STABILIZATION OF THE SILVER BELL MINE:

JOSHUA TREE NATIONAL PARK, RIVERSIDE COUNTY, CALIFORNIA

PREPARED FOR THE NATIONAL PARK SERVICE

by

THE SCHOOL OF ENGINEERING

UNIVERSITY OF VERMONT

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Prepared for
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OCTOBER 2017

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Cover photo: Silver Bell Mine, Joshua Tree National Park; helicopter operations to deliver tools and materials to the build site prior to rehabilitation, November 8, 2016

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EXECUTIVE SUMMARY

In 2015, the School of Engineering at the University of Vermont (UVM) and Joshua Tree National Park (JOTR) entered into a cooperative agreement focused on assessment and pilot treatment of historic wood structures associated with the Silver Bell and Golden Bell Mines, located within the park. Assessment and treatment activities were to result in the training of students and volunteers in assessment and repair techniques used in the preservation of historic timber structures. Early in the planning process, it became clear that the training and

Figure 1: Tipples (ore bins) at the Silver Bell Mine site as seen from Pinto Basin Road, looking south to the Hexie Mountains, Joshua Tree National Park, 2016

stabilization goals could be most fully realized at the Silver Bell site, and the decision was made to limit assessment and treatment activities to the surviving tipples, or ore bins at Silver Bell.

A site visit by the assessment team was conducted in February 2016 for the purpose of updating an assessment completed by Vanishing Treasures Historical Architect Randall Skeirik in 2009 (Field Assessment and Preliminary Treatment Recommendations for Grubstake Cabin, the Ryan Ranch House, The Silver and Golden Bell Mines and Keys Ranch, August 2009, unpublished report). Assessment activities included identification of members requiring repair or replacement, collection of samples for species identification, measurement of the bins for materials lists and documentary drawings, and development of repair strategies to address the deterioration.

This report presents assessment findings, and describes the subsequent treatment and repair of the Silver Bell ore bins; field work was completed in the fall of 2016. The report is divided into six parts: a description of the mine structure with a brief consideration of its history and significance, a summary of condition assessment results, presentation of preservation strategies, a description of the repairs and recommendations for future work. Architectural drawings produced for this report are included in an appendix.

HISTORY AND SIGNIFICANCE

The Silver Bell mine is located in the eastern Hexie Mountains, in the Middle Pinyon Mining District and overlooking Pinto Basin. The mine site follows a northwest trending fault zone and several minor faults yielding oxidized gold-bearing quartz veins in Augustine Gneiss (Trent).

Figure 2: Tipples (ore bins) at the Silver Bell Mine site, Joshua Tree National Park, Photo by D. D. Trent, 2001.

Remains of the Silver Bell and adjacent Golden Bell mines include ore bins, shafts, adits, foundations, tanks, and tailings.

Although mining in the Pinyon district dates back to as early as 1892, the Silver Bell mine was in operation from 1934 to 1962, producing modest amounts of gold, silver, lead and copper[1]. In the 1930's, mining activities in this area were focused primarily on the reworking of established claims, rather than the development of new ones. This was due in part to the introduction of cyanide processing, which allowed for extraction of additional resources from old tailings. The Silver Bell mine was an apparent exception to this trend.

[1] Hickman, 1977

While in production, the mine was not exceptionally successful and did not produce a large quantity of ore in comparison to other area mines. Production totals at the mine between the years of 1934 to 1954 include 219 oz. of gold, and 53 oz. of silver[2].

During World War II, the mine produced lead and between 1956 and 1962 the mine was operated for copper production by the Farrington-Mann Company.[2] During the majority of the mines productive years, the mining site was an inholding in the Joshua Tree National Monument (established in 1936). The mine site became part of the Joshua Tree National Park in 1994 with the signing of the California Desert Protection Act. The Silver Bell mine is one of the most easily accessed mining sites in Joshua Tree National Park, and the historic integrity of the ore bins is relatively high; however, they are currently ineligible for listing on the National Register of Historic Places.

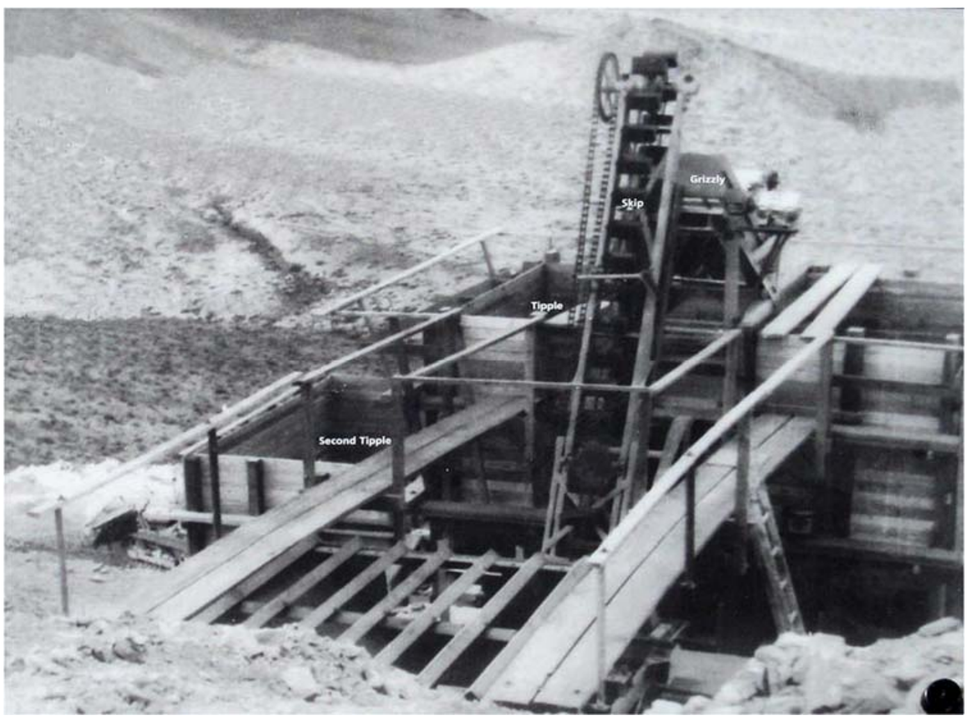

Figure 3: An undated image showing the ore bins in use.

[2] Emerson, 2000

INVESTIGATION AND CONDITION ASSESSMENT

WOOD CONDITION

The bins are arranged to operate in tandem, and occupy a steeply sloping site that permitted charging of the upper bin, the transfer of ore from the upper to the lower bin, and the discharge of the lower bin from positions at grade in both cases. The bins are nominally 9’-10” x 16’-07” (inside-to-inside) and are similarly framed, though their construction dates may differ. Bins have inclined floors supported on dimension lumber joists that fasten to girts oriented across the width of the bins. Timber columns or posts are supported on the tops of these girts; below the girts, the bins are supported on column extensions fastened with wood splints that are, in turn, supported on the timber sills. The sills of bin #1 (the upper, or east, bin) rest on grade; the sills of bin #2 (the lower, or west, bin) are supported on concrete grade beams. Both bins incorporate walkways with guardrails. Member sizes are approximately the same in each bin, but TECO connectors used in the construction of bin #2 are absent in bin #1.

In his 2009 Assessment, Randall Skeirik noted decay in several wood members at or near grade. The out-of-plumb condition of both ore bins appeared to be at least partially the result of the crushing of timber sills and other supporting members at or below grade. Prior to the assessment visit in 2016, information concerning the configuration of the frames below grade, element dimensions, species, condition, and structural grade was generally unavailable, largely because the lowest tier of the construction was buried in tailings. The assessment consisted of an archeological evaluation of the tailings and artifact scatter conducted by the park, inspection of the bins including first order evaluation of connection condition, determination of member condition, and collection of samples for species identification.

Inspection techniques included visual inspection, probing defects with a sharp pick to identify areas of deep deterioration, resistance drilling to quantify surviving structural section in members with surface deterioration, and species identification:

1) *Visual inspection* of the wood allows for identifying components that are missing, broken, or in an advanced state of deterioration. Missing components are those that have been intentionally removed or have fallen away due to deterioration. Where missing components were intended to provide structural support, their replacement may be essential to prevent long-term damage to the structure. Visual inspection also allows for the detection of past or current moisture problems, as evidenced by moisture stains on exposed surfaces of the wood. Further,

visual inspection enables detection of external wood decay fungi or insect activity as indicated by the presence of decay fruiting bodies, fungal growth, insect bore holes or losses due to wood-destroying insects. Visual inspection provides a rapid means of identifying areas that may need further investigation.

2) *Probing the wood with an awl* enables rapid detection of voids that may not be visible on the surface; internal decay and insect damage are often difficult to detect due to the absence of visual cues on exposed surfaces of the wood. Probing can also indicate the approximate depth of deterioration that is visible on the surface. Probing can often reveal areas of incipient (early-stage) decay or insect damage in timber that has experienced sufficient deterioration to allow for easy penetration of an awl. Wood without deterioration just below the surface tends to offer greater resistance to probing than wood that has wood decay fungi present in sufficient quantity to impact structural performance.

3) *Resistance drilling* is a quasi-nondestructive technique for determining the relative density of wood. It is best suited for locating internal voids in wood members that do not show obvious signs of deterioration, such as surface decay. Internal voids at the location drilled can be detected by determining the relative density of the wood; multiple drillings of an internal void can yield information on the surviving structural section. In practice, the relative density of the wood at a drill site is recorded as a small diameter needle penetrates the wood.

4) *Identifying wood species* makes it possible to determine material properties for conducting a structural analysis and to identify compatible material for repairs. Small samples were removed from select components representative of columns, girts, and braces, and the species or species group of each sampled element was identified using optical microscopy.

By combining these inspection techniques, the assessment team was able to make determinations as to whether the individual members in the structure were (a) in sound condition, (b) deteriorated and in need of repair, or (c) unfit to remain in service.

The findings of the wood assessment can be summarized as follows:

- Wood decay, crushing, damage by wood-boring insects, and weathering due to exposure to UV light were the primary mechanisms of deterioration.
- In general, timber elements above grade and out of contact with soil, tailings, and debris were in fair to good condition, and required no repair.

- Dimension lumber elements above grade were subject to end splits and relish failure due, in part, to weathering of the wood by UV-light and stresses associated with differential settlement of the structures. Dimension lumber splints, joining column extensions to girts and columns, were especially affected.
- Moisture content was elevated in wood members in ground contact or covered by tailings and other debris.
- Deterioration by wood decay fungi tended to be limited to wood elements in ground contact or covered by tailings and other debris. In particular, this condition affected sills, column extensions, spreaders, and dimension lumber used to protect sills from soil contact. Damage by decay of these members was apparent upon visual inspection. Resistance drilling of select elements allowed investigators to identify members with surface damage but having sufficient section to remain in use.
- Crushing was limited to structural elements in ground contact or covered by tailings and other debris, and was likely the result of overloading of the structures while the mine was in operation, and/or high moisture content.
- High moisture content encouraged attack by wood-boring insects, which tended to be limited to damaged wood in ground contact or covered by tailings and other debris.
- The south sill of ore bin #1 and four of six column extensions on the south elevation were determined to be in structural distress and in need of repair.
- The east and west sills of ore bin #2 and seven of twelve (12) column extensions were found to be in structural distress and in need of repair.
- Based on sampling of select elements (including columns, girts, and braces) wood elements requiring repair or in-kind replacement were originally of Douglas fir (Pseudotsuga menziesii).

STRUCTURE CONDITION

The ore bins were originally designed to support tons of ore in addition to their own weight. They are currently empty, so that the excess capacity is available to offset some reduction in the original structural section of some members due to deterioration. It is reasonable to assume that if repairs are made to restore original section in material of equal quality, that at least most of that excess capacity can be recovered. Since integration of matching materials in original members and in-kind replacement of unsalvageable members meet the requirements of the Secretary of the Interior’s Standards for Preservation of Historic Properties, these repair strategies have the advantage of protecting historic integrity while recovering capacity. Due to the reduced demands on the out-of-service structures, a detailed structural analysis was not completed.

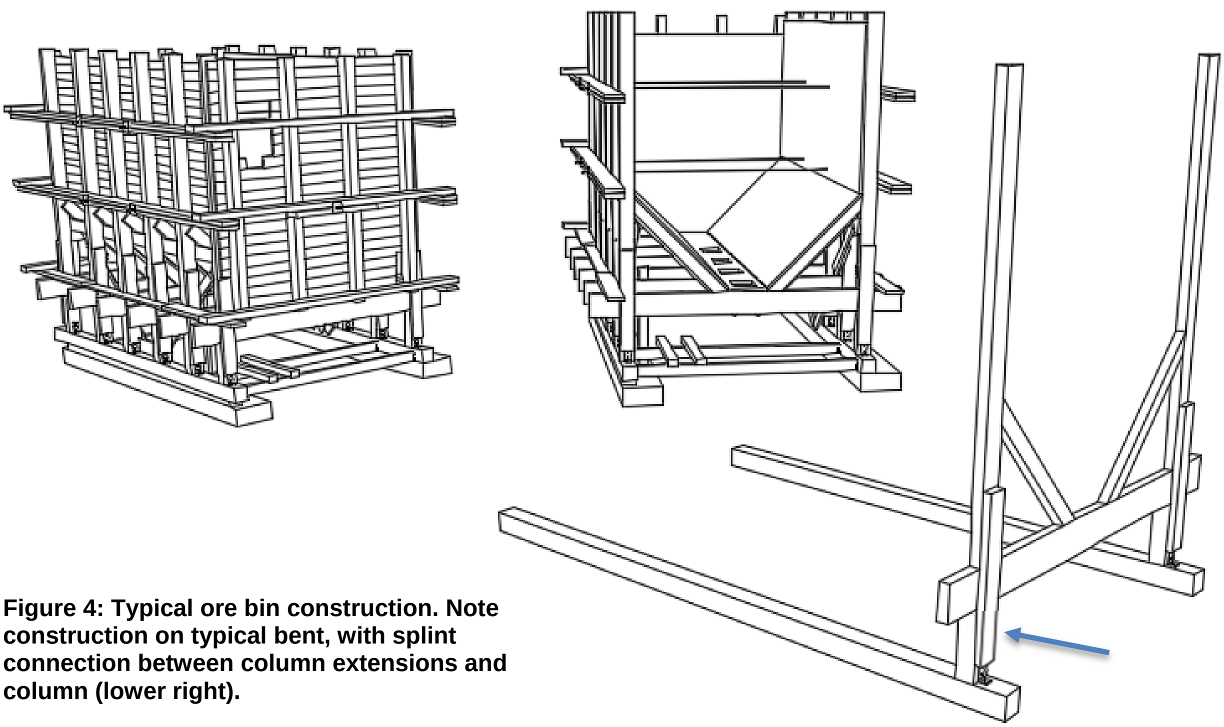

Figure 4: Typical ore bin construction. Note construction on typical bent, with splint connection between column extensions and column (lower right).

In the original framing configuration, six braced bents (column-girt-column assemblies) support and make up the heavy timber frame of the ore bins; these are sheathed with tongue and groove decking to make up the “bin” of each tipple. Each bent has two column extensions (feet), independent of the main frame, that support the bent. Connections between the bent and the column extensions are made up with wood splints and malleable iron fasteners; the splints span from each column extension across the girt, to the column. This detail allows for relatively easy replacement of column extensions. Since the bases of columns are prone to decay (because of their location), this represents an important advantage in repairing the bins. However, this construction cannot achieve the structural rigidity of a one-piece column, and the two-piece construction is prone to rotation. Splint connection capacity (and, therefore, splint condition) is an important determinant of the structural performance of the bins.

Differential settlement of the bins due to the deterioration of some, but not all, of the supporting elements resulted in rotations that placed stress on some of the bolted connections that exceeded capacity. An inspection of splint-column and brace-column connections discovered end splits and relish failures in splints and other small-dimension members that resulted in reductions in connection capacity. UV weathering of small dimension members contributes to this reduction in capacity insofar as weathering promotes the development of drying checks that can become end splits and relish failures.

At the east bin (Bin #1), loss of support on the south side due to decay of the sill, column extensions, and diagonal bracing resulted in rotation of the bin around the north sill (out of plumb to the south). At the west bin (Bin #2), encroachment of the bank on the south side of the bin caused significant timber decay to the south end of both the east and west sills, along with the loss of several column extensions and dimension lumber braces on the east and west sides of the structure. This resulted in settlement and an out-of-plumb condition to the south.

TREATMENT RECOMMENDATIONS

In managing and maintaining historic mine sites in the park, Joshua Tree National Park is broadly guided by the Secretary of the Interior's Standards for the Treatment of Historic Properties, and the project team has been additionally guided by the ICOMOS Principles for the Preservation of Historic Timber Structures and the ISCARSAH Principles and Guidelines.[3]

Both ore bins were shifted out-of-plumb to the south. Extensive decay of sills, column extensions, spreaders, and braces in contact with tailings, soil, and debris resulted in substructures that were minimally braced, and several splints failed at bolted connections. Reducing connection stress by returning the bins to level and plumb (so that loads are shared more equally by all of the supporting members), and replacing deteriorated splints and braces with new, un-weathered wood, can be an effective treatment for this condition.

To recover capacity without altering original configuration, the following treatment recommendations were made:

BIN #1 (east):

- Jack and return the ore bin to a plumb position using screw jacks positioned on the south side of the structure;
- Excavate and replace the decayed south sill and four of six column extensions supporting the ore bin in order to fix the bin in a plumb position;
- For splints in salvageable condition, reattach with existing hardware, torqued to establish sufficient connection capacity. Replace unsalvageable splints in-kind, using original hardware;
- Replace deteriorated bracing to tie all column assemblies to new timber sill;
- Repair/replace boards on south retaining wall as necessary to reduce accumulation of soil on new sill;
- Replace wood spreaders between north and south sills;
- Re-attach all existing clip angles, TECO ties, and hardware;
- Apply borate preservative to mitigate future decay and insect infestation.

[3] International Council on Monuments and Sites (ICOMOS) and the International Scientific Committee on the Analysis and Restoration of Structures of Architectural Heritage (ISCARSAH)

BIN #2 (west):

- Jack and return the ore bin to a plumb position using screw jacks positioned at both the east and west side of the structure;
- Excavate and replace the decayed east and west sills and seven of twelve column extensions supporting the ore bin in order to fix the bin in a plumb position;
- For splints in salvageable condition, reattach with existing hardware, torqued to establish sufficient connection capacity. Replace unsalvageable splints in-kind, using original hardware;
- Replace deteriorated bracing to tie all column assemblies to new timber sills.
- Repair/replace boards on east and west of structure as necessary to reduce accumulation of soil on new sills;
- Re-attach all existing hardware;
- Apply borate preservative to mitigate future decay and insect infestation.

Repair recommendations were intended to result in a performance period of at least 50 years with routine maintenance to minimize wood contact with the soil.

Figure 5: Bin #1, looking east. Decay at the south sill (just out of view) has allowed the ore bin to rotate out of plumb to the south. Also, note the condition of the timber spreader between the north and south sill (bottom center).

Figure 6: Bin #2, looking west. Note the condition of the east sill at its south end (bottom left, foreground). The sill and column extensions have completely decayed allowing the tipple to rotate out of plumb to the south.

REPAIR WORK

The stabilization strategy proposed by the project team focused on returning the ore bins to a plumb and level condition using screw jacks, timber cribbing, and jacking posts. Once the bins were jacked and plumbed, decayed substructure elements were removed, and reapaired or

Figure 7: Cribbing and screw jacks were used to plumb Bin #2 (west) prior to removal of deteriorated sills and column extensions for repair or replacement.

replaced. Structural connections were reinstated (using original fasteners where possible) tightened to recover capacity. Due to the incorporation of removable column extensions by the original builders, the scarfing of new wood into decayed columns was not necessary. Recovery of the original capacity of splinted connections was essential to the axial stability of the columns and the success of the repairs.

In addition to the stabilization and repair of the ore bin substructures, measures were proposed to address site stability issues and prevent contact between substructure and soil. These included the repair and / or replacement of dimension lumber elements originally installed to prevent eroded soil from settling against sills and other substructure elements, and use of a borate preservative for treatment of the sills and column extensions to prevent decay and insect attack.

REPAIR TECHNIQUES

The Secretary's Standards for the Treatment of Historic Properties allows for in-kind replacement of historic elements that cannot be repaired. At the Silver Bell Mine, these included sills, spreaders, column extensions, and dimension lumber elements that include splints, braces, and boards installed to prevent eroded soil from settling against sills and other substructure elements. In replacing wooden elements of an historic structure, guidelines often encourage the use of materials that match the original in both species and quality. While select structural timber and lumber was not used in every instance in the original construction of the ore bins, the project team elected to use this grade for the repair work. High-quality materials have greater structural capacity and are likely to be more durable, meaning that for a given repair, the investment in making the repair is likely to yield better performance and longer-lasting results.

REPAIR WORK: ORE BIN #1 (EAST)

OVERVIEW

Ore bin #1 was several inches out of plumb to the south due to decay of the south sill and several of the column extensions on the south façade. Repair work on the ore bin included: in-kind replacement of the south sill, four column extensions, diagonal bracing of the substructure on the south façade, and one of two spreaders; installation of splints and re-torqueing of all splint connections. Replacement members were secured using existing hardware where possible; where original hardware could not be salvaged, connections were made with bolts, nuts and washers custom-fabricated to match the originals.

SUBSTRUCTURE

Repair of the substructure required that the bin be returned to a plumb and level condition. Ledgers were attached to columns at existing dimension lumber stiff-backs[4] on the south façade to serve as jacking points, and, the bin was repositioned using screw jacks. Once the weight of the bin had been lifted from the substructure on the south, the sill was removed, providing access to deteriorated column extensions. Deteriorated column extensions (specific locations are shown in the drawing set in Appendix 1) were disconnected from floor girts and bin columns and replacement members (sill and column extensions) were installed. Replacement pieces

[4] Refer to page 02 of the attached drawing set in the appendix for further clarification of structural members. They are labeled for the purposes of this report.

were bored for through bolts and splint connections were reinstated. Once the weight of the ore bin was returned to the substructure, columns extensions were connected to the sill using existing clip angles and lag screws.

BRACING

Diagonal bracing connects sills to column assemblies, providing shear capacity. On the south elevation, diagonal bracing was decayed below grade, and sufficiently weathered above grade that connection capacity at outer columns was substantially reduced. Replacement members

Figure 8: Ore bin #1 after installation of replacement column extensions, south sill, diagonal bracing, and spreader (foreground). Original splints were salvaged for reinstallation. Holes bored for borate rod installation are visible at the base of each column extension.

were bolted in place, using original hardware where possible, and additional structural fasteners were installed (these are hidden from view) to stiffen the assembly.

The east ore bin included two horizontal braces (spreaders) between the north and south sills (spreaders do not appear to have been used in the construction of the west ore bin). The spreader on the south, buried in tailings, was unsalvageable and a replacement member was installed with the existing hardware.

REPAIR WORK: ORE BIN #2 (WEST)

OVERVIEW

Ore bin #2 was also several inches out of plumb to the south due to decay of sills and column extensions; the bin is positioned against a steep bank to the south, and erosion of the bank resulted in burial of much of the substructure. Repair work included in-kind replacement of east and west sills, seven of twelve column extensions, and diagonal bracing on east and west; replacement or reinstallation of splints, and re-torqueing of all splint connections in the substructure.

Figure 9: West ore bin supported on cribbing and screw jacks. New timber sill (right) is ready for installation on the west elevation.

SUBSTRUCTURE

For lifting ore bin #2, cribbing and screw jacks were placed underneath the structure (as opposed to outside the structure, as for one bin #1), to lift and support floor girts while allowing room for removal of both sills. Once the ore bin had been lifted, sills were removed, providing access to deteriorated column extensions. Deteriorated column extensions (specific locations

Figure 10: Ore bin #2, following replacement of east sill, column extensions, and diagonal bracing (left).

are shown in the drawing set in Appendix 1) were disconnected from floor girts and bin columns and replacement members (sills and column extensions) were installed. On the west elevation, a total of four column extensions and two splints were replaced; on the east, three of six column extensions and three of six splints were replaced. Replacement pieces were bored for through bolts and splint connections were reinstated. Jacks were removed and column extensions were connected to the sills using existing clip angles and lag screws.

Figure 11: Ore bin #2, following replacement of west sill, column extensions, splints, and diagonal bracing. Note boarding installed to isolate the sill and column bases from soil (right).

BRACING

Diagonal bracing connects sills to column assemblies, providing shear capacity. On east and west elevations, diagonal bracing was decayed below grade, and sufficiently weathered above grade that connection capacity at outer columns was substantially reduced. Replacement members were bolted in place, using original hardware where possible, and additional structural fasteners were installed (these are hidden from view) to increase the stiffness of the assembly.

SUBSTRUCTURE PROTECTION AND BORATE TREATMENT

Decay of ore bin elements was largely restricted to the substructure where wood was in contact with soil and tailings. Soil accumulations on the south (uphill) side of each bin resulted in the decay of sills and column extensions, causing rotation of the bins and contributing to the connection failures observed by the project team.

Remnants of boards originally installed to isolate substructure elements from the soil were found at both structures. These can be considered sacrificial elements and periodic replacement of them is required to avoid substructure decay. The original boarding had exceeded its effective service life, allowing soil to accumulate against sills and column extensions. These were repaired or replaced in kind to provide protection against further soil infiltration. Borate preservative rods were installed in sills and column extensions as an additional preventative measure.

Figure 12: West ore bin with repairs completed, looking southeast. Note replacement boards attached to column extensions and intended to isolate substructure from soil (foreground).

CONCLUSIONS/RECOMMENDATIONS FOR ONGOING MAINTENANCE

The ore bins at the Silver Bell Mine are currently in stable condition as the result of substructure repairs. Through a detailed inspection and assessment of the surviving woodwork, a repair plan was implemented that stabilized and strengthened the structure to a level sufficient for its intended future use, while also carefully conserving as much of the original material as possible. Three student interns (Historic Preservation Program, UVM; School of Engineering, UVM; Timber Framers Guild) were involved in the assessment, documentation, repair design, and implementation phases of the project.

The service life of the structure will be lengthened with appropriately implemented maintenance measures. At the Silver Bell mine, timber structures should be inspected annually in the spring, and after heavy rains. Inspectors should be particularly alert to undermining of the sills and rotation and/or subsidence of the bins out of plumb and level condition. Soil and debris collected against sills and other wood components should be cleared annually.

Section losses due to decay and insect attack in large dimension members are unlikely to significantly affect capacity in the short term. Inspectors should watch for surface decay at or near grade, and where contact between two or more members inhibits drying. A sharp pick (like an icepick or awl) will help to probe areas with incipient decay. Inspectors should be alert to settlements and other changes in the structure that might indicate the development of new areas of deterioration.

Weathering is typically not a significant factor in the failure of wood components and the collapse of structures; significant damage is more often due to wood decay or wood-boring insects. However, severe weathering can reduce the capacity of bolted connections on braces and other members that are relatively small in cross section; end splits and loss of relish at these connections allow for settlements and rotations that result in additional structural stresses.

Because those members of the structure in contact with the ground are more prone to decay and deterioration, we have treated sills and column extensions with a borate preservative. Installation sites should be inspected annually and new borate rods installed in holes bored for that purpose as needed.

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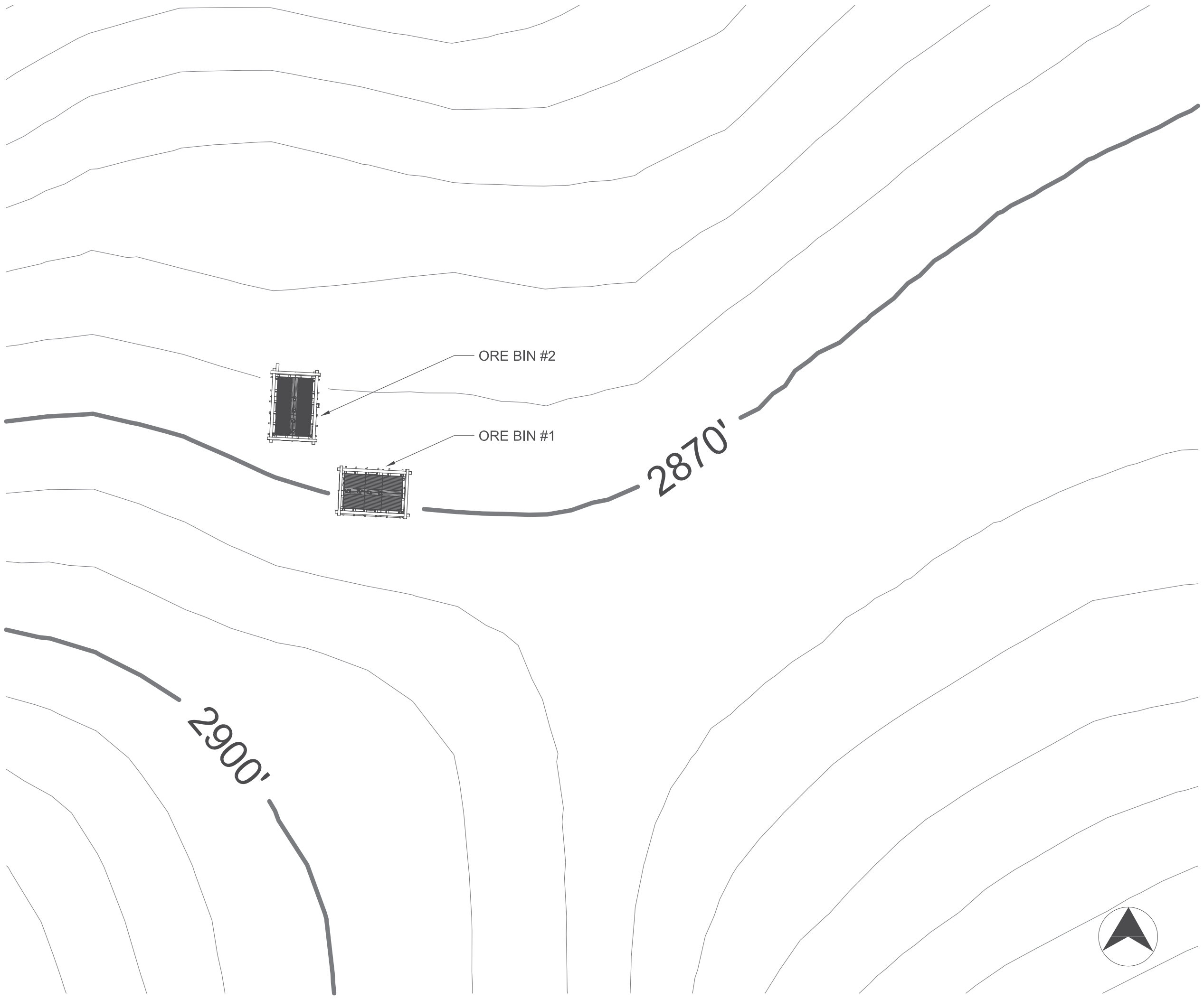
APPENDIX 1: DRAWINGS

SILVER BELL MINE STRUCTURE

JOSHUA TREE NATIONAL PARK, RIVERSIDE COUNTY, CA



1/1 SILVER BELL MINING STRUCTURE: **SITE PLAN**
SCALE: 1" = 16'

SHEET INDEX

01	COVER PAGE
02	PLAN & ISOMETRIC
03	OVERALL ELEVATIONS
04	REPAIR DETAILS

GENERAL NOTES:

DOCUMENTATION FOR THIS PROJECT WAS COMPLETED BY DOUG PORTER (UNIVERSITY OF VERMONT), JOSEPH COTTER (UNIVERSITY OF VERMONT), AND MIKE COTRONEO (HOUSEJOINER, INC.). DRAWINGS IN THIS SET ARE BASED ON FIELD MEASUREMENTS TAKEN IN NOVEMBER, 2016.

ALL DRAWINGS DEPICT THE 'AS-BUILT' STATE OF THE SILVER BELL MINE STRUCTURES AS INFERRED FROM SURVIVING FEATURES. EXISTING CONDITIONS SHOULD BE VERIFIED IN FIELD. THIS DRAWING SET WAS PRODUCED BY THE UNIVERSITY OF VERMONT FOR THE NATIONAL PARK SERVICE IN MARCH 2017.

THESE DRAWINGS HAVE BEEN SIZED TO BE RE-PRODUCED AT 24" X 36" (SIZE ARCH D). IF YOU ARE VIEWING THIS DRAWING SET AT ANY OTHER SIZE THIS SET IS NOT TO SCALE.

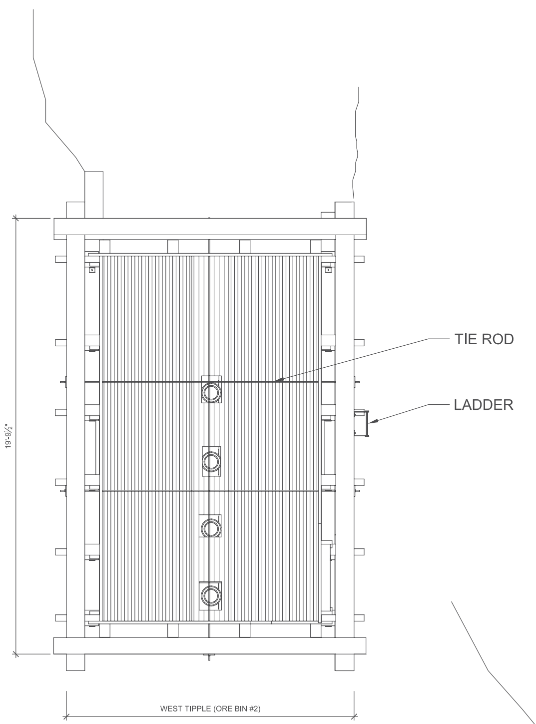
2/1 VICINITY MAP
N.T.S.

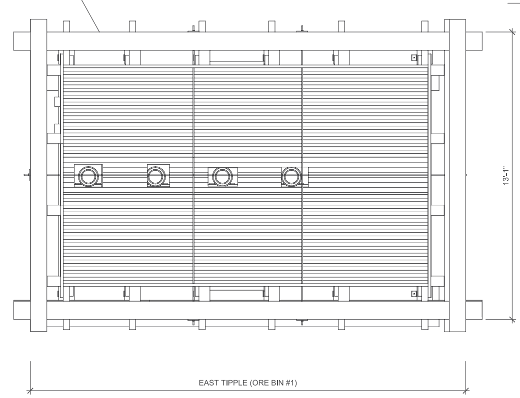
3/1 LOCATION MAP
N.T.S.

UNIVERSITY OF VERMONT
SCHOOL OF ENGINEERING
DOUG PORTER, PRINCIPLE INVESTIGATOR
DRAWINGS PREPARED BY: JOSEPH A. COTTER

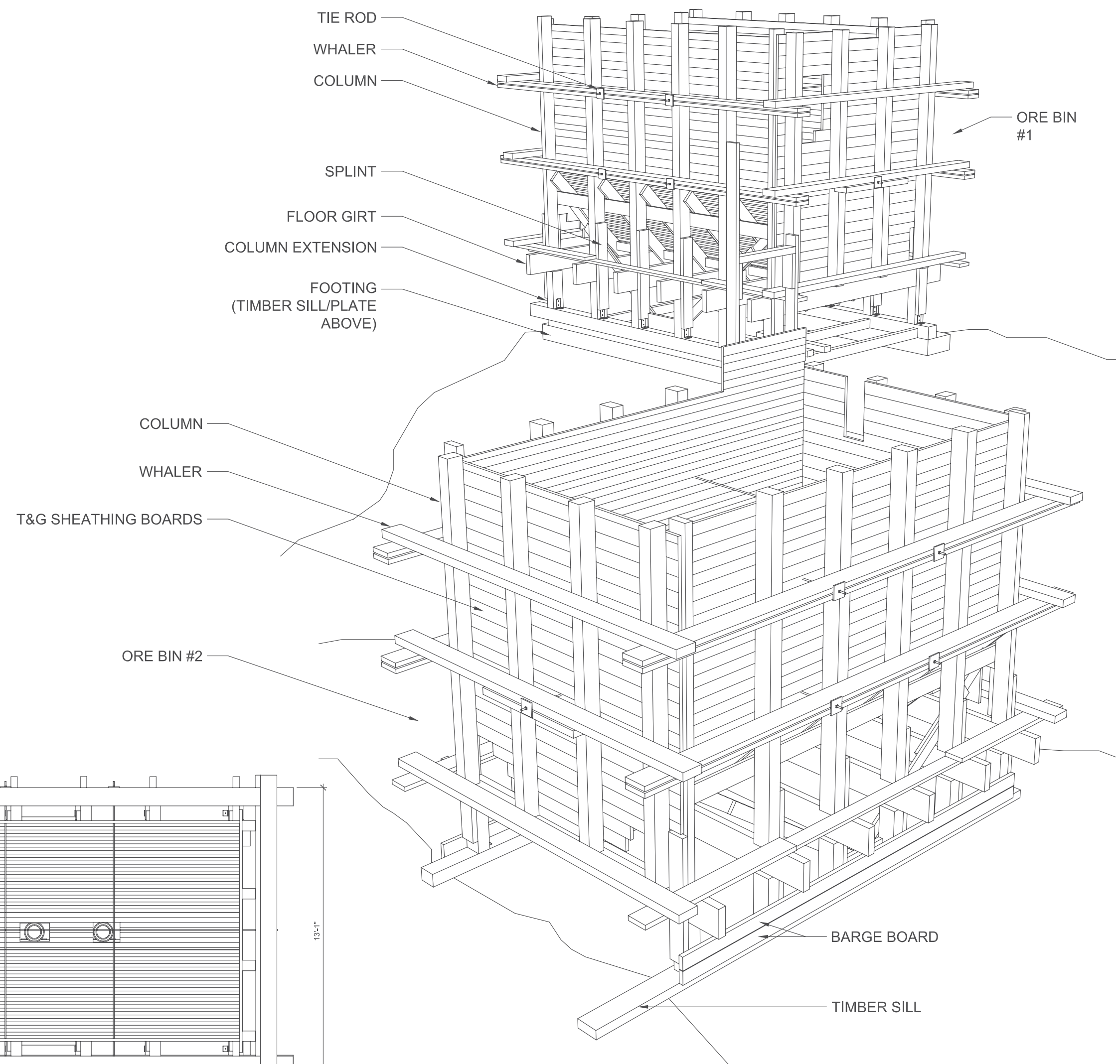
SILVER BELL MINE STRUCTURE
STABILIZATION AND REPAIR
JOSHUA TREE NATIONAL PARK, RIVERSIDE COUNTY, CA

DATE: March 8, 2017





1/2 SILVER BELL: **PLAN VIEW**
SCALE: $\frac{3}{8}$" = 1'



2/2 SILVER BELL: **NORTHWEST ISOMETRIC**
SCALE: $\frac{1}{4}$" = 1'

NOTES:

1. DIMENSIONS ARE BASED ON FIELD MEASUREMENTS TAKEN IN NOVEMBER, 2016. ALL DRAWINGS ARE REPRESENTATIVE OF THE SILVER BELL STRUCTURE IN AN 'AS-BUILT' STATE, AS INFERRED FROM SURVIVING FEATURES, AND DO NOT NECESSARILY REFLECT CURRENT CONDITIONS. EXISTING CONDITIONS SHOULD BE VERIFIED IN FIELD.

SILVER BELL MINING STRUCTURE: **PLAN & ISOMETRIC**

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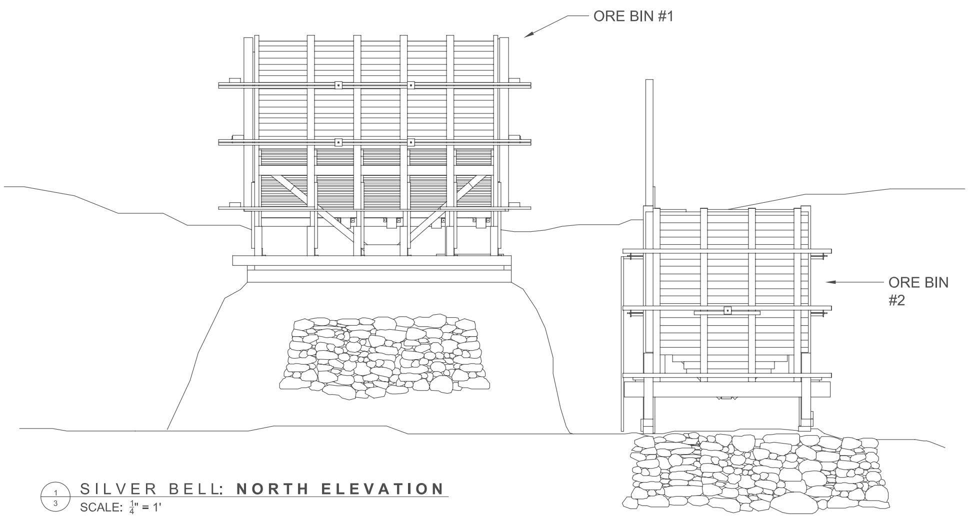
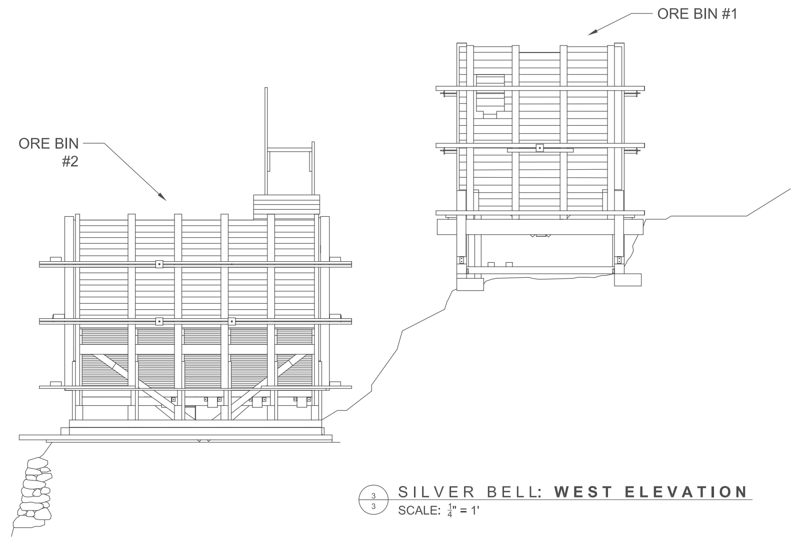
SCHOOL OF ENGINEERING
DOUG PORTER, PRINCIPLE INVESTIGATOR
DRAWINGS PREPARED BY: JOSEPH A. COTTER

SILVER BELL MINE STRUCTURE
STABILIZATION AND REPAIR
JOSHUA TREE NATIONAL PARK, RIVERSIDE COUNTY, CA

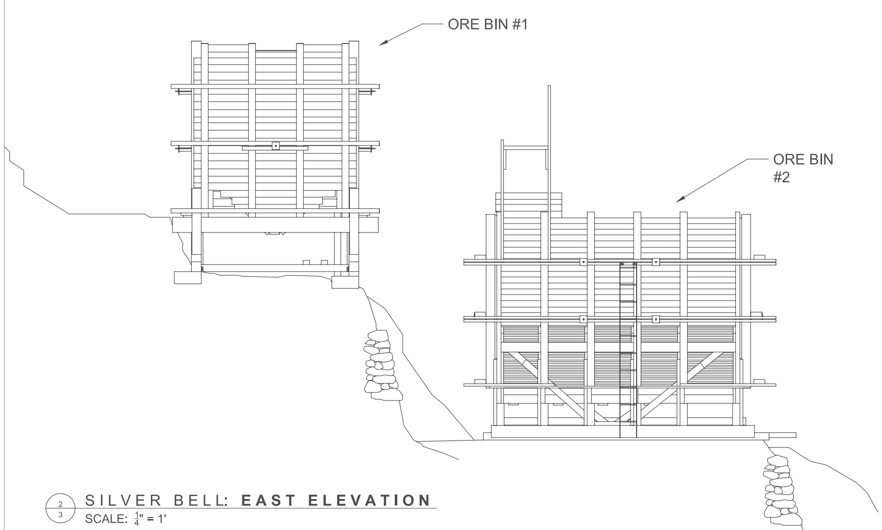
DATE: March 8, 2017



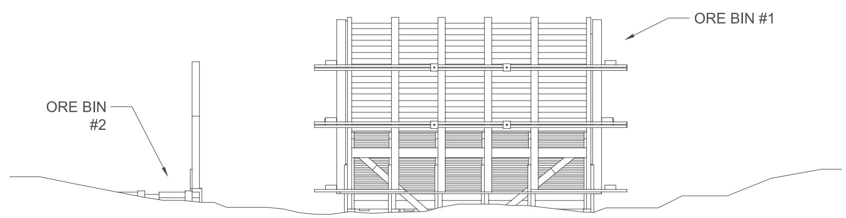
1/3 SILVER BELL: **NORTH ELEVATION**
SCALE: $\frac{1}{4}$" = 1'



3/3 SILVER BELL: **WEST ELEVATION**
SCALE: $\frac{1}{4}$" = 1'



2/3 SILVER BELL: **EAST ELEVATION**
SCALE: $\frac{1}{4}$" = 1'



4/3 SILVER BELL: **SOUTH ELEVATION**
SCALE: $\frac{1}{4}$" = 1'

SILVER BELL MINING STRUCTURE: **OVERALL ELEVATIONS**

NOTES:

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SILVER BELL MINE STRUCTURE
STABILIZATION AND REPAIR
JOSHUA TREE NATIONAL PARK, RIVERSIDE COUNTY, CA

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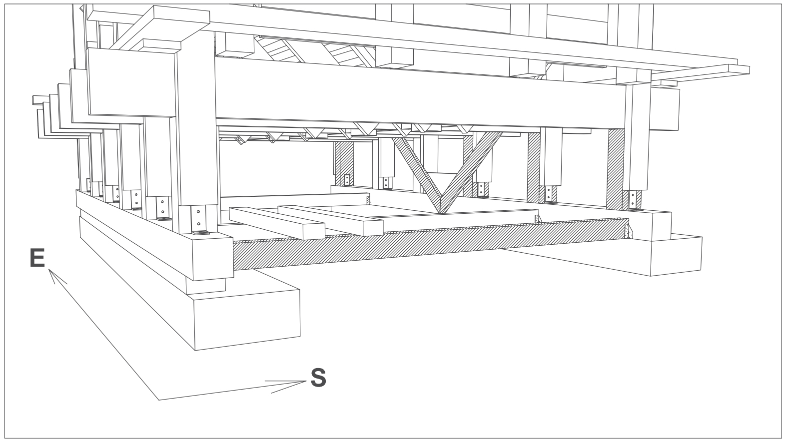
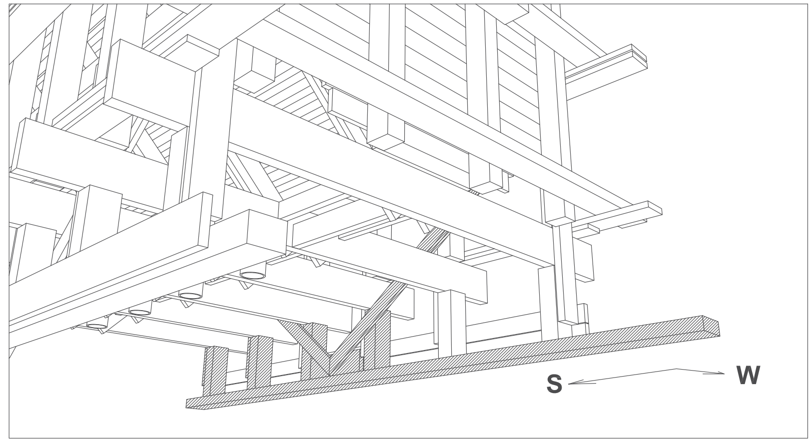
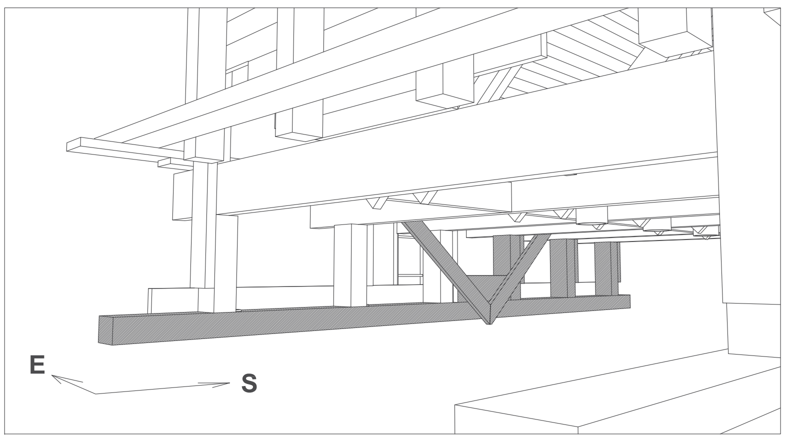


1/4 SILVER BELL: **BIN #1 ISOMETRIC**
SCALE: NTS



3/4 SILVER BELL: **BIN #2 ISOMETRIC**
SCALE: NTS



2/4 SILVER BELL: **BIN #2 ISOMETRIC**
SCALE: NTS

LEGEND:

DETERIORATED MEMBER REPLACED IN-KIND

NOTES:

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SILVER BELL MINING STRUCTURE: **REPAIR DETAILS**

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SILVER BELL MINE STRUCTURE
STABILIZATION AND REPAIR
JOSHUA TREE NATIONAL PARK, RIVERSIDE COUNTY, CA

DATE: March 8, 2017

APPENDIX 2: DRILL LOG

Tumacacori Drilling Log

Location:Silver Bell Mine, Joshua Tree NP **Date: 2/23/2016**

Drilling Number	Elevation	Member ID	Location	Drilling Direction	Comments
1	Bin 2 N side	N side C6	Bin 2 North, sill center of member, W of C1	N>S	No Void
2	Bin 2 N side	N side sill	Bin 2 North sill, center of member, between C3 &C4	N>S	No Void
3	Bin 2 N side	N side sill	Bin 2 North sill, center of member, E of C1	N>S	No Void
4	Bin 1 S side	S side C6	Bin 1 C6, on West through G6	N>S	No Void
5	Bin 1 S side	S side G6	Bin 1, G6 on incline joist through joist and girt	N>S	No Void
6	Bin 1 S side	S side G6	Bin 1, G6 on E side of C6 through girt and stringer	N>S	No Void
7	Bin 1 S side	S side G6	Bin 1, G6 through incline joist into girt	N>S	No Void