EVALUATION OF

COLD SHUTDOWN AND ACCIDENT MITIGATION SYSTEMS

FOR

SAN ONOFRE NUCLEAR GENERATING STATION, UNIT NO. 1

NOVEMBER 2, 1984

I. INTRODUCTION

In a meeting on October 4, 1984, the NRC requested additional seismic information for San Onofre Unit 1. Specifically, SCE was requested to address those safety related systems which are not being completely upgraded during the current outage. In a meeting on October 10, SCE responded with qualitative analysis including the performance of major industrial equipment in actual earthquakes. In a meeting on October 16, SCE provided the results of a quantitative evaluation of portions of not fully upgraded systems. The information presented at these meetings was documented in a letter from Kenneth P. Baskin to H. R. Denton dated October 17, 1984. Additional information was provided by letter dated October 22, 1984.

The purpose of this report is to document in more detail the results of the quantitative evaluation provided in the October 16 meeting and the October 17 and 22 letters. Specifically, detailed analyses were performed on a sample of accident mitigation and out of scope safe shutdown equipment as well as large and small bore piping to determine their seismic withstanding capability. The purpose of this effort was not to validate that the original plant met its design basis but rather to provide additional assurance that the plant as it exists today is capable of withstanding a 0.5g earthquake using contemporary methodology. With the exception of the 0.5g response spectra, assumptions and criteria used in these analyses are consistent with the Return to Service Criteria used for the hot safe shutdown systems. Specific additions or exceptions to these criteria are noted in the later sections of this report.

The scope of these detailed seismic evaluations included thirteen large bore pipe analyses, twenty-one small bore pipe analyses, eight equipment anchorage analyses and two tanks. This sample was selected based on a review of the April 30, 1982 Balance of Plant Mechanical Equipment and Piping (BOPMEP) Report. The piping and equipment analyses were selected from stress problems with high stresses in this report and were supplemented with additional analyses. On a quantitative basis, the sample covered 33% of the not fully upgraded large bore piping analyses, all of the not fully upgraded small bore piping analyses in the BOPMEP report, and most of the non-upgraded equipment. The small bore BOPMEP evaluations included portions of the cold shutdown and accident mitigation systems.

This report is divided into six sections, including this Introduction. Section II provides a discussion of the development of the 0.5g response spectra used in these evaluations. Section III describes the evaluation and results for the equipment and tanks analyzed. Section IV describes the results of the evaluation of large bore piping. Section V describes the results of the evaluation of small bore piping. Section VI summarizes the conclusions of these evaluations. It should be noted that wherever appropriate the results in Sections III, IV and V have been updated to provide the most current information available on the analyses.

II. RESPONSE SPECTRA GENERATION

The Design Basis Earthquake (DBE) postulated for the San Onofre Unit 1 site has a zero period acceleration (ZPA) of 0.67g. The original plant design was based on a DBE ZPA of 0.5g. For the evaluation of the accident mitigation (AM) and out-of-scope safe shutdown (OSSS) piping and equipment, the original design basis of 0.5g (DBE event) was used.

The response spectra which were used for piping and equipment analysis were developed for the 0.67g event. The response spectra which correspond to the 0.5g event were developed from the 0.67g spectra. To develop the in-structure spectra for the 0.5g event for this current evaluation, generic scale factors were developed to reduce the in-structure spectra already developed for the 0.67g DBE. Reduction factors were also developed to generate in-structure response spectra for a possible 0.4g event.

The development of the 0.5g response spectra from the existing 0.67g spectra included two steps:

1. develop scale factors for spectra amplitude.

2. develop broadening or peak shifting factors to account for change in soil stiffness properties.

To adjust the amplitude of the spectra for a lower level of earthquake, a reduction of 35 percent was established between the response level of the horizontal design basis earthquake and the response to half its value (0.33g). A reduction of 40 percent was established for the vertical earthquake. These reduction factors were based on actual ratios of in-structure spectra for the SSE and OBE events for the Hope Creek nuclear plant and are consistent with other SSE/OBE ratios seen in the industry. Using these generic factors, scale factors were linearly interpolated to scale the amplitudes of the spectra for both the 0.5g and 0.4g events. These factors are summarized in Table 1.

In addition, a review of soil behavior for a reduced level of earthquake was evaluated. A comparison of soil strains for the 0.33g and 0.67g earthquakes shows that the soil stiffness increases by about 25 percent when the level of earthquake is reduced to half its value for a horizontal earthquake. This is shown in Figure 1. There is an insignificant effect on soil strains for the vertical earthquake. To conservatively account for the higher soil stiffness for a lower level earthquake, the first mode peaks in the response spectra were shifted toward the high frequency end by 6 percent and 10 percent for the 0.5g and 0.4g horizontal earthquakes, respectively. Only the first mode peak was broadened since this peak represents the soil mode. These results are given in Table 2.

The above technique to generate the 0.5g spectra conservatively assumes that lower damping occurs in a 0.5g earthquake as compared to a 0.67g earthquake. However, review of the 0.5g scenario shows that the same damping values can be taken for both the 0.67g and 0.50g earthquakes. This is justified for both structure and soil damping for the following reasons:

1. Both the 0.5g and 0.67g events cause stresses at or near yield in structures, equipment, and piping. Therefore, it is appropriate to use Reg. Guide 1.61 "SSE" damping values for both levels of earthquake.

2. The 0.67g earthquake causes soil damping near 35 percent. This is for the rocking mode; other directions are higher. For a 0.5g earthquake, soil damping is near 30 percent. For SONGS-1, a maximum allowable soil damping of 20 percent was used for the development of the 0.67g spectra. Therefore, the same damping value (20%) is also justified for the 0.5g earthquake. The 0.5g spectra reduction factors (Table 1) are conservative. As damping can be justified as being at the same levels for both the 0.67g and 0.50g earthquakes, the spectra reduction factor for the 0.5g earthquake could be reduced 10% to 0.75.

Additionally, these factors are based on standard procedures. The design floor spectra are developed by Bechtel using time history methods and using detailed mathematical building models. The artificial time history used to develop the spectra is based on a synthetic time history which envelops the smooth Housner spectra. As shown in Figure 2, reductions of 20 percent are common in the amplified range of the spectra due to the artificial versus smooth spectra differences. Therefore, a further reduction in the spectra reduction factors (Table 1) is justified. Based on the conservatisms in soil damping and artificial vs. smooth spectra, the factors in Table 1 could be further reduced by a factor of 0.80.

The effects of secondary steel flexibility on the spectra have not been included. These effects are important only in cases where interaction effects are significant (i.e., where flexibility of pipe and support structures are comparable and where piping mass is large). The design floor spectra developed for SONGS-1 incorporate large margins which can accommodate any changes in the spectra due to secondary steel flexibility. These margins include:

1. Reduced responses in the amplified portions of the spectra due to pipe-structure coupling when interaction effects are significant.

2. Extra conservatism in floor spectra due to conservative enveloping of multiple soil conditions and multiple building model nodes.

3. Flexibility of some secondary steel structures already accounted for by floor spectra.

III. EVALUATION OF EQUIPMENT AND EQUIPMENT SUPPORTS

The evaluation of the accident mitigation and out-of-scope safe shutdown systems included a sample of equipment, tanks and their supports. This section discusses (A) equipment components and sample selection criteria, (B) evaluation criteria and methodology, and (C) the evaluation results

A. Equipment Components and Sample Selection Criteria

The equipment reviewed in this evaluation was selected from the April 30, 1982 BOPMEP report previously submitted to the NRC. The equipment included in the BOPMEP report, which was not addressed in the return to service (RTS) scope, was reviewed and the equipment items which showed overstress were selected for evaluation. The equipment components included in the review are listed in Table 3.

B. Evaluation Criteria and Methodology

The evaluation of the equipment was performed to address its ability to withstand the 0.5g seismic event. The equipment evaluation considered the structural adequacy of the components and included the loadings imposed by the seismic event on the component and the loadings imposed from the piping at the nozzles. The equipment components in this scope were grouped into three categories:

1. pumps

2. horizontally mounted equipment (heat exchangers and surge tank)

3. refueling water storage tank (RWST)

The evaluation criteria and methodology for each category were different so that this grouping was utilized for discussion of the component evaluations.

1. Pumps

The pumps represent relatively rigid, thick-walled components. Since the pump bodies and casings are thick when compared to the attached piping, the effects of nozzle loads on the casing are not critical. For the pump assemblies, the major structural concern is the pump anchorage and support. Therefore, the seismic assessment of the pump focuses on the support structure and its ability to withstand the seismic and nozzle loads. The evaluation criteria for the pump supports are the same as the RTS criteria. The acceptance criteria are defined in the ASME B&PV Code Section III, Subsection NF and Appendix F. For the seismic evaluation, the faulted condition (Level D) criteria were used. The only deviation from standard Code and industry practice was that a factor of safety of 2.0 was used for expansion anchor bolt allowables. This approach is consistent with the RTS criteria.

The evaluation of the pumps was performed using hand calculations with standard static, frequency, and strength of materials correlations. A simple frequency calculation was performed using the flexibility of the pump and pump supports. The calculated natural frequency was then used to define the seismic acceleration which was applied to the component. The seismic acceleration was determined by taking the maximum spectral acceleration at or above the natural frequency and scaling by 1.5 (if $f \leq 33$ Hz) or 1.0 (if $f > 33$Hz, rigid). The loads in the pump support members were then determined by statically applying a force equal to the mass of the component times the acceleration in each of three orthogonal directions and by statically applying the nozzle loads. (The nozzle loads include deadweight, seismic inertia, seismic anchor motion, and thermal expansion loads.) A stress evaluation was performed on the members. These calculated stresses were compared with the Code criteria to assess the qualification level of the pumps.

2. <u>Horizontally-Mounted Components</u>

The horizontally-mounted equipment consist of thin-shelled vessels supported on saddles and attached to building floors or steel frames. Since these components have thin shells, the stresses produced in the shell by the nozzles were significant and were included in the evaluation. Additionally, the support of these components was a critical item due to the weight of the components. Therefore, the evaluation of the horizontal components considered the analyses of the support structural adequacy and the analyses of the shell structural adequacy.

The criteria used for the horizontal component qualification were:

1. for supports: Level D criteria in ASME B&PV Code Section III, Subsection NF and Appendix F.

2. for shells: Level D criteria in ASME B&PV Code Section III, Subsections NB and NC.

The criteria are similar to the RTS criteria.

Since the horizontally-supported components are usually flexible, a more-detailed evaluation was performed compared to the pump analyses. A beam and lumped mass finite element model was developed for the equipment and its supporting structure. A natural frequency evaluation was performed to determine if the structure was flexible or rigid. For flexible structures, a response spectra analysis was performed to determine the seismic loads in the support members. For rigid structures, an equivalent static analysis was used. Additionally, nozzle loads were applied at appropriate locations to determine their effects on the support members. These calculated loads on the support members were then used in a stress evaluation of the supports. For the nozzle-shell junctures, a Bijlaard analysis was performed using WRC-107 (March 1979 revision) to determine the stresses in the shell. The stresses in the shell and supports were compared to the appropriate allowable stresses.

3. Refueling Water Storage Tank

The refueling water storage tank (RWST) is an anchored atmospheric storage tank. The RWST was originally designed to the API-650 requirements. The evaluation of this component considered the structural adequacy of the vessel shell, the shell-nozzle junctures, and the tank anchorage and foundation. Since the tank is partially located on in-situ backfill soil, the effects of settlement were then considered as well as the seismic, deadweight, and nozzle loads.

The criteria used in the evaluation are described below. Since the RTS criteria did not include any criteria for tanks, the following are in addition to the RTS criteria.

1. for the tank shell: The ASME B&PV Code Section III, Subsection ND-3800 was used for the tank. Additionally, a review of API-650 criteria was addressed. For the compressive stress allowables, a reduced factor of safety was used for the Code Level D allowable compressive stress. Additional margins due to pressure effects and axial versus bending load effects were included.

2. for the tank anchorage and foundation: The ASME B&PV Code Section III, Subsection NF and Appendix F, was used for the steel members in the anchorage. Standard concrete stress allowables according to ACI-349 were used for the concrete slab evaluation.

The methodology used in the RWST evaluation is as follows:

1. Seismic analysis of the tank was performed using a modified Housner approach considering fluid sloshing and tank flexibility ("Vibration Studies and Tests of Liquid Storage Tanks" by M. Haroun, Earthquake and Structural Dynamics, Vol. II, 1983).

2. Settlement of the tank and its concrete slab was evaluated by performing a beam on elastic foundation analysis of the slab by assuming a 1-1/4" settlement for the 0.5g seismic event.

3. Nozzles were evaluated by applying piping loads and loads produced by settlement using a Bijlaard analysis technique.

The tank evaluation addressed the structural adequacy of the tank, the concrete slab, the steel anchorage, and the shell-nozzle junctures.

C. Evaluation Results

The results of the equipment evaluations indicate that the components and supports meet the RTS acceptance criteria during a 0.5g seismic event. The loads applied at the nozzles were based on the results of the piping analyses for the 0.5g seismic event described in Section IV. The pumps and horizontally-mounted equipment were qualified using the Return to Service criteria, which is similar to the ASME Code criteria for the equipment and supports, and the RWST was qualified using increased compressive stress allowables considering experimental data on tank buckling. The average margin to the allowables for these items was approximately 20%.

IV. EVALUATION OF LARGE BORE PIPING AND SUPPORTS

This section addresses the 0.5g evaluation effort for a sample of accident mitigation and out-of-scope safe shutdown large bore piping and supports. A total of thirteen large bore piping problems was evaluated. Ten of these were evaluated by Impell and three by Bechtel. This section addresses (A) the criteria and methodology, (B) the Impell analyses, and (C) the Bechtel analyses.

A. Criteria and Methodology

The Return to Service Criteria for Hot Safe Shutdown Large Bore Piping and Supports were used for this effort. (Additional criteria were developed for cast iron pipe since this was not addressed by the RTS criteria. In addition, in a limited number of support analyses, credit was taken for some of the conservatism in the analysis methodology as described below.) The seismic response spectra used for this evaluation were those corresponding to a 0.5g ground acceleration. The spectra were factored from the "0.67g" spectra as noted in Section II.

The piping analysis was performed using either the Impell Computer Code SUPERPIPE or the Bechtel Computer Code ME-101, which are linear elastic piping analysis codes. The pipe support flexibilities which were modeled in the analyses are as follows:

General Support Flexibilities for Various Pipe Sizes

Pipe Diameter (inch)	Translational Flexibility (in/lb)
2 1/2	1.60×10^{-4}
3	1.11×10^{-4}
4	6.25×10^{-5}
6	2.78×10^{-5}
8	1.56×10^{-5}
10	1.00×10^{-5}
12	6.94×10^{-6}
14	5.10×10^{-6}
16	3.91×10^{-6}

These values were developed based upon typical values for supports at other nuclear plants. These values are substantiated as being in the range of flexibilities of supports typically designed for the given pipe sizes.

B. Impell Analyses

1. Sample Selection and Characteristics

The primary criterion in the sample selection was to choose highly stressed large bore piping problems from the April 30, 1982 BOPMEP report. The ten analyses which Impell performed included the following six BOPMEP piping problems:

Piping Problem Number	"BOPMEP" Stress, ksi
AC-05	149.9
AC-06	141.7
MW-05	129.5
MW-04	112.0
AC-03	95.6
SI-04	43.1

The second major criterion in the sample selection was that the major systems be represented. The Impell sample includes the following systems: feedwater, auxiliary coolant, miscellaneous water, safety injection, and containment air conditioning.

Other significant characteristics of the large bore sample are that it includes over 200 pipe supports, and covers nominal pipe sizes from 2" to 16". Seven of these ten large bore piping problems run between buildings or other major independent substructures. In every instance, the evaluations have included the effect of the relative seismic anchor motion displacement of these substructures. The effects of the seismic anchor motion have been evaluated in accordance with the return to service criteria for hot safe shutdown large bore piping and supports.

The ten lines in the sample which were evaluated by Impell are as follows:

- FW-05 6", 4", 3" and 2" from Condenser E-2A to Pump G-3B
- FW-06 3" and 2" from Condenser E-2A to pump G-3A

- AC-05 14", 8", 6", 3", 2", 1" from Upper and Lower Bearing Oil Coolers and other HXS to CCW HX
- AC-03 4" and 3" from CC Surge Tank C-17 to 14" Aux. Cooling Line and Make-up Water
- CA-55 6" from Penetration B-17B to AC Duct
- MW-04 8" Miscellaneous Water from Pen. B-11 to Recirc. HX E-11
- MW-05 8", 6", 14" from Pen. B-11 to Refueling Canal Sump and Filter and SI Recirc. Pumps G-45A and G-45B
- MW-51 8", 3" Vapor Containment Cooling and Ventilating Units through Pen. A-9A
- SI-04 16", 14", and 8" from SI Pump G-50A to the RWST and FW Pump G-3A
- AC-06 14", 10", 8", 3", and 2 1/2" from CC. HX to Excess Letdown HX, Upper and Lower Bearing Oil Coolers, etc.

2. <u>Results</u>

All of the ten large bore piping/support systems evaluated by Impell meet the RTS acceptance criteria for the 0.5g earthquake. The average margin to the allowable for the pipe stress was about 30%.

In a few instances (less than 5 percent), square root of the sum of the squares combination of support loads due to Seismic Anchor Movement and due to Seismic Inertia was taken to qualify pipe supports. This combination is less conservative than absolute summation of the loads, but is technically justified. In addition, for approximately 10 percent of the supports, credit was taken for some or all of the 20% conservatism in the response spectra as addressed in Section II.

C. <u>Bechtel Analyses</u>

The Bechtel selected large bore piping scope included three (3) out-of-scope safe shutdown lines. Two of these lines were selected from the lines in the BOPMEP report that had primary stresses which exceeded the BOPMEP reevaluation critria. The remaining line is a buried cast iron pipe that was not listed in the BOPMEP report. This line was specifically chosen to address the adequacy of the cast iron pipe.

1. Evaluation of the BOPMEP Lines

The two lines selected for evaluation from the BOPMEP report were:

- AC-01 The four (4) inch Auxiliary Coolant Line from the Seal Water Heat Exchanger E-34 to the fourteen (14) inch Auxiliary Coolant Line 3037-14"-152N.

- AC-23 The six (6) inch Auxiliary Coolant Line from the RHR Pumps G14 (A&B) to the Heat Exchangers E21 (A&B).

All pipe stresses, pipe supports, and valve accelerations met the RTS acceptance criteria for the 0.5g earthquake. The maximum combined primary stress for AC-01 is 20,450 psi versus 66,800 psi allowable stress. Likewise, the maximum combined primary stress for AC-23 is 37,800 psi versus 43,200 psi allowable stress.

2. Evaluation of Cast Iron Line

The cast iron line selected for evaluation was SW-06. This is a twelve (12) inch cast iron pipe in the Salt Water System from the Salt Water Pump G-13B to the Component Cooling Water Heat Exchanger E-20A. The portions of this line selected for analyses were:

a. The buried portion between the intake structure penetration and the native soil (Figure 3): This portion is buried in insitu backfill soil which has negligible settlement during the earthquake, but has significant settlement (up to 5 inches) after the earthquake.

b. The portion between the native soil and the Component Cooling Water Heat Exchanger (Figures 4 and 5): The analysis of this portion included the exposed portion between the soil and the Salt Water Heat Exchanger nozzle. This was done because there was no anchor between the buried and exposed pipe and also to account for the effect of two (2) supports in the exposed pipe which are supported from the soil. The pipe and the pipe support foundations are buried in insitu backfill soil with significant settlement both during the earthquake (up to 0.75 inches) and after the earthquake (up to 2.67 inches).

Portion 'a' of this line was analyzed for pressure and 0.5g DBE. No deadweight was considered in the loading because the piping is surrounded by soil. The portion 'b' analysis considered deadweight loading due to the exposed portion of the piping. Since both portions of this line operate at ambient temperature, it was not necessary to consider any thermal loading.

For Portion 'a', two analyses were performed as follows:

(i) During the earthquake: inertial analysis was done per Bechtel Topical Report BC-TOP-4-A for the buried pipe.

(ii) After the earthquake: static analysis was performed which conservatively assumed the pipe to be unsupported at the bottom and carrying an expanded column of soil. This was done to account for soil settlement.

For Portion 'b', two analyses were performed as follows:

(i) During the earthquake: inertial analysis considered the weight of the soil on the buried pipe and the support foundations and assumed the pipe to be unsupported at the bottom at certain locations to account for soil settlement.

(ii) After the earthquake: analysis was performed similar to Portion 'a'.

For the cast iron pipe, the allowable stress was chosen to be the minimum ultimate tensile strength. Use of the minimum ultimate tensile strength as the maximum allowable stress is conservative since experience has indicated that there is generally a margin between the minimum requirements and the actual capability. The maximum pipe stresses were obtained by combining longitudinal pressure stress, seismic inertial stress, and deadweight stress, as applicable.

All pipe stresses met the assessment criteria. The maximum combined stresses in Portion 'a' are 5,900 psi during the earthquake and 14,000 psi after the earthquake. For Portion 'b', these stresses are 13,100 psi during the earthquake and 13,000 psi after the earthquake. The minimum ultimate tensile strength for the pipe material (A21.6) is 18,000 psi and for the fittings material (A126 GRB) is 31,000 psi.

V. EVALUATION OF SMALL BORE PIPING

Twenty-one (21) out-of-scope safe shutdown pipe stress calculations were evaluated. These calculations included all of the safety related pipe problems within the small bore section listed in the BOPMEP report that were not part of the Hot Safe Shutdown Systems, and that had indicated stresses which exceeded the BOPMEP reevaluation criteria (2.4 S_h). A listing of the piping systems evaluated is given in Table 4. All evaluations were performed using the "As Is" design information supplemented in some cases by walkdowns. This section addresses (A) the evaluation criteria and methodology and (B) the results.

A. Evaluation Criteria and Methodology

The evaluation used Project Design Criteria 15691-583 "Walkdown Criteria for Evaluation Safety Related Small Bore Piping and Tubing." These criteria were approved by the NRC for use for the RTS Hot Safe Shutdown small bore piping. These criteria require that the support spans be maintained to specific lengths which are a function of the pipe size. Also, these criteria require adjustments in span lengths to account for concentrated masses, multiple bends and valves with extended operators. The evaluation was performed using isometrics and supplemented with walkdowns where necessary.

B. Results

Most of the safety related small bore lines selected for evaluation were demonstrated to meet the Project Design Criteria 15691-583. In a few cases, where actual spans exceeded the criteria allowable span lengths, calculations were performed to obtain the actual primary stresses for a 0.5g DBE in accordance with the RTS criteria. The actual primary stresses were demonstrated to be less than the RTS criteria allowable of 2 Sy.

VI. CONCLUSION

The results of these evaluations demonstrate the capability of the piping and equipment to withstand a 0.5g earthquake, in accordance with the same methodology used to evaluate the return to service systems wherever applicable. All eight equipment items and the two tanks satisfy the evaluation critria for 0.5g. For the thirteen large bore pipe analyses, all were shown to have pipe stresses within the allowables. Of the pipe supports analyzed, all were shown to be able to withstand a 0.5g earthquake. Finally, the twenty-one small bore pipe analyses all satisfied the Return to Service Criteria.

These results are due to a number of factors including:

1) the substantial amount of modifications completed on the not fully upgraded systems during the current outage,

2) the current calculational techniques used for these analyses,

3) the application of the Return to Service Criteria, and

4) the fact that these calculations were done to a 0.5g level in lieu of a 0.67g level.

Based on the combination of all of the information discussed above and the fact that the design process, NRC and ACRS reviews, and hearing board process provide a high degree of assurance that the plant was built in accordance with its original design criteria, it is concluded that those systems not completely upgraded during the current outage have the capability to withstand an earthquake of 0.5g.

JLR:2824F

Table 1

SCALE FACTORS TO DEVELOP REDUCED SPECTRA

Earthquake Level (ZPA)	Ratio to 0.67g	Scale Factors Used	
		Horizontal EQ	Vertical EQ
0.5g	0.75	0.825 (1)	0.800 (2)
0.4g	0.60	0.720 (1)	0.685 (2)

(1) Interpolated from 0.65 horizontal factor for OBE/SSE ratios at other nuclear plants

(2) Interpolated from 0.60 vertical factor for OBE/SSE ratios at other nuclear plants

Table 2

BROADENING FACTOR FOR RESPONSE SPECTRA

Earthquake Level	Strain-Iterated Soil "K" Factor	Soil Strain (%)	Soil Mode Broadening Factor
0.67	40 to 55	0.25 to 0.40	1.0
0.50	45 to 62 (1)	--	1.06
0.40	48 to 67 (1)	--	1.10
0.33	50 to 70	0.08 to 0.12	1.13

(1) Interpolated from 0.67g and 0.33g results

TABLE 3

EQUIPMENT ITEMS

- RHR Pumps (G-14A, B)
- Component Cooling Water Pumps (G-15A, B, C)
- Refueling Water Pumps (G-27)
- Safety Injection Pumps (G-50A, B)
- Salt Water Cooling Pumps (G-13A, B)
- Recirculation Heat Exchanger (E-11)
- Component Cooling Water Heat Exchangers (E-20A, B)
- RHR Heat Exchangers (E-21A, B)
- Component Cooling Water Surge Tank (C-17)
- Refueling Water Storage Tank (D-1)

TABLE 4

SMALL BORE PIPING SYSTEMS
SELECTED FOR EVALUATION

NUMBER OF STRESS CALCULATIONS EVALUATED	SYSTEM*
8	AUXILIARY COOLANT
1	CHEMICAL FEED SYSTEM
1	MISC. WATER SYSTEM
3	REACTOR SAMPLE
1	COMPRESSED AIR
3	SAFETY INJECTION
1	MAIN STEAM
3	CIRCULATING WATER

*Only Safety Related portions of these systems were evaluated

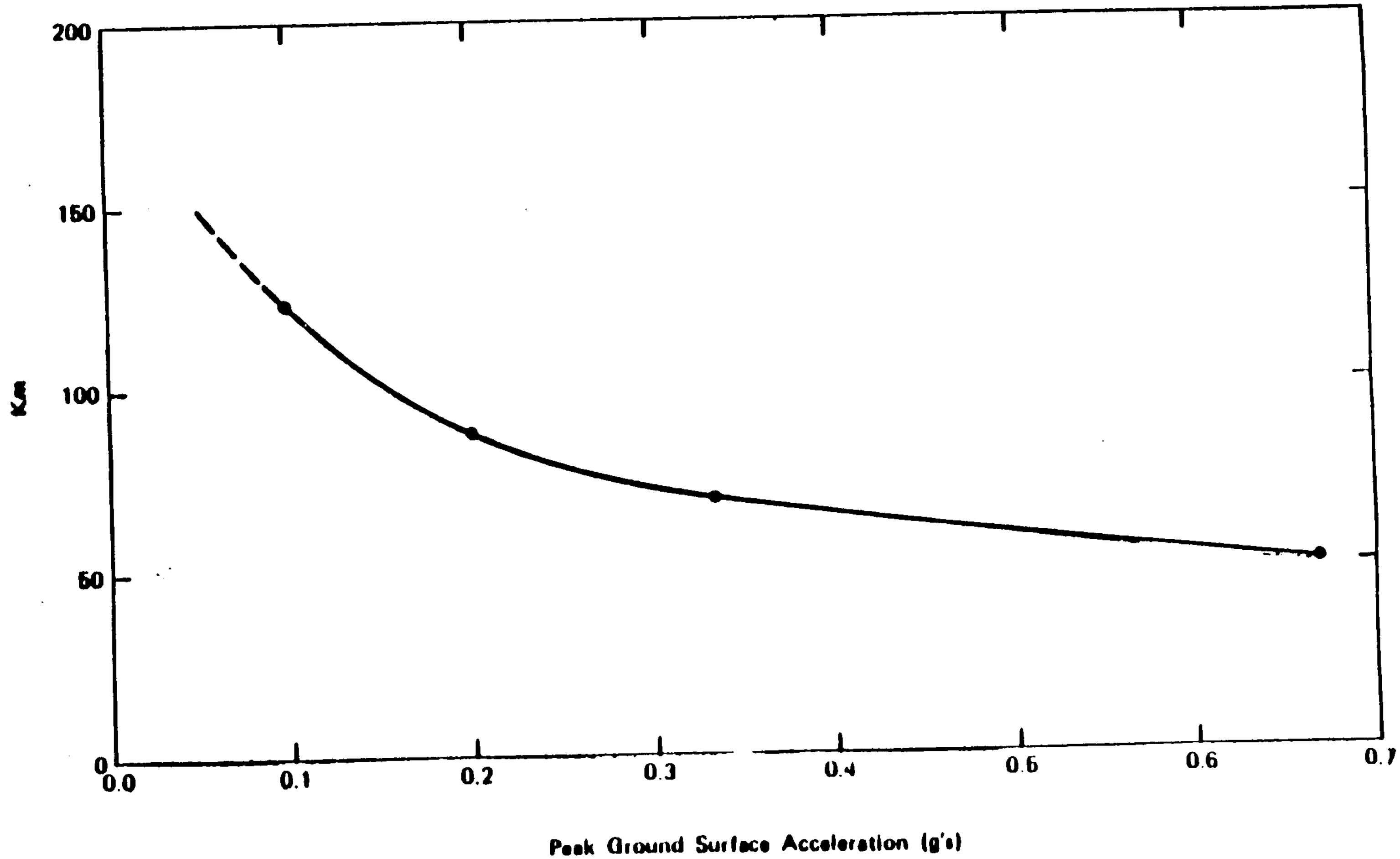

FIGURE 1

VARIATION OF Km WITH PEAK GROUND SURFACE ACCELERATION

FIGURE 2

FREE FIELD RESPONSE SPECTRA: COMPARISUN OF ARTIFICIAL TIME HISTORY AND 0.67G HOUSNER SPECTRA

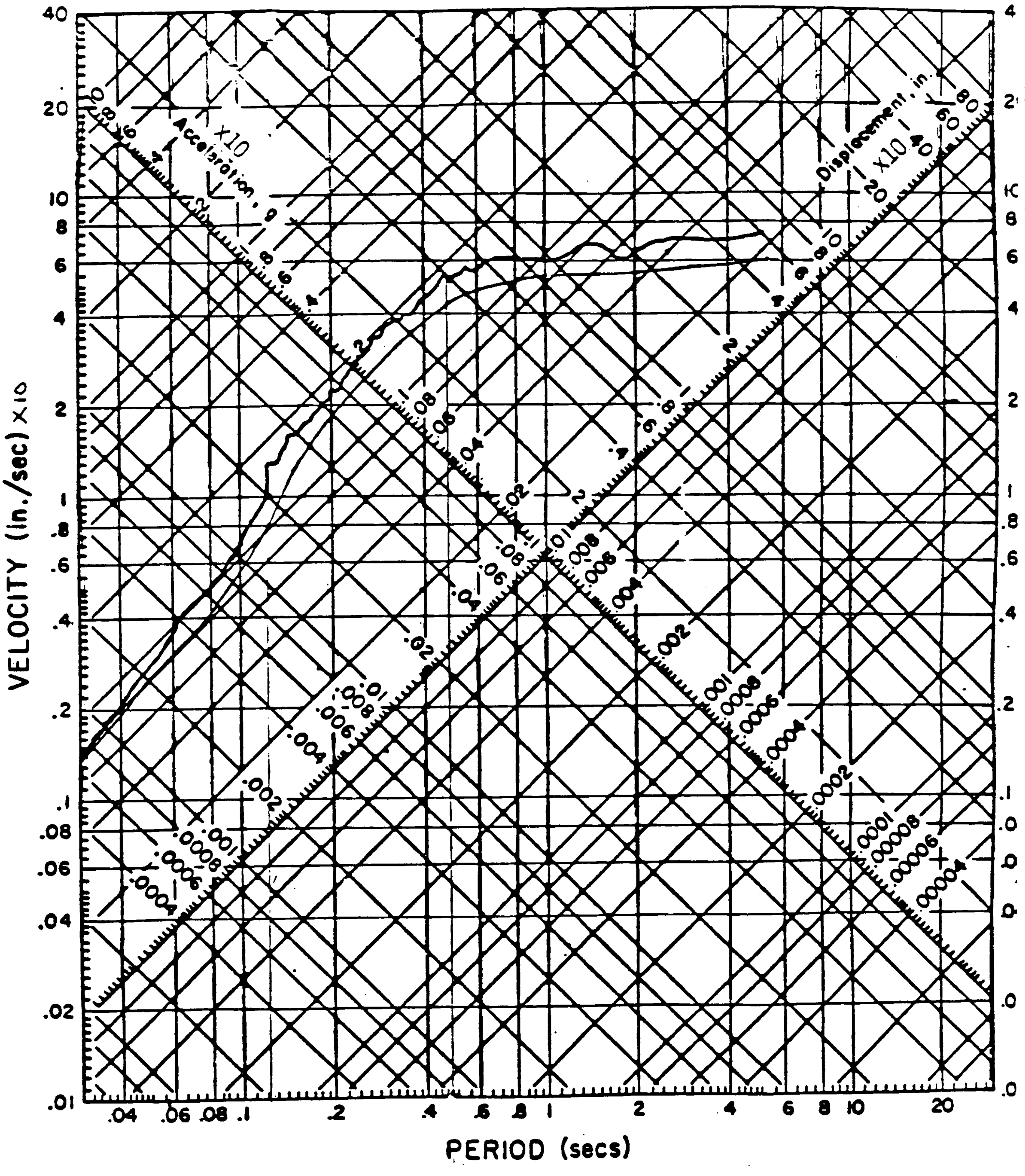

FIGURE 3

PORTION "a" OF SALT WATER COOLING CAST IRON LINE

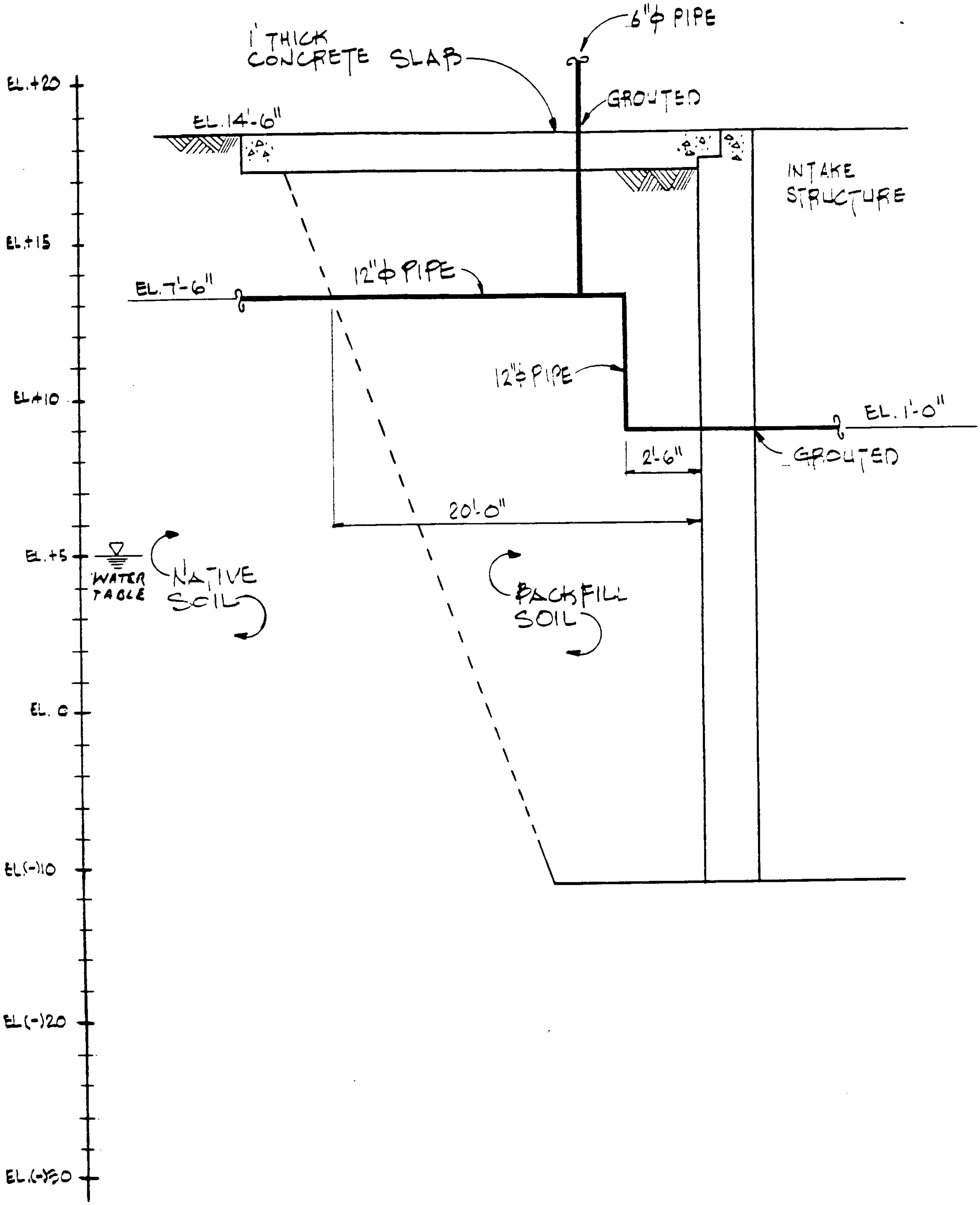

FIGURE 4

PORTION "b" OF SALT WATER COOLING CAST IRON LINE
(one line)

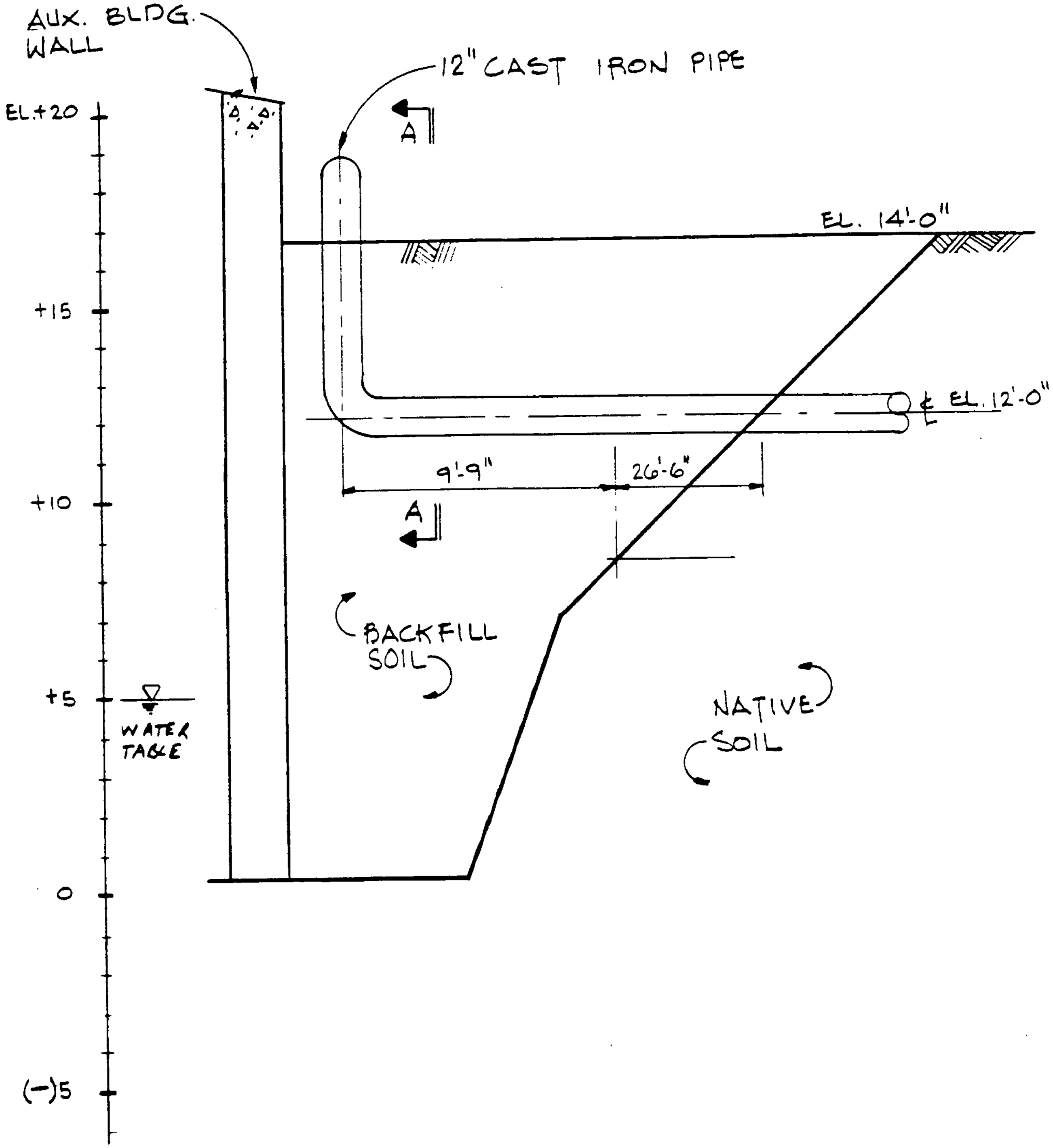

FIGURE 5

PIPE SUPPORT
(TYP.)