ENCLOSURE 1

ADDENDUM 2 TO REPORT ON

SOIL BACKFILL CONDITIONS

SAN ONOFRE NUCLEAR GENERATING STATION

UNIT 1

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1.0 General

The effects of the soil backfill behavior during and following the DBE event of the safety related structures, equipment and components were reported in Reference 1. Therein, the present condition of the backfill at the Ventilation Equipment Building and the Motor Control Center #3 was described in Sections 4.4.1 and 5.7.1, and it was noted that the structural evaluation results would be reported later.

This addendum provides the results of the structural evaluation of the Ventilation Equipment Building and the Motor Control Center #3 for the postulated during-seismic and post-seismic backfill settlements.

1.1 Ventilation Equipment Building

1.1.1 Present Condition

The Ventilation Equipment Building foundation was constructed during initial plant construction in 1964 and 1965. As shown in Figure 2-22 of Reference 1, 19 ft of the north wall and about 10 feet in the northern portion of the east wall are founded on native soil. A cross-section of the backfill beneath the Ventilation Equipment Building is shown in Figure 4-2a of Reference 1 and discussed below. The cross-section in Figure 4-2a of Reference 1 shows less backfill beneath the west wall than was documented in Section 2 of Reference 2. This change was made based on observations which have been located regarding the inspection of foundations for the dog house structure north of the Ventilation Building in December 1980. The western 3 feet of the north wall is founded on about 4 feet of backfill, designated as category D. The center 24 feet of the east wall is founded on up to about 8 feet of category D backfill and the southern 10 feet of the east wall is founded on backfill with depth varying from 8 feet to a maximum of 21 feet near the Fuel Storage Building. The west wall is founded on about 4 feet of category D backfill with the southern 10 feet of this wall founded on from 4 feet to a maximum of 21 feet of category D backfill. The south wall of the structure is founded on category D backfill with a thickness of about 21 feet near the Fuel Storage Building. As indicated in Figure 3-4 of Reference 2, the category D backfill on the south side of this stucture could develop high pore water pressures when subjected to the 0.67g Housner DBE.

The estimated maximum seismically induced settlement of the soil below this structure is summarized in Figure 4-2b of Reference 1. The proportion of settlement above the water table is designated by (a), and the proportion of settlement below the water table is designated by (b). It is expected that the settlement of soil above the water table, shown as a maximum of one and one-half inches of settlement in the settlement profiles in Figure 4-2b of Reference 1, would occur during seismic shaking. The settlement caused by liquefaction of soil below the water table would occur as pore water pressures dissipate after seismic shaking. The total soil settlement beneath the south end of the building is three inches, including post-seismic settlement.

The fill soil may affect the seismic response of the structure along the west, south, and portions of the east sides of the structure. During seismic shaking a reduction of the foundation stiffnesses (which are based on 95% relative compaction) has been considered as discussed in Section 3 of Reference 2. The range of reduced soil stiffnesses which were used for this structure are provided in Table 4-8 of Reference 1. The stiffnesses consider the effects of backfill as well as potential soil separation beneath the south wall footing and 10 feet of the adjoining east and west wall footing.

1.1.2 Structural Evaluation

During seismic shaking the change in the soil parameters affects the structure in two ways. First, the dynamic stiffness of the soil in the affected area is reduced and secondly, seismic settlement of a maximum of one and one-half inches can occur in the backfill below the building. An analysis was performed using the stiffness values, modified to account for the reduced dynamic stiffness of the soil, listed in Table 4-8 (Reference 1).

The lumped mass model of the Ventilation Equipment Building was utilized to analyze the structure with both the original (as reported in Table 4-8, Reference 1) and the modified soil stiffness. Response spectrum analyses were performed and the resulting overturning moments and base shears were computed.

The response of the structure to the inertial forces generated during a DBE seismic event was evaluated considering the induced settlements in soil backfill. The postulated soil settlement would result in the building tilting southward as a rigid box. For this condition, the analysis conservatively assumed a loss of soil support for the south wall and portions of the east and west walls (Figure 1). A comparison of building stresses during the DBE to allowable stresses and ultimate stresses is given in Table 1. This evaluation shows that for this condition flexural stresses in the floor slab and shear stresses in the walls exceed the allowable stresses given by the BOPSSR criteria (Reference 3). The table also shows that even though the values of calculated shear stresses in the walls exceed BOPSSR allowables, they are less than the ultimate capacity stresses.

The stresses induced by the postulated post-seismic soil settlement beneath portions of the east and west walls and the entire south wall of the structure have also been evaluated. The evaluation considered the building's east and west walls acting as cantilevered deep beams with the southern most 10 feet of the structure completely unsupported. Only the dead load of the structure was considered in this post-seismic settlement analysis. A summary of stresses for this evaluation is shown in Table 2. This post-seismic condition results in a less severe state of stress in the structure than the during-seismic condition previously described. The moments developed in the floor slab exceed the allowable while shear stresses in the walls do not.

1.1.3 Component Evaluation

The only safety related components on the Ventilation Equipment Building are the electrical raceways attached to the walls and the T.M.I. vent stack sample line attached to the roof. The structural integrity of the supports for these components during and after a DBE event has been investigated.

For the purpose of this evaluation the effect of building tilting and backfill settlement on these components has been assessed. Since the building behaves as a box system, it is concluded that the relative wall displacements between conduit supports due to backfill settlement are small in magnitude and will not affect the integrity of the conduits completely supported by the building.

The safety related conduits that span between the Ventilation Equipment Building and adjacent buildings have been identified by field walkdowns and are depicted in Figure 2 and 3. The stresses in these conduits and their supports, induced by the relative building displacement, have been considered.

The backfill beneath the southern edge of the Ventilation Equipment Building is expected to settle 1 -1/2 inches during a DBE and to have a total settlement, including both seismic and post-seismic components, of 3 inches. However, over 75 percent of the west wall is supported on soil which is expected to settle 1/2 inch or less during a DBE with no additional post-seismic settlement expected in this portion. Consequently the building will behave as a cantilever with the northern portion being supported by native San Mateo and the southern portion spanning above the settled fill. Therefore, the southern edge of the building is expected to only deflect about 5/8 of an inch.

The most severe loading due to differential building settlement will occur in the support for the conduits spanning between the southwest corner of the Ventilation Equipment Building and the northwest corner of the Fuel Storage Building. A total of 27 conduits span between these two structures. Seventeen 2 inch and two 1 inch diameter conduits span 8 feet between adjacent supports at this location. These conduits are shown in Figure 2. During a DBE, under the worst case loading, the 1/2"ϕ, A307 through bolts anchoring the support for these conduits would experience loads of 755 lbs per bolt in tension and 535 lbs per bolt in shear. Since all bolts occur in separate blocks, the loads are within the respective allowables of 945 lbs per bolt in tension and 800 lbs per bolt in shear. Similarly, the 1/2"ϕ Hilti Kwik Bolts for these conduits on the northwest corner of the Fuel Storage Building would experience a tension of 1322 lbs per bolt and 944 lbs per bolt in shear. The allowable loads for tension and shear respectively are 1260 lbs per bolt and 1970 lbs per bolt. The circular interaction for both tension and shear gives a value of 1.33 which is below the allowable of 1.5. Consequently the anchorage is adequate. The maximum forces induced in the individual conduits, resulting from dead, seismic and settlement loads, are small and the associated stresses negligible. Therefore, the integrity of each of the nineteen conduits will be maintained.

Similar analyses were performed for the other 8 conduit raceways which span between the Ventilation Equipment buildings and the Fuel Storage building. These conduits are shown in Figure 3. Based on these analyses modifications are required for these conduit runs. Specifically, these modifications will involve the strengthening of the six support anchorages which are marked with an asterisk in Figure 3.

The TMI vent stack sample line spans from the vent stack east of the Ventilation Equipment Building to the Reactor Auxiliary Building west of the Ventilation Equipment Building (Figure 2). The 3/4" sample line and 2 conduits (1" and 1-1/2"ϕ) are attached to a W6 X 15 spanning approximately 45 feet from the vent stack to the south east end of the Reactor Auxiliary Building. An intermediate support occurs approximately 19.5 feet south east of the Reactor Auxiliary Building, mounted on the Ventilation Equipment Building roof. The support is hinged for south east rotations. The geometric placement of the support is such that the southern most anchorage to the Ventilation Equipment Building roof is 17 feet south of the north wall. Due to the flexibility of the support and the long spans of the W6 X 15, the small vertical displacements expected at this portion of the Ventilation Equipment Building due to southward tilting will have no impact upon the integrity of the TMI vent stack sample line or attached conduits.

Based on the results of the analyses performed, it is concluded that the integrity of the Ventilation Equipment Building and the safety related components it supports will not be impaired by backfill settlement and will retain the integrity required with only minor modifications to some conduit supports.

1.1.4 <u>Instructure Response Spectra For The Ventilation Equipment Building</u>

The instructure response spectra for the Ventilation Equipment Building were originally calculated based on 95 percent soil compaction in all areas. These spectra were subsequently modified to reconcile the effects of the in-situ soil as described in Reference 5.

The required spectra modifications were developed in the following manner. A modal analysis was performed using the lumped parameter stick model earlier developed, and the soil-structure interaction parameters that reflect the in-situ soil conditions. The results of the modal extraction indicate a lowering of the fundamental frequencies of the structure. These lowered frequencies were termed as lower bound frequencies while the fundamental frequencies obtained from the original analysis which used soil-structure interaction based on 95% soil compaction were termed upper bound. Therefore, the instructure response spectra were generated using a +15 percent peak broadening from the upper bound frequency and a -15 percent peak broadening from the lower bound frequency. These widened spectra will be further modified to reflect the change in insitu soil conditions from Reference 5 to Reference 2 in order to produce the final instructure spectra. All raceway and piping evaluations in the Ventilation Equipment Building will be checked against these final spectra.

1.2 Motor Control Center #3 (Item #7)

1.2.1 Present Condition

As indicated on Figure 5-8 of Reference 1, the southern portion of the 8" slab foundation that supports the Motor Control Center #3 is founded on native soil. The northern end is founded on up to 16 feet of category D fill of which about 1 foot is below the water table. Based on a settlement analysis, performed in accordance with procedures documented in Section 3 of Reference 2, the estimated potential seismically induced settlement for the backfill soil beneath the structure is about 1-1/2 inches. It is estimated that all of this settlement would occur during seismic shaking.

1.2.2 Structural Evaluation

Motor Control Center #3 is located at the northwest corner of the south extension of the Turbine Building. During the current outage, building modifications have been made in this area as discussed in Section 4.3.1 of Reference 1. Specifically, the slab west of MCC #3 was cut and foundation F was placed. Additionally an approximate 3' X 4' hole was cut in the slab, adjacent to foundation F and to the southwest turbine pedestal column. This hole was subsequently replaced with concrete. In implementing both modificatons the slab's reinforcement was cut, thereby removing the structural continuity between the slab and the modification. When these modifications were installed this continuity was not restored, consequently the support previously provided by the adjacent portions of the slab can no longer be considered in these regions.

The portion of the south extension's slab in the vicinity of Motor Control Center #3 was analyzed as a plate. Due to the lack of structural continuity with the modifications, the north and west edges of the plate were assumed to be free. The eastern edge, supported by the adjacent portion of the slab was assumed to be fixed and the southern edge, supported by native soil, was modeled as simply supported. The settled backfill beneath the slab was assumed not to provide any support.

The analysis of this slab configuration indicates that a maximum slab moment of 7.5 K-ft/ft could develop during a DBE. The slab's moment capacity is 1.57 K-ft/ft and the corresponding ductility ratio is about 12; which is in excess of the criteria allowable of 3. The same analysis, which includes the affects of concrete cracking, indicates that the maximum slab deflection will be less than 1-1/2 inches which is the estimated settlement of the underlying soil. Consequently, no support from the settled soil can be expected. Therefore, the slab does not meet the seismic reevaluation criteria.

Modifications are required to restore the criteria margins. A conceptual modification scheme is shown in Figure 4 and would consist of an east-west running grade beam, anchored on foundation "F" and cantilevered out over the backfill. This beam would provide support at the north end of the MCC #3 foundation for the slab.

The slab would then act as a wide beam spanning between the grade beam at the north and native soil at the south. Alternatively, additonal analyses may be performed which would demonstrate the integrity of the slab and the ability of MCC #3 to remain functional following a DBE or which would demonstrate that MCC #3 is not required to be operable following an earthquake.

TABLE 1
VENTILATION EQUIPMENT BUILDING REACTIONS DURING EARTHQUAKE

See Figure 1 For Sections	Shear Stress			Flexural Moments		
	Actual (PSI)	Allow (PSI)	Ultimate (PSI)	Actual (FT-K)	Ultimate (FT-K)	Ductility: Actual / Allow
North Wall						
Sect a-a	82	74[a]	110[c]	–	–	–
Sect G-H	58	72[d]	–	–	–	–
South Wall						
Sect b-b	75	74[a]	110[c]	–	–	–
Sect E-F	58	72[d]	–	–	–	–
East Wall						
Sect c-c	83	74[a]	110[c]	–[e]	–	1.3 / 3
Sect d-d	–[e]	–	–	1274	984	
West Wall						
Sect e'-e'	161	74[a]	173[c]	–[e]	–	1.1 / 3
Sect f-f	–[e]	–	–	566	498	
Floor Slab						
Sect g-g	99	122	–	2.76[b]	1.15	3.4 / 3
Roof Deck						
Sect A-B	2023 PLF	3263 PLF	–	–[e]	–	–
Typ Span	–[e]	–	–	6559 PSI	31680 PSI	

NOTES:

(a) ALLOW $v = 1.5 \times 1.1 \times \sqrt{f'm}$ (i.e., 1.5 x ACI CODE 531-79 EQUATION FOR FLEXURAL SHEAR, TABLE 15.1, AND TABLE 3.8.4 OF REFERENCE 3).

$f'm$ = 2025 PSI BASED ON EVALUATION OF COMPRESSIVE STRENGTH TESTS.

(b) BASED ON DEFLECTION OF SLAB LIMITED BY SOIL SETTLEMENT PROFILE.

(c) BASED ON AN ULTIMATE SHEAR STRESS FOR COMBINED LOADS $V = 0.85\ \rho_h f_y$, (REFERENCE 4).

(d) BASED ON AN ALLOWABLE SHEAR STRESS OF $V = 0.425\ (\ell/H)\ (\rho_v f_y + \sigma_c)$, (REFERENCE 4).

(e) NOT A GOVERNING CASE.

TABLE 2
VENTILATION EQUIPMENT
BUILDING REACTIONS AFTER EARTHQUAKE

See Figure 1 For Sections	Shear Stress		Flexural Moments		
					Ductility
	Actual (PSI)	Allow (PSI)	Actual (FT-K)	Allow (FT-K)	Actual / Allow
East & West Walls Sect c-c	63.3	74[a]	555.7	1835	-
Floor Slab Sect g-g	-[e]	-	2.76[b]	1.15	3.4 / 3
Roof Deck Typ Span	-[e]	-	-[e]	-	-

NOTES:

(a) ALLOW v = 1.5 x 1.1 x $\sqrt{f'm}$ (i.e., 1.5 x ACI CODE 531-79 EQUATION FOR FLEXURAL SHEAR, TABLE 15.1, AND TABLE 3.8.4 OF REFERENCE 3).

f'm = 2025 PSI BASED ON EVALUATION OF COMPRESSIVE STRENGTH TESTS.

(b) BASED ON DEFLECTION OF SLAB LIMITED BY SOIL SETTLEMENT PROFILE.

(c) BASED ON AN ULTIMATE SHEAR STRESS FOR COMBINED LOADS $V = 0.85\ \rho_h f_y$, (REFERENCE 4).

(d) BASED ON AN ALLOWABLE SHEAR STRESS OF $V = 0.425\ (\ell/H)\ (\rho_v f_y + \sigma_c)$, (REFERENCE 4).

(e) NOT A GOVERNING CASE.

References:

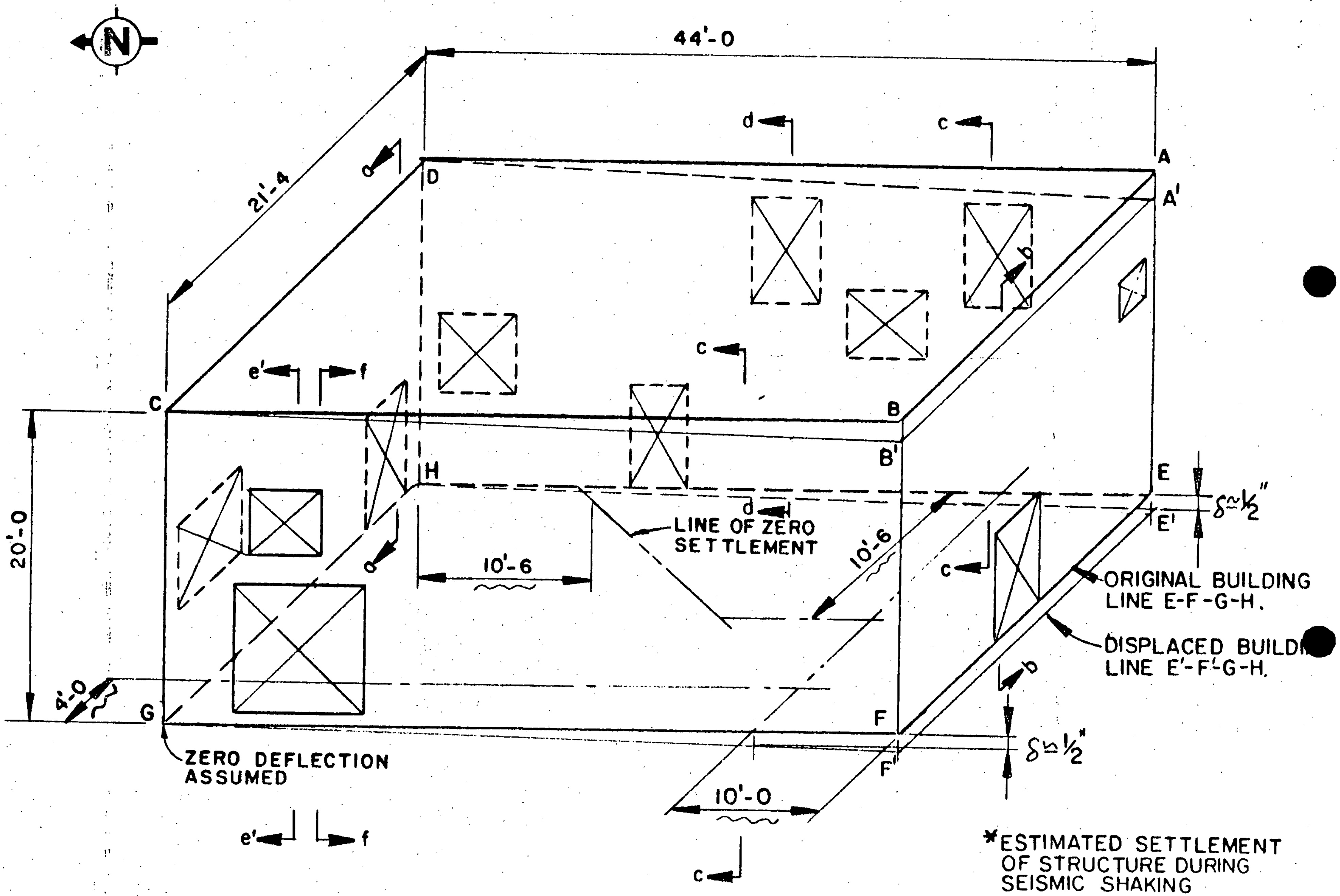
1) "Soil Backfill conditions Report, San Onofre Nuclear Generating Station, Unit 1", forwarded by letter from K. P. Baskin (SCE) to D. M. Crutchfield (NRC) dated September 1 1983.

2) "Soil Backfill Conditions - San Onofre Nuclear Generating Station, Unit 1" forwarded by Letter from K. P. Baskin (SCE) to D. M. Crutchfield (NRC) dated April 18, 1983.

3) "Balance of Plant Structures Seismic Reevaluation Criteria, San Onofre Nuclear Generating Station Unit 1," dated February 17, 1981.

4) Computech Engineering Services, Inc., "San Onofre Nuclear Generating Station, Unit 1, Seismic Evaluation of Reinforced Concrete Masonry Wall, Volume 1: Criteria," forwarded by letter from K. P. Baskin to D. M. Crutchfield dated January 15, 1982.

5) "Soil Backfill Conditions Report, San Onofre Nuclear Generating Station Unit 1", forwarded by letter from K. D. Baskin (SCE) to D. M. Crutchfield (NRC) dated August 17, 1982.



VENT BUILDING ISOMETRIC

FIGURE I

CONDUIT ATTACHED TO VENT BLDG AND SURROUNDING STRUCTURES

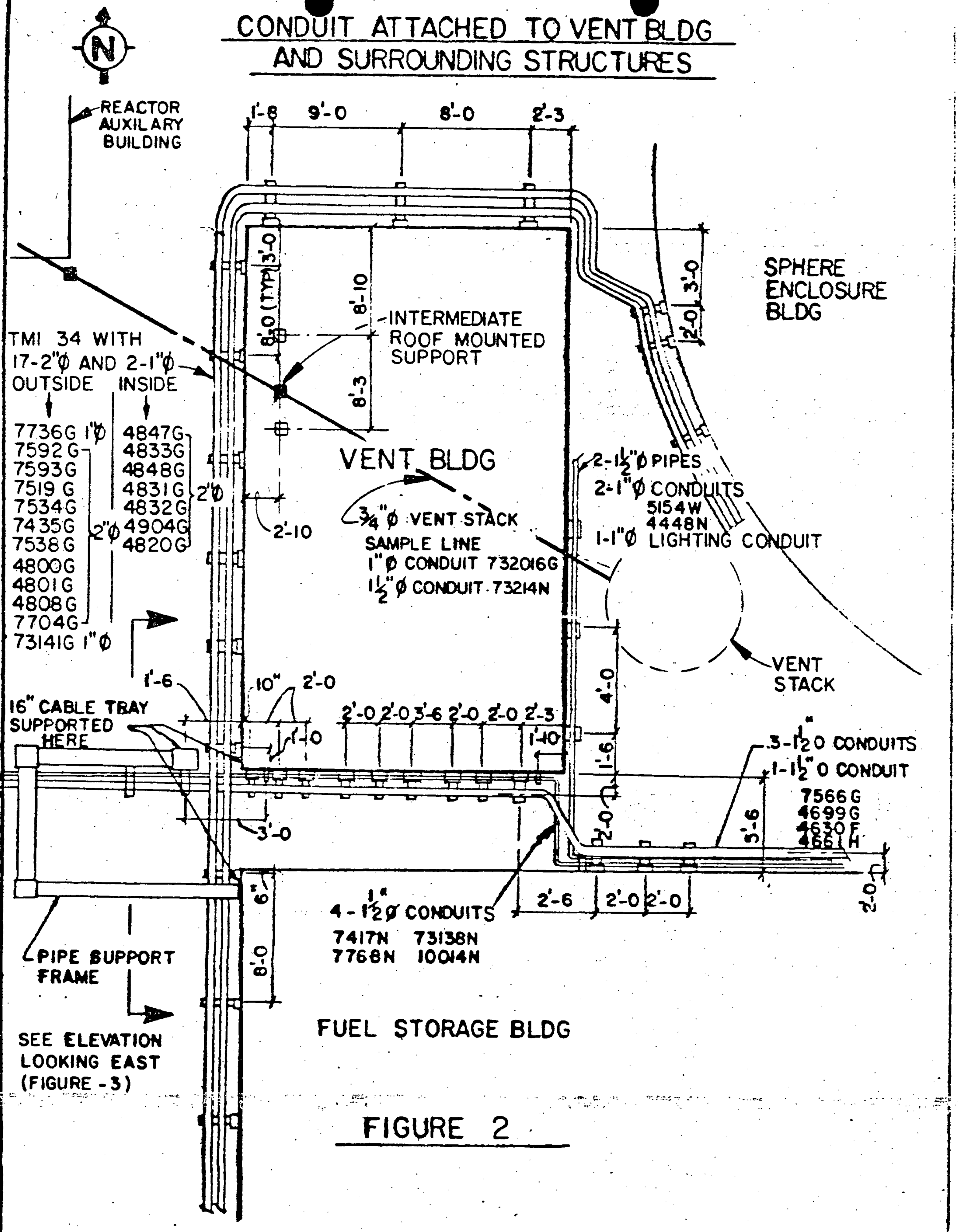
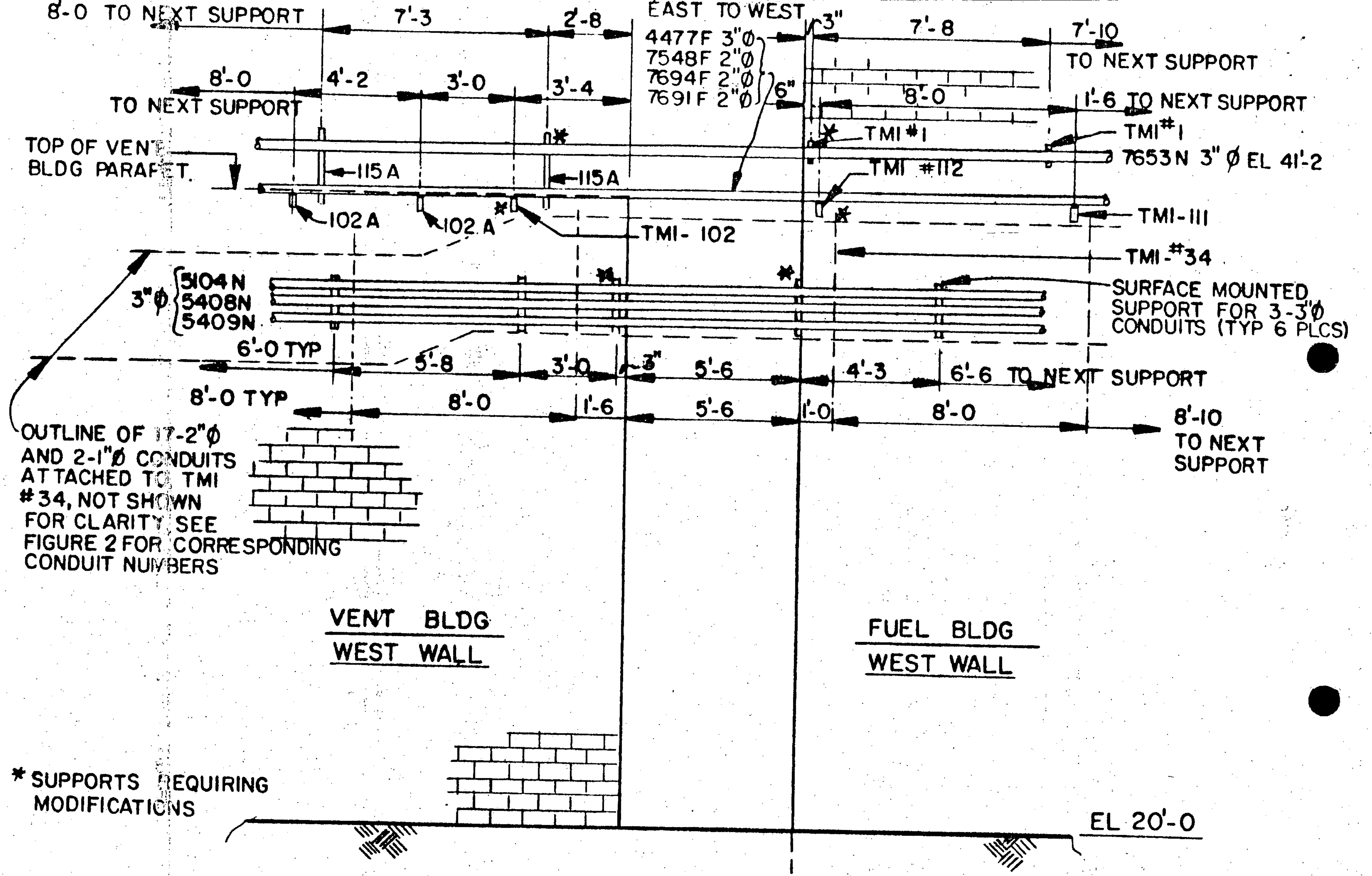
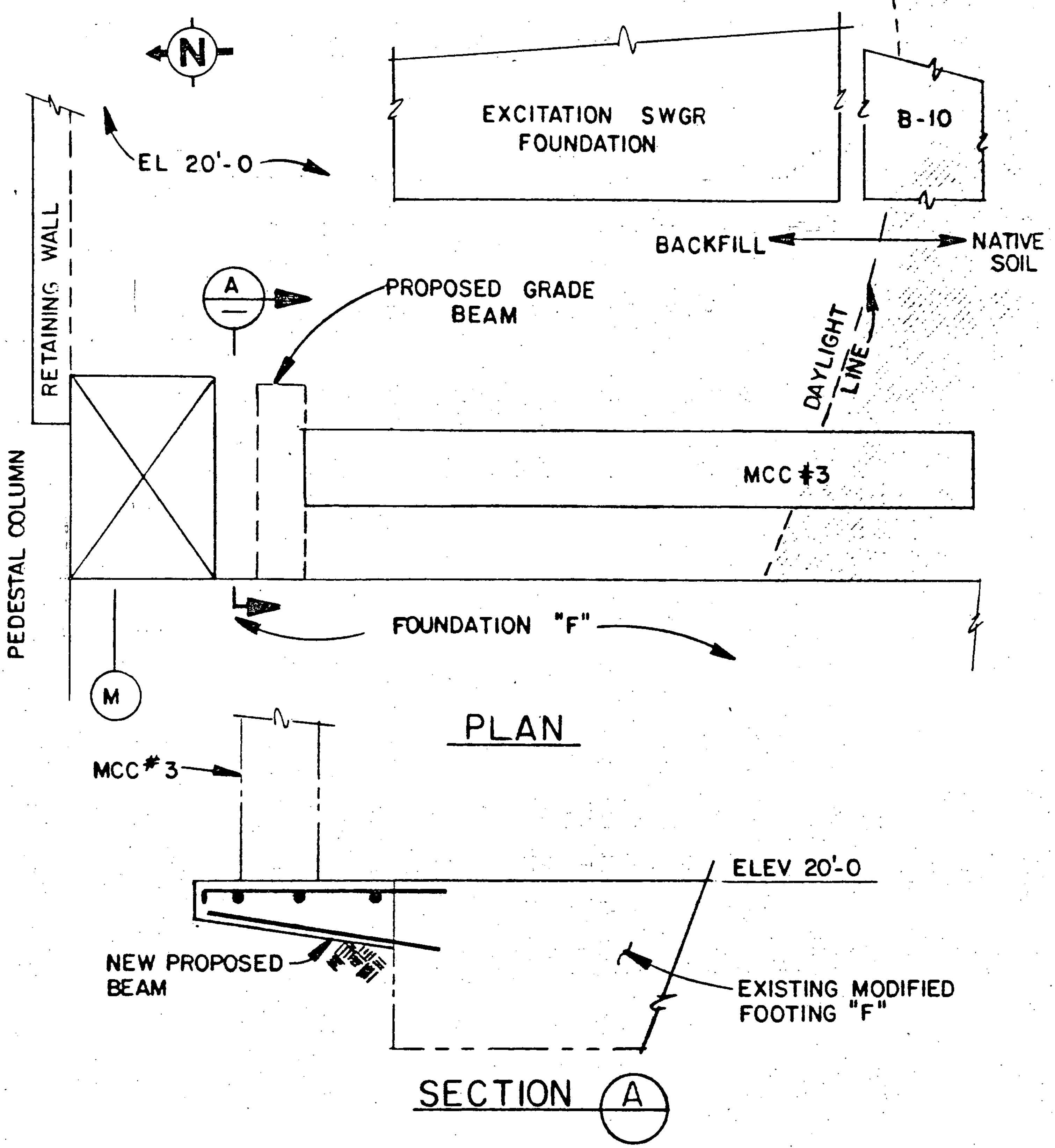


FIGURE 2



THE CONDUIT SUPPORTS REQUIRING MODIFICATIONS AT THE VENTILATION AND FUEL STORAGE BLDGS.

FIGURE 3



CONCEPTUAL MODIFICATION FOR MCC# 3

FIGURE 4