Converse Consultants

Geotechnical Engineering
and Applied Sciences

Volume II

AGGREGATE STUDY FOR PROPOSED DEVICE ASSEMBLY FACILITY NEVADA TEST SITE - AREA 6

Prepared for:

Holmes and Narver Inc.
2753 Highland Drive
Las Vegas, Nevada 89114

CCI Project No. 84-3100-02

November 30, 1984

Converse Consultants, Inc.
4055 South Spencer Street
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Las Vegas, Nevada 89109
Telephone 702 732-2121

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Converse Consultants

Geotechnical Engineering
and Applied Sciences

November 30, 1984 84-3100-02

Holmes and Narver Inc.
P.O. Box 14340
2753 Highland Drive
Las Vegas, Nevada 89114

Attention: Mr. William Cross

Subject: DAF Site Aggregate Study

Gentlemen:

In accordance with your request we have conducted an assessment of the DAF Site as a potential source of aggregate. This study was performed under your Purchase Order J10S04 Revision No. 7 and our labor costs are based on our fee schedule, N-H-1/83. The scope of work was defined by Mr. Bill Cross following our recent soil and foundation investigation of the DAF site.

In summary the rock material comprising the coarse aggregate is generally sound but there is a deficiency of oversize material for crushing and a high percentage of caliche coated particles. The coating results in a potentially weak bond of the aggregate with cement so that the strength of the concrete particularly the flexural strength is expected to be reduced.

We are pleased to have been of service to you. If there are any questions, please call.

Respectfully,

CONVERSE CONSULTANTS, INC.

for Gerald P. Lindsey
Senior Geologist

Algirdas G. Leskys, P.E.
Managing Vice President

JMC:GPL:js

Dist: 4/Addressee

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Purpose and Scope

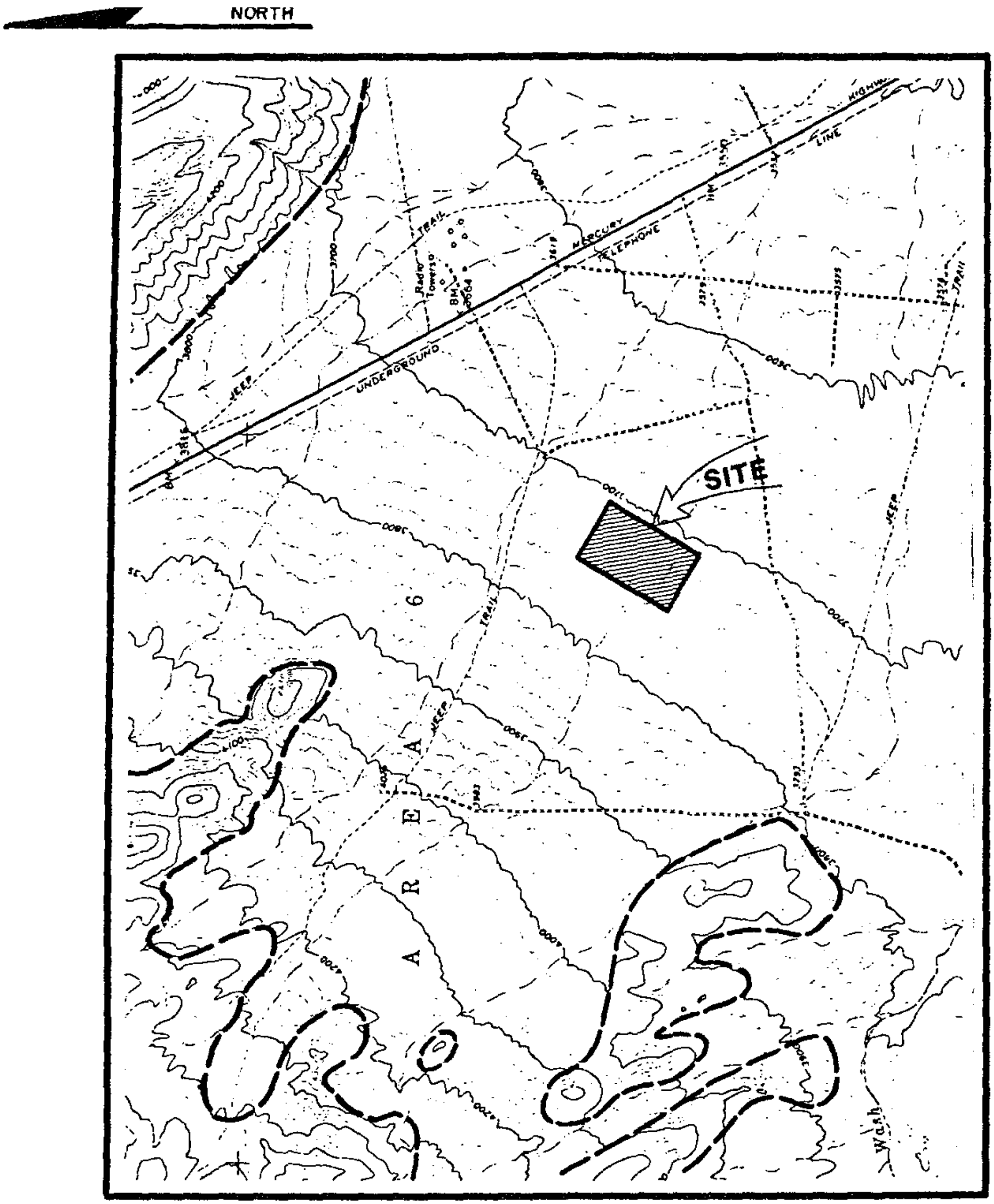
The purpose of this investigation is to determine the potential of the granular alluvial soils in the vicinity of the DAF site in area 6 of the Nevada Test Site as a source of aggregate for use in concrete. The area of the investigation is located within a 5000 feet square area which has the DAF facility near its center. The area was delineated in the field by a staked grid system. See Figure 1.

The instruction for making the assessment was to evaluate the potential suitability of the material and provide our conclusions on whether a more advanced study such as conducting actual mix design or testing for aggregate reactivity might be warranted. The tests as defined by Mr. Bill Cross were to determine soundness, wear, and grain size with mineral content evaluated by petrographic analysis.

Geologic Setting

The site is located on an alluvial fan on the flanks of a mountain ridge known as "The Benches" or as CP hills. The site is about 1.5 miles downslope from the bedrock contact which is the source of the alluvial detritus. The bedrock consists of a volcanic sequence of welded tuff overlying a sequence of fine grained air fall tuff which in turn lies uncomformably over Paleozoic limestone and quartzite formations.

The alluvial deposits are very thick here possibly on the order of 400 to 1000 feet. The slope of the surface



Source: U.S.G.S. 7.5 min. Series, Yucca Lake Quadrangle.

LEGEND

— — — Contact between bedrock and alluvium

SITE LOCATION MAP

PROPOSED DEVICE ASSEMBLY FACILITY Nevada Test Site - Area 6 for Holmes & Narver, Inc.	Scale 1"=300'±	Project No. 84-3100-01
	Prepared by DMcK	Date 10/23/84
Converse Consultants — Geotechnical Engineering and Applied Sciences	Checked by GPL	Figure No. 1
	Approved by RLP	

which is a determining factor in the coarseness of the aggregate is 4.0 to 5.0 percent.

Surface Conditions

The vegetation consisted of a sparse to moderate growth of desert vegetation comprised principally of creosote brush, 3 to 4 feet high with smaller scrub brush 1 to 2 feet high, some cholla cactus and an occasional joshua tree with height ranging from a few feet to 12 feet. The surface is gently rolling across the face of the fan broken by shallow minor washes. The average local relief is about one to two feet. Two wheel drive vehicles with clearance for vegetation can travel easily.

The drainage channels are typically smooth sided and flat bottomed. None of the washes appeared to have active deposition and erosion along Line A and all appeared to have the same mature desert vegetation in the channels as that on the low ridges. This indicates that the surface runoff has been captured at the upper part of the alluvial fan.

FIELD PROGRAM

Rationale of Exploration

The location of test pits for sampling were placed on the western or up-slope perimeter of the study area at regularly spaced intervals of 1250 feet along grid line A. The rationale for this is that the coarsest particle sizes are going to be closest to the bedrock source and also that by traversing laterally across the fan we would encounter the greatest variation in mixtures of rock types which contribute to the alluvial deposits.

Grid line A commences on the south end of grid line I and is marked at 625-foot intervals through grid line 9. Test pits T-1 through T-5 were located at grid station A1, A3, A5, A7 and A9 respectively. Test pit T-6 was located 450 feet north of grid station A-9 (T-5) to evaluate an apparent trend of an increased coarseness of surficial deposits and a general improvement in material quality observed north of station A-8.5. This improved quality upgradient and north of the site was expected based on our reconnaissance of the site, however our instructions were to not extend the investigation much beyond 400 feet of the grid area.

Exploration

The test pits were dug with a John Deer JD500-C backhoe supplied by Holmes and Narver. The depths of excavation ranged from 8.5 to 10 feet. The soils consisted of dense alluvial soils with occasional weakly cemented lenses. Sampling of the pits was done by cutting a vertical groove of uniform depth and width through a cross section of the trench wall of the material which would be excavated during a pit operation. The sample excluded the topsoil portion in the upper 12 to 24 inches which consists of silty gravel-gravelly silt containing desert vegetation roots. The material removed from the trench wall cut was collected in plastic liners at the bottom of the trench and was then placed in bags for transport. The logs of the six test pits are shown in the Appendix as Drawing Nos. 1 through 6. The size of the samples ranged from 300 to 400 pounds from each test pit.

Subsurface Conditions

The soils encountered in the test trenches consisted of interbedded lenses ranging from gravelly silt to sandy gravel. Paleosols, or fossil soil profiles, comprised of silty gravel weakly cemented with calcium carbonate or caliche were observed in all of the pits at several various depths. Typically these zones were encountered at 2 to 3 feet, 5 to 6 feet and 8 to 10 feet. The back-hoe had little difficulty excavating the thin cemented zone except where it was encountered at about eight to ten feet near the extended limits of the backhoe. There were a few widely scattered cobbles and small boulders observed along the traverse of the A line to the north boundary. North and west of this area, boulders of volcanic, tuff, limestone and quartzite became more frequent. As observed in the test pits, however, these coarse material appeared to be limited to the upper one or two feet of topsoil.

Test pits T-5 and T-6 showed fewer fine silty lenses and less calcareous or partially cemented lenses suggesting a younger more active part of the alluvial fan.

LABORATORY PROGRAM

The collected samples from each test pit were recombined and quartered by passing through an adjustable sample splitter to obtain a representative size for grain size analysis. The program and test methods which were conducted on the aggregate samples are described as follows:

Program of Aggregate Test Methods for Preliminary Assessment of Aggregate Quality

Grain Size Analysis: Washed Sieve Analysis
ASTM C136 Test for Sieve Analysis of Fine and Coarse Aggregates
ASTM C117 Test for Materials Finer than No. 200 Sieve in Mineral Aggregate by Washing

Los Angeles Abrasion Test:
ASTM C131 Test for Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine

Soundness Test:
ASTM C88 Test for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate. (Sodium sulfate method used)

Petrographic Analysis:
ASTM C295 Recommended Practice for Petrographic Examination of Aggregate for Concrete

Discussion of Laboratory Test Results

Grain Size Analysis. The analysis indicates that there is an excess amount of sand-sized material and a deficiency of large size coarse aggregate sizes. This lack of cobbles and small boulder sizes prevents the ability to produce by rock crushing clean fractured-face particles to make good quality concrete. The results of the analysis is shown on Table 1 and the grain size curves are shown in the appendix on Drawings 9 through 14. The sieve analysis for coarse concrete aggregate, sizes [(+) No. 4 sieve, (-) 1.5 inch] indicates that the natural sizing is only 10 to 15 percent coarser in the middle range than the desired grading for a 1.5-inch maximum sized aggregate. The computed grain size curve of the fine aggregate sizes [(+) No. 100 sieve, (-) No. 4 sieve] indicates that overall sizing is only about 5 to 10 percent finer than recommended grain size.

Table 1

Grain Size Analysis of Combined Test Pit Samples

Sieve Sizes	Test Pit Location Percent Passing					
	T-1	T-2	T-3	T-4	T-5	T-6
3"	96		100	82		
2"	93	100	99	80	100	100
1 1/2"	91	98	98	79	99	98
1"	87	95	93	75	98	95
3/4"	82	92	90	70	95	93
1/2"	75	88	83	64	88	85
3/8"	69	83	76	58	81	78
#4	53	68	56	45	62	56
#8	42	54	43	36	47	42
#16	34	41	33	27	30	28
#30	27	28	25	18	17	18
#50	19	19	16	12	10	11
#100	14	11	12	8	6	7
#200	8	7	8	5	4	4

The normal range of the percentage of fine aggregate in a grading of (-) 1.5 maximum size coarse aggregate, is on the order of 29 to 35 percent of the total weight. The natural gradation indicates that the percent of fine aggregate ranges from 45 to 68 percent for an average of 57 percent. This indication that the amount of excess fine aggregate including the 10 to 12 percent of (-) No. 100 sieve material is on the order of 18 to 39 percent. This amount of waste material might be usable if there was sufficient crushed aggregate available from the processing of oversized material. As stated previously, the amount of oversized material [(+1) 1.5 inch to 8 inch] is not sufficient to upgrade the material for use as select base course or hot mix aggregate or to reduce the percentage of caliche coated particles to improve the potential strength as concrete aggregate.

Los Angeles Abrasion Test. The test results indicate a maximum percent loss of 30.3 percent and a minimum of 22.9 percent. There appears to be a trend of decreasing wear loss going from the south end of the site at Test Pit 1 with 30.3 percent loss to the north side where test pits T-5 and T-6 materials show the least percent of wear. Since the wear loss is less than the maximum allowable loss of 50 percent, the aggregate is well within the acceptable range.

Table 2
Los Angeles Abrasion Test

ASTM C131 Abrasion Test (LA Wear Test)

Location	Percent Wear
T-1	30.3
T-2	25.3
T-3	24.8
T-4	25.8
T-5	22.9
T-6	23.1

Maximum allowable wear per ASTM C33 - 50 percent

Petrologic Examination. The material passing 1.5 inch and retained on the No. 4 sieve were examined to assess those constituents which would have an affect on the quality of concrete. Volcanic rock types were included because it appeared to be the weakest material and most likely to be reactive of the three main rock types which were present. Limestone and quartzite were the other main rock types present. Other constituents examined were calcium carbonate or caliche coatings, caliche cemented clasts, soft particles (clay bounded or air-fall tuff or unwelded tuff) and flat and elongated particles. The caliche coating restricted the ability to distinguish rock types. The results shown in Table 3 indicate that a high percentage of the particles are caliche coated averaging 49 percent of the total coarse and intermediate sized aggregate with individual fractions larger than 1/2-inch size having about 70 to 80 percent coated particles. Material retained on the 3/8-inch and #4 sieves have only about 30 to 40 percent coated particles. The coatings appear to separate more readily due to normal weathering from the non-carbonate rock types, i.e. welded tuffs and quartzite. Some fine gravel and coarse sand particles consist entirely of fragments of caliche coatings. A significant percentage of the total loss that occurs in the soundness and abrasion testing is due to the coating.

Soft particles composed of weakly consolidated tuff and clay cemented clasts comprise less than one percent of the coarse aggregate and flat and elongated particles constitute less than two percent.

The particle sphericity and roundness were not examined, however the material is generally classified as follows: the limestone particles which appears to constitute the majority of the rock material is subrounded and the volcanic and quartzitic rock types are typically subangular.

The rock types which are present suggest a low to negligible amount of reactive silicate minerals (opal, chert, chalcedony, christobalite). Only trace amounts are expected in some of the fine-grained welded tuffs.

We conclude that chemical reactivity is not likely to be a problem. No rock type containing mica were observed during the inspection. A cursory examination of the sand sized material indicated that quartz or chert constituted less than 10 percent of the particles and that caliche fragments or caliche-coated material is a significant portion of the aggregate. The remaining sand particles are equally divided between limestone and volcanic rock types.

Table 3

Petrologic Examination of Coarse Aggregate
Adjusted Percentage of Constituents Contained Between 1½ Inch to #4 Sieve

	Constituents	T-1	T-2	T-3	T-4	T-6	Average
1.	Volcanic Rock, (air fall tuff, welded tuff, andesite, etc.) (1)	--	29	27	40	18	30
2.	Caliche coated particles	55	46	42	58	45	49
3.	Cemented particles	-0-	-0-	-0-	4	-0-	-0-
4.	Soft particles	0.2	0.9	-0-	0.6	0.6	0.6
5.	Flat and elongated particles	1.3	1.2	4.3	1.8	1.5	2.0

Note (1): The calcium carbonate (caliche coating prevented the examination of many of the particles.

Comment: Casual observations for reactive siliceous minerals or micaceous rock materials were made during the examination. None were observed.

Sodium Sulfate Soundness Test. The test was conducted in accordance with ASTM C-88. Both coarse aggregate and fine aggregate were tested. The results are reported in Table 4 and indicate the individual grading size, average loss of each size of the test fraction on the basis of the test sample dry weight. The coarse aggregate soundness loss is within the allowable limits of 12 percent except one individual test fractions from test pit T-4 at 13.3 percent. About 40 to 50 percent of the loss is attributed to the splitting or fracturing of weak rock types such as weathered volcanic welded tuff, or thin bedded quartzitic rocks. About 50 to 60 percent of the loss appears to be related to the breakdown or separation of the calcium carbonate (caliche) coating or rind or to the disintegration of weakly cemented clasts.

Table 4

Sodium Sulfate Soundness ASTM C-88
Coarse Aggregate

Percent Loss After Five (5) Cycles (1) (2)

Sample Location	T-1	T-2	T-3	T-4	T-5	T-6	Avg.
Sieve Sizes							
1 1/2 - 3/4"	3.4	3.5	2.9	7.0	5.9	5.3	4.75
3/4 - 3/8"	4.5	5.0	3.6	8.1	5.0	2.9	4.85
3/8 - #4	3.4	6.5	4.2	13.3(2)	7.0	6.4	6.8
							5.5

Fine Aggregate (1)(3)

Sieve Sizes	T-1	T-2	T-3	T-4	T-5	T-6	Avg.
#4 - #8	12.4	21.2	17.6	29.4	21.4	---	20
#8 - #16	14.5	27.6	19.9	39.3	42.8	---	29
#16 - #30	16.6	30.8	22.5	34.2	32.4	---	27
#30 - #50	21.9	27.5	28.1	29.9	21.9	---	26
Avg.	16	27	22	33	30		

Comment: The majority of material lost during the tests was due to breakdown of calcium carbonate coating or particles and the separation of the coating from the aggregate. Some loss due to splitting of quartzitic and volcanic types.

Note 1: Reported as percent loss of test fraction
Note 2: The allowable limits for coarse aggregate is 12 percent
Note 3: The allowable limits for fine aggregate is 10 percent

The results of the soundness test on fine aggregate indicated that all sand sized fractions exceeded the minimum allowable loss of 10 percent with average loss of each size ranging from 20 to 29 percent and the individual test samples showing a maximum of 43 percent. There is an apparent trend with test location T-1 showing the least percent loss and locations T-4 and T-5 showing the greatest loss. Sand material from test pit T-6 was not tested for soundness. Most of the loss appears to be a result of the breakdown and disintegration of caliche fragment particles.

Conclusion

- There is an excess of fine aggregate on the order of 10 to 30 percent even when discounting the minus No. 100 sieve size material which is normally wasted.

- There is an insufficient amount of oversize aggregate in the range of 1.5 inch to 8-inch rock to produce crushed rock particles.

- The calcium carbonate or caliche coatings on 75 percent of the plus 1/2-inch sized particles and on about 35 percent of the No. 4 to 1/2-inch particles was adequately bonded so that the soundness test limits are not exceeded on the coarse aggregate. What material losses that did occur, however, was due primarily to the caliche. It is expected that this condition will significantly affect the strength and durability of structural concrete particularly the flexural strength. The coatings will tend to break during handling and may produce excess fines and dust coatings that further degrade the cement-aggregate bond.

- Soft particles and flat or elongated particles are not present in significant amounts

- The coarse aggregate is acceptable for use in concrete on the basis of the abrasion test. The percentage of loss due to abrasion (wear) is well below the maximum allowed loss indicating it is of durable rock material and suitable at least on this basis for use in concrete.

- The coarse aggregate is acceptable for use in concrete on the basis of soundness tests. The percentage of loss due to soundness testing of coarse aggregate indicates that the loss does not exceed the ASTM specified limits of 12 percent. A majority of the lost material consisted of caliche coating and caliche cemented aggregate.

- The fine aggregate is unacceptable for use as concrete aggregate on the basis of the soundness test. THe soundness loss experienced in the tests with fine aggregate greatly exceeds the allowable limits of 10 percent in each individual test sample. It is not expected that crushing of oversized material would benefit the sand.

- The aggregate contains occasional thin lenses with clayey silt fines and much of the material is classed as silty. All of the material will require washing prior to use or either concrete as hot mix aggregate.

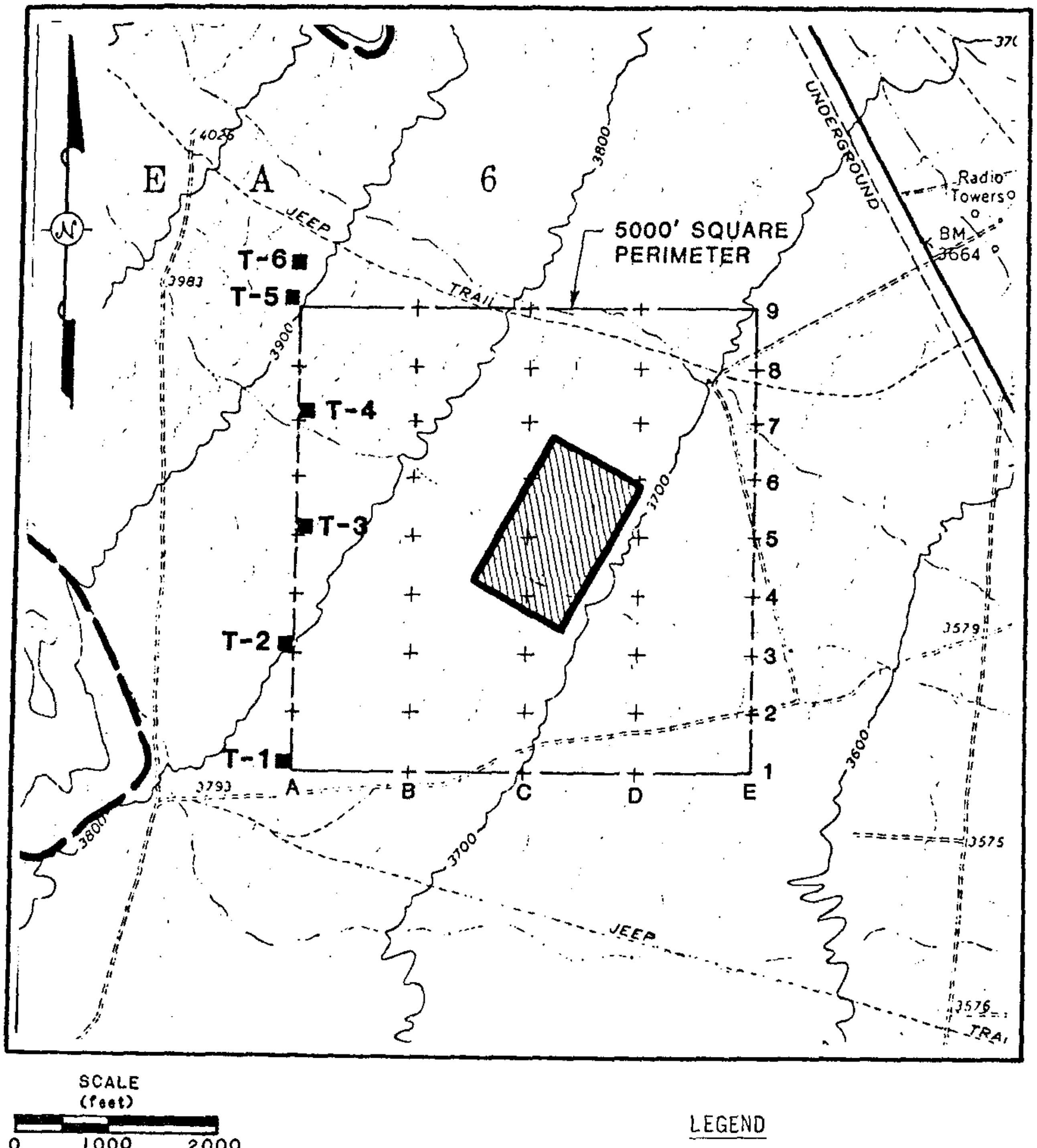
- There was little evidence of observed reactive silceous minerals. It is not expected that the aggregate will have a significant harmful reaction with cement.

Recommendations

We recommend that further tests be conducted on the coarse aggregate to determine the affects of the caliche coating on the strength of concrete specimens. Such tests should include the freeze-thaw test, ASTM C-666, and compressive strength and flexural strength on test specimens.

It is expected that the particle coating may prove to be deleterious to concrete. In that case we suggest that this condition may be ameliorated by the incorporation of material attained by crushing oversized rock. Evidence on the site suggests that coarser material, cobbles and boulders, are more prevalent closer to the bedrock contact north and west of the site. The use of the sand size material in concrete or hot mix aggregate is not recommended. Any additional testing of the coarse aggregate in concrete mix designs or test specimen should utilize fine aggregate from previously accepted source and not from this site.

APPENDIX A



LEGEND

■ Approximate location of exploratory trench

LOCATION OF TRENCHES

AGGREGATE STUDY
Device Assembly Facility
Nevada Test Site - Area 6

Scale	Project No.
As Shown	84-3100-02
Prepared by DMcK	Date 11/26/84
Checked by JMC	Drawing No.
Approved by [signature]	1

Converse Consultants Geotechnical Engineering and Applied Sciences

LOG OF TRENCH NO. T-1

DATE: 9/26/84

LOCATION:

ELEVATION: 3775' (est.)

DEPTH IN FEET	SAMPLES	SYMBOL	SOIL DESCRIPTION	COLOR	MOISTURE	CONSISTENCY	REMARKS
0		GM/ ML	SILTY GRAVEL with occasional cobbles (Topsoil)	brown	dry to sl. moist	medium dense	
			SAND & GRAVEL partially cemented, in platy lenses	light gray		mod. hard to dense	
		SM	SILTY SAND & GRAVEL	light brown	sl. moist	dense	
5							
		ML	GRAVELLY SILT				
		GP	SANDY GRAVEL				
		ML	GRAVELLY SILT	red-brown			
			CEMENTED GRAVEL	lt brown		mod hard	
10							
15							

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

AGGREGATE STUDY
Device Assembly Facility
Nevada Test Site - Area 6

DRAWING NO. 2

Converse Consultants

Consulting Engineers and Geologists

PROJ. NO. 84-3100-02

LOG OF TRENCH NO. T-2

DATE: 9/27/84

LOCATION:

ELEVATION: 3810' (est.)

DEPTH IN FEET	SAMPLES	SYMBOL	SOIL DESCRIPTION	COLOR	MOISTURE	CONSISTENCY	REMARKS
0		GM	SILTY GRAVEL (Topsoil)	light brown	dry to sl. moist	medium dense	
		GP	SANDY GRAVEL			dense	
		ML	GRAVELLY SILT				
		GM	SILTY GRAVEL occasional cobbles with thin, scattered caliche lenses			very dense	
5		GP/ GM	SANDY GRAVEL			dense	Combined bulk sample taken from 1.5'-8.0'
		GC	CLAYEY GRAVEL	red-brown	sl. moist		
			CEMENTED GRAVEL & SAND			v.dense	
			End of Trench at 8.5 feet.				
10							
15							

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AGGREGATE STUDY
Device Assembly Facility
Nevada Test Site - Area 6

DRAWING NO. 3

Converse Consultants — *Consulting Engineers and Geologists*

PROJ. NO. 84-3100-02

LOG OF TRENCH NO. T-3

DATE: 9/26/84

LOCATION:

ELEVATION: 3855' (est.)

DEPTH IN FEET	SAMPLES	SYMBOL	SOIL DESCRIPTION	COLOR	MOISTURE	CONSISTENCY	REMARKS
0		SM	GRAVELLY SILT	brown	dry to sl. moist	medium dense	
	■	SW	GRAVELLY SAND	light brown		dense	
	■	GM	SILTY GRAVEL ---with thin, cemented lenses from 5.0'-5.5'	brown			
5	■						Combined bulk sample taken from 1.5'-7.7'
	■	SW	GRAVELLY SAND			very dense	
			End of Trench at 7.7 feet.				
10							
15							

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AGGREGATE STUDY
Device Assembly Facility
Nevada Test Site - Area 6

DRAWING NO. 4

Converse Consultants *Consulting Engineers and Geologists*

PROJ. NO. 84-3100-02

LOG OF TRENCH NO. T-4

DATE: 9/27/84

LOCATION:

ELEVATION: 3875' (est.)

DEPTH IN FEET	SAMPLES	SYMBOL	SOIL DESCRIPTION	COLOR	MOISTURE	CONSISTENCY	REMARKS
0		ML	GRAVELLY SILT (Topsoil)	brown	dry to sl. moist	medium dense	
		SM	SILTY SAND & GRAVEL	light brown		dense	
			GRAVEL partially cemented	lt.gray		mod.hard	
		GM	SILTY GRAVEL calcareous	light brown		dense	
		SW	SAND				
			CEMENTED GRAVEL	lt.gray		v.dense	
5		GW	SANDY GRAVEL with cobbles	light brown		dense	Combined bulk sample taken from 1.5'-9.0'
		SW	GRAVELLY SAND				
		GM	SILTY GRAVEL with occasional cobbles		sl. moist		
10			End of Trench at 9.5 feet.				
15							

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AGGREGATE STUDY
Device Assembly Facility
Nevada Test Site - Area 6

DRAWING NO. 5

Converse Consultants *Consulting Engineers and Geologists*

PROJ. NO. 84-3100-02

LOG OF TRENCH NO. T-5

DATE: 9/27/84

LOCATION:

ELEVATION: 3910' (est.)

DEPTH IN FEET	SAMPLES	SYMBOL	SOIL DESCRIPTION	COLOR	MOISTURE	CONSISTENCY	REMARKS
0		GM	SILTY GRAVEL with occasional cobbles	brown	dry	medium dense	
	■	GM	SILTY GRAVEL slightly (calcareous) cemented	lt.gray to brown		very dense	
	■	SW/SM	GRAVELLY SAND with inter-bedded thin lenses of silty sand	light brown		dense	Combined bulk sample taken from 1.0'-10.0'
5	■						
	■	SM	SILTY SAND				
	■	GP	SILTY GRAVEL				
10			End of Trench at 10.0 feet.				
15							

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AGGREGATE STUDY
Device Assembly Facility
Nevada Test Site - Area 6

DRAWING NO. 6

Converse Consultants *Consulting Engineers and Geologists*

PROJ. NO. 84-3100-02

KEY TO SOILS SYMBOLS AND TERMS

TERMS USED IN THIS REPORT FOR DESCRIBING SOILS ACCORDING TO THEIR TEXTURE OR GRAIN SIZE DISTRIBUTIONS ARE GENERALLY IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM.

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
Coarse-grained soils (More than half of material is larger than No. 200 sieve size)	Gravels (More than half of coarse fraction is larger than No. 4 sieve size)	Clean gravels (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines
		Gravels with fines (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixtures
			GC	Clayey gravels, gravel-sand clay mixtures
	Sands (More than half of coarse fraction is smaller than No. 4 sieve size)	Clean sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines
			SP	Poorly-graded sands, gravelly sands, little or no fines
		Sands with fines (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures
			SC	Clayey sands, sand-clay mixtures
Fine-grained soils (More than half of material is smaller than No. 200 sieve)	Silts and clays (Liquid limit less than 50)		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
			OL	Organic silts and organic silty clays of low plasticity
	Silts and clays (Liquid limit greater than 50)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
			CH	Inorganic clays of high plasticity, fat clays
			OH	Organic clays of medium to high plasticity, organic silts
	Highly organic soils		Pt	Peat and other highly organic soils

TERMS DESCRIBING CONDITION, CONSISTENCY AND HARDNESS

COARSE GRAINED SOILS (major portion retained on No. 200 sieve): Includes (1) clean gravels, (2) silty or clayey gravels and (3) silty, clayey or gravelly sands. Consistency is rated according to relative density, as determined by laboratory tests.

Descriptive Term	Relative Density
Very loose	0 to 15%
Loose	15 to 40%
Medium dense	40 to 70%
Dense	70 to 85%
Very dense	85 to 100%

FINE GRAINED SOILS (major portion passing No. 200 sieve): Includes (1) inorganic and organic silts and clays, (2) gravelly, sandy or silty clays, and (3) clayey silts. Consistency is rated according to shearing strength as indicated by penetrometer readings or by direct shear tests.

Descriptive Term	Shear Strength (ksf)
Very soft	less than 0.25
Soft	0.25 to 0.50
Firm	0.50 to 1.00
Stiff	1.00 to 2.00
Very stiff	2.00 to 4.00
Hard	4.00 and higher

ROCK: Includes gravels, cobbles, rock, caliche and bedrock materials. Hardness is related to field identification procedures described below.

Descriptive Term	Field Identification Test
Soft	Can be dug by hand and crushed by fingers
Moderately hard	Friable, can be gouged deeply with knife and will crumble readily under light hammer blows
Hard	Knife scratch leaves dust trace, will withstand a few hammer blows before breaking
Very hard	Scratched with knife with difficulty, difficult to break with hammer blows

SOIL MOISTURE

From low to high the soil moisture is indicated by:

- Dry
- Slightly moist
- Moist
- Very moist
- Wet

SIZE PROPORTIONS

Designation	Percent by Weight
Trace	0 to 10
Little	10 to 20
Some	20 to 35
And	35 to 50

SOIL TYPE KEY

Clay, Silt, Sand, Gravel, Gypsum, Caliche, Peat

SAMPLER TYPES

Shelby, Converse, Split-Spoon, Bulk, Pitcher or Core, No Recovery

LEGEND OF LABORATORY TESTS

G-Grain-size	S-Swell	DS-Direct Shear
A-Liquid & Plastic Limits	Ch-Chemical	T-Triaxial
PP-Pocket Penetrometer	H-Chemical Heave	Sol-Solubility
U-Unconfined	C-Consolidation	P-Compaction

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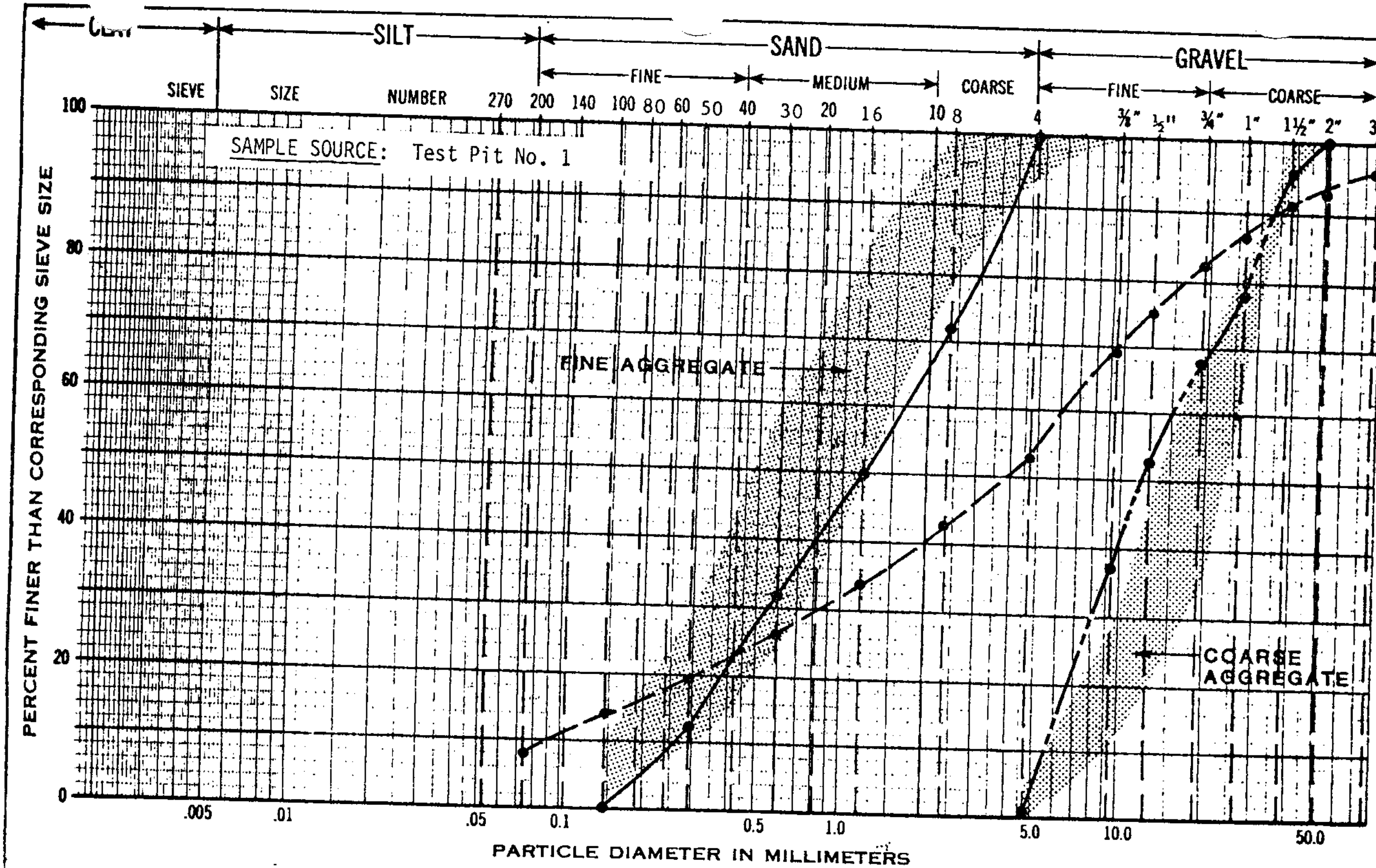
Drawing No. 8



LEGEND

- Specification limits (ASTM L-33)
- Gradation of combined coarse and fine aggregate
- Gradation of fine aggregate
- Gradation of coarse aggregate

GRAIN-SIZE DISTRIBUTION CHART

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Device Assembly Facility
Nevada Test Site - Area 6

Project No. 84-3100-02

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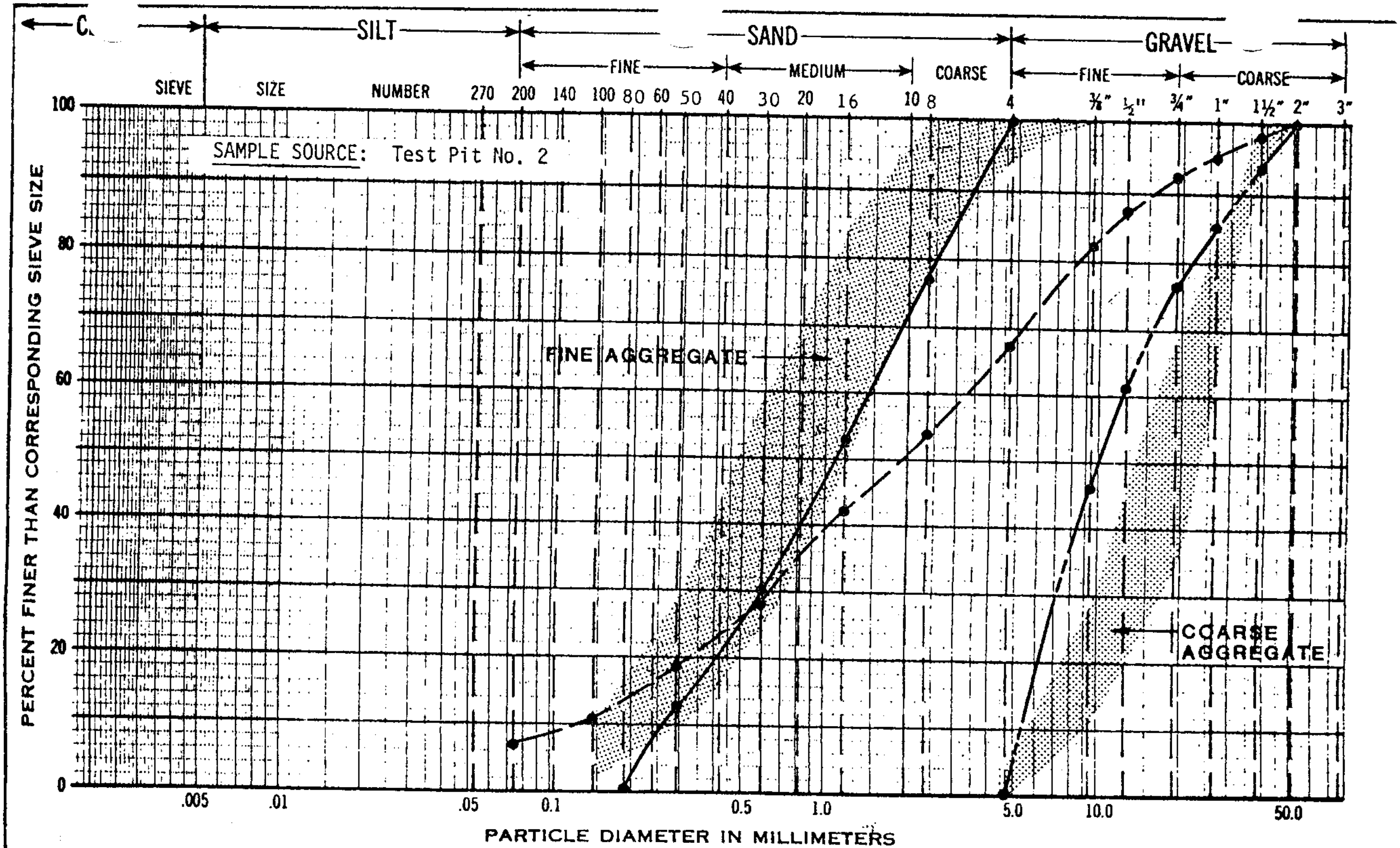
Drawing No. 9



LEGEND

- Specification limits (ASTM L-33)
- – – – Gradation of combined coarse and fine aggregate
- ——— Gradation of fine aggregate
- – – – Gradation of coarse aggregate

GRAIN-SIZE DISTRIBUTION CHART

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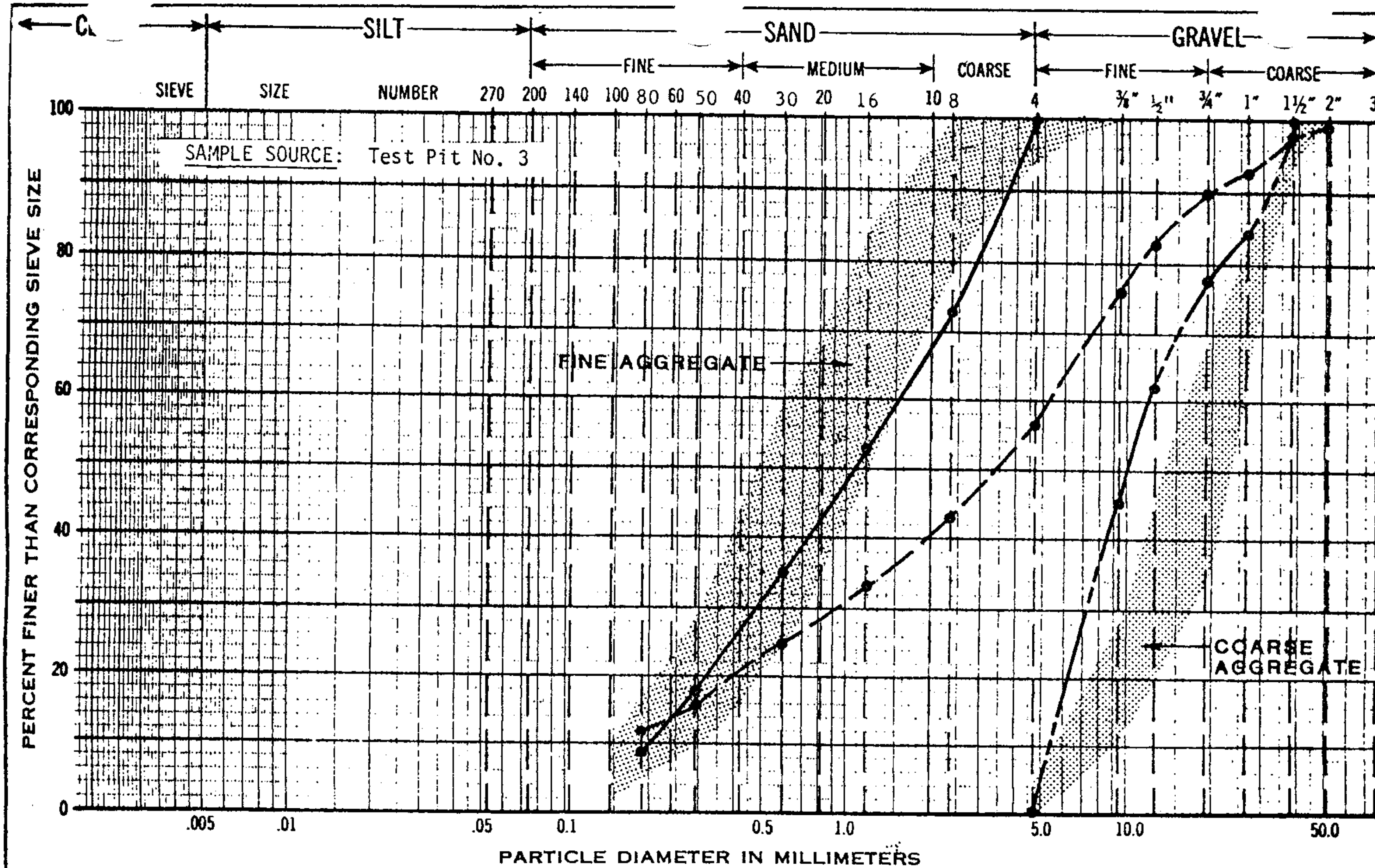
Drawing No. 10



LEGEND

- Specification limits (ASTM L-33)
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- Gradation of coarse aggregate

GRAIN-SIZE DISTRIBUTION CHART

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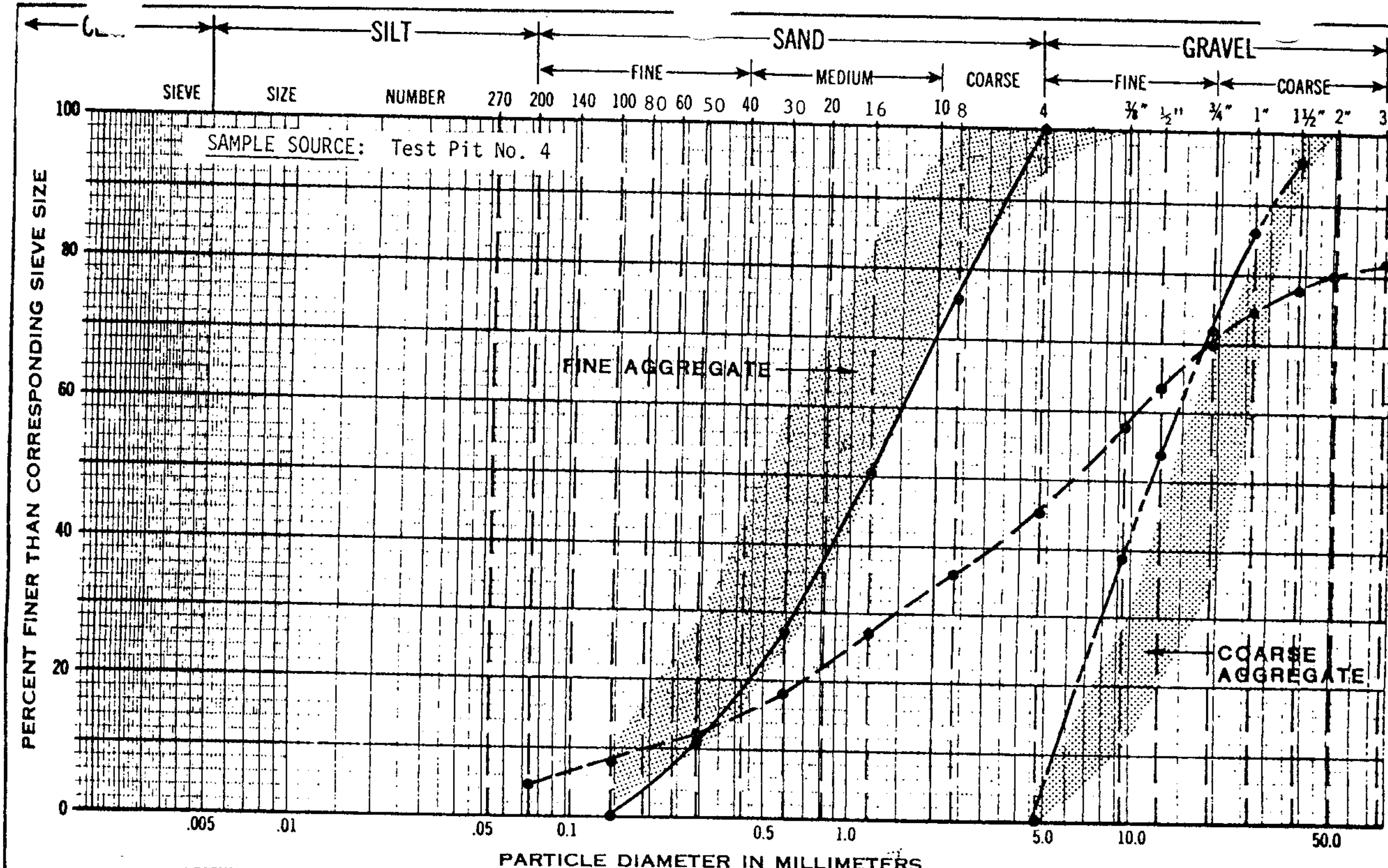
Drawing No. 11



LEGEND

- Specification limits (ASTM L-33)
- Gradation of combined coarse and fine aggregate
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GRAIN-SIZE DISTRIBUTION CHART

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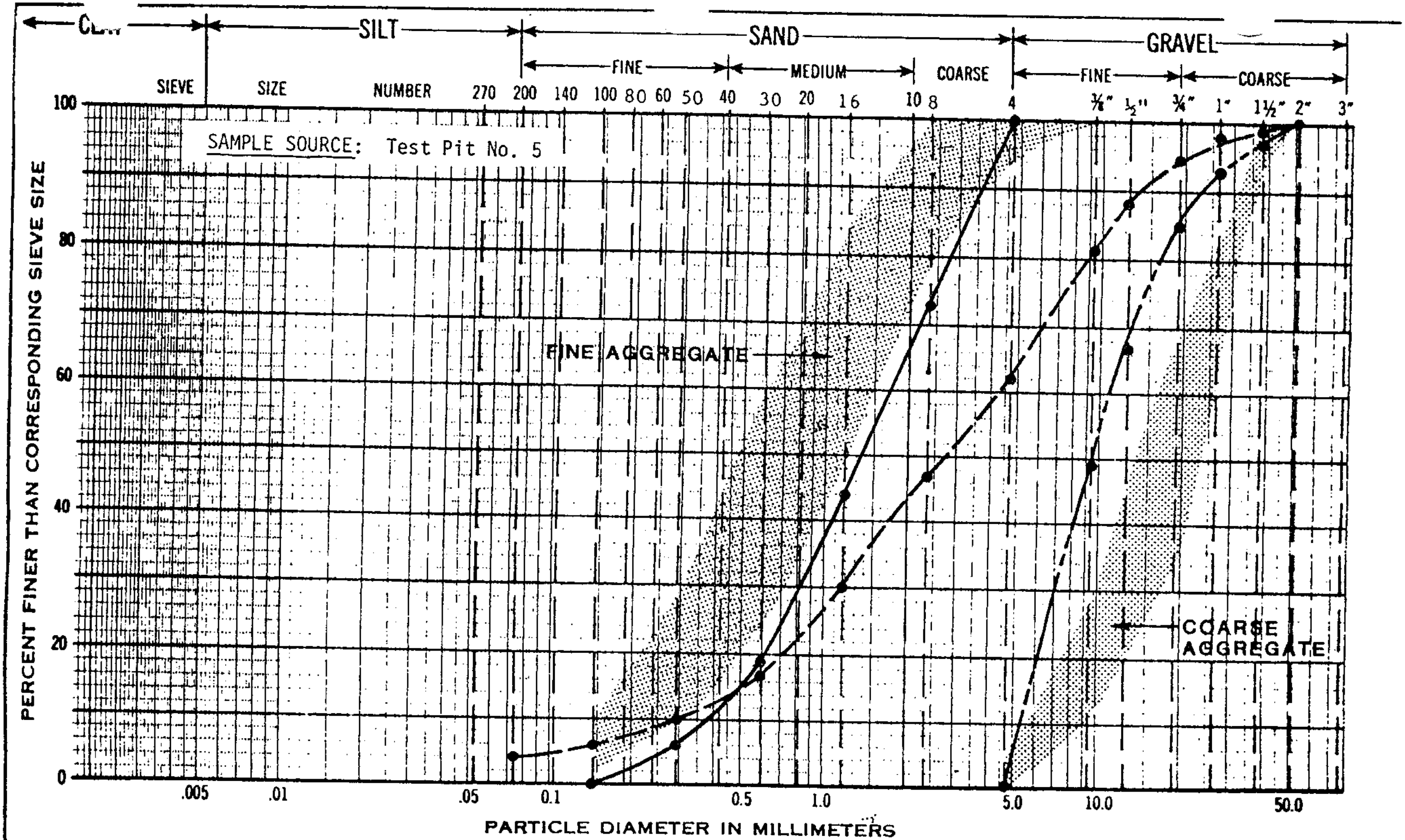
Drawing No. 12



LEGEND

- Specification limits (ASTM L-33)
- Gradation of combined coarse and fine aggregate
- Gradation of fine aggregate
- Gradation of coarse aggregate

GRAIN-SIZE DISTRIBUTION CHART

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Drawing No. 13

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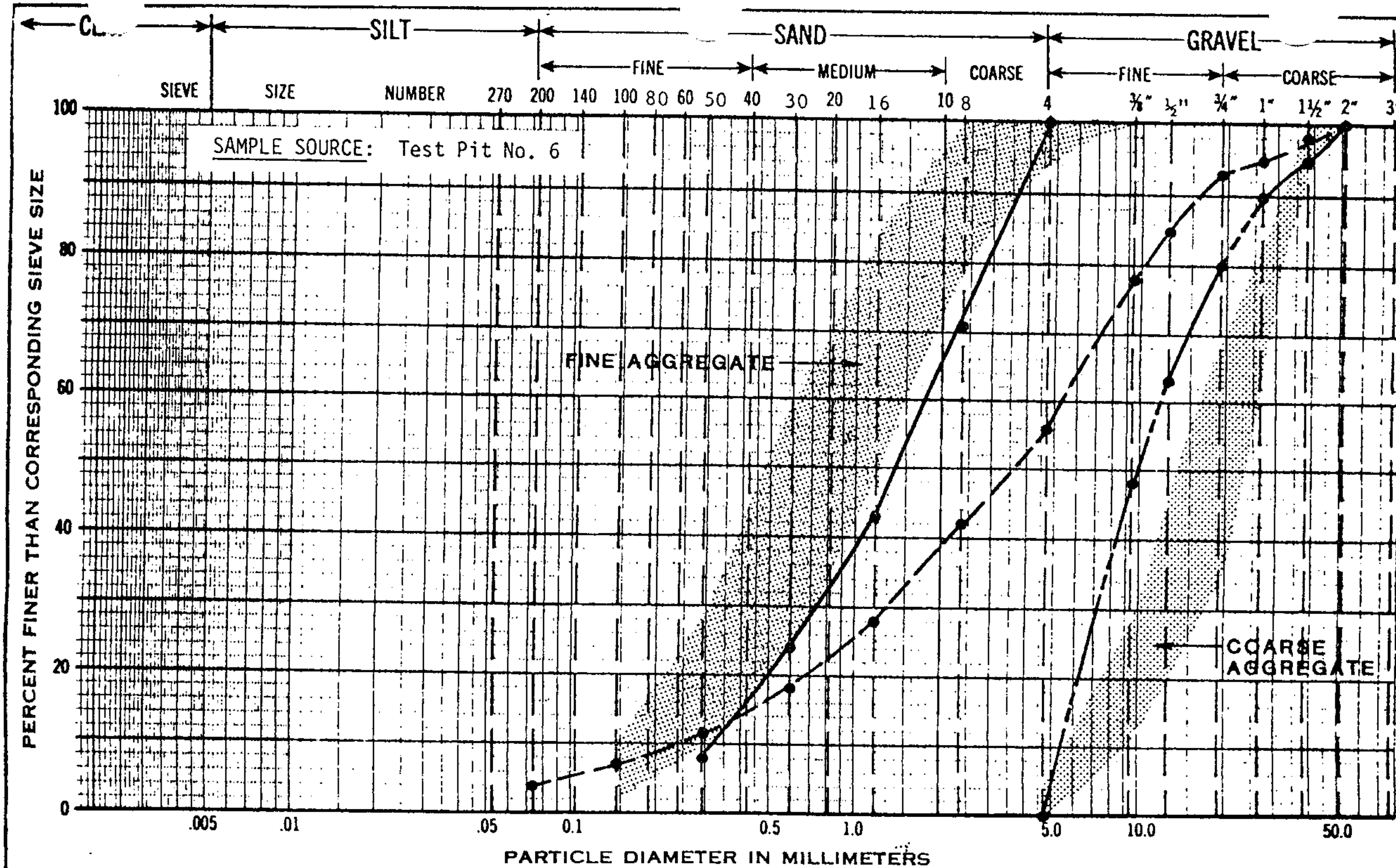

LEGEND

- Specification limits (ASTM L-33)
- — — — Gradation of combined coarse and fine aggregate
- ——— Gradation of fine aggregate
- —·—·— Gradation of coarse aggregate

GRAIN-SIZE DISTRIBUTION CHART

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Drawing No. 14

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