STABILIZATION PLAN
FOR
THE CHRISTENOT MILL
(24MA1215)

BLM Report No. 97-MT-070-076-06

Bureau of Land Management
Dillon Resource Area
1997

STABILIZATION PLAN
FOR THE CHRISTENOT MILL (24MA1215)

Bureau of Land Management
Dillon Resource Area

Prepared by:

Mark B. Sant — 3/17/97

Dillon Resource Area Archaeologist — Date

Reviewed by:

Kent C. Satterlee — 3/12/97

Butte District Engineer — Date

Lee J. Walsh — 3/11/97

Butte District Engineering Technician — Date

Approved by:

Scott Powers — 3/18/97

Dillon Resource Area Manager — Date

INTRODUCTION

The intent of this stabilization plan is to identify the goals, needs, and actions required for the immediate protection and continued preservation of the historic Christenot Mill (24MA1215)in Madison County, Montana (Figure 1). The goals of these efforts are to:

1. Preserve the important cultural resource values (historic and interpretive) of the property and the site location.

2. Manage the property using a minimal interventionist approach, limiting preservation actions to re-establishing load bearing structural stability and maintain a state of "arrested decay".

3. Preserve the historic values of the property with respect to the National Register of Historic Places.

The historic values of the Christenot mill are derived from the important role it played in the technological and economic development of early gold mining in Alder Gulch and western Montana. Interpretive values stem from the fact that the mill still retains evidence of early lode mining and quartz gold ore milling technology and continues to attract visitors in spite of the remote location and difficult access.

The Christenot mill site has been determined to be eligible for listing in the National Register of Historic Places by consensus agreement between the Dillon Resource Area and the Montana State Historic Preservation Office. The mill site is eligible for the register under several criteria as identified in 36 CFR 60.4. The mill site is associated with early gold rush mining in Montana and the "opening" of the west. As such the mill has both local, regional, and national significance (Criterion A). The mill was also associated with the lives of persons locally and nationally significant (Criterion B), and is one of the few surviving examples of 1860's period quartz gold mills in Montana and the only one in Alder Gulch using Chilean rollers and amalgamation barrels. (Enough remains of the mill to visually reconstruct the milling process, though specific machinery has long since vanished.) The mill is within the Virginia City Mining District as defined by Gray (1991:7), and represents a distinctive period of early mining history in western Montana. As such the property should be considered a contributing element to the mining district and is eligible to the register under Criterion C. In addition to the mill structure, site 24MA1215 contains the remains of the mining complex known in the 1860's and 1870's as Union City. Though intact structural remains have long since vanished, cabin foundations and other evidence of the historic occupation may still remain. The site may also retain significant potential for historic archaeological investigations and retains scientific value under Criterion D. Efforts are currently underway in cooperation with Nick Schrauger and the Christenot Mill Stabilization Association to formally list the property on the National Register.

In consideration of the goals discussed above, the specific objectives of the plan are to:

1. Conduct emergency stabilization to protect the property from further decay.

2. Initiate additional protective measures. Specifically the construction of an exclosure fence to keep cattle away from standing walls, and placement of an interpretive sign. Both of which will be compatible with the historic integrity of building and natural setting.

3. Preserve and maintain the National Register values of the property by designing and implementing emergency stabilization and additional protective measures which conform to The Secretary of the Interior's Standards for Historic Preservation Projects (36 CFR Part 68) and The Secretary of the Interior's Standards for Rehabilitation and Guidelines for Rehabilitating Historic Buildings.

4. Site 24MA1215 is also located within the Axolotl Wilderness Study Area. Though the wilderness study area was not recommended for wilderness designation, management of the area must meet in conjunction with wilderness guidelines until congress has made a final determination of wilderness in Montana.

PROPERTY DESCRIPTION

It is fortunate in this instance that a pencil sketch of Union City and the Christenot mill was made by A.E. Mathews in 1867 (Figure 2). We therefore have a fairly clear view of what the mill looked like while in operation. The sketch clearly shows the mill building with gable roof, windows, doorways, an exterior stairway to the upper story and the relationship of the mill building to other structures and features of Union City. As originally constructed, the Christenot mill was a one and a half story, random rubble, masonry building. In plan view, the building was "T" shaped with a mill room, boiler room, office and vault on the main floor. The upper 1/2 story was used as a personal residence for mill workers/management.

The walls of the mill were constructed using locally available granite (dressed and undressed stones) bonded with a lime mortar. Walls exhibit a random rubble pattern and are 20-24 inches in thickness. Walls were constructed on a well built masonry foundation slightly greater in width than the walls and incorporating larger rocks and boulders. A plan view map of the mill is presented in Figure 3.

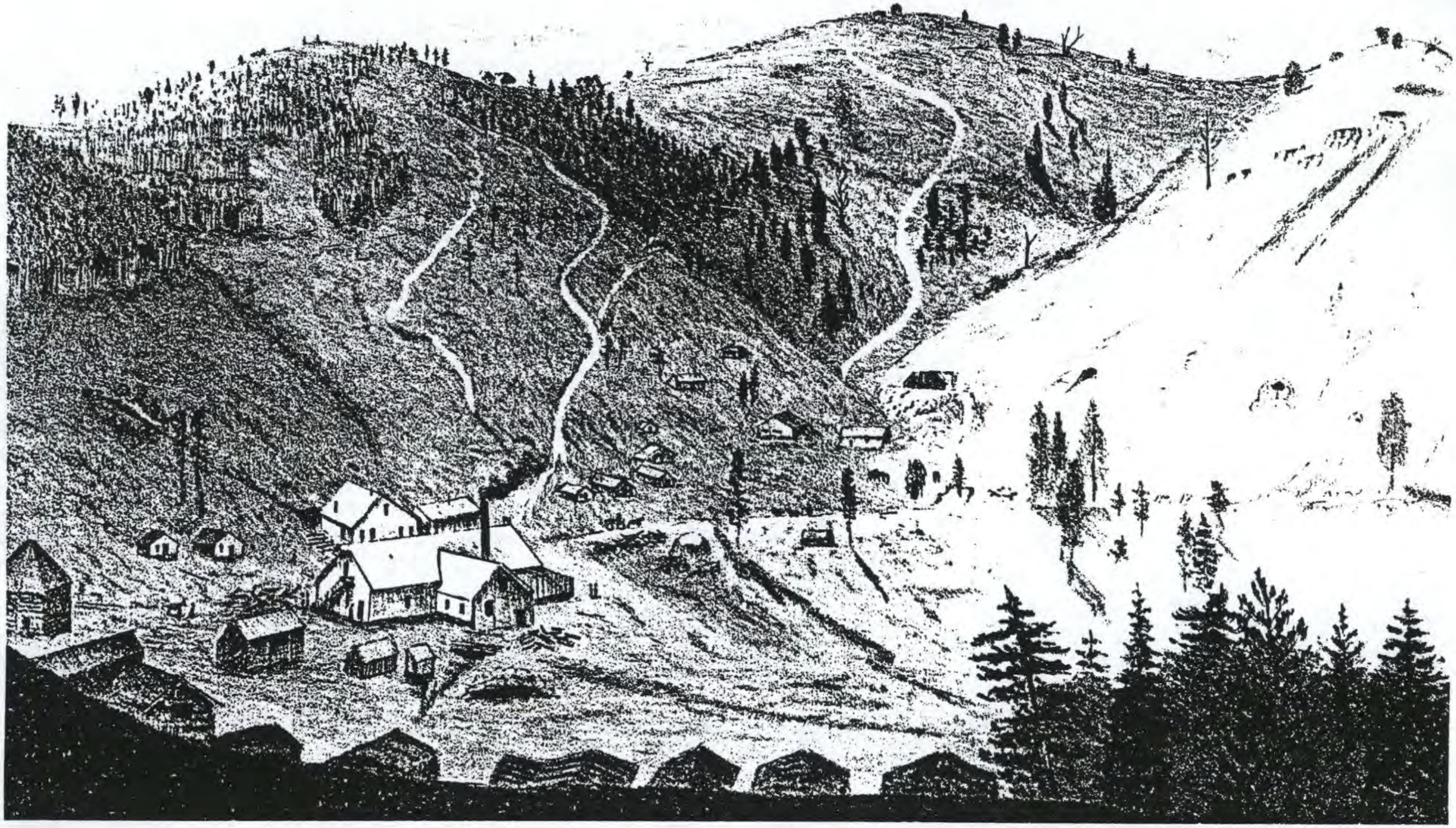


Figure 2. Sketch of Union City and the Christenot Mill from A.E. Mathews, Pencil Sketches of Montana, New York, 1868.

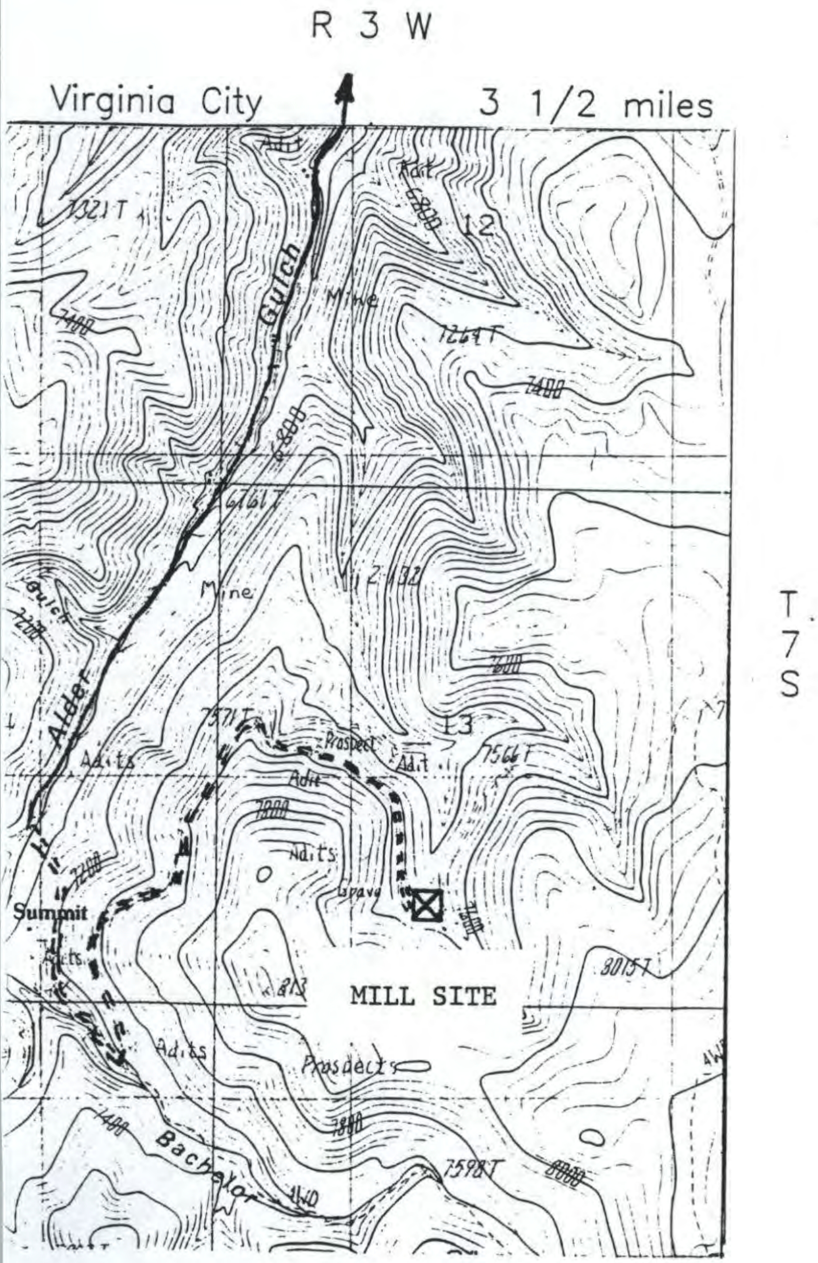
:TMENT OF THE INTERIOR

AND MANAGEMENT

)T MILL SITE

NTY, MONTANA

Figure 1. Location of Project Area.



WORK LOCATION MAP

1/2 1/4 0 1

LOCATION

Spring Gulch in
Madison County
Township 7 South
Range 3 West
SE 1/4 SW 1/4 Section 13
elevation 7600 ft
Varney Quad, 15',1949

ALWAYS THINK SAFETY

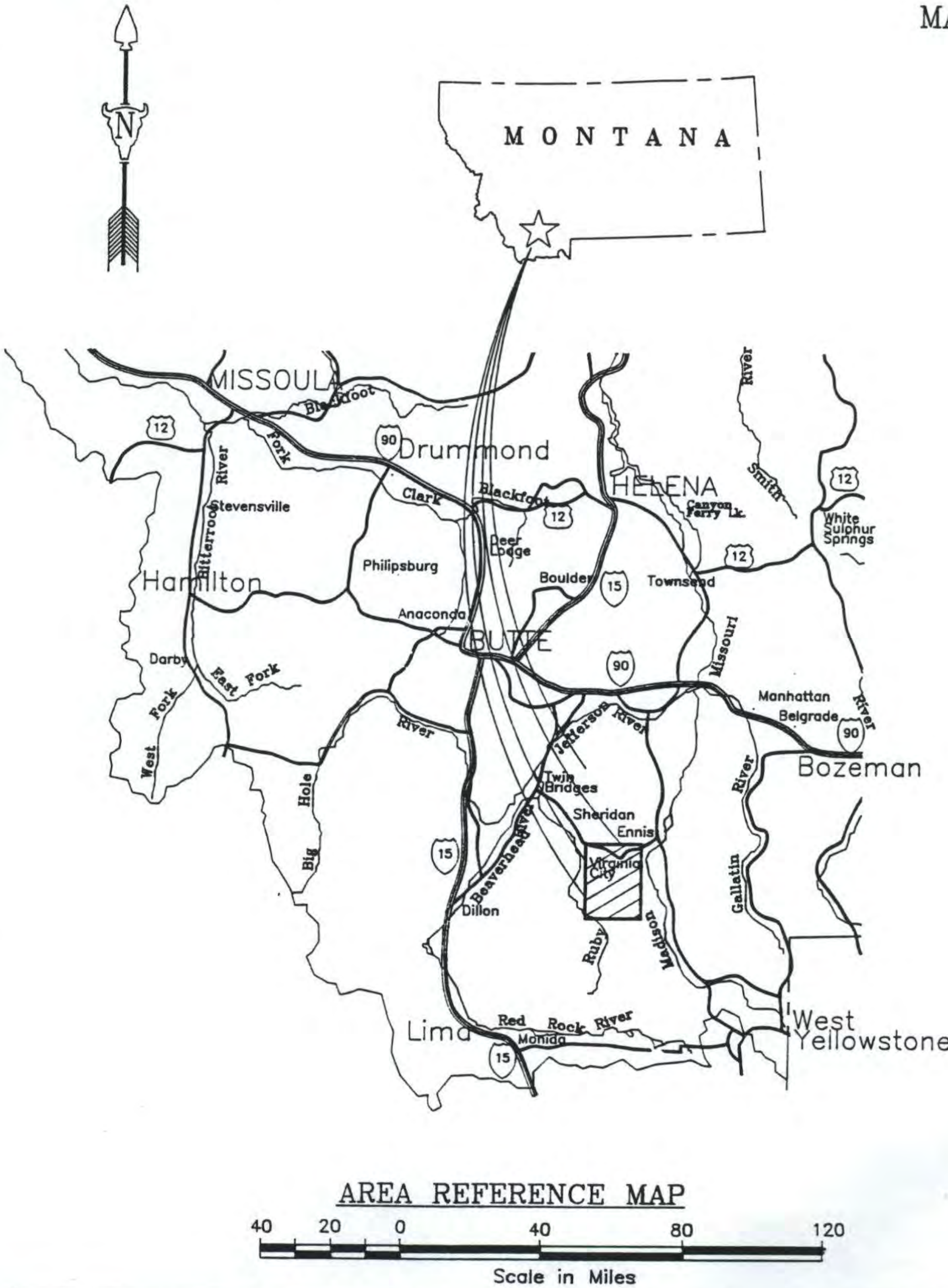
UNITED STATES DEPARTMENT OF THE INTERIOR BUREAU OF LAND MANAGEMENT BUTTE DISTRICT MONTANA	
CHRISTENOT MILL SITE LOCATION MAP	
DESIGNED ______ REVIEWED ______ APPROVED ______	
DRAWN Walsh	SCALE AS SHOWN
DATE 11/5/96	SHEET 1 OF 7

UNITED STATES DEP

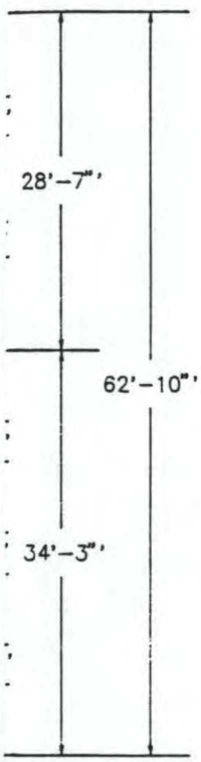
BUREAU OF

CHRISTE

MADISON C



11X17-B



1/2" x 7 1/2"
nber tenon joints

Door and Window Opening Details

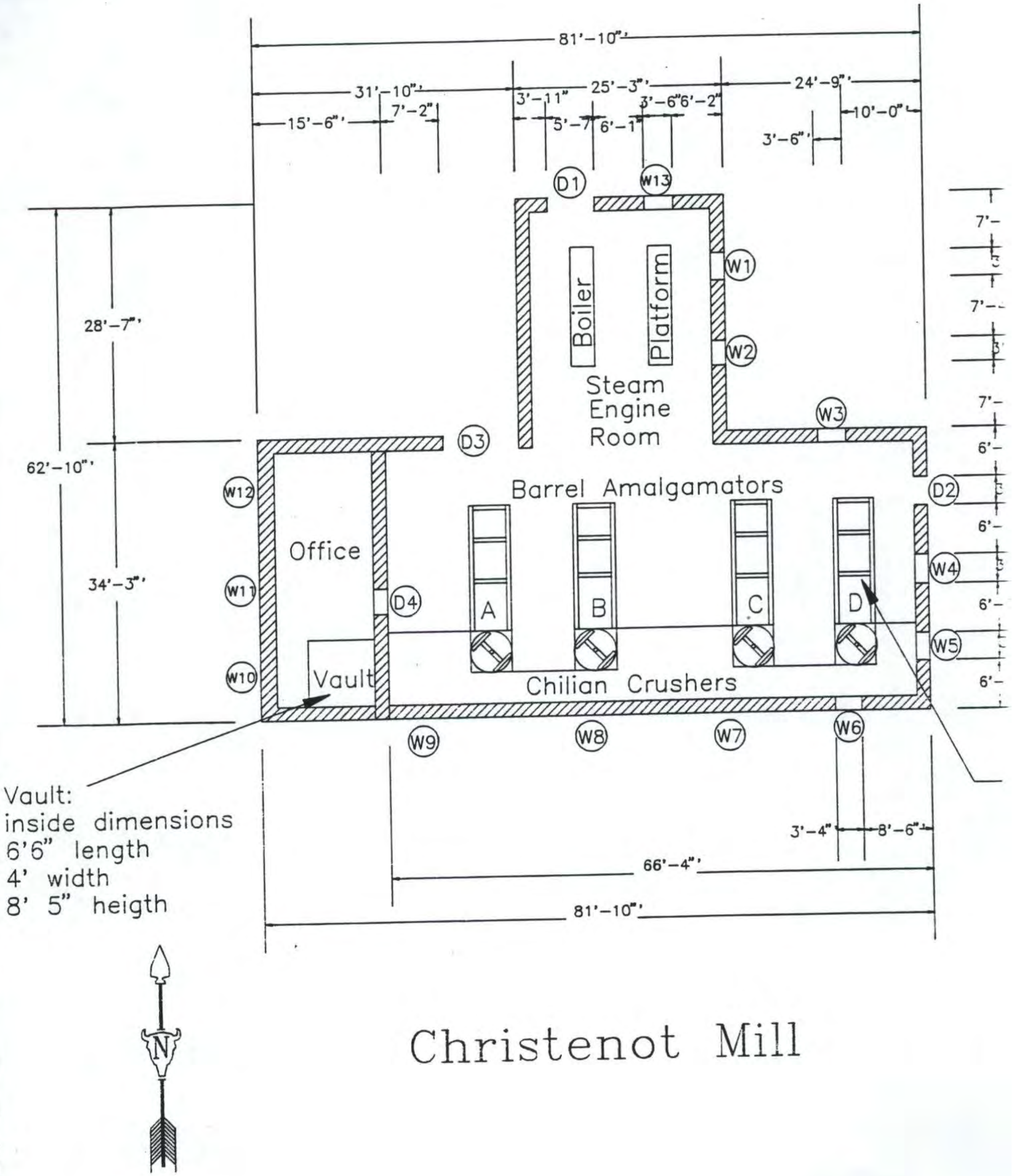
D1	5'7"w x 10'h
D2	3'5"w x 6'10"h (arch)
D3	(collapsed)
D4	3'1"w x
W1	3'4"w x
W2	3'w x
W3	3'6"w x 10'10"h
W4	3'3"w x 5'1"h (arch)
W5	3'4"w x
W6	3'4"w x
W7	
W8	
W9	
W10	
W11	
W12	
W13	3'6"w x

Figure 3. Plan view map of the Christenot Mill.

Notes:

20"–24" thick granite randon rubble pattern walls
Steel door to vault may be in area to the north of structure.
Main roof pitch is 30°
shed roof pitch is 10°

UNITED STATES DEPARTMENT OF THE INTERIOR BUREAU OF LAND MANAGEMENT BUTTE DISTRICT MONTANA	
CHRISTENOT MILL SITE SPECULATED ORIGINAL LAYOUT	
DESIGNED	
REVIEWED	
APPROVED	
DRAWN Lee Walsh	SCALE AS SHOWN
DATE 11/6/96	SHEET 2 OF 7
DRAWING NAME CHMILL.DWG	



Christenot Mill

X17-B

The mill room contained four Chilean rollers/crushers and four banks of four barrel amalgamators. This is the largest room in the structure measuring 66'4" by 34'3", with the long axis oriented roughly east/west. The boiler room is located on the north side of the mill rooms and measures 25'3" by 28'7", with the long axis oriented north/south. As illustrated in Mathew's sketch map, both the mill room and boiler room exhibited gable roofs. The office is located on the west side of the mill room and measures 14'6" by 34'3", with the long axis oriented north/south. This room had a shed roof and contained a vault in the southeast corner. The vault has/had a steel door and door frame. Within the last 30 years the vault door has been removed from the premises. The vault is 6'6" by 4' and 8'5" in height.

Windows are located at regular intervals along the east, west, and south facing exterior walls. A large entryway is located on the north end of boiler room, probably to facilitate the loading of machinery and firewood for the boiler. Numerous photos were taken of the structure and structural features (Attachment 1).

HISTORY OF PROPERTY

A majority of the information presented below was compile by Nick Shrauger in his genealogical research of the Christenot family, and background research on the development and operation of the Christenot mill and associated mining properties (Shrauger 1996).

On June 24, 1864, B.F. Christenot, Nelson Story, and others recorded the Oro Cache lode claims with the Madison county Clerk and Recorder. In 1864 and 1865 ore was extracted and processed using a primitive mule powered arrastra. The results of these early efforts were promising, but the productive potential of quartz lode mining was limited by the lack of proper milling machinery. In 1865 B.F. Christenot was aggressively acquiring mining properties and seeking necessary financial backing for continued mining ventures.

After acquiring title to 87 mining properties, B. F. Christenot sold his mining interests to the Montana Gold and Silver Mining Company on April 4, 1866, for $1,140,000. In October of 1866 machinery for the mill arrived in Virginia City by wagon train. The mill structure was most likely built by the construction firm of Griffith and Thompson who built other mill buildings of similar style in Alder gulch during that period. Other mills in operation at this time were more commonly stamp mills. The Christenot mill was perhaps the only mill in the area using Chilean roller crushers at that time. Descriptions of the everyday operations at the mill are available from several different sources including: A.E. Mathews (1868), A.J. McClure (1869), D.S. Tuttle (1906), Rolle (1960). The completed mill delivered its first product in mid March, and reported that rock from the Oro Cache was yielding $100 a ton.

Representing the Pennsylvania interests in the Montana Gold and Silver Mining company, A.K. McClure traveled to Virginia City and managed the operation of the mill from July of 1867 and January of 1868. During this time the Chilean rollers were improved by filling the rollers with lead (instead of rocks) from the Argenta works. In addition, the barrel amalgamators were operational increasing the gold recovery from $140 to $840 per ton. While fully operational the mill as able to process 20 tons of ore a day.

In spite of preliminary indications of success, by 1872 the Montana Gold and Silver Mining Company is said to have recovered only $60,000 from the Oro Cache, and failed disastrously. Lode mining elsewhere in the gulch did not fare much better as veins began to play out. By 1876 the Oro Cache was the only lode being worked in the Summit District and the mill was again put in running order. Little is mentioned of the mill or Oro Cache lode after this time.

MANAGEMENT HISTORY

In an examination of records at the Bureau of Land Management, the first documentation of the Christenot Mill was found in Mineral Survey No.380 for the Lode Mining Claim (Lot 42B) of Samuel B. Rice. The survey was recorded by Albert S. Knight, U.S. Mineral Deputy Surveyor on October 17th, 1875. Identified improvements on the claim included: One steam quartz mill built by the Montana Gold and Silver Mining Company in 1866 at a cost of $150,000. and one two story frame residence valued at $2,500.

The Christenot mill was formally identified and recorded as an historic site (24MA1215) during an archaeological reconnaissance inventory of historic mining resources in the Summit, Browns Gulch, and Hungry Hollow mining districts (Clark, 1990). The mill and site area are contained within the BLM-Dillon Resource Area Axolotl Wilderness Study Area. Based on the analyses conducted, the Axolotl Wilderness Study Area was not recommended for wilderness designation. However, until the wilderness study areas are designated wilderness or released by congress, these areas must be managed in a manner that will not compromise natural values in accordance with the BLM Interim Management Policy for Lands Under Wilderness Review (BLM Manual H-8550-1).

With the cooperation of Nick Shrauger and the Christenot Mill Preservation Association, the BLM is in the process of preparing a formal nomination for the mill site to the National Register of Historic Places.

CONDITION ASSESSMENT

It should be noted that the remains of the Christenot mill exhibit detailed craftsmanship in terms of the stonework and woodwork. It is apparent that the building was constructed to be sturdy enough to withstand the stresses and strains created by the tons of continuously vibrating milling machinery. As an initial step in the assessment of the condition of the mill structure, arrangements were made for a field examination of the mill by professionals in historic architecture and building stabilization. Herb Dawson, Historic Architect-Montana Historic Preservation Office, visited the mill on July 28, 1995. Richard Teer of Intermountain Restoration examined the structure on September 26, 1995. On October 9, 1996 the mill was examined by Engineers from the Butte District BLM (Lee Walsh and Chris Nemeth) and a representative of the Forest Service Region 1 Historic Building Stabilization Crew (Carey King). The concerns expressed over the problems/conditions adversely affecting the structural condition of the mill (and the remedial actions that could be taken to correct the problems), were for the most part consistent.

The roof and upper story of the building have either decayed or been dismantled historically and construction materials scavenged for re-use elsewhere. Consequently, most of the damage that has occurred to the structure is a result of natural weathering and decay from continuous exposure over the last hundred years or so. Of particular concern, is the surface water drainage pattern. Currently, water from spring snow melt flows into the structure and collects to a depth of several inches, and has caused the foundation to weaken and the walls to partially collapse in segments along the northern and southern walls. Two major cracks are present in the exterior walls in the eastern and southern portions of the structure (Figure 4). The cracks are threatening the structural integrity of the standing walls which in some cases are in excess of 15 to 20 feet in height.

The stone walls are no longer protected from moisture and the elements. The upper wall segments are starting to lose mortar and exfoliate, due to the absorption of moisture and associated freeze/thaw cycles. Window and door framing materials are missing in several places and have resulted in the structural weakening of the upper wall segments (Figure 5). There are also several small trees growing on the interior of the building and/or immediately adjacent to fragile walls. Continued root and limb growth appear to be weakening the foundation and threatening the wall stability.

Another important, but less immediate concern is the wood framing which supported the crushers and amalgamation barrels (Figure 6a and 6b). For the most part, the wood is rotted or badly weathered. If the framing is lost, it would make it difficult to visualize how the mill operated, resulting in the loss of integrity of design.

Figure 4. Christenot Mill (24MA1215) example of cracks in wall segment, view looking south. (Roll: MBS/96-10, Frame: 9)

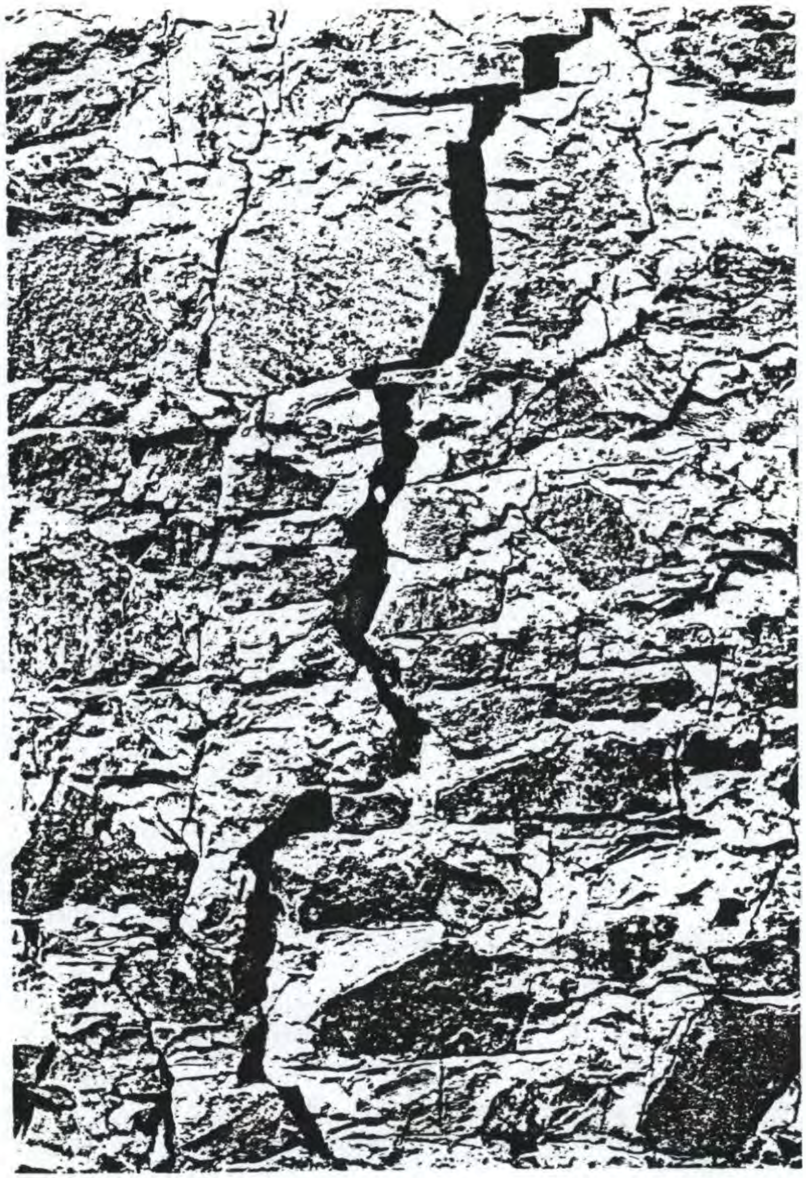


Figure 5. Christenot Mill (24MA1215) example of weakening of wall above unframed doorway, view looking west. (Roll:MBS/96-10, Frame: 7)

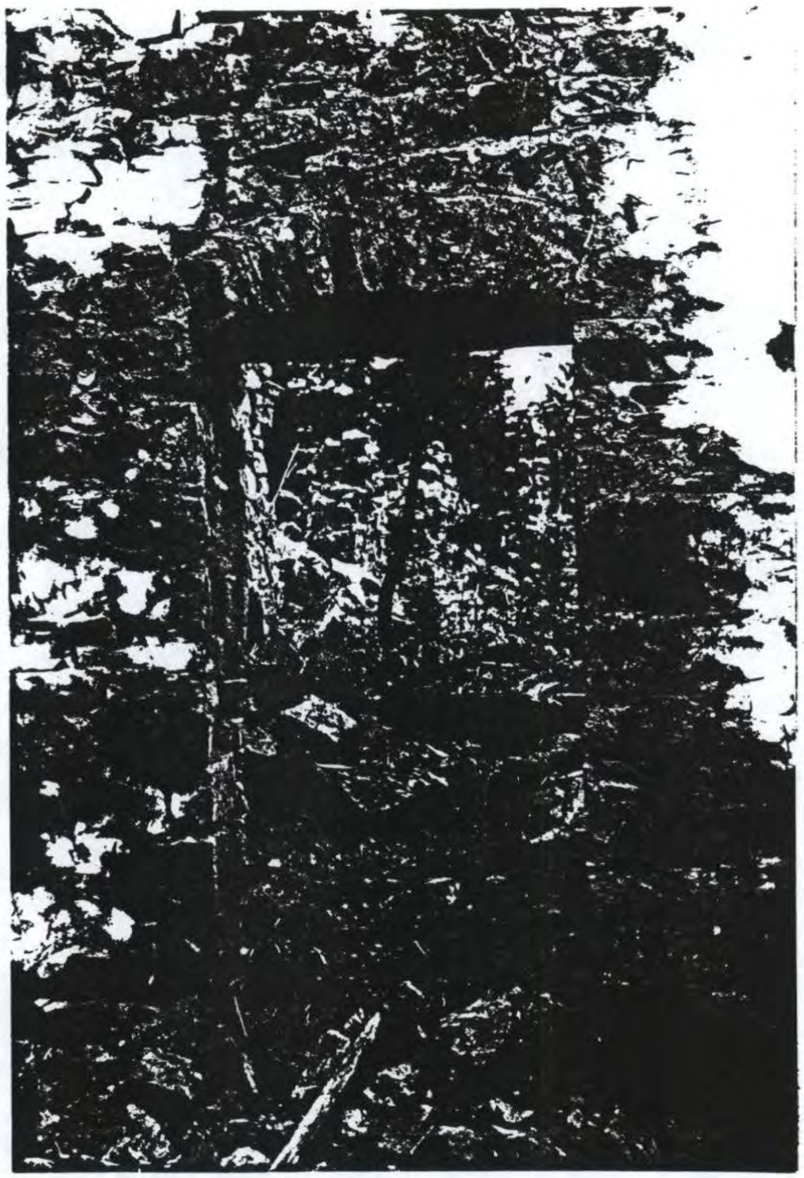


Figure 6a. Christenot Mill (24MA1215) view of timber framing for amalgamator tables looking southeast. (Roll: MBS/92-6, Frame:6)

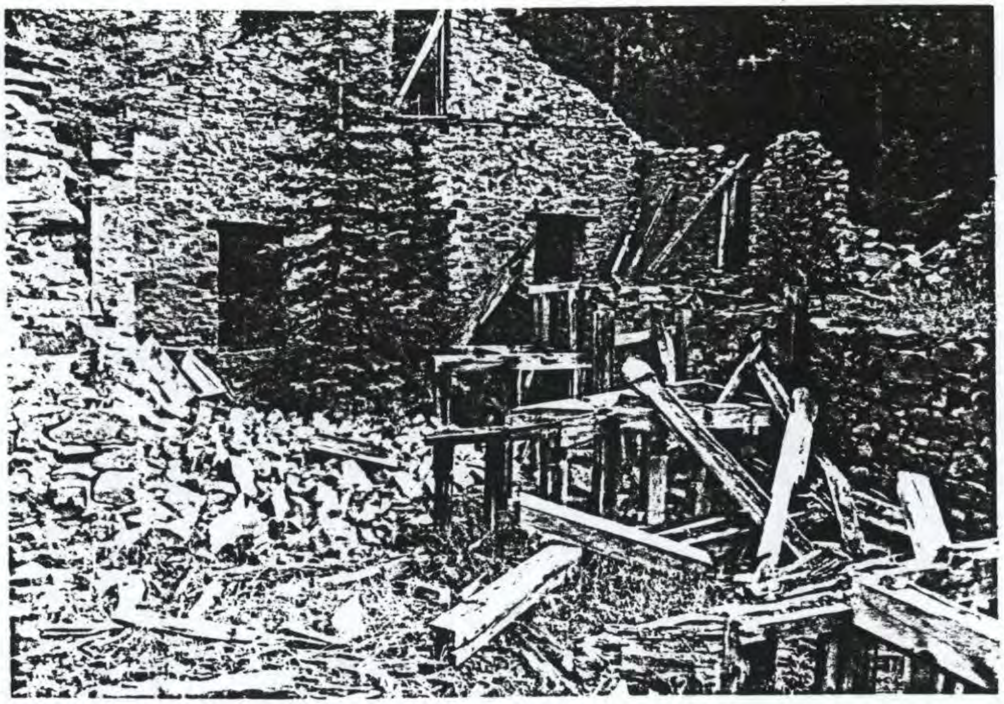


Figure 6b. Christenot Mill (24MA1215) view of timber framing for amalgamator tables looking south. (Roll: MBS/92-6, Frame:5)

STABILIZATION ACTIONS

The proposed stabilization actions are based upon input obtained from architectural and stabilization professionals, and consistent with the established preservation goals for the mill building. The critical stabilization needs and/or necessary remedial actions are addressed as follows:

1) Correct runoff drainage problems: In order to correct the drainage problems, it will be necessary to divert water from running through building site. The most effective way to accomplish this is to construct an open ditch, with a berm placed just up slope from the existing access road. The ditch would divert water above the building into the existing drainage to the east of mill site. There will be considerations for blending the new ditch into existing surroundings.

2) Mortar work: Necessary mortar work will involve the repair and sealing of wall cracks, and the resetting of weathered and loose stones along the upper portions of the exposed walls. In order to protect the walls from moisture, a mortar cap (or coping) will be placed along the top of the walls as a moisture seal. Prior to mortar work, analysis of the historic mortar will be conducted (see Attachment 2) so that new mortar will match in color and texture and be consistent with the historic character of the original construction materials.

3) Repair window and door frames: It is necessary to repair window and door frames in order to provide structural support for upper wall segments. Rough-cut milled lumber, of appropriate thickness and dimensions, will be used to match original construction materials as closely as possible in order to retain the historic character of the building. A photo and map record will be kept of the location and use of all new construction materials.

4) Wood preservative: The wood framing that supported the amalgamation barrels is in various states of decay. It is important to attempt to preserve what remains of these features by stabilizing the deteriorating wood components. A Water Repellant Preservative (WRP) with a natural finish will be applied to the intact wooden frames. It will be necessary to reapply this mixture on a regular basis to insure the long term preservation of the material.

5) Tree removal: Fir and pine saplings have invaded the mill building and are growing in close proximity to walls and other structural elements of the mill. It will be necessary to cut and remove the saplings and young trees in order to protect structural elements of the building from continued root and limb growth.

6) Exclosure fence: There have been minor impacts to the mill building and site area as a result of cattle grazing and

vandalism. Given the unstable nature of certain wall segments it will be important to keep cattle and casual visitors a safe distance away from the building. An exclosure fence will help protect the building from rubbing or trampling by cattle, and inadvertent visitor impacts, and will protect them from potentially hazardous situations at the mill. The exclosure fence will need to be constructed of materials that do not detract from the historic character of the mill building, and are also compatible with guidance and requirements to retain the esthetic values of a wilderness study area. A wooden buck and pole (jackleg and rail) fence will be constructed around the mill building. Jack legs will be placed at 12 ft. spacing connected by four - 14 ft. rails (see Attachment 3).

7) Interpretive Sign: Though the location of the Christenot mill is remote, and access is difficult, a surprising amount of visitation does occur at the location. An interpretive sign is warranted at the location to briefly identify and explain the significance of the structure to local history. It is also hoped that the identification of the historic importance of the location will discourage inadvertent and/or intentional vandalism to structure and surrounding site area.

MAINTENANCE AND FUTURE ACTIONS

Once the proposed stabilization measures are completed, only routine maintenance and monitoring type activities should be required. Maintenance will involve re-application of Water Repellent Preservative to wood elements, and periodic maintenance of the exclosure fence. Monitoring of the structure and site area will be important, in order to identify any future structural problems at the mill and to deter vandalism. Such limited maintenance and monitoring activities would fit well into a site stewardship program with the Christenot Mill Preservation Association which was formed by Nick Shrauger of Bozeman, Montana, and other descendants of the Christenot family. Future actions involve working cooperatively with Mr. Shrauger on a formal nomination of the Christenot Mill to the National Register of Historic Places, and establishing a formal site stewardship program.

ESTIMATED COSTS

Drainage problem:

Equipment needs- 510 backhoe with a operator for approximately 3 days. No materials needed. (Identify this work on the F/A schedule for DRA)

Mortar Work:

```
Lime; hydrated, 500 lbs @ 7.19 per 50# sack          = $ 71.90
Portland Cement; type 1, 500 lbs @ 6.98 per 94# sack=    41.80
Sand; colored, bulk, 500 lb  x 10.00 per 100         =    50.00
(mortar mix quantities may vary depending on crew
available.)
water, containers for hauling to site(use BDO pumper)
wheel barrow, (2)
Trowels; varies types, District will provide
scaffolding, (2) sets, rental of $41/month x 2       =   $82.00
                                          total = $245.70
```

Timber placement:

Materials and equipment needed:

Use 2"x12" untreated, unplaned timbers to match existing material. Will need to remeasure existing doors and windows for a recheck on size and quantities. Preliminary estimate use: 2"x12"x 300 lineal ft (600 bd ft.) at $650/bd ft quote from R & S log & Lumber in Dillon = $390.00

Wood Preservative:

Materials for Water Repelent Preservative = $200.00

Tree Removal:

labor-1 day - no materials needed.

Fencing:

```
Material list:
Jacklegs, (set) $8.60 ea @ 45                    =  387.00
Rails, peeled, untreated (14') 6.00 ea @ 180 = 1080.00
posts, wood treated, 8', 7.25 ea @ 10           =   72.50
spikes, ringshank, 60d, .80 @ 50 lbs            =   40.00
                                     total      = 1579.50
```

labor: delivery 1 day + crew of 4 for 2 days = 3 days

Interpretive Sign

Estimate for a 3' x 5' sign is = $300.00
(A good example of a sign from Rawlins Sign shop is the new Dillon BLM office sign, cost $230.00).

Materials Cost Summary:

Fencing material	- 1600.00
Mortar material	- 250.00
Timber replacement	- 400.00
Wood Preservative	- 200.00
Interpretive Sign	- 300.00
total	$ 2750.00

REFERENCES CITED

Clark, Gerald
1990 A Reconnaissance Inventory of Historic Mining Resources in the Summit, Browns Gulch, and Hungry Hollow Mining Districts, Madison County, Montana. Report on file, Bureau of Land Management, Dillon Resource Area.

Gray, Dale M.
1991 Cultural Resource Inventory and Assessment of Select Virginia City Area Mines. Prepared under contract with Department of State Lands, Abandoned Mines Reclamation Bureau, Helena, Montana.

McClure, A. K.
1869 Three Thousand Miles through the Rocky Mountains. J.B. Lippincott & Co., Philadelphia.

Mathews, Alfred Edward
1868 Pencil Sketches of Montana. New York.

Rolle, Andrew
1960 The Road to Virginia City, the Diary of James Knox Polk Miller. University of Oklahoma Press, Norman, Oklahoma.

Shrauger, Nick
1996 Chronological Citations for Christenot Mill- Oro Cache Mining District. Manuscript on file, Bureau of Land Management, Dillon, Montana.

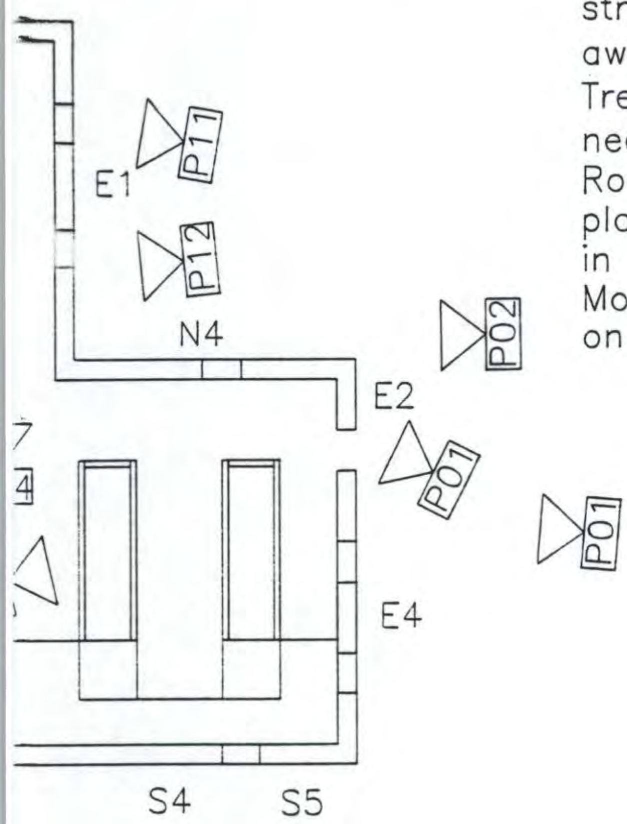
Tuttle, Daniel Sylvester
1906 Reminiscences of a Missionary Bishop. Thomas Whittaker, New York.

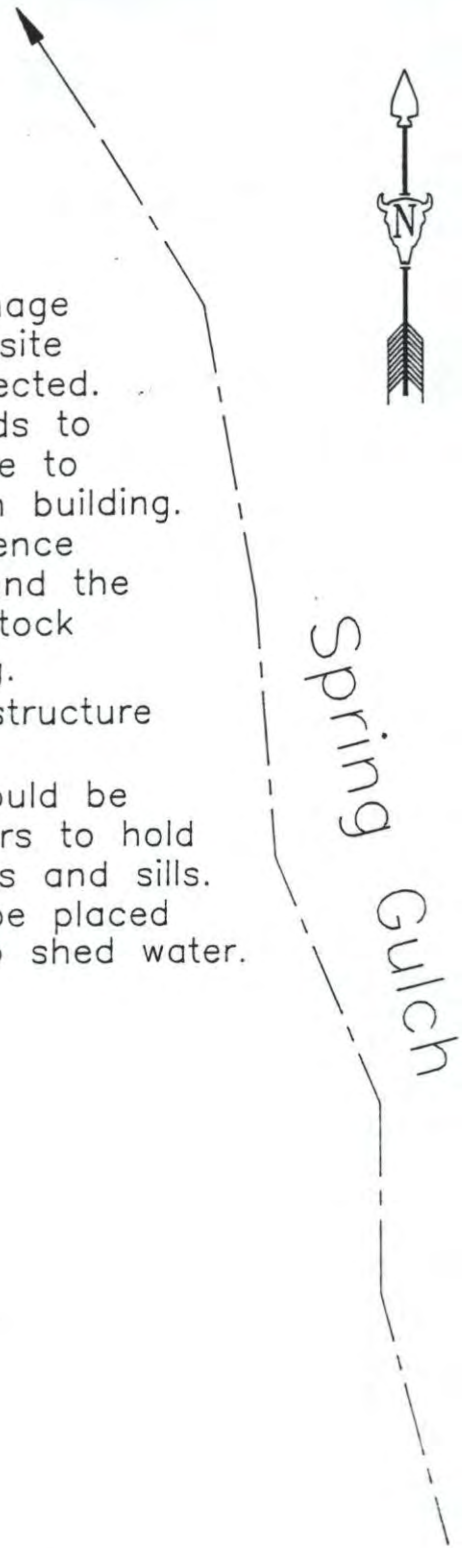
Attachment 1.
Mill Photos in Relation to Plan View Map.

ıber,location
ıed photo pages)

ication number

Mill Site lays in lodgepole pine forest with 20–30% slope. There is a drainage problem south of the site that needs to be corrected. A drainage ditch needs to be places south of site to divert water away from building. Also a jack and rail fence needs to be built around the structure to keep livestock away from the building. Trees standing within structure need to be removed. Rough cut timbers should be placed in windows/doors to hold in existing wood arches and sills. Mortor caps need to be placed on all existing walls to shed water.





ulch Road

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
BUTTE DISTRICT MONTA

CHRISTENOT MILL SITE
Site/Photo Layout

DESIGNED	
REVIEWED	
APPROVED	

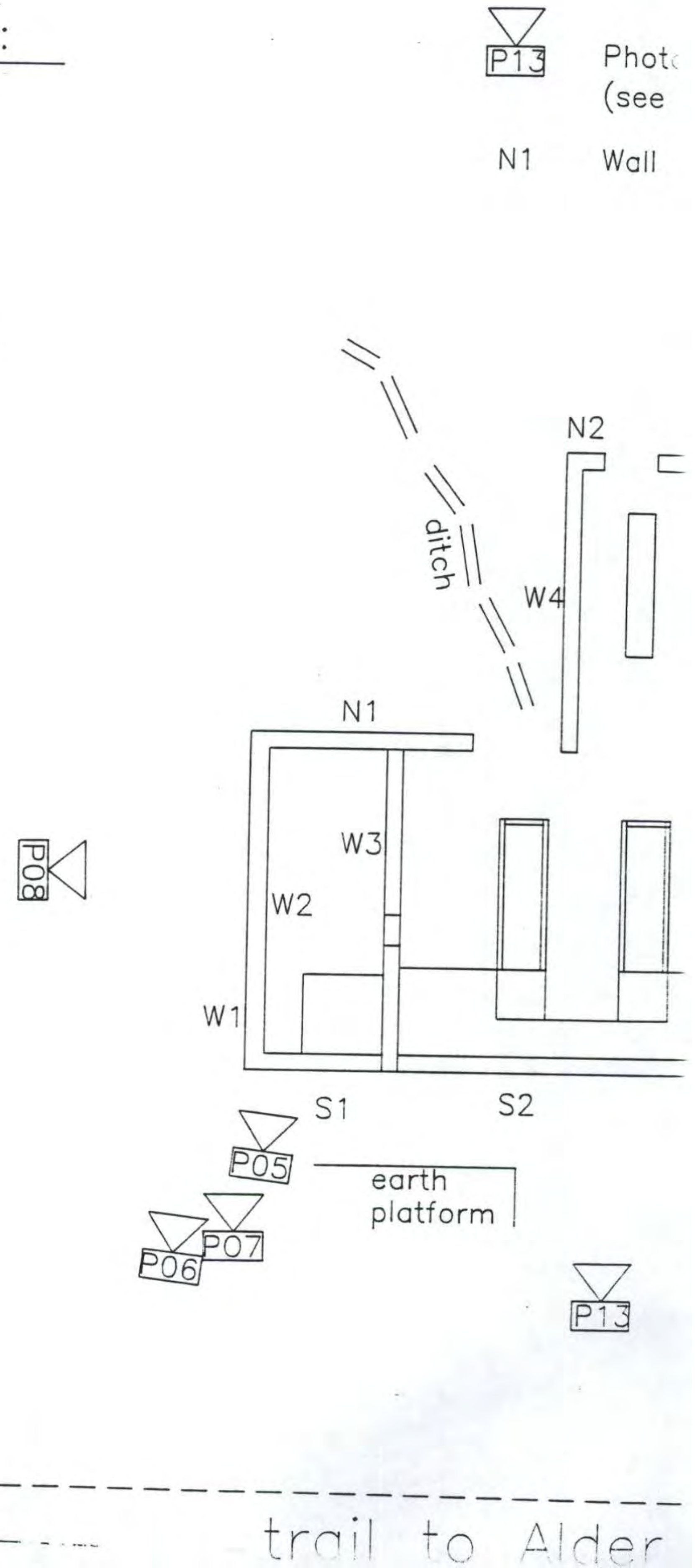
DRAWN	Lee Walsh	SCALE	AS SHOWN
DATE	11/6/96	SHEET	3 OF 7

Data collected by:

Larry Kingsbury
Archaeologist
BLM, Butte District
Sept 30,1985

Mark Sant
Archaeoiogist
BLM, Dillon Resource Area
1996

Nick Shrauger
7825 Gooch Hill Road
Bozeman, Mt 59715
406-586-5113



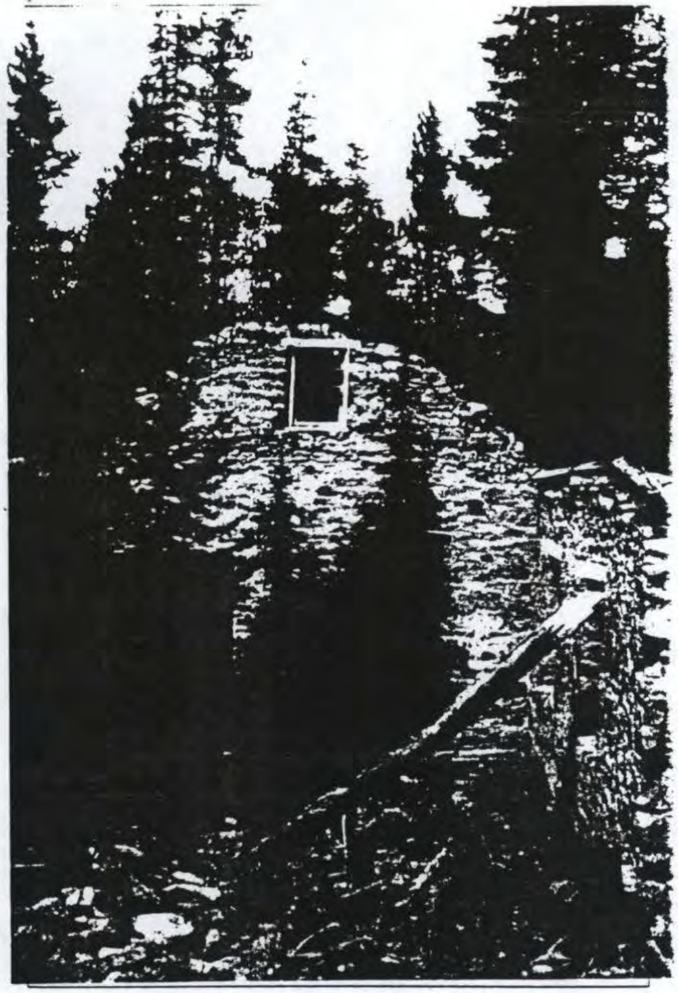


PHOTO 4
looking north at
wall N2 & N3
9/11/96

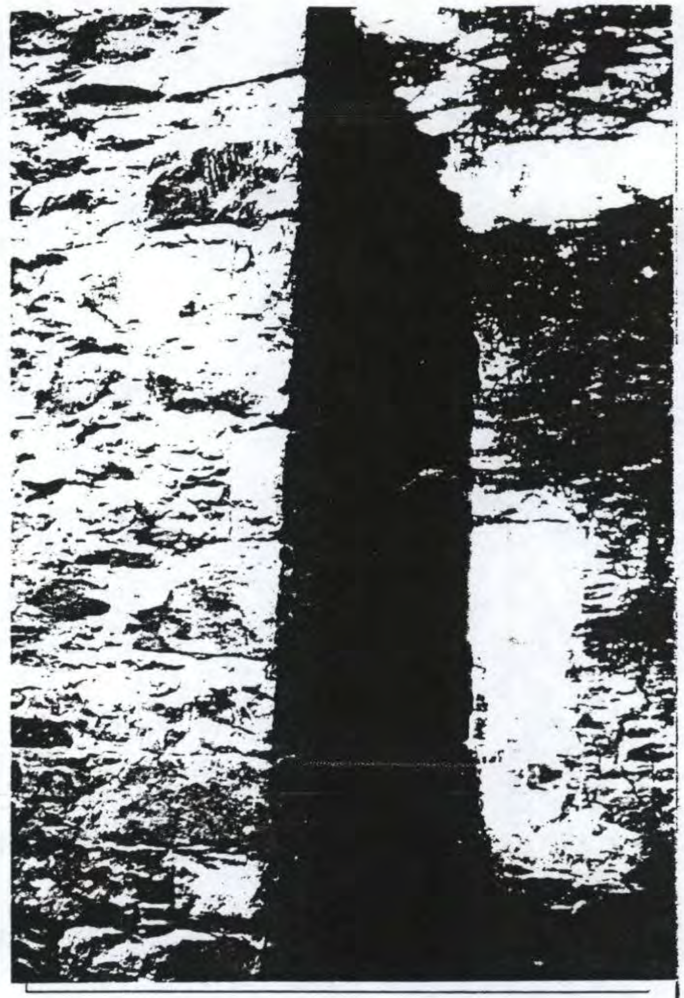


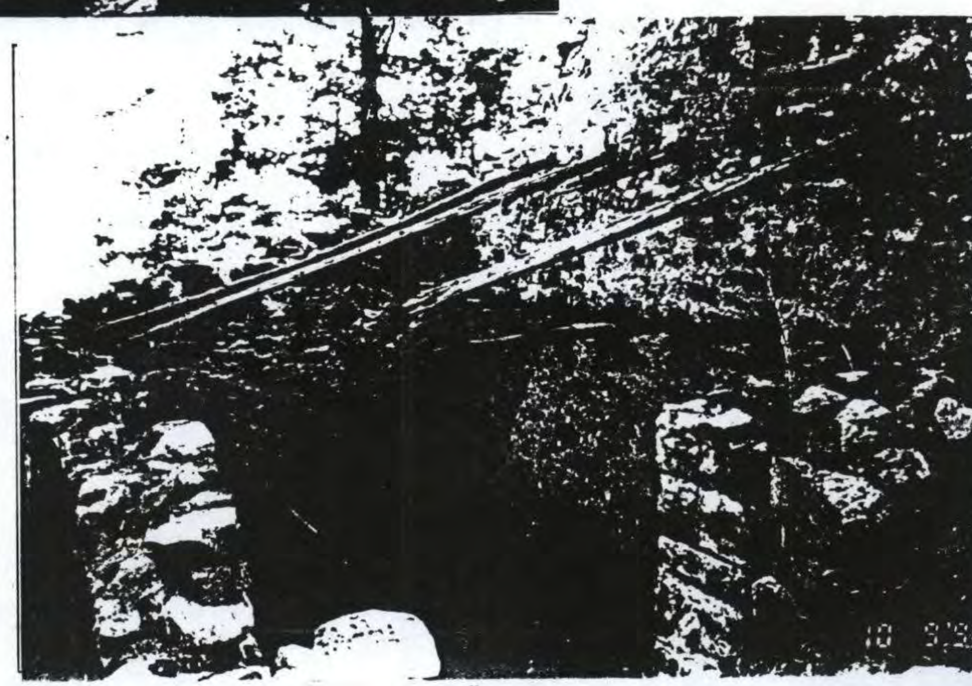
PHOTO 2
corner of wall N4
and wall E2
10/9/96

PHOTO 7
looking south
at office
10/9/96

PHOTO 8
looking east at
wall W2 & W3
9/11/96

PHOTO 6
office
9/11/96

PHOTO 5
looking northeast
at wall W1,W2,W3
10/9/96



X11-B2

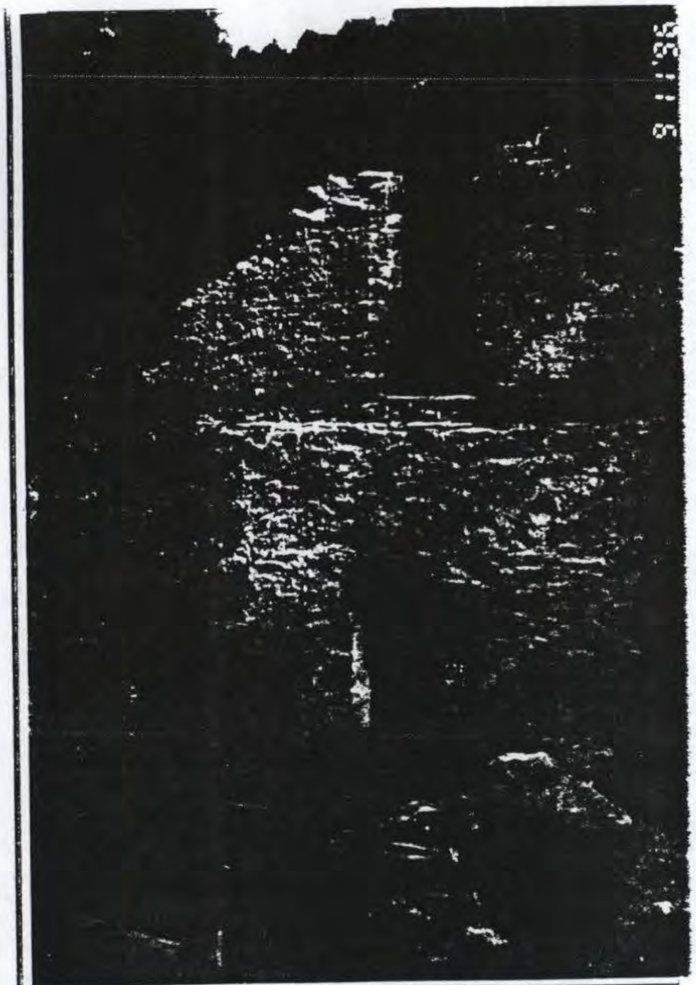


PHOTO 10
looking east at
wall E3
9/11/96

PHOTO 12
crack in wall E1
10/9/96

PHOTO 13
Looking south
10/9/96

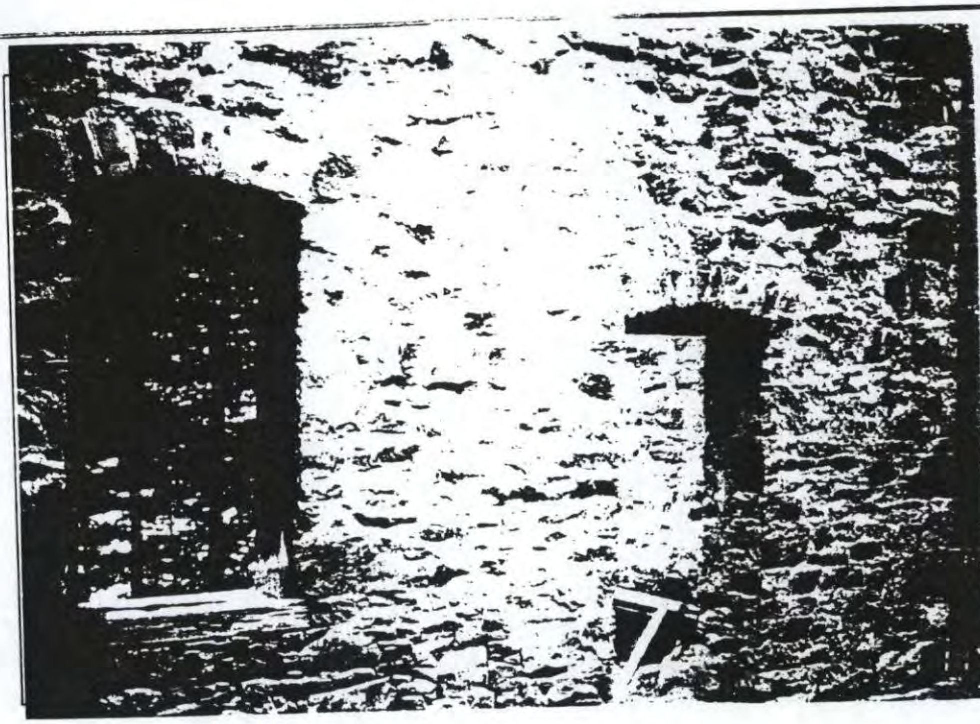


PHOTO 1
east wall
9/[illegible]/96

PHOTO 11
north window on
wall E3
10/9/96

PHOTO 3
door opening
on wall E2

Attachment 2.
Mortar Analysis and Selection Procedures.

Mortar Analysis

The purpose of mortar analysis is to determine the type and proportions of materials from which the mortar in a historic masonry structure is composed. However, there are significant limitations to the type of information which can be obtained from mortar analysis. It does not provide information on the following mortar characteristics, each of which can be critical to the durability and performance of a masonry wall:

- The amount of water used in mixing (too much mixing water will weaken mortar)
- The method of mixing and placing the mortar
- The cleanliness and condition of the aggregate (i.e., the presence of salts or organic materials)
- The drying conditions under which the mortar set up

Mortar analysis is not, by itself, an appropriate tool for dating historic structures. The constituent materials of most historic mortars – sand and lime - are so variable in their characteristics that they can rarely be traced to a specific place of origin or historic period. Also, many masonry walls have been repointed so often that it may be impossible to determine whether a mortar sample is original to the construction of a wall. This can be further complicated by the fact the original pointing mortar may differ from the mortar used to lay up the core of the wall.

There are other practical difficulties in isolating and identifying constituent materials through mortar analysis. Certain types of clay, present as impurities in the aggregate may be indistinguishable from the silicates which give hydraulic limes their properties.

The final and most important limitation to the use of mortar analysis in matching historic masonry materials is that even where it is possible to precisely determine the constituent materials of historic mortar, the use of modern materials in the same proportions will not yield mortar with the same properties. Modern manufactured lime is produced under controlled conditions and lacks the variations and chemical impurities which characterize historic limes and accounts for a wide variation in their properities. Therefore the exact chemical and physical properites of the original mortar are generally not of major importance in specifying mortar mixes for preservation work. Choice of an appropriate mortar for repairs or repointing must be determined by:

- The type of existing masonry - hardness, durability, chemical composition, etc
- Condition of the existing masonry - uniformity of masonry units, amount of weathering, etc.

- Conditions of exposure - climatic conditions and location in structure (i.e. parapet walls, projecting cornices, water tables, etc.)

These properties can be adequately addressed by the specification of contemporary masonry materials in a compatible mix. A compatible mix is one which:

- Matches the original mortar in color, texture, and detailing.
- Is softer (measured in compresive strength) than the brick or stone.
- Is as soft (measured in compresive strength) as the original mortar.

Although mortar analysis is not a dating tool or a recipe for matching the structural properties of historic mortars it is the best means of matching the visual characteristics of the historic material. By identifying the color, size, and other properties of the aggregate it is possible to select an aggregate that will duplicate these properties.

Methods of Analysis

Mortar samples should be taken from a minimum of three representative locations on the building. It is important to determine exactly which mortar is to be matched, realizing that a building may have been repointed a number of times. Samples should be unweathered lumps of approximately 2 oz. One sample should be labelled and retained for reference.

The remaining samples are then crushed with a mortar and pestle, or wooden mallet. A portion of the sample is stirred into a glass containing dilute hydrochloric acid to dissolve the binder. If there is a vigorous chemical reaction accompanied by heat and vigorous bubbling, and most of the binder disappears leaving clean aggregate, the binder was predominately lime. Cement will leave a murky liquid which takes several days to disssolve. Rinse the aggregate thoroughly in water and dry to obtain a sample for matching.

After obtaining a matching aggregate, a number of mortar samples should be prepared for comparison. Kitchen measuring spoons can be used to measure the sand, lime, and cement, in a number of pancake size samples, using a range of compatible mortar mixes. To match old and new mortar samples, snap a piece of old mortar in half to expose the unweathered interior and compare it directly with cured test samples of trial mixes. Samples can be cured in an oven to accelerate drying, or the old sample can be wetted for comparison. If a sample matches an unweathered section of historic mortar it will eventually weather to the same color as the exposed mortar on the building exterior.

A more comprehensive chemical analysis can be done as follows to determine the proportions of binder, aggregate, and fines (cement, fine brick dust, or crushed stone).

Chemical Analysis Procedure

reprinted from Practical Building Conservation: Voume 2 - Brick, Terracotta, and Earth. John Ashurst and Nicola Ashurst. Halsted Press. New York. 1988. pp 26-7.

1 Collect an unweathered sample of about 40–50 grams. Examine it and record characteristics such as colour, texture, aggregates, inclusions and hardness (scratch resistance). Retain half as a record

2 Powder half the sample with a mortar and pestle. Dry at 110°C for 24 hours and then weigh it with a balance (to an accuracy of 0.1 g)

3 Place the sample in a glass beaker and moisten it with deionized water. Then immerse the moistened sample in a 10–15 solution of hydrochloric acid to dissolve the lime binder. The mixture will effervesce as CO_2 is given off. Carefully observe the reaction through the side of the beaker. (Safety glasses should be worn). The mixture should then be stirred with a glass rod to make sure the reaction is complete

4 Weigh a piece of filter paper, place it in a funnel positioned over a large flask

5 Add a few drops of hydrochloric acid to the sample to ensure complete acid digestion of the binder and stir. Add water to it slowly and swirl with a glass rod to suspend the fines

6 Pour the liquid with the suspended material through the filter, being careful to keep the solid particles at the bottom of the beaker. Add more water and repeat the swirling and pouring until the water added to the beaker remains clear

7 Dry the fines collected on the filter paper and weigh. Determine the weight of the fines

8 Wash the sand with water several times and leave to dry for 24 hours. Weigh the dry sand.

Alternatively: Steps 6–8 may be combined. All the sand and fines from the beaker may be poured into the filter and dried and weighed together (see step 11)

9 Express the amounts of sand and fines as a percentage of the whole sample. The amount of dissolved binder is calculated by subtracting the sand and fines weights from the weight of the original sample. The weights determined will give the proportions of binder, fines and aggregates of the original mix. Allowances must be made for the loss of any calcareous aggregates dissolved with the binder. The results of the analysis can be recorded on a sheet such as the one at Figure 3.1

10 Inspect the colour of the dried fines. Simple inspection of this kind is normally sufficient to identify clay (yellow, plastic when wetted), brick (red/brown), cement (grey), sand (almost any colour, gritty to touch)

11 More accurate examination must be made with a binocular microscope to determine colour, particle shape and material types. Sieve through standard sieves to determine particle size distribution expressing the amount of each particle size as a percentage of the whole. (*Note*: the acid may have changed the colours of the sand)

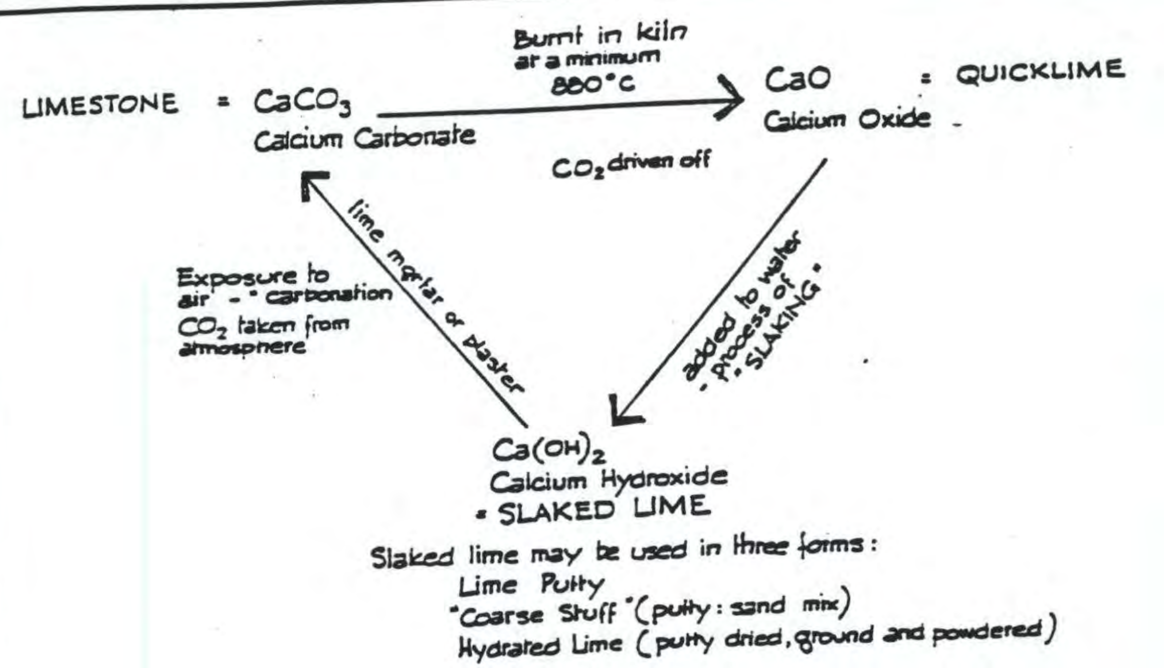
Masonry Materials

Mortar

Mortar is the agent that bonds masonry into an integral structural unit. It fills the voids between stones or bricks of varying sizes, and by distributing uneven structural forces throughout the wall, causes the masonry mass to function as a single structural element. It allows walls to be made weather tight, and contributes in a major way to the visual and aesthetic qualities of the building.

Until the late 19th century almost all mortars used in building construction consisted of a mixture of sand and lime. Pozzolana, a type of natural concrete composed of lime and volcanic ash, was used by the Romans for large engineering works like the Pantheon and the Coliseum. However, with the fall of the Empire, knowledge of its use was lost until 18th century engineers and inventors began to explore the properties of hydraulic materials. Any mortar which will harden under water is considered to be hydraulic. Some limestones contraining clay, when burned, yield a natural cement with hydraulic properties. In the United States, natural cement was first used in the construction of the Erie Canal where a natural cement stone was discovered by an engineer name Canvass White, who patented his method of manufacture in 1820. Portland cement, an artificial material, was patented in 1824 by Joseph Aspdin, an English mason. Although it gradually replaced the natural cements because of its uniform quality, it was not manufactured in the United States until 1871, and did not become generally used in construction until after 1880. The slow acceptance of natural and artificial cements into universal building practice is due to a number of factors. When first developed, their characteristics of great strength, hardness, and resistance to moisture were only required on large scale engineering projects. Craftsmen skilled in the traditional methods resisted the use of portland cement because its workability was inferior to that of lime mortar, and because of its shrinkage on hardening. The grey color of portland cement was also offensive to period tastes.

Most important was the fact that the characteristics of lime mortar were appropriate to the properties of the available building materials until 20th century materials and engineering techniques revolutionized building design and trade practices. Modern masonry structures are designed to use modular elements - brick, concrete block, pre-cast panels, and veneers - manufactured to a standard of uniformity, hardness, and strength which require a mortar of equal hardness and strength. In contrast most historic structures are built with materials of relatively low rigidity and compressive strength. Rather than "gluing" brick and stone together in a high strength bond, lime mortar provided a plastic cushion that allowed materials to settle, to expand and contract with thermal changes, and to compensate for variable qualities in the masonry units.



"THE LIME CYCLE" - burning, slaking and hardening of non-hydraulic lime

reprinted from Practical Building Conservation: Volume 1 - Stone Masonry by John and Nicola Ashurst. Halsted Press. New York. 1988.

Lime is the principal binder of most traditional mortars and plasters. It is produced by burning or calcining natural materials - limestone, shells, or marble - containing a high proportion of calcium carbonate. Early kilns were sometimes no more than simple clamps of alternate layers of stone and fuel covered with clay and ventilated with stoke holes. Modern rotary kilns are fueled by oil or gas, burning the lime at temperatures of about 1650 degrees F. During burning, carbon dioxide and water is given off, producing a solid product, calcium oxide, also known as **quicklime (ASTM C5)** or **unslaked lime.** Quicklime is an extremely reactive and unstable material which **hydrates or slakes** in the presence of water. When quicklime is mixed with from two to three times its weight of water, a chemical reaction takes place. The calcium oxide combines with water to form calcium hydroxide, and enough heat is generated in the reaction to bring the mixture to a boil. Traditionally, this process was carried out in pits and the slaked lime was left to mature for months or even years. **Slaked quicklime putty** is the product of the chemical reaction. Historically it was used in this form after screening to remove unburnt lumps and coagulations. Old lime putty, which is protected from the air becomes rigid and gelatinous. When the rigid mass is worked through or "knocked up" it regains its plasticity and workability. This property is unique to non-hydraulic lime putty. Materials which have taken a hydraulic set cannot be made plastic again.

for mortar mixes, despite the fact that traditionally slaked lime is said to produce a better quality mortar. **Mason's Hydrated Lime (ASTM C207)** is manufactured from quicklime under controlled conditions by the addition of a limited amount of water. The product of this controlled hydration process is a fine powder. Two types of mason's hydrated limes are commercially available. **Type N** is used primarily for agricultural applications. It does not have the same degree of plasticity as slaked lime putty and is not recommended for use in masonry mortar. **Type S** mason's hydrated lime is produced by burning limestone containing known amounts of magnesium oxide, under pressure. The resulting product has plasticity and workability almost equivalent to slaked quicklime putty, and is the standard for most masonry mortar mixes.

Lime mortars harden by by "carbonation", that is, the absorption of carbon dioxide from the air which reacts with calcium hydroxide to form calcium carbonate (the same chemical composition as limestone). There is no chemical "set" as is the case with cements and hydraulic limes. The carbonation process can continue almost indefinitely, although soft mortar isolated from the air may never completely harden.

Hydraulic Limes and Natural Cements

Hydraulic mortars harden (set) by chemical reaction with water. Limestone which contains a proportion of clay and other impurities such as calcium and magnesium carbonates will yield "hydraulic" lime after calcination. Depending on the proportion of clay and other chemical elements some materials are so strongly hydraulic that they are classified as natural cements, sometimes called Roman cement. Many historic mortars exhibit some degree of hydraulic properties due to impurities in the limestone which was burned to manufacture the lime used. Natural cements were the focus of much research and experimentation during the 19th century until the manufacture of artificial cement was perfected.

Cement

Portland cements are the most common of the modern hydraulic cements. They are manufactured by blending carefully proportion mixes of clay and calcium carbonate. The mixture is burned in a rotary kiln at a temperature of about 2700 degrees F to form hard pellets called clinker. The clinker is ground with a retarder (usually rock gypsum) to a fine powder which constitutes the portland cement. The composition of the various types of cement depends on the proportions of various elements such as tricalcium silicate, tricalcium ferrite, dicalcium silicate, and others, which determine the properties for which the different types of cement are used. Portland cements **(ASTM C150)** are made in five different types having different properties based on their chemical makeup.

- **Type I, Normal Portland Cement**, is the one commonly used for most structural purposes, and it is well suited for use in masonry mortar.

- **Type II, Modified Portland Cement** varies in having a greater resistance to sulfate attack than Type I, and a lower heat of hydration. Type II cement gains strength a little more slowly than Type I but will ultimately reach equal strength. It is generally available in most sections of the country and is preferred by some engineers over Type I for general construction, including use in masonry mortar.

- **Type III, High Early Strength Portland Cement** is ground more finely than other grades of portland cement and has a higher tricalcium silicate content. These additives cause it to reach its ultimate strength more quickly than other types. The 3 day strength of concrete made with Type III cement is nearly equal to the strength of Type I or Type II cements at 28 days. Type III cement has poor sulfate resistance. It develops great heat during curing and should not be used in large masses of concrete. It is not generally used for applications other than concrete.

- **Type IV, Low Heat Portland Cement** has been developed for mass concrete construction. Normal Type I cement, if used in large masses that cannot lose heat by radiation, will liberate enough heat during the hydration of the cement to raise the temperature of the concrete by 50-60 degrees F. This results in relatively large increases in dimensions while the concrete is still soft and plastic. Later as the concrete cools after hardening, shrinkage causes cracks to develop. This type of concrete gains its ultimate strength relatively slowly.

- **Type V, Sulfate-resistant Portland Cement** is a special cement designed for use in concrete where high sulfate resistance is required, for example around sea water. Both Type IV and Type V cements are special purpose materials for concrete construction and are not generally available from dealers. Their special properties are not applicable to masonry mortar.

- **Air-entraining cements (ASTM C175)** are available in **Types IA, IIA, and IIIA.** They are used in concrete construction to improve freeze/thaw resistance and reduce surface scaling from contact with salt applied for snow and ice removal. They should not be used in masonry mortars because they result in decreased bonding of the mortar to the masonry units. Air entraining is not necessary with lime mortars because these mortars are inherently flexible with temperature changes.

- **White non-staining Portland Cement** is manufactured to conform to the specifications of ASTM C150 and C175. It is preferred for use in mortar mixes for historic preservation projects because its white color matches that of most historic lime mortars. It is available in Types I, II, or III.

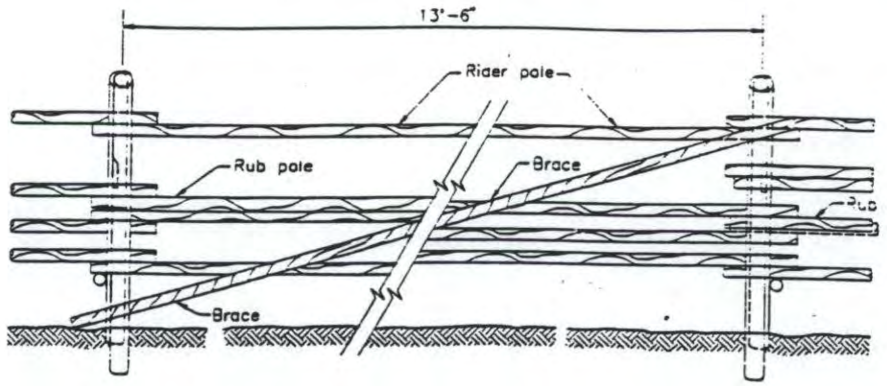
- **Masonry Cements (ASTM C91)** are proprietary mixes containing portland or natural cements mixed with pulverized limestone. They are design to be mixed with sand and used for setting brick, tile, stone, etc. There is no specification as to the physical requirements and chemical content of masonry cement and some manufacturers vary the composition widely, depending upon competition and the availability of materials. Resulting mortars vary widely in properties but generally contain 50-60% lime.

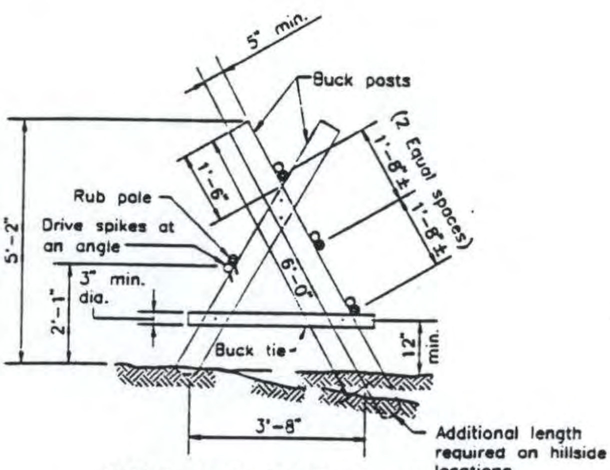
The two most important requirements for sand used in masonry mortar are that it be clean and well-graded. Sand should be free of clay, silt, organic matter, and salts. Contaminants or chemicals may weaken the mortar, and enter into chemical reactions in the presence of water which will contribute to the deterioration of the finished wall. The aggregate should be uniformly graded in size to pass through sieves have from 4 - 100 openings per inch. Well graded aggregate retards the separation of the materials in the mortar mix. Sand that has too many fine particles results in weak mortar, while sand that has too few fine particles produces mortars that are "harsh" and difficult to work. Also, as a matter of economy, well-graded sands fill up the voids between particles more completely, and less binder (cement/lime) is required. **ASTM C144** specifies in detail the required physical properties for sand as an aggregate in masonry mortar.

Historically most mortars were made with naturally occuring bar or beach sand. Natural sand has rounded edges and tends to "flow" easily in the application of the mortar. Today most commercially available sands are manufactured by crushing rock. Therefore the sand grains are jagged and sharp-edged. While this allows the aggregate particles to "lock" together, resulting in a stronger mortar, it also makes it more difficult to work. Adding small amounts of portland cement improves its workability and helps to compensate for the different properties of contemporary aggregates. Up to 20% portland cement can be added to the total lime/cement binder without significantly affecting the hardness of the mortar. The amount of portland cement in the binder should generally not exceed 40% for historic preservation work.

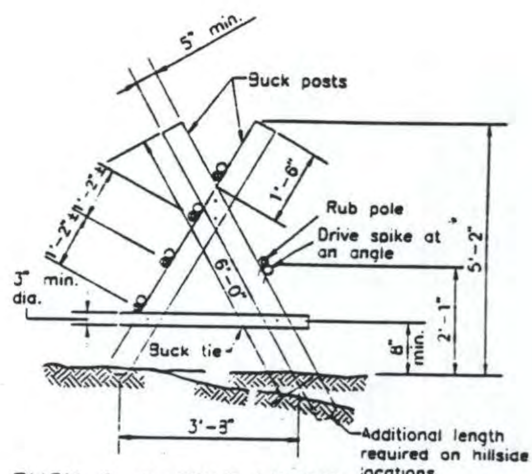
The other significant property of sand is its color. In matching historic masonry work, the color and texture of the sand used is the most important factor in determining the character of the finished mortar. In some cases it may be necessary to mix aggregates from several different sources to match the historic color.

Attachement 3.
Design Specifications for Buck and Pole Exclosure Fence

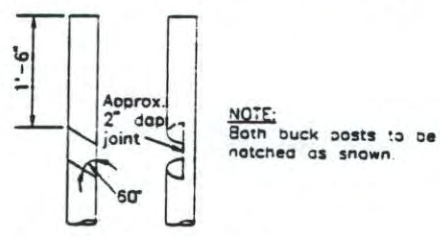




BUCK & 3-POLE FENCE



BUCK & 4-POLE FENCE



BUCK POST JOINT DETAIL

NOTES:

1. Spikes shall be used as fasteners. Two spikes shall be used to fasten buck posts together. One spike shall be used to fasten poles, braces & buck ties to buck posts.
2. Poles, braces, ties, & buck posts shall be of material as shown in the specifications.

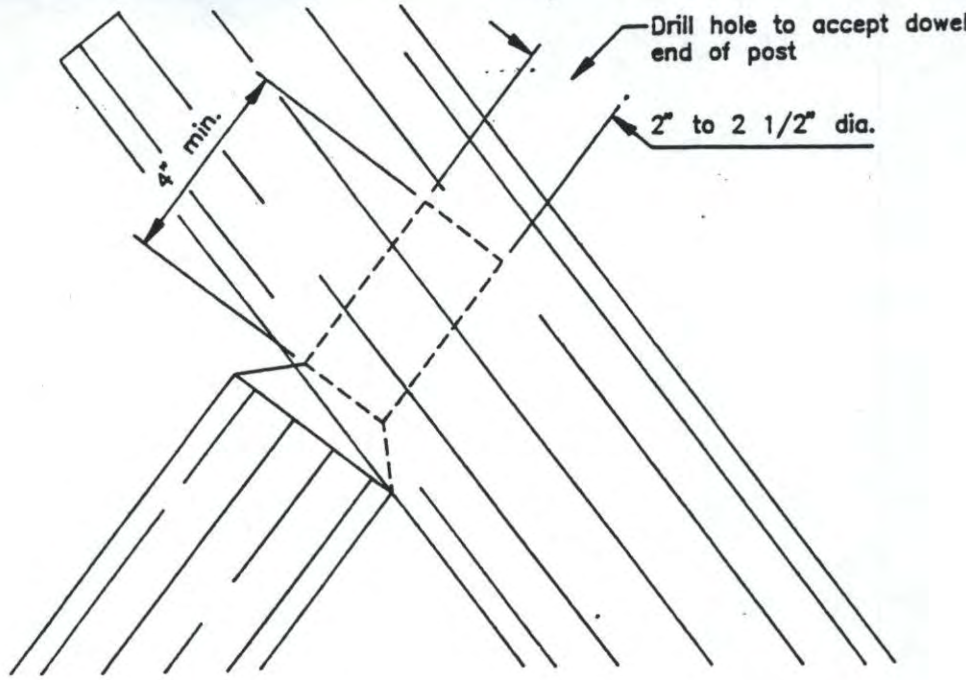
ALWAYS THINK SAFETY

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
DIVISION OF TECHNICAL SERVICES SERVICE CENTER

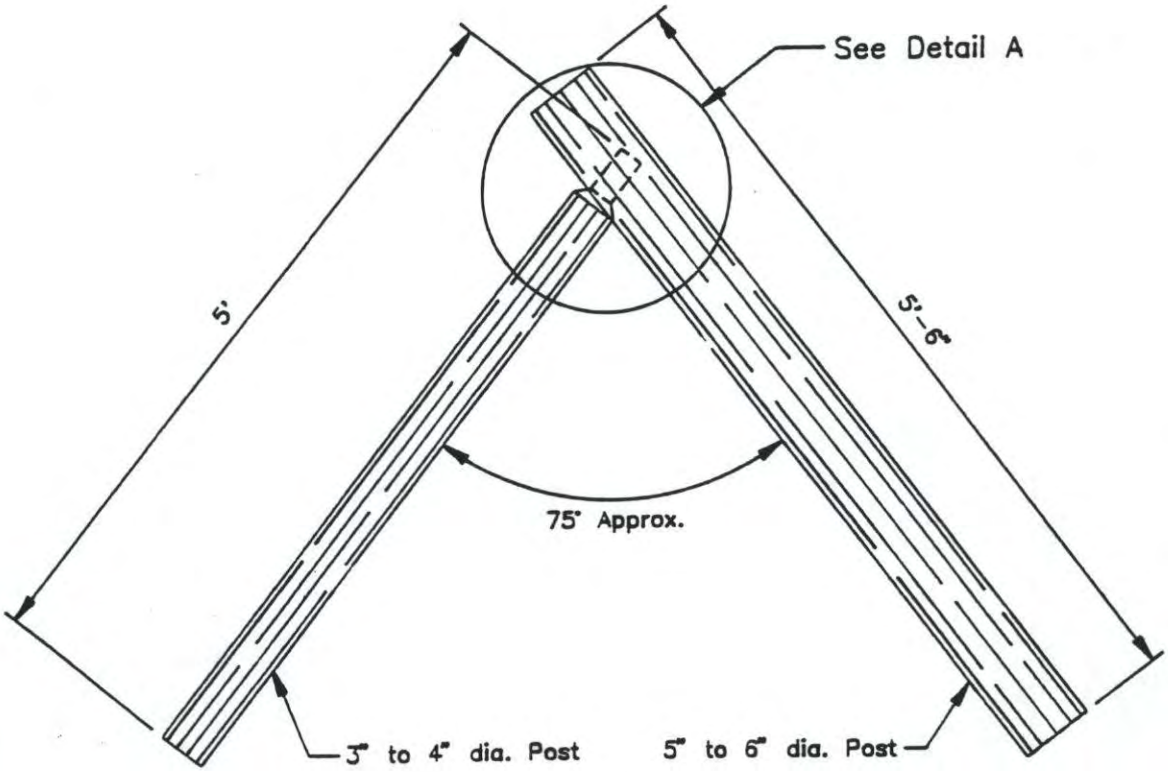
BUCK & POLE FENCE

DESIGNED by others
REVIEWED
APPROVED

DRAWN
SCALE NONE
DATE SEPTEMBER 27, 1990
SHEET OF
DRAWING NO. 02835-7



DETAIL A



SIDE VIEW

TITLE JACKLEG	U.S. DEPARTMENT OF THE INTERIOR BUREAU OF LAND MANAGEMENT
DATE 9/93 DRAWN dp	
SHEET 1 of 1	DRAWING NO.

DESIGNED REVIEWED APPROVED

U.S. Department of the Interior
Bureau of Land Management

CATEGORICAL EXCLUSION REVIEW RECORD

CER No. MT-076-CE-97-4

Authority (516 DM 6, Appendix 5.4) H(9)

Reference Document N/A

Project Christenot Mill Exclosure Fence

Project Location NESESW Meridian MPM Sec. 13 T. 7S R. 3W Co. Madison State Montana

File No. ______ Lease No. ______ Field/Unit ______

Applicant ______ Date Submitted/Initiated ______

CER Preparer Mark B. Sant, Archaeologist, Dillon Resource A Field Inspection Date 9/11/96

The affected Resource Area received a copy of this action proposal for review before or during the field inspection. Stipulations ☐ were ☐ were not received from the Area and appropriate stipulations were incorporated.

Exception Criteria*	Exception Criteria Exceeded		Confirmation		Stipulations, Comments, Data Sources, etc. (Refer to next page)	
	Yes	No	Signature/ Initials	Date	Yes	No
1. Public Health & Safety		X	MBS	2/7/97		
2. Unique Characteristics		X	MBS	2/7/97		
3. Environmentally Controversial		X	MBS	2/7/97		
4. Uncertain and Unknown Risks		X	MBS	2/7/97		
5. Establishes Precedent		X	MBS	2/7/97		
6. Cumulatively Significant		X	MBS	2/7/97		
7. Cultural Res. & Nat. Reg. Hist. Places		X	1 MBS	2/7/97	Cultural Clearance No. 97-MT-072-076-06	
8. Endangered/Threat. Species		X	2 BH JWR	FEB 11, '97 2/11/97		
9. Violate Fed., State, Local, Tribal Law		X	MBS	2/7/97		

Check one:

☒ This proposal meets all the requirements of a categorical exclusion, and does not negatively affect other environmental resources.

☐ Exception criteria were exceeded and appropriate mitigation cannot be provided without further environmental analysis.

Environmental Coordinator/Environmental Scientist Russ Sorensen (Signature) 2-11-97 (Date)

Manager Scott Powers (Signature) 2-11-97 (Date)

*Refer to BLM Categorical Exclusion Review (CER) Procedures; Criteria for Exception — Description for full explanation (516 DM 2.3A(3)).
[1]Archaeologist signature required
[2]Wildlife Biologist signature required

Project Description:

A Jack and pole fence will be constructed around the mill site to protect fragile walls from being impacted from cattle grazing and vandalism, and to keep visitors away from potentially hazardous areas. The fence will be approximately 540 ft in length.

Exception Criteria No.	Stipulations (additional details can be attached on appended sheet)
516-DM6 app.5.4 H(9)	

Field Inspection Members	Position	Representing
Mark Sant	Archaeologist	Dillon Resource Area
Chris Nemeth	Engineer Tech	Dillon Resource Area
Lee Walsh	Engineer	Butte District Office
Nick Schrauger	Public	Christenot Mill Preservation Association

Data Sources:

Project Description
Christenot Mill Exclosure Fence - RIP#7321

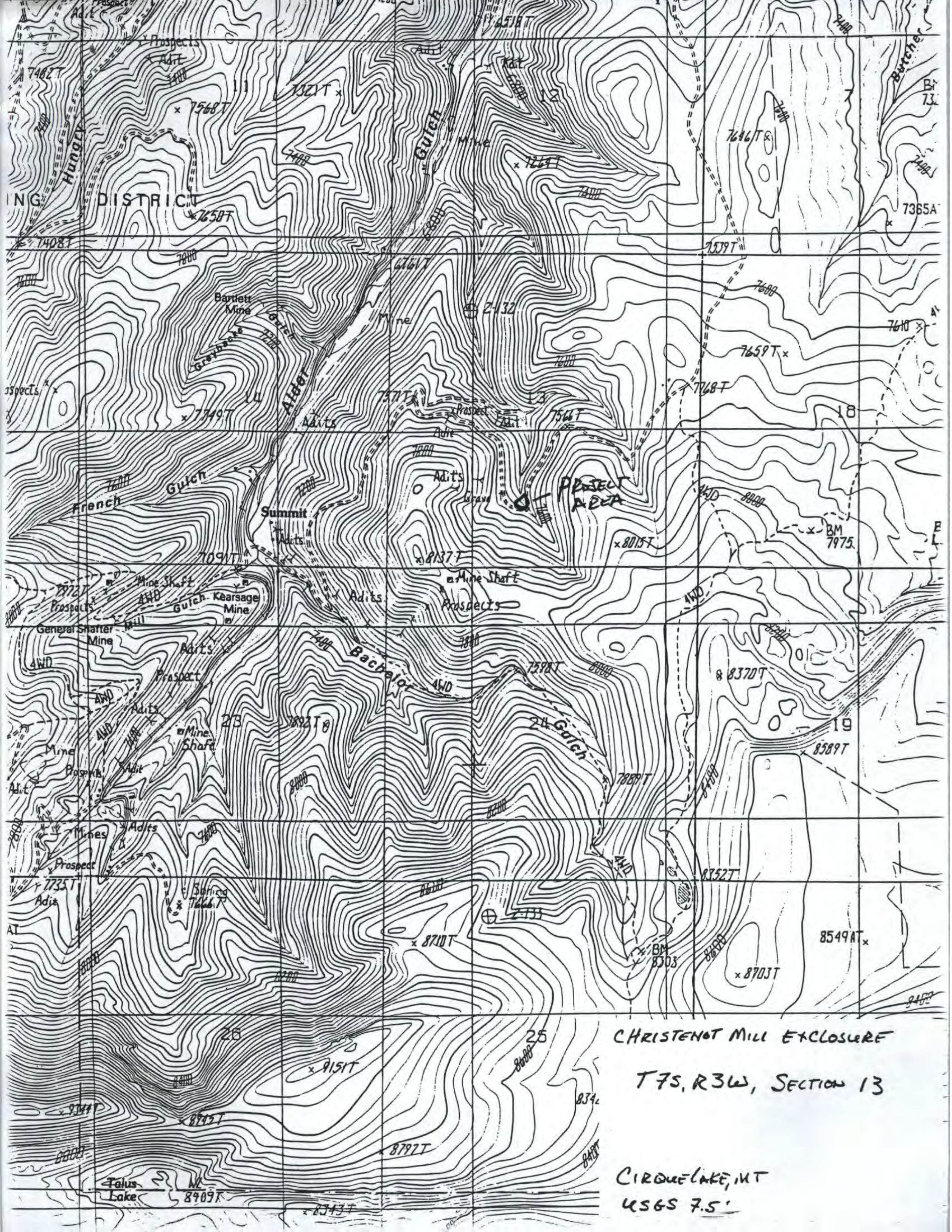
The Christenot Mill (24MA1215) was constructed in 1866 to process ore from early lode mining efforts in Alder Gulch. Currently, the mill represents one of the finest examples of early ore milling in southwestern Montana. Efforts are underway to list this building and surrounding site area on the National Register of Historic Places. Due to the fragile nature of the standing walls of the structure, it is important to protect them from potential damage by cattle grazing. Cows currently have unrestricted access to the structure and may scratch or rub against standing walls.

Due to the remote location of the structure, the building has also suffered impacts from casual visitation and vandalism. A fence around the structure should serve as an additional protective measure. Representatives from the Montana State Historic Preservation Office have been consulted on this proposal and future efforts to stabilize the structure and provide for an interpretive sign. Stabilization and interpretive efforts are being supported through a cooperative agreement between the BLM and members of the Christenot Family (Nick Schrauger of Bozeman, MT).

In order to maintain the historic character of the mill, it will be necessary to construct a jack and pole fence. Approximately 400-500 ft of fence will be required to enclose the mill structure.

In addition, while constructing the exclosure fence it would be appropriate to have force account fix surface water drainage problems. Spring runoff is currently channelled through the mill structure. A small amount of backhoe work would be required to divert runoff around the building. Chris Nemeth of the Dillon Resource Area and Lee Walsh of the Butte District Office have already visited the structure, and are currently working on the engineering aspects of the exclosure fence, runoff diversion, and other stabilization efforts.

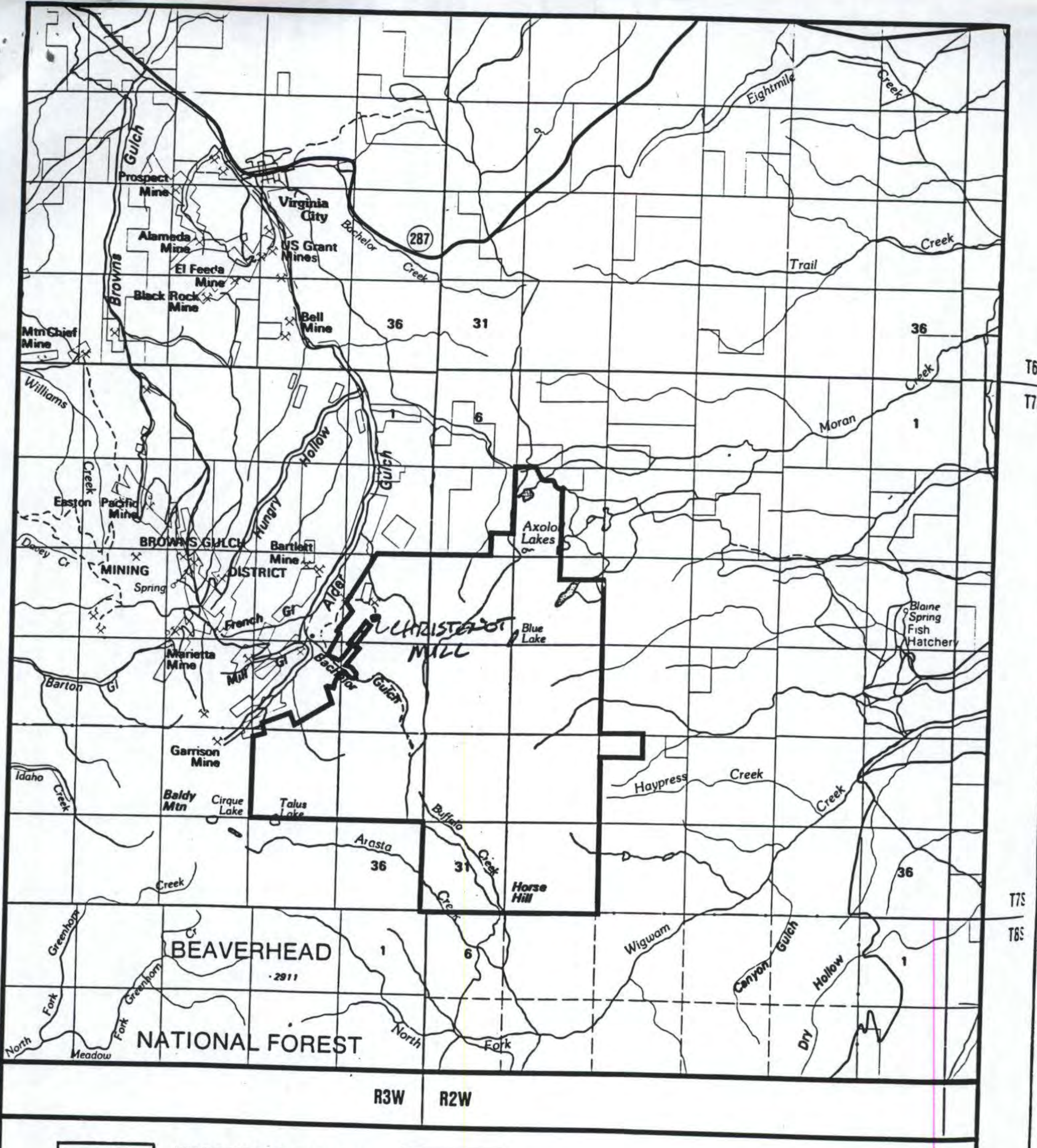
It will be necessary to prepare a condition assessment and stabilization plan for the work at the mill. These documents will need to be reviewed by the Montana State Historic Preservation Office. In addition, Roy Moen of Virginia City has active mining claims at the location. It will be necessary to inform him of our intentions to nominate the building to the National Register and of our stabilization efforts.



CHRISTENOT MILL EXCLOSURE

T7S, R3W, SECTION 13

CIRQUE LAKE, MT
USGS 7.5'



NONE	RECOMMENDED FOR WILDERNESS
	RECOMMENDED FOR NONWILDERNESS
NONE	LAND OUTSIDE WSA RECOMMENDED FOR WILDERNESS
NONE	SPLIT ESTATE
NONE	STATE
NONE	PRIVATE

-N-

Axolotl Proposal

0 1 2 3 Miles
0 1 2 3 4 5 Kilometers

MT-076-069
SEPTEMBER 1, 1990