mountain Lake. The pool would need to be dredged from the intake out to the log boom and likely beyond. Once that was accomplished, future large sediment releases would be prevented. Still, a characteristic of the dam's operation in the early 1960's was the regular release of small amounts of sediment, and that circumstance would be expected to reoccur. Fall recreational releases would be eliminated. A winter pool of at least 25 feet would still be required in order to prevent the gates from freezing.

MODIFY INSTRUMENTATION

The existing instrumentation at Ball Mountain Dam utilizes a floatwell, in which the water level moves up and down coincident with the pool level. The dam's data recorder for flood control operations uses a float mechanically connected to digital encoding devices.

The data recorder contains a transmitter allowing it to transmit data directly to the New England Division Reservoir Control Center in Waltham, Massachusetts over the GOES satellite system. A backup data recorder contains a telephone modem programmed to dial several telephone numbers in sequence in response to both low and high pool level alarm readings. The modem operates through conventional telephone lines which are vulnerable to storm damage.

The center automated gate at Ball Mountain Dam was installed in 1992. Its control system relies on two membrane-type pressure sensors installed in the float well. A separate controller receives data from the sensors and activates the gate mechanism electronically as necessary to maintain a set pool level. The accidental sediment release in the spring of 1993 was attributed to a failure of one of the sensors. Although it was replaced by a more robust sensor, the membrane sensors, in general, are more prone to damage from sediment than float-type sensors.

Several opportunities have been identified to improve the reliability of the existing instrumentation. The aforementioned membrane level sensors could be replaced with a new float sensor, tape, and shaft encoder that connected to the automated gate operating system. The estimated cost to install such a change is $11,500. As an alternative to this, the existing gate controller could be entirely replaced by an available unit that has more commonality with devices in place at other New England Division projects. The existing controller relies on certain proprietary technology. The principal advantage of the proposed replacement is better maintainability, from both the standpoint of a standardized spare parts inventory and the availability and responsiveness of repair technicians. The cost of the gate controller replacement is estimated to be $12,000.

To protect the integrity of alarm communications against failure of telephone lines, a cellular telephone modem could be installed. It is proposed that one of the existing data recorders be modified to transmit data to both GOES satellite and conventional telephone lines. The other unit would be dedicated to the cellular communications. The proposed modifications to the equipment are expected to cost $2560. The cost of the cellular telephone service would be approximately $20.00 per month.

To provide additional insurance that operating personnel can be reached in an emergency, both phone systems could be programmed to automatically dial a 24-hour answering service which would then call a list of responsible persons until one was notified. The cost of such a service for the low volume of calls anticipated is $30.00 per month.

The dam's float well valve itself was replaced in October 1995. An important change was to equip the new valve with a means to be flushed out without complete disassembly. Throughout the dam's operational history, the intake pipe and float well valve have not been particularly susceptible to clogging with sediment. However, flushing the system on an annual basis is recommended to guard against damage by sediment. A written procedure needs to be prepared to ensure that level-sensing instrumentation is protected during flushing.

Another possibility is the installation of a new, redundant level sensor independent of the float well. A proposal received from the U.S.G.S. calls for a non-contact pressure transducer linked to a bubble system and orifice. Both data recorders in the gate house would be linked to a sensor located below at the edge of the pool. The instruments' output could be tied to the existing data recorders with or without the previously described proposed modifications. The cost to install this system is $26,000.00, with an estimated annual maintenance cost of $1,000.00 through U.S.G.S.

NO CHANGES TO EXISTING PROJECT

This alternative accepts the repairs and modifications to the float well valve that were performed in October 1995. An annual clean out of the float well valve is the extent of the required maintenance. An average new sediment load of 4100 cubic yards is expected to continue to settle in the pool each year. The project staff coverage would be increased during the period when the 25 foot pool was being maintained.

PLAN FORMULATION

The remedial measures under consideration to reduce the chances of further accidental sediment releases through Ball Mountain Dam fall into two categories. Some are physical modifications that must be either constructed or installed. Others address operational changes that could be made on the Project. The following is a list of measures that were considered either singly or in combination.

ALTERNATIVE MEASURES TO PREVENT ACCIDENTAL SEDIMENT RELEASES

PHYSICAL MODIFICATIONS	OPERATIONAL CHANGES
Removal of Accumulated Sediment	Modify Operating Guidelines
Construct Intake Weir	-Pool Levels
Modify Instrumentation	-Personnel Staffing Levels

An effective plan to solve the problems at Ball Mountain Dam must address both removal of some quantity of sediment that has already accumulated and the adequacy of installed safeguards that warn operating personnel of pool fluctuations and other irregularities. The plans proposed by this study are combinations of the alternative measures listed above. The following is a description of the plans and a comparison of their estimated costs. The costs of all variations of Plans A, B and C consider the use of the Mudcat hydraulic dredge to remove sediments from the pool. For all variations of Plan D, the costs reflect the use of conventional earth moving equipment to remove sediments from the pool.

TABLE 2 - COMPARISON OF PLANS

PLAN	DESCRIPTION	COST
A1	Dredge 24,000 CY	$ 498,700
	Dredged material to:	
	K or R - 20,600 CY	
	Spillway - 3,400 CY	
	Improve Instrumentation	$ 14,600 + $50/mo.
	New float sensors, Enhanced communications	
	TOTAL	$ 513,300 + $50/mo.

TABLE 2 - COMPARISON OF PLANS
(Continued)

PLAN	DESCRIPTION	COST
A2	Dredge 24,000 CY	$ 963,400
	Dredged material to:	
	J - 13,500 CY (build containment dike)	
	K or R - 7,100 CY	
	Spillway - 3,400 CY	
	Institute permanent 55 FT pool*	
	Improve Instrumentation	$ 14,600 + $50/mo.
	New float sensors, Enhanced communications	
	TOTAL	$ 978,000 + $50/mo.
A3	Dredge 72,000 CY	$ 1,086,200
	Dredged material to:	
	K and R - 65,000 CY	
	Spillway - 3,400 CY	
	Behind Shop - 3,600 CY	
	Improve Instrumentation	$ 14,600 + $50/mo.
	New float sensors, Enhanced communications	
	TOTAL	$ 1,100,800 + $50/mo.
A4	Dredge 72,000 CY	$1,429,300
	Dredged material to:	
	J - 13,500 CY (build containment dike)	
	K and R - 55,100 CY	
	Spillway - 3,400 CY	
	Institute permanent 55 FT pool*	
	Improve Instrumentation	$ 14,600 + $50/mo.
	New float sensors, Enhanced communications	
	TOTAL	$ 1,443,900 + $50/mo.

*Except for the smolt migration period, when a 25 foot pool level would be maintained.

TABLE 2 - COMPARISON OF PLANS
(Continued)

PLAN	DESCRIPTION	COST
A5	Dredge 72,000 CY	$1,884,300
	Dredged material to:	
	J - 18,500 CY (build containment dike)	
	K or R - 50,100 CY	
	Spillway - 3,400 CY	
	Institute permanent 60 FT pool*	
	Improve Instrumentation	$ 14,600 + $50/mo.
	New float sensors, Enhanced communications	
	TOTAL	$1,898,900 + $50/mo.
A6	Dredge 120,000 CY	$ 1,869,700
	Dredged material to:	
	K and R - 65,000 CY	
	Spillway - 3,400 CY	
	Off Site Location - 51,600 CY	
	Improve Instrumentation	$ 14,600 + $50/mo.
	New float sensors, Enhanced communications	
	TOTAL	$ 1,884,300 + $50/mo.
A7	Dredge 240,000 CY	$ 3,828,500
	Dredged material to:	
	K and R - 65,000 CY	
	Spillway - 3,400 CY	
	Off Site Location - 171,600 CY	
	Improve Instrumentation	$ 14,600 + $50/mo.
	New float sensors, Enhanced communications	
	TOTAL	$ 3,843,100 + $50/mo.

*Except for the smolt migration period, when a 25 foot pool level would be maintained.

TABLE 2 - COMPARISON OF PLANS
(Continued)

PLAN	DESCRIPTION		COST
B1	Dredge 240,000 CY		$ 3,828,500
	Dredged material to:		
	K and R - 65,000 CY		
	Spillway - 3,400 CY		
	Off Site Location - 171,600 CY		
	Institute dry bed operation		
		TOTAL	$ 3,828,500
C1	Dredge 24,000 CY		$ 963,400
	Dredged material to:		
	J - 13,500 CY (build containment dike)		
	K or R - 7,100 CY		
	Spillway - 3,400 CY		
	Construct Intake Weir		$ 187,000
	(Dry, with drawn down pool)		
	Institute permanent 55 FT pool*		
	Improve Instrumentation		$ 14,600 + $50/mo.
	New float sensors, Enhanced communications		
		TOTAL	$1,165,000 + $50/mo.
C2	Dredge 24,000 CY		$ 963,400
	Dredged material to:		
	J - 13,000 CY (build containment dike)		
	K or R - 7,100 CY		
	Spillway - 3,400 CY		
	Construct Intake Weir		$ 745,000
	(dry, with bulk bag cofferdam)		
	Institute permanent 55 FT pool*		
	Improve Instrumentation		$ 14,600 + $50/mo.
	New float sensors, Enhanced communications		
		TOTAL	$1,723,000 + $50/mo.

*Except for the smolt migration period, when a 25 foot pool level would be maintained.

TABLE 2 - COMPARISON OF PLANS
(Continued)

PLAN	DESCRIPTION	COST
C3	Dredge 24,000 CY Dredged material to: J - 13,500 CY (build containment dike) K or R - 7,100 CY Spillway - 3,400 CY	$ 963,400
	Construct Intake Weir (In wet, with H-piles and precast panels)	$ 435,000
	Institute permanent 55 FT pool*	
	Improve Instrumentation New float sensors, Enhanced communications	$ 14,600 + $50/mo.
	TOTAL	$1,413,000 + $50/mo.
C4	Dredge 24,000 CY Dredged material to: K or R - 20,600 CY Spillway - 3,400 CY	$ 498,700
	Construct Intake Weir (In wet, with H-piles and precast panels)	$ 435,000
	Institute permanent 25 FT pool	
	Improve Instrumentation New float sensors, Enhanced communications	$ 14,600 + $50/mo.
	TOTAL	$ 948,300 + $50/mo.
C5	Dredge 72,000 CY Dredged material to: K and R - 65,000 CY Spillway - 3,400 CY Behind Shop - 3,600 CY	$ 1,086,200
	Construct Intake Weir (In wet, with H-piles and precast panels)	$ 435,000
	Improve Instrumentation New float sensors, Enhanced communications	$ 14,600 + $50/mo.
	TOTAL	$ 1,535,800 + $50/mo.

*Except for the smolt migration period, when a 25 foot pool level would be maintained.

TABLE 2 - COMPARISON OF PLANS
(Continued)

PLAN	DESCRIPTION	COST
D1	Draw down pool, Excavate 24,000 CY	$ 367,000
	Excavated material to:	
	K or R - 20,600 CY	
	Spillway - 3,400 CY	
	Improve Instrumentation	$ 14,600 + $50/mo.
	New float sensors, Enhanced communications	
	TOTAL	$ 381,600 + $50/mo.
D2	Draw down pool, Excavate 72,000 CY	$ 1,069,800
	Excavated material to:	
	K and R - 65,000 CY	
	Spillway - 3,400 CY	
	Behind Shop - 3,600 CY	
	Improve Instrumentation	$ 14,600 + $50/mo.
	New float sensors, Enhanced communications	
	TOTAL	$ 1,084,400 + $50/mo.
D3	Draw down pool, Excavate 120,000 CY	$ 1,898,200
	Excavated material to:	
	K and R - 65,000 CY	
	Spillway - 3,400 CY	
	Off Site Location - 51,600 CY	
	Improve Instrumentation	$ 14,600 + $50/mo.
	New float sensors, Enhanced communications	
	TOTAL	$ 1,912,800 + $50/mo.
E1	Improve Instrumentation	$ 14,600 + $50/mo.
	New float sensors, Enhanced communications	
	TOTAL	$ 14,600 + $50/mo.
E2	No Changes to Existing Project	$ 0
	TOTAL	$ 0

ENVIRONMENTAL IMPACTS

This section evaluates the environmental impacts of plans developed to reduce or eliminate the risk of damaging sediment releases from Ball Mountain Lake. Most plans involve dredging and significant changes in reservoir operation. A brief description of each plan and its environmental impacts are presented below. Plate 3 provides a concise summary of the environmental impacts of each plan.

Plan A

The variations of Plan A would dredge from 24,000 to 240,000 cubic yards of sediment from near the dam and institute a long-term sediment monitoring and maintenance dredging program. A floating, hydraulic dredge would be used. Dredged material would be disposed at on-site upland borrow areas (Borrow Areas K and/or R) at the Ball Mountain Dam spillway, at a diked confinement area within the reservoir (Borrow Area J), and off-site. All plans include maintaining a permanent 55 to 60 foot pool at the lake, except during smolt migration and fall whitewater releases when the pool stage would temporarily lowered to 25 foot. Improved instrumentation and enhanced communications equipment would also be installed.

Plans A1 and A3 would remove 24,000 and 72,000 cubic yards of dredged material, respectively, from the pool at Ball Mountain. All of the material would be placed at the upland onsite disposal sites.

Plan A2 and Plan A4 would feature a diked confinement area built at Borrow Area J. The top of the dike would be at elevation 859.0 feet. The dike would have a capacity of 13,500 cubic yards of dredged material. Upon its completion, a permanent 55 foot pool would be maintained at the lake, except during smolt migration and fall white water releases when the pool stage would temporarily lowered to 25 feet.

Plan A5 would also feature a diked confinement area built at Borrow Area J. The top of the dike would be at elevation 859.0 feet. The dike would have a capacity of 18,500 cubic yards of dredged material. Upon its completion, a permanent 60 foot pool would be maintained at the lake, except during smolt migration and fall white water releases when the pool stage would temporarily lowered to 25 feet.

Plans A6 and A7 would remove 120,000 and 240,000 cubic yards of dredged material, respectively, from the pool at Ball Mountain. All of the upland onsite disposal sites would be fully utilized, and the remainder of the dredged material would be transported to an offsite disposal area.

All of the plans would offer long-term protection of water quality and aquatic habitat downstream of the dam by greatly reducing the risk of major sediment releases due to failure of the automated gate or human error. The chief benefit of plans dredging more than 24,000 cubic yards is the reduced frequency of follow-up maintenance dredging.

For all plans, use of silt curtains and other techniques would allow dredging to proceed without violating water quality standards or impacting downstream aquatic life.

Disposal of dredged material could be accomplished without significant adverse environmental impacts. For Plans A1 through A5, all material could be disposed of on-site. Plans A6 and A7 would require both off-site and on-site disposal. Placement of dredged material at Borrow Areas K and R would require clearing of existing vegetation but would ultimately improve soils and enhance long-term vegetation growth at both sites. Use of Borrow Area R would impact 0.5 acres of wetland present in drainage swales. It would be possible to replace the swales and no net loss of wetland would occur. Because of the disturbed nature of the borrow areas, no archaeological resources would be impacted by disposal operations.

Plans A2, A4, and A5 would dispose of dredged material within a diked containment area at Area J and would create about 1 acre of emergent wetland. The wetland would provide habitat for fish, waterfowl and wading birds during most of the year. Habitat value for fish and wildlife would be somewhat limited, however, because the pool would need to be lowered to 25 feet in the spring (for smolt migration) and fall (for white water releases). The containment dike would require a rock revetment to protect the area against ice action. The dike would be submerged and would provide good cover and foraging habitat for fish during most of the year.

Operating the project with a semi-permanent 55 foot pool rather than a 65 foot pool would allow development of about 10 acres of riparian vegetation along shoreline and on mudflats near head of pool. This area is currently inundated by the 65 foot summer pool, is dry in the winter, and has little value for fish or wildlife. Lowering the pool would also restore several hundred feet of stream habitat and reduce potential erosion at a prehistoric site located near the head of the 65 foot pool.

Maintaining a permanent pool would continue to benefit downstream water quality by retaining suspended sediments. Cool water releases from a 55 foot pool would likely benefit downstream aquatic life, particularly juvenile salmon.

None of the variations of Plan A would impact whitewater recreation. Recreational value of the West River downstream of the dam would be protected by reducing the risk of periodic damaging sediment releases from Ball Mountain Lake.

Plan B

This plan would dredge about 240,000 cubic yards of sediment from near the dam to allow long-term operation of the project as a dry bed reservoir. A floating, hydraulic dredge would be used. Dredged material would be disposed at on-site upland borrow areas (Borrow Areas K and R), the Ball Mountain dam spillway, and off-site.

This plan would protect aquatic life downstream of the dam by eliminating the risk of massive periodic sediment releases. Elimination of a permanent pool, however, would cause increased transport of sediment downstream during storm events. Most sediment passing through Ball Mountain Dam would eventually be trapped at Townshend Lake, but could temporarily be deposited downstream the dam and degrade stream habitat.

Operating the project as a dry bed reservoir would restore about 1.5 miles of stream habitat. The restored stream would provide good warmwater fisheries habitat, but poor habitat for juvenile salmon and trout due to high stream temperature. The value of restored stream habitat would be limited by lack of shading, high water temperature during the summer, and periodic inundation. The existing Ball Mountain Lake fishery is of marginal value and its loss would not be significant.

Operating the project without a 25 foot pool would eliminate any smolt mortality associated with passage through submerged gates under current operating conditions.

Operating the project without a permanent pool would eliminate the potential for cool water releases from the reservoir during warm summer months. Juvenile salmon habitat downstream of the dam could be adversely affected.

Maintaining a dry bed reservoir would allow development of about 70 acres of riparian vegetation. This area is currently inundated by the 65 foot summer pool and has little wildlife habitat value. Vegetation in the area would probably eventually become dominated by shrubs and come to resemble the community occurring at the Union Village Dam in Thetford, Vermont. Wildlife habitat value of area would be limited by occasional inundation caused by flood control operations.

Eliminating the permanent pool would also reduce erosion potential at a prehistoric site located near the head of the 65 foot pool.

Operating Ball Mountain Lake as a dry bed reservoir would preclude the fall whitewater recreation release. It would not be possible to store water in late summer (i.e. August/September) in advance of the releases without causing significant damage to vegetation and wildlife habitat. Hundreds of whitewater enthusiasts and several outfitters would be adversely impacted if the release was canceled. The spring release would still be possible because vegetation would be dormant and could tolerate inundation prior to the release. Of the two releases, the fall release is probably most important to the whitewater community. Opportunities for whitewater recreation elsewhere in the region are much more limited in the fall than in the spring. Higher water temperature also make the fall releases more desirable than the spring release.

As discussed above for Plan A, disposal of dredged material at Borrow Areas K and R could be accomplished without significant adverse environment impacts.

Plan C

Variations on this plan would construct an inlet weir in order to maintain a 25 foot pool during the smolt migration period. Some degree of sediment removal by dredging would first be accomplished using a floating, hydraulic dredge. Improved instrumentation and enhanced communications equipment would also be installed. After construction of the weir, Ball Mountain Lake would be maintained at a permanent 25 foot pool stage or at 55 foot except during the smolt migration period, when a 25 foot pool would be maintained.

Plan C1 would construct the inlet weir in the dry with a drawn down pool after dredging 24,000 cubic yards of material from near the outlet. Dredged material would be disposed at Borrow Areas J and K or R, and the spillway.

Plan C2 would construct the inlet weir in the dry, using a sand bag cofferdam, after dredging 24,000 cubic yards of material from near the outlet. Dredged material would be disposed at Borrow Areas J and K or R, and the spillway.

Plan C3 would construct the weir in the wet, using H-piles and precast panels, after dredging 24,000 cubic yards of material from near the outlet. Dredged material would be disposed at Borrow Areas J and K or R, and the spillway.

Plan C4 would construct weir in the wet, using H-piles and precast panels, after dredging 24,000 cubic yards of material from near the outlet. Dredged material would be disposed at Borrow Areas K or R, and the spillway.

Plan C5 would construct weir in the wet, using H-piles and precast panels, after dredging 72,000 cubic yards of material from near the outlet. Dredged material would be disposed at Borrow Areas K or R, and the spillway.

All variations of Plan C would offer long-term protection of water quality and aquatic habitat downstream of the dam by eliminating the risk of major sediment releases due to failure of the automated gate or human error.

With proper construction practices, water qualify impacts during construction would be minimal except for Plan C1. Plan C1 would construct the weir in the dry after lowering the reservoir pool stage to 0 foot. Dropping the pool could release a great deal of sediment downstream and violate Vermont Water Quality Standards unless more extensive dredging was done in advance.

Impacts and possible environmental benefits associated with dredged material disposal at borrow areas J, K, and R are as discussed above for Plan A.

The weir would eliminate any smolt mortality associated with passage through submerged gates under current operating conditions. With an adequate splash pool, no mortality would occur when fish pass over the weir.

Once the weir was constructed the reservoir could be operating the project with a semi-permanent 55 foot or a 25 foot pool. The 25 foot pool would be maintained, except prior to the smolt migration period when the pool stage would temporarily raised to ca. 65 ft. to provide water for a spring whitewater recreation release.

Maintaining a 55 foot pool would allow development of about 10 acres of riparian vegetation along the reservoir shoreline and on mudflats near head of pool. The pool would also restore several hundred feet of stream habitat and reduce potential erosion at a prehistoric site located near the head of the 65 foot pool.

The 55 foot pool would continue to benefit downstream water quality by retaining suspended sediments during storm events Cool water releases from the 55 foot pool would benefit juvenile salmon and any native trout present in the stream.

Maintaining a 55 foot pool would have no impact on whitewater recreation. The value of the West River downstream of the dam for trout fishing would be protected by reducing the risk of periodic damaging sediment releases from Ball Mountain Lake.

A 25 foot pool would continue to benefit downstream water quality by retaining suspended sediments during storm events. Unlike with a 55 foot pool, however, there would be no cool water releases to benefit downstream juvenile salmon and trout populations.

Maintaining a 25 foot pool would restore about 1.4 miles of stream habitat. The restored stream would provide good warmwater fisheries habitat, but poor habitat for juvenile salmon or trout. The value of restored stream habitat would be limited due to lack of shading, high water temperature during the summer, and periodic inundation. The existing Ball Mountain Lake fishery is of marginal value and its loss would not be significant.

Maintaining a permanent 25 foot pool would allow development of about 50 acres of riparian vegetation along shoreline and on mudflats near head of pool. This area is currently inundated by the 65 foot summer pool and has little wildlife habitat value. Vegetation in much of the area would eventually be dominated by willow, alder and other low shrubs and come to resemble the community occurring at the Union Village Dam in Thetford, Vermont. Wildlife habitat value of area would be limited by occasional inundation during flood control operations.

Eliminating the 65 foot pool would also reduce erosion potential at a prehistoric site located near the head of the pool.

Operating Ball Mountain Lake with a permanent 25 foot pool would preclude the fall

PLATE 3: MATRIX OF ENVIRONMENTAL IMPACTS OF PROPOSED PLANS

PLAN	ENVIRONMENTAL RESOURCES		
	WATER QUALITY	AQUATIC LIFE	WILDLIFE HABITAT
Plan A Dredge 24,000 to 240,000 cy of sediment from reservoir and institute long-term maintenance dredging program. Dispose of dredged material at on-site upland borrow areas, spillway, diked confinement area (A2, A4, A5) and off-site (as needed). Maintain permanent ca. 55-ft. pool except during smolt migration and fall white water releases. Install backup instrumentation and enhanced communications equipment.	(+) Reduced risk of highly damaging sediment release due to failure of automated gate or human error. Risk decreases as volume of sediment dredged initially and frequency of maintenance dredging increases. (-) Increased suspended solids levels downstream during dredging. Use of silt curtains should assure compliance with VT water quality criteria.	(+) Reduced risk of damage downstream of dam caused by inadvertent sediment release. Risk decreases as volume of sediment dredged initially and frequency of maintenance dredging increases. (+) Rock protection of diked containment area and constructed wetland would provide cover and foraging habitat for fish (A2, A4, A5). (-) Possible exposure to increased suspended solids levels downstream during dredging. Compliance with VT water quality criteria would adequately protect aquatic life.	(+) Maintaining 55-ft. pool would promote development of about 10 acres of riparian vegetation along shoreline and on mudflats near head of pool. (+) Wetland created at diked confinement area would provide habitat for waterfowl and wading birds. Functional value of area would be low due to low water level in spring and fall (A2, A4, A5). (-) Temporary loss of wildlife habitat at borrow areas K and R.
Plan B Dredge sufficient material to allow operation of project as a dry bed reservoir (240,000 cy). Dispose of dredged material at on-site upland borrow areas, spillway, and off-site (as needed).	(+) Eliminate risk of highly damaging sediment release due to failure of automated gate or human error. (-) Increased suspended solid levels in West River during dredging. Use of silt curtains should assure compliance with VT water quality criteria. (-) Elimination of reservoir pool would increase downstream transport of sediment during storm events. Reservoir would no longer act as a settling basin. Stabilization of sediments with vegetation may difficult at lower elevations due to frequent inundation. (-) Increased sedimentation at Townshend Lake. (-) Elimination of cold water releases from reservoir could result in increased water temperature in West River downstream of dam during summer.	(+) Risk of damage downstream of dam due to inadvertent sediment release eliminated. (+) Restoration of ca. 1.5 miles of West River stream habitat upstream of dam. Value of habitat would be somewhat limited by frequent inundation and high stream temperature during summer. (+) Enhanced passage of smolts through Ball Mountain Dam. Any delay or mortality associated with passage through submerged gates would be eliminated. (-) Possible exposure to increased suspended solids levels downstream of dam during dredging. Compliance with VT water quality criteria would adequately protect aquatic life. (-) Possible damage to aquatic life caused by increased siltation downstream of dam during storm events. (-) Lack of cold water outflow from dam during summer could adversely impact downstream salmon and trout habitat.	(+) Elimination of summer pool would promote development of about 70 acres of riparian habitat. Herbaceous vegetation low shrubs would likely predominate. (-) Temporary loss of wildlife habitat at borrow areas K and R.
Plan C	(+) Eliminate risk of highly damaging sediment release due to failure of automated gate or	(+) Risk of damage downstream of dam due to inadvertent sediment release eliminated.	(+) Maintaining 55-ft. pool would promote development of about 10 acres of riparian vegetation along shoreline and on mudflats near head

PLATE 3: MATRIX OF ENVIRONMENTAL IMPACTS OF PROPOSED PLANS

PLAN	ENVIRONMENTAL RESOURCES		
	PROTECTED SPECIES	CULTURAL RESOURCES	RECREATION AND AESTHETICS
Plan A Dredge 24,000 to 240,000 cy of sediment from reservoir and institute long-term maintenance dredging program. Dispose of dredged material at on-site upland borrow areas, spillway, diked confinement area (A2, A4, A5) and off-site (as needed). Maintain permanent ca. 55-ft. pool except during smolt migration and fall white water releases. Install backup instrumentation and enhanced	(+) Reduced risk of highly damaging sediment release from Ball Mountain Dam. Risk increases as sedimentation decreases volume of 25-foot pool.	(+) Maintaining permanent 55 ft. pool would reduce potential erosion at prehistoric site located on reservoir shoreline near head of existing 65-ft. summer pool.	(+) Reduced risk to trout fishery downstream of Ball Mountain Dam from inadvertent sediment release. No impact on white water releases.

whitewater recreation release. As in Plan B, it would not be possible to store water in late summer (i.e. August/September) in advance of the release without causing significant damage to vegetation and wildlife habitat in the reservoir.

Plan D

Each of the variations of Plan D would excavate from 24,000 to 120,000 cubic yards of sediment from near the dam and institute a long-term sediment monitoring and maintenance dredging program. Conventional earth moving equipment would be used to excavate material in the dry after gradually lowering Ball Mountain Lake to the 0 foot pool stage (dry bed). The dewatering of the excavated would be handled in the same manner as described in the section entitled Disposal Options For Dredged Material. Material would be disposed at on-site upland borrow areas (Borrow Areas K and/or R), at the Ball Mountain Dam spillway, and off-site (Plan D3 only). All plans include maintaining a permanent 55 or 65 foot pool at the lake, except during smolt migration and fall whitewater releases when the pool stage would temporarily lowered to 25 foot. Improved instrumentation and enhanced communications equipment would also be installed.

All of the plans would offer long-term protection of water quality and aquatic habitat downstream of the dam by greatly reducing the risk of major sediment releases due to failure of the automated gate or human error. The chief benefit of plans dredging more than 24,000 cubic yards is the reduced frequency of follow-up maintenance dredging.

Gradually lowering the lake to the 0 foot pool stage and maintaining a dry bed while the sediment was being excavated would almost certainly mobilize a large amount of sediment which would be deposited in the West River between Ball Mountain Dam and Townsend Lake. The sediment would likely eliminate the existing salmon fry/parr year class and adversely effect other aquatic life. Any remaining brook floater in the reach would likely be extirpated. Based on experience with previous accidental releases, it would take at least 2 years before the stream recovered and possibly much longer. Lowering the pool prior to sediment excavation would also undoubtedly violate VT water quality standards for turbidity.

As with Plan A, disposal of dredged material could be accomplished without significant adverse environmental impacts. For Plans D1 and D2 all material could be disposed of on-site. Plan D3 would require both off-site and on-site disposal. Placement of dredged material at Borrow Areas K and R would require clearing of existing vegetation but would ultimately improve soils and enhance long-term vegetation growth at both sites. Use of Borrow Area R would impact 0.5 acres of wetland present in drainage swales. It would be possible to replace the swales and no net loss of wetland would occur. Because of the disturbed nature of the borrow areas, no archaeological resources would be impacted by disposal operations.

Operating the project with a semi-permanent 55 foot pool rather than a 65 foot pool would allow development of about 10 acres of riparian vegetation along shoreline and on mudflats near the head of the pool. This area is currently inundated by the 65 foot summer pool, is dry in the winter, and has little value for fish or wildlife. Lowering the pool would also restore several hundred feet of stream habitat and reduce potential erosion at a prehistoric site located near the head of the 65 foot pool.

Maintaining a permanent pool would continue to benefit downstream water quality by retaining suspended sediments. Cool water releases from a 55 foot pool would likely benefit downstream aquatic life, particularly juvenile salmon.

None of the variations of Plan D would impact whitewater recreation. Recreational value of the West River downstream of the dam would be protected in the long-term by reducing the risk of periodic damaging sediment releases from Ball Mountain Lake. For several years, however, sediment released during the project would severely impact the recreational fishery and aesthetic value of the river.

Plan E

Plan E1 would rely on installation of backup instrumentation and enhanced communications equipment to prevent accidental loss of the 25 foot pool and damaging sediment releases. The plan includes maintaining a permanent 55 foot pool at the lake, except during smolt migration and fall whitewater releases when the pool stage would temporarily lowered to 25 foot.

This plan would protect aquatic life downstream of the dam by reducing the risk of damaging sediment releases due to failure of the automated gate or human error. The potential for a damaging release, however, would remain if pool were to drop below about 20 foot.

Maintaining a semi-permanent 55 foot pool is not essential to preventing sediment releases, but has other benefits (see above, Plan A). These include development of about 10 acres of riparian habitat along shoreline and on mudflats near the head of the 65 foot pool, restoration several hundred feet of stream habitat, and reduced erosion at a prehistoric site located near the head of the pool.

The plan would have no impact on whitewater recreation. The value of the West River downstream of the dam for trout fishing would be protected by reducing the risk of periodic damaging sediment releases from Ball Mountain Lake, but the threat of a detrimental sediment release would remain.

Plan E2 would make no change to the existing project. Under this option a significant, unacceptable, risk of damaging sediment releases due to equipment failure or human error would remain indefinitely. The plan would also forgo the benefits of lowering the existing 65 foot permanent pool to a 55 foot or 25 foot level.

GULATORY REQUIREMENTS

A major dredging project or change in reservoir operations would require completion of Environmental Assessment pursuant to Corps National Environmental Protection Act (NEPA) gulations.

Dredging and dredged material projects would require state water quality certification rsuant to Section 401 of the Clean Water Act (CWA)and completion of a 404(b)(1) evaluation rsuant to the Section 404 of the CWA.

Proposed plans would be coordinated with appropriate state and Federal agencies rsuant to the National Historic Preservation Act, the federal Endangered Species Act, and the ederal Fish and Wildlife Coordination Act.