SUMMARY OF CHEN AND ASSOCIATES (1980) RECOMMENDATIONS

FOR DEVELOPMENT OF SITE OF SPRING CREEK ESTATES

Geologic Hazard Recommendations

1. Maintain a minimum setback of 50-feet from faults mapped by Chen and Associates (1980). This recommendation should be applied to all of the north-south trending faults. Recent field mapping by the U. S. Geological Survey (Nelson and Personius, in prep.) indicate that there are not any east-west trending faults in the areas where Chen and Associates (1980) mapped east-west trending faults. It is recommended that the developers not be required to maintain setbacks from these 3 east-west trending faults.

2. Foundation excavations, in the area mapped by Chen and Associates (1980) as a graben, must be inspected for faults by a qualified engineering geologist. If faults are found, Weber County Building Inspectors should not approve footing inspection.

3. Because the site is located near the Wasatch fault zone, the potential for severe ground shaking due to earthquakes is high. Construction should incorporate earthquake resistant design required for Uniform Building Code Seismic Zone 3, with inspection and monitoring by Weber County Building Inspectors as outlined for Utah Seismic Safety Advisory Council Seismic Zone U-4.

4. A hydrologic engineer should perform a study to determine the areas prone to flooding.

Site Grading Recommendations

1. Development on slopes greater than 40% should be avoided.

2. Cut and fills within the area should be kept to a minimum.

3. Permanent unretained cuts on slopes less than 40% should be no steeper than 1.5 horizontal to 1 vertical.

4. Temporary cuts up to 10 feet should be no steeper than 1:1 unless braced to provide a safe working area.

5. Unretained fill slopes up to 10 feet high should not exceed 2 horizontal to 1 vertical.

6. Cut and fill slopes in excess of 10-feet high should be analyzed by an engineer.

7. Prior to placement of fill, the ground surface should be prepared by removing all soft and organic material. All fill should be compacted in layers not exceeding 8 inches.

Foundation Recommendations

1. Foundation walls for structures constructed in the graben and/or near known faults, as mapped by Chen and Associates (1980), should be reinforced to span an unsupported length of at least 15 feet. All other foundation walls should be designed to span an unsupported length of at least 10 feet.

2. Perimeter drains will be required in areas of the site underlain by thinly interlayered silts and clays which can selectively transmit perched ground waters from normal runoff.

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PRELIMINARY ENGINEERING GEOLOGY
AND SUBSOIL INVESTIGATION
EASTWOOD REAL ESTATE CO.
MOUTH OF WEBER CANYON
WEBER COUNTY, UTAH

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CONCLUSIONS

(1) The major geologic hazard present at the site is the presence of geologically recent, Class I faulting. These areas will be extremely hazardous in the event of a major earthquake in the general site area. It is recommended that a setback policy of a minimum 50 feet be established for the Class I faults which are mapped on Plates I and II.

100' clearance for class I
50' for class II/III

(2) All building excavations within the graben and vicinity of Class II and III faults should be inspected to avoid construction over faults with appreciable offsets.

(3) Slope stability and erosion control will be a major consideration in site development. A relatively high proportion of the total land area have slopes over 40 percent and will require mitigating engineering consideration.

no building on slopes over 40%. prefer 25% or less.

(4) Seasonal perched waters occurring in selected areas of the site will contribute to slope instability unless properly controlled. Perimeter drains will be required in these areas.

(5) The site subsoils can readily be excavated with conventional construction equipment. Minor occurrences of very large boulders may require limited blasting.

(6) Spread footing type foundations placed on the natural soils or compacted fill can be used for the residential structures. Foundation wall reinforcements as discussed in the report should be observed.

(7) A hydrologic study, as discussed in the report, is recommended.

(8) Other recommendations, precautions and discussions are presented in the body of this report.

SCOPE

This report presents the results of a preliminary engineering geology and subsoil investigation of the Eastwood Real Estate property located in the Hambre Spring area. The property is situated to the north of the mouth of the Weber Canyon in Weber County, Utah, (Fig. 1). Environmental geologic conditions and possible hazards and constraints to residential development are discussed together with general site and subsoil conditions. Observation and recommendations are based on geologic mapping, test pit excavations, analysis of aerial photographs and a review of geological literature. The study includes areas beyond the site boundaries in order to obtain an analysis of the property. Data and recommendations presented are suitable for preliminary analysis and design.

PROPOSED CONSTRUCTION

We understand that residential development is considered for the site. It is assumed that construction will consist of one to two-story wood frame and brick veneer structures with and without basements, similar to that in the surrounding area. Lot sizes are estimated to be 1/2 acre. Location of the dwellings and access roads have not been determined. Property boundaries are shown on Plates I and II.

SITE DESCRIPTION

The property is comprised of roughly 145 contiguous acres located in the extreme southeast corner of Section 23 and portions of the SW-1/4, Section 24 and the NW-1/4, Section 25, T.5N., R.1W., Weber County, Utah. U.S. Highway 89 passes within 2000 feet west of the site. The Union Pacific Rail Road and Interstate 80 East, entering Weber Canyon, lie 1500 and 2000 feet south of the site, respectively. The east site margin is formed by the 5350 foot contour interval. The drainage of Spring Creek forms the east portion of the north boundary. Remainder of the property is outlined by surveyed ownership boundaries as shown on Plates I and II. The property abuts the Cache National Forest on the east, Utah Fish and Game Property on the south and privately owned land on the north and west.

From east to west, site topography begins with very steep west facing bedrock slopes which terminate abruptly at a nearly level lake terrace remnant at 5200 feet elevation. This feature is bounded on the west by very steep slopes which extend down to a moderately west sloping surface at approximate elevation 4850. This surface continues to the west, comprising the bulk of the remainder of the property. This feature is highly dissected with steep to very steep slopes bounding the active and relic drainages and its western margins. Maximum relief across the entire site is approximately 730 feet.

The site is undeveloped with access consisting of a series of interconnecting, unbladed vehicle trails. The southwest portion has been explored for commercial gravel course by a series of parallel trails trending across the southwest most slope of the site. The Weber

Aqueduct crosses the approximate center of the site in a north-south direction. The 48-inch reinforced concrete conduit supplies culinary irrigation water to Ogden and area communities. Depth of burial is roughly 5 feet with a 25-foot right-of-way through the property. Design capacity is 80 cfs with the volume dropping to 10 cfs seasonally. Constructed in 1956, the conduit has no diversion control; however cutoff controls are located at a portal within the mouth of Weber Canyon.

Spring Creek is the main drainage of the immediate area and contains two perennial streams which run parallel through the lower extent of the drainage. Spring Creek is derived directly from Spring Canyon within the mountain front. The second stream (canal) originates from artificial diversion of a portion of Spring Creek in the canyon and produces water to a reservoir located north of the site. The reservoir drains into a tributary to Spring Creek and then into Spring Creek. At this point, Spring Creek occupies a broad shallow drainage.

Hambre Spring is located in the southwest portion of the site. The spring, shown on Plate I, is perennial and originates from a series of closely spaced seeps within an approximate one acre area.

Occasional small seeps and moist areas occur locally throughout the general site during high runoff periods. These are confined primarily to the base of the bedrock slopes and west facing, open slopes.

Climate is temperate with approximately 20 inches of annual precipitation.

Vegetation consists of Grambel Oak, Maple, abundant low shrubs and grasses and occasional open grass areas. Juniper are found at higher elevations within the site.

REGIONAL GEOLOGY

The site is located within the foothills of the Wasatch Front, just north of the mouth of Weber Canyon as it enters the basin of the Great Salt Lake. Two regional geologic features are predominant in the area; the Wasatch Mountain Front to the east of the site and deltaic lacustrine deposits and erosional features associated with Pleistocene Lake Bonneville which occur within the site.

The Wasatch Front, an extensive escarpment forming the westernmost slope of the Wasatch Mountain Range comprises the east boundary of the site. Repeated, near vertical displacements along the Wasatch fault zone, approximately parallel to the base of the Front, have created the escarpment over the past several million years. The fault zone is a persistent geologic and topographic feature, extending for nearly 200 miles, from southern Idaho to southern Utah. Geologically recent movements along the fault zone are evidenced by offsets in Lake Bonneville sediments throughout much of its extent.

Bedrock exposed locally in the escarpment consists of coarse grained gneiss and schist of the Pre-Cambrian Farmington Canyon Complex. These rocks are dated at approximately 3.5 billion years. The bedrock in the escarpment is generally mantled with a thin surficial layer of residual soil. At lower elevation within the site, bedrock outcrops generally consist of a surface rubble of fragmental rock with very minor soil cover due to erosional activity of Lake Bonneville.

Pleistocene Lake Bonneville, extending back over 30,000 years, formerly occupied the basin of the Great Salt Lake leaving the present lake as its remnant. Site foothill topography is developed by erosional activity of the ancient lake and by deltaic sedimentation as drainages from Weber Canyon and closely spaced mountain streams entered the former high lake levels. These deltaic deposits extend to the north, joining with the Ogden River delta thus forming an extensive complex of similar settings. Relic shorelines of the lake are visible up to a maximum elevation of 5200 feet. At this level, a prominant laterally extensive terrace has been developed by wave cutting. The surface is generally mantled with a layer of relic beach cobbles and pebbles and is underlain by an extensive gravelly sand deposit. A lower terrace, the most recent of the two levels discussed in this report, represents the Provo standstill of the ancient lake, and is indicated at approximate elevation 4800 feet. At this level, lake activities were mainly erosional, having an overall leveling effect on pre-existing deposits. This surface has been considerably dissected and cut by faulting associated with the Wasatch fault zone and modified by varying stages of slope erosion. Deposits consist of predominantly sands and sandy gravels. A third major standstill, the oldest of the lake, is represented by depositional features consisting of deposits of the Alpine Formation. These deposits are primarily the slabby thinly interlayered silts and clays which occur at the central and lower elevations of the site.

The various fluctuations of Lake Bonneville that have created the above features are coincident with the more extensive glaciation in the surrounding highlands of the region. These climatic fluctuations determine the intensity of slope degrading and other erosional processes which shape the landforms. Ancient debris flows, heterogeneous mixtures of clay, silt to huge boulders, are extensive throughout much of the lower site elevations. These are closely associated with the more lengthy interglacial periods of Lake Bonneville. Leveling activity of the Provo standstill is evident in a large portion of the debris surface which extends from elevation 5050 to 4800. The main debris flow deposit is overlain by Alpine lake deposits. Other debris flows, deposited during a lake lowering within the Alpine period, are indicated on the site and mapped as Df.

Traces of a minor lake standstill are also evident as wave cut notches in bedrock at elevation 5025 feet at the south portion of the site.

Extensive gravelly sands occur at the western margin of the site and are interpreted as spit deposits deposited by lake longshore currents and were successively accumulated during various lake levels. The large included boulders were derived from overlying and interlayered debris flows.

Other surficial deposits are alluvium, colluvium, and debris cones emerging from several of the small canyons at the upper site margins. Occasional, very limited rock slides are found on the upper bedrock slopes.

REGIONAL SEISMICITY

The site lies within Seismic Zone III, Uniform Building Code Classification, 1979. This zone extends to the north and south to include the major metropolitan centers of the state. Probablistic studies of the regions earthquake history and resultant ground response assign a 90 percent probability that acceleration in bedrock will not exceed 21 percent of gravity within a given 50-year period for the general area, (Algermisson and Perkins, 1976).

The maximum regional historical earthquake was of magnitude 6.6, occurring in 1939 and centered near Hansel Valley in northern Utah. This area also experienced a magnitude 6.0 event in 1906. Other major events occurred in Bear Lake Valley in 1894, of magnitude 6.0, near Salt Lake City in 1914, of magnitude 5.5, near Eureka, Utah in 1900 of magnitude 5.5, and near Ogden, Utah in 1910 of magnitude 5.5. Sole evidence of surface faulting was at the 1939 Hansel Valley event with vertical displacement of 1.5± feet (Arabaz, 1980).

Research studies eight miles south of the site, near Kaysville, Utah, (Swan and others, 1979) indicate in that area at least three surface faulting episodes have occurred on the Wasatch fault within the last 1580 ± 150 years. Earthquake events of an estimated magnitude 7.0 or larger are assigned for the resulting displacements of between 7 to 11 feet. Accompanying the displacements are evidence of eastward ground tilting ranging from 0.5° to 10° on the west side of the faults. Recurrence interval in this area is estimated to be between 500 to 1000 years for a magnitude of 7.0 or larger event.

Estimates based on the 133 year historical record place a recurrence interval of up to 430 years for magnitude 7.5 earthquake. This size event would cause considerable damage and destruction throughout an appreciable area. Another probability treatment (Cluff, 1980) based on the geologic and historical evidence combined with modeling behavior of strain accumulation and release, indicate a high probability of a major earthquake somewhere along the nearly 200 mile long Wasatch fault zone in the next 50 years.

SITE GEOLOGY

Site geology was determined by mapping, trenching and by analysis of aerial photographs. The accompanying Geologic Map, Plate I, and Potential Hazards Map, Plate II, were prepared on the basis of these surveys.

Bedrock: Bedrock of the metamorphic Farmington Canyon, Map Symbol pef, underlies the very steep, easternmost slopes of the site. Occasional outcrops project through the thin surficial soil mantle at these higher elevations. Intermittent outcrops, occurring at the central and lower elevations in the southern portion of the site are generally blocky, highly fragmented rubble of rock. The Farmington Canyon complex consists of strongly folliated, coarse grained gneisses and schists. Bedding attitudes generally strike east-west with a near vertical dip. Prominant jointing is developed parallel to the bedding and nearly normal to it with resultant weathering into quite small rock fragments.

Several rock slide areas are developed in the uppermost slopes but are very local in extent. They consist of small frost rivened blocks below the occasional outcrops. The slides do not extend down to the break in slope at the 5200 foot terrace level.

could affect upper-most

Overburden: Debris cones, Map Symbol Qdc, consisting of mixtures of unsegregated clay to boulder size material, are found at the mouths of the entrant canyons at approximate elevation 5200 feet. These are geologically recent in age and local in extent. A well developed cover indicates their lengthy inactivity.

Colluvium, Map Symbol Qcl, is found locally throughout the site. The material is mainly derived from slope wash and consists of a mixture of silt, gravel, cobbles and occasional boulders.

Lake Bonneville deposits, Map Symbol Qbg, are evident throughout the site. Wave cutting activity at elevation 5200 feet has resulted in benches cut into the bedrock with subsequent deposits of extensive gravelly sands which are capped with a four to six foot thick layer of beach gravels. A second lengthy standstill of the lake level is evident at elevation 4800. Lake activity at this level has been predominantly erosional with an overall leveling effect. Gravelly sands with occasional large boulders occur at the lowest elevations of the site. These are assumed to originate from longshore currents within Lake Bonneville, reworking and redepositing pre-existing sediments and accumulating over various lake stages.

Thinly interlayered silts and clays occur throughout the middle and lower site elevations. The more firmly indurated represent deposits of the oldest or Alpine level of Lake Bonneville. Area dip of these thinly interlayered silts and clays is slightly to the west. Silt deposits from other lake stages occur as dropping mantles over bedrock at the south portion of the site. These are also thinly layered but are more sandy and much less indurated than the Alpine Silts. Map Symbol of the silts is Qba.

* | An extensive debris flow, Map Symbol Qdf is found at elevations from 5175 to 4725. The deposit consists of a heterogeneous mixture

of silt to angular rocks and boulder size material. The deposit is overlain by Alpine lake level silts.

Alluvium, Map Symbol Qal, occurs in the more well developed drainage within the site and consists of silty to sandy gravels and boulders derived from the surrounding debris flows and lake deposits.

Faulting: Surface faulting is evident in much of the site area as shown on Plates I and II. A graben, which consists of a down dropped block of earth bounded by faults, extends southernly through the approximate center of the site. The feature also extends to the north where it contains a small manmade reservoir. Other displacements occur throughout the site and are mainly evident in the debris flow material, Map Symbol Qdf, and in the Alpine lake level silts, Qba. A moderate displacement was noted at the 5200 elevation outside the immediate site. No displacements were noted at this level within the site.

The faulting, as mapped on Plates I and II, has been categorized as Class I, II and III faults.

Class I faults are obvious faults with a distinct, linear topographic expression with accompanying vertical displacement. These have been verified by trenching where accessible. Trench locations are shown on Plates I and II.

Class II faults are probable faults with definite linear trends and minor vertical relief. These faults are either ground adjustments secondary to Class I faulting or faults branching from Class I faults.

Class III faults are considered possible faults with little or no vertical relief but with lineation on aerial photos indicated.

Class I faulting is considered a major weakness surface where displacements will most likely occur in the event of a major seismic event in the immediate area. Class II and Class III faults are considered decreasingly subsidiary, respectively, to Class I faults and generally represent random adjustments in the unconsolidated material due to strong ground shaking and vertical displacements which produced the Class I features.

SUBSOIL CONDITIONS

Subsoil conditions at the site were examined by excavation of trenches and test pits by backhoe. Four trenches up to 50 feet long were excavated to verify or determine surface indicated faulting. Four test pits were dug to determine general soil conditions. Pit locations are shown on Plates I and II. Logs of the pits and trenches are shown on Fig. 2. Samples were taken from all pits excavated.

Subsoils consist of two main groups:

I. Debris flow and debris cone deposits (Map Symbol Qdf and Qdc); these consist of a 1.0 to 1.5-foot layer of silty sand overlying a heterogeneous deposit of material ranging from clay size particles to large, angular boulders. Minor horizontal lineations are infrequently indicated by the smaller pebbles. Random, small lenses of sand and silt are occasionally included.

II. Lake Bonneville deposits - These are subdivided into three subgroups:

   A. Terrace deposits at the 5200 elevation. These consist of a 1 to 1.5-foot layer of silty sand overlying gravelly, cobbly sands. Cobbles are well rounded and lenticular from beach activity. At 4-foot depth, these are generally underlain by fine to coarse, clean sands that extend to 6 feet, the maximum depth excavated. Slope exposures indicate the sand is of 50 to 80 feet in vertical extent.

B. Middle elevations (4800 to 5000 feet). These deposits consist of a 1.0 to 1.5-foot thick silty clay overlying essentially horizontal, thinly interlayered clays, silts and fine sands. The material is slightly moist to moist, with locally varying degrees of induration approaching a near bedrock firmness with depth.

C. Lower elevations (4650 to 4800 feet). These deposits consist of 0 to 1 foot of silt and silty sand overlying predominantly clean, gravelly sands with included large boulders. Occurrence of this material is restricted to the west limits of the site.

Subsurface evidence of faulting was encountered in Test Pits 2, 3 and 4. Test Pit 3 encountered a partially developed buried topsoil horizon at depth 5 feet. This horizon was underlain by material similar to the overlying material down to depth 10 feet, maximum depth excavated.

Ground water was not encountered in the test pits. The thinly interlayered fine-grained material encountered in Test Pit 5 does, however, show occasional thin zones of saturation indicating selective permeability.

LABORATORY TESTING

Undisturbed samples and bulk samples of minus 6-inch material were taken at varying depths in the test pits to obtain specimens for laboratory testing. The samples were tested in accordance with ASTM standards to determine their general engineering characteristics.

Test results of the thinly interlayered clays and silts show low to moderate compressibility with negligible swell upon loading and wetting. The material is of moderate plasticity. Test results are shown on Figs. 6 and 7.

Test results of the lake terrace material at elevation 5200 feet show a clean, poorly graded gravel. Test results are shown in Fig. 5.

Test results of the debris flow material comprising the bulk of the intermediate and lower site elevations indicates a moderately graded gravelly sand to sandy gravel, occasionally silty to clayey. Test results are shown in Figs. 3 to 5.

GEOLOGIC CONDITIONS AFFECTING THE PROPOSED DEVELOPMENT

Several geologic conditions exist at the site which will require recognition in planning and design and use of mitigating engineering practices.

Earthquake Effects: Geologically recent traces of the Wasatch fault zone cross the central portions of the site. There is a likelihood of a moderate to large magnitude earthquake at some time in the future. Accompanying displacements will most likely be along prominant existing fault lines (Class I). Estimates placing a probability of recurrence range from a minimum 50 years to 430 years. Estimates are based on the 133-year historical record, a combination of the historical and geological record and recent stress-strain modelings (Cluff, 1980). The estimates apply to the entire Wasatch fault zone.

We recommend a setback of a minimum 50 feet be established for the site in corridors mapped as Class I faults shown on Plate II. Permanent structures should not be constructed within the setback areas. This will serve to reduce immediate hazard loss due to vertical displacements, secondary ground fracturing and back tilting which will probably accompany a major seismic event. Back tilting is generally confined to the down dropped portions of fault blocks. Highrise structures are therefore not recommended below elevation 5000 feet due to the possibility of ground tilting accompanying faulting.

All underground utilities which must cross setback corridors should cross at right angles to reduce the rupture zone in the event of displacements. For critical utilities, crossings should be constructed with flexible joints, provided with easy access for repair and provisions made for prompt or automatic cutoff in the event of rupture.

Class II and III fault occurrence represents generally random ground adjustments due to earthquake activity. Within the graben and in the vicinity of the Class II and III faults, excavations for structures should be carefully inspected for presences of faults. If faults with appreciable offsets are observed, the structure should be relocated so the fault does not intercept the structure.

Effects on Existing Man Made Features:

Weber Aqueduct: The aqueduct is buried in a portion of the alignment coinciding with a Class I fault. The conduit may rupture in the event of a major seismic event. Rupture may release large volumes of water which will create a hazard by flooding and rapid erosion to property downslope from it.

Transmission Lines: High voltage overhead transmission lines traverse the site. Ground movements due to a major seismic event may cause loss of support resulting in line failure.

Earth Dam: A small earth dam and reservoir is located in a fault controlled feature just northwest of the property. During a major seismic event, the dam and its predominant features may sustain damage and cause release of water.

Slope Stability: Natural slopes at the site appear to be stable and show limited signs of past instability. An exception are the slopes developed on the thinly interlayered silts and clays. These can become unstable if high amounts of seasonal perched waters occur or unmanaged artificial watering of areas upslope is not controlled.

The inherent stability of the majority of the slopes could be affected by oversteepening caused by construction activities. Slopes in excess of 60 percent should be avoided in cuts and fills where possible. Cut and fill slopes in excess of 10 feet high should be analyzed by an engineer.

Erosion: The area is well drained with no appreciable erosion problems in areas with natural, undisturbed ground cover. The generally dense protective ground cover is of prime importance in protecting the surface from erosional destruction. Excessive channel erosion has occurred on the site where ground cover has been altered or destroyed. Construction planning will be required to avoid lengthy exposures of unprotected cut slopes and construction trails in those subsoils which contain appreciable amounts of fine grained material. It is recommended that minimum alterations be made in the natural ground cover and that discharge control surface waters is implemented.

Flooding: Flooding will probably not be a hazard at the site. Small debris cones exist at the mouths of several of the adjacent entrant canyons and extend onto the east property margins. These are due to large precipitation runoff from their drainage areas. The cones have a well developed soil cover indicating an appreciable geologic interval since the last occurrence. There is no evidence of flooding by Spring Creek or the adjacent canyons bordering the east site boundary. A hydrologic study is beyond the scope of this report. We recommend a hydrologic engineer perform a study to determine the areas prone to flooding. Flood flows from the breach of the earth embankment northwest of the site should be considered in this study.

Seeps, Perched Waters, Springs: Seeps and perched waters will occur in the thinly interlayered silts and clays which exist at the site. These can be dealt with by conventional engineering procedures. A perrenial spring, Hambre Spring, is located near the approximate center of the site. Due to the nature of its occurrence, construction activities within the immediate source area should be carefully monitored to avoid displacing the established seep pattern.

Rockfall: Rockfall is not considered a hazard. The bedrock slopes are well mantled with colluvium and surficial soils. Occasional outcrops are highly fractured and broken with nearly vertical major planes of weakness which trend approximately perpendicular to the predominant slope direction.

SITE DEVELOPMENT RECOMMENDATION

Development of the site will require careful planning, design, engineering and construction procedures with respect to the natural features. These include recognition of the fault lines and erosion potential and stability of the steep slopes, shown on Plate II. Minimal disturbance to existing ground conditions should be a prime consideration.

Site Grading: When construction is necessary on the steeper slopes, careful evaluation of its effects upon slope stability should be made. We suggest development on slopes greater than 40 percent be avoided. For preliminary planning, we recommend that the following criteria be utilized in preparing grading plans:

(1) Generally, we recommend cuts and fills within the area be kept to a minimum. This approach will reduce slope instability, drainage and revegetation problems and will tend to preserve the natural regime of the area.

(2) Permanent unretained cuts in the surficial deposits on slopes less than 40 percent should be no steeper than 1.5:1 (horizontal to vertical). Cuts in excess of 10 feet should be studied on an individual basis by an engineer.

(3) Temporary cuts up to 10 feet deep in the surficial deposits should be no steeper than 1:1 unless braced to provide a safe working area. If seepage is encountered in permanent or temporary cuts, the likelihood of slope failure is increased. If this condition is encountered during construction, we recommend that careful stability evaluation be made of the excavations.

(4) It is anticipated that most all excavations in the surficial deposits can be made with standard excavating equipment. Some

occasional large boulders may be encountered. These may require enlarging the excavation or blasting. Such boulders may be particularly troublesome in confined excavations such as utility trenches. Any blasting should be carefully controlled and consist of small charges.

(5) The minus 6-inch on-site surficial deposits are suitable for general, structural and road fill. Prior to fill placement, the ground surface should be prepared by removing all soft and organic material. In areas where fill is placed on side hills, the fill should be tied into the hill by benches. No brush, sod, frozen material, or other perishable or undesirable material should be placed in the fill. All fill should be compacted in layers not exceeding 8 inches. Fill supporting streets and concrete slabs should be compacted to 95% standard Proctor density (ASTM D-698) and fills which will support footings for permanent structures should be compacted to 100% standard Proctor density near optimum moisture content.

(6) Unretained fill slopes up to 10 feet high should not exceed 2:1 (horizontal to vertical). Slopes greater than 10 feet should be investigated by a geotechnical engineer.

(7) All fill placement should be observed and frequently tested by a geotechnical engineer familiar with the subsoil conditions at the site.

Site Drainage: The surficial soils in cut and fill sections will be susceptible to erosion, particularly when slopes exceed 10 percent and if vegetation cover is appreciably disturbed. Accordingly, the drainage plan must be carefully evaluated and designed so surface water flow is adequately controlled to reduce erosion. For preliminary planning, we recommend the following design and construction factors be considered in preparing a drainage and erosion control plan:

(1) Revegetation of permanent cut and fill surfaces as soon as possible with fast-growing shrubbery or grass, preferably of the local on-site varieties.

(2) A fabric could be considered for a faster method of earth containment and erosion control, particularly during construction when slopes may be left unprotected for lengthy periods of time. The fabric holds soil in place and will hold seed and provide a stable vegetative cover for permanent protection.

(3) Roadside drainage ditches should be lined with an asphalt mat or short vegetation such as grass.

(4) A crown interceptor ditch for cuts may be necessary to prevent water flowing over cut surfaces.

(5) Fills should not block natural drainages.

STRUCTURAL CONSIDERATIONS

Foundation: The shallow overburden soils at the site are suitable to support the anticipated light loads. Maximum soil pressures on the order of 1,000 to 3,500 psf should be suitable depending on soil type encountered. Footings placed on granular compacted soil should support loads on the order of 2,500 to 3,500 psf. Foundation walls for structures constructed in the graben, shown on Plates I and II, and near known faults should be reinforced to span an unsupported length of at least fifteen feet. All other foundation walls should be designed to span an unsupported length of at least ten feet.

Seismic: The Uniform Building Code designates the Ogden and Salt Lake areas as Seismic Zone III, and the buildings should be designed to resist earthquake ground motions. Earthquake ground motion and probability studies (Algermissen and Perkins, 1976) indicate there is a 90 percent probability that bedrock accelerations in a given 50-year period will not exceed 21 percent gravity. This factor should be used as a basis for design against earthquake affects.

Floor Slabs: The natural granular soils at the site are suitable for floor slab support. Compacted granular soil is also suitable for slab support.

Underdrains: Perimeter drains will be required in areas of the site underlain by the thinly interlayered silts and clays which can selectively transmit perched ground waters from normal runoff. The drains should consist of a drain tile or perforated plastic pipe installed in a gravel-filled trench around the perimeter of the building at least 2 feet below the lower floor slab leading to a sump where water can be removed by pumping or gravity flow.

MISCELLANEOUS

This report has been prepared in accordance with generally accepted geotechnical engineering practices in this area for use by the client for preliminary planning and conceptual purposes. The conclusions and recommendations submitted in this report are based upon field reconnaissance, data obtained from other relevant reports, aerial photos, exploratory test pits excavated at the site and laboratory test results. Difference in soils or geology may be encountered during construction. We recommend additional studies to provide site specific recommendations. Because of the proximity of certain hazards to the area of proposed development, actual location of sites in the field and continued involvement by the geotechnical consultants are recommended during pre-design and construction stages. All cut and fill placement should be observed and tested by a geotechnical engineer familiar with the site subsoil conditions.

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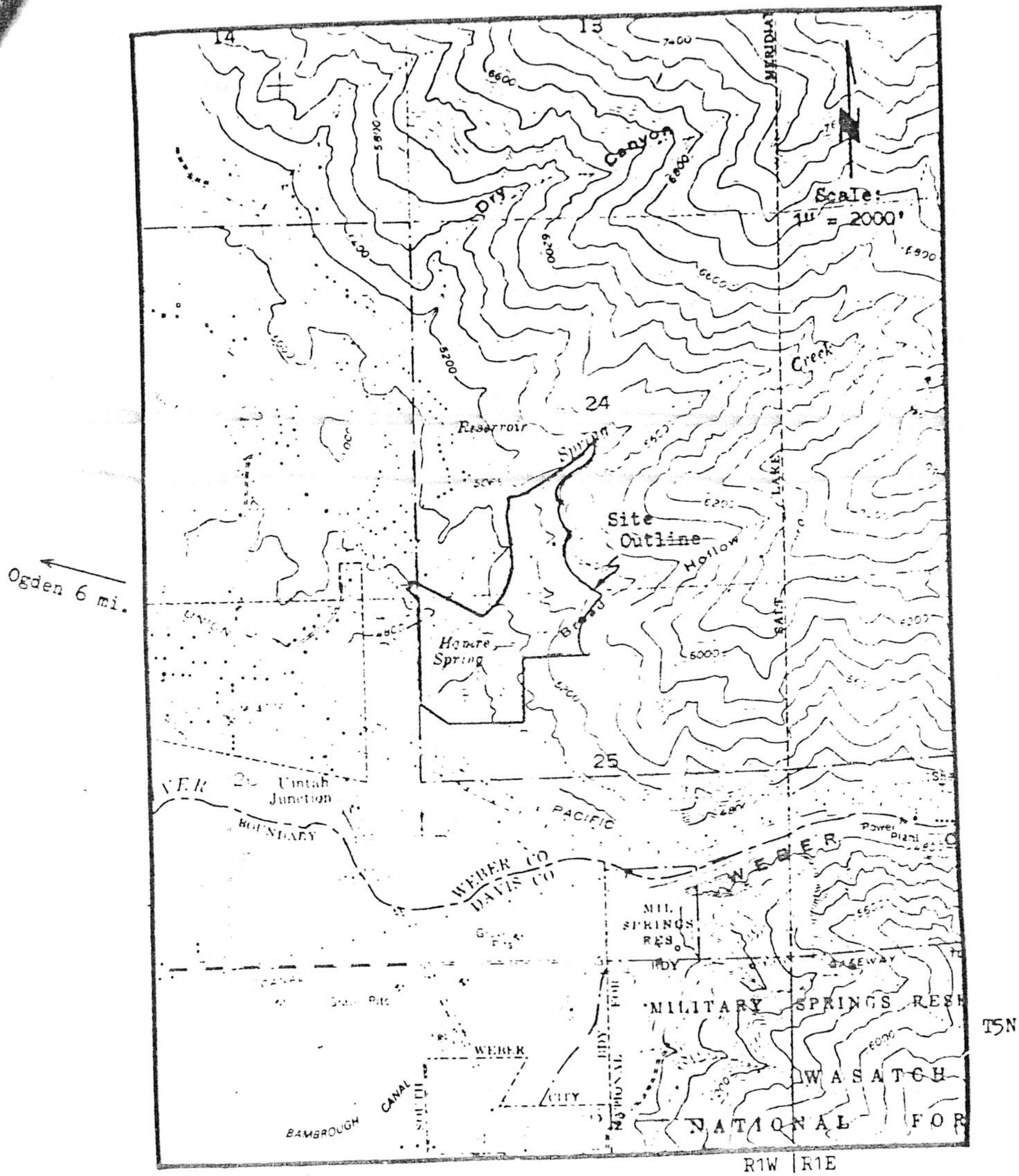
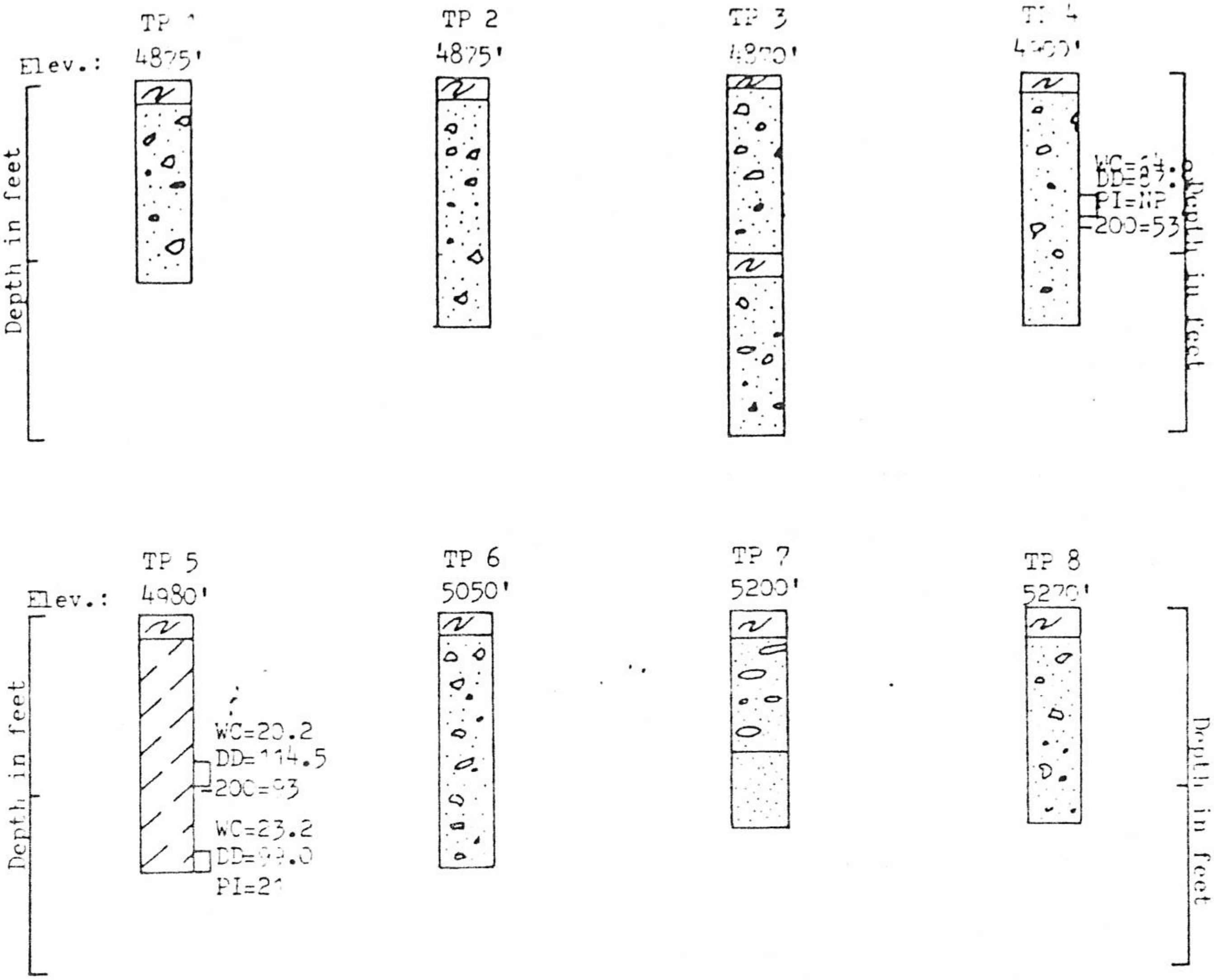


VICINITY MAP
Eastwood Real Estate Company
Weber County, Utah

Figure 1



LEGEND

- Topsoil, silty sand w/angular and rounded pebbles. Loose, dry, gray.
- Gravel, sandy to sand, gravelly (GP, GM, SP) W/ang. cobbles, boulders. Med. dense-dense, sltly moist, brown.
- Gravel (GP), well rounded cobbles common, dense-v. dense, dry, brown.
- Sand (SW) medium dense, moist, brown to rust to gray.
- Clay (CL) thinly interlayered with silt, stiff-hard with depth, medium moist, tan to light salmon.

NOTES

(1) Test pits excaveted July 22, 23, 1980 using standard backhoe

(2) Elevations approximate, based on topo. map by Great Basin Egr.

(3) Free water or appreciable subsurface moisture was not encountered in the excavations.

(4) Location of Test Pits shown on Plates I and II.

WC = water content (%).
DD = dry density (pcf).
PI = plasticity index (%).
-200 = amount passing #200 sieve (%).

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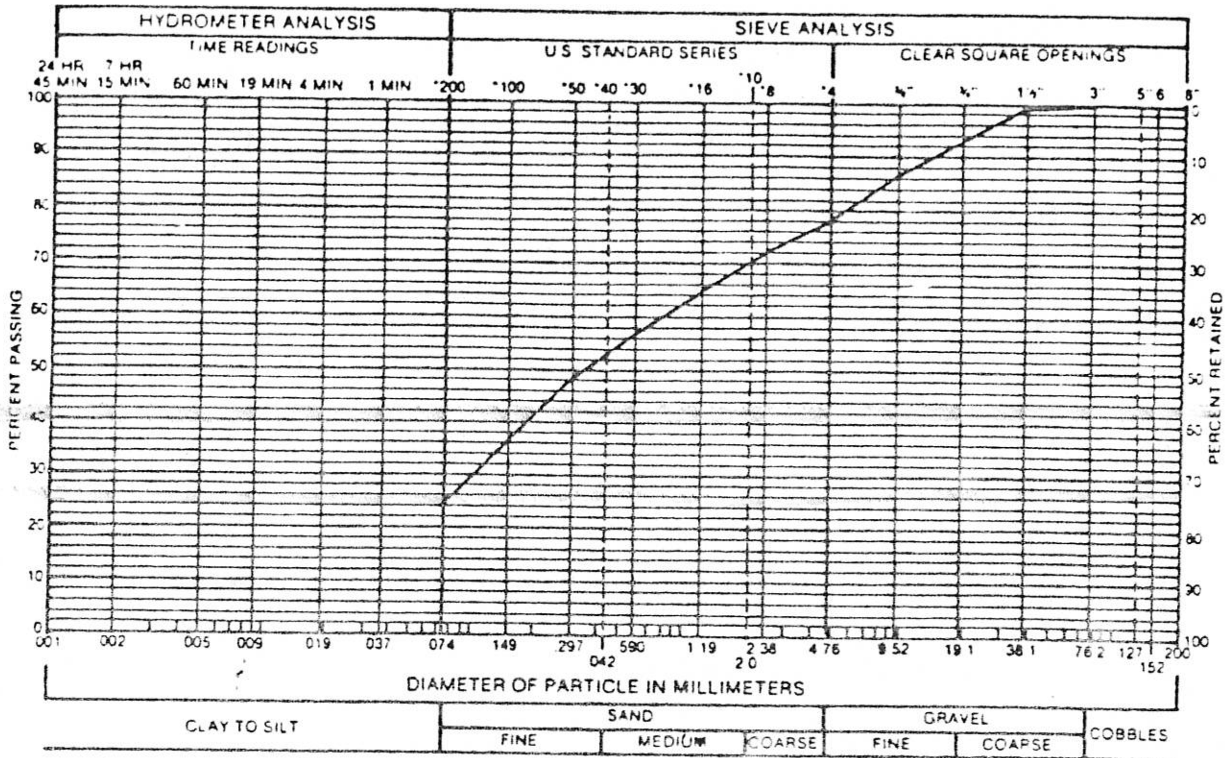
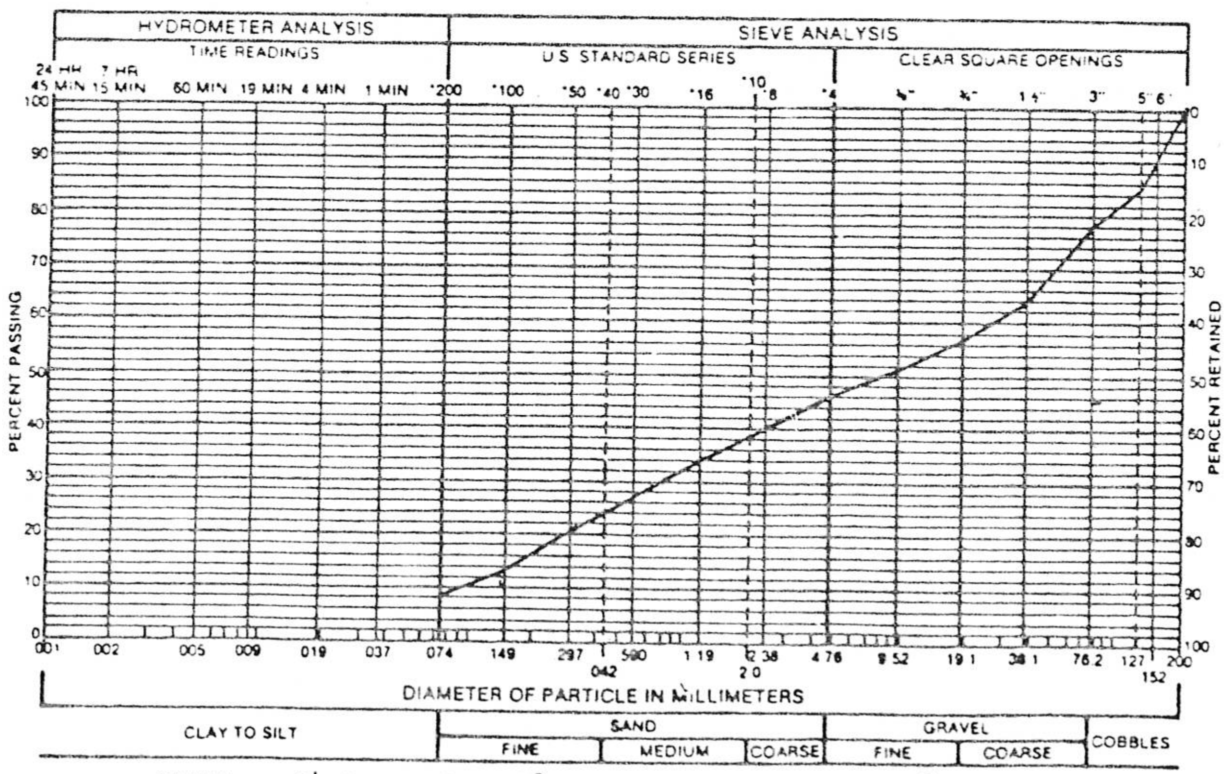


GRAVEL 22 % SAND 54 % SILT AND CLAY 24 %

LIQUID LIMIT % PLASTICITY INDEX NP %

SAMPLE OF Gravelly, Silty Sand FROM TP 1 @ 4.0'

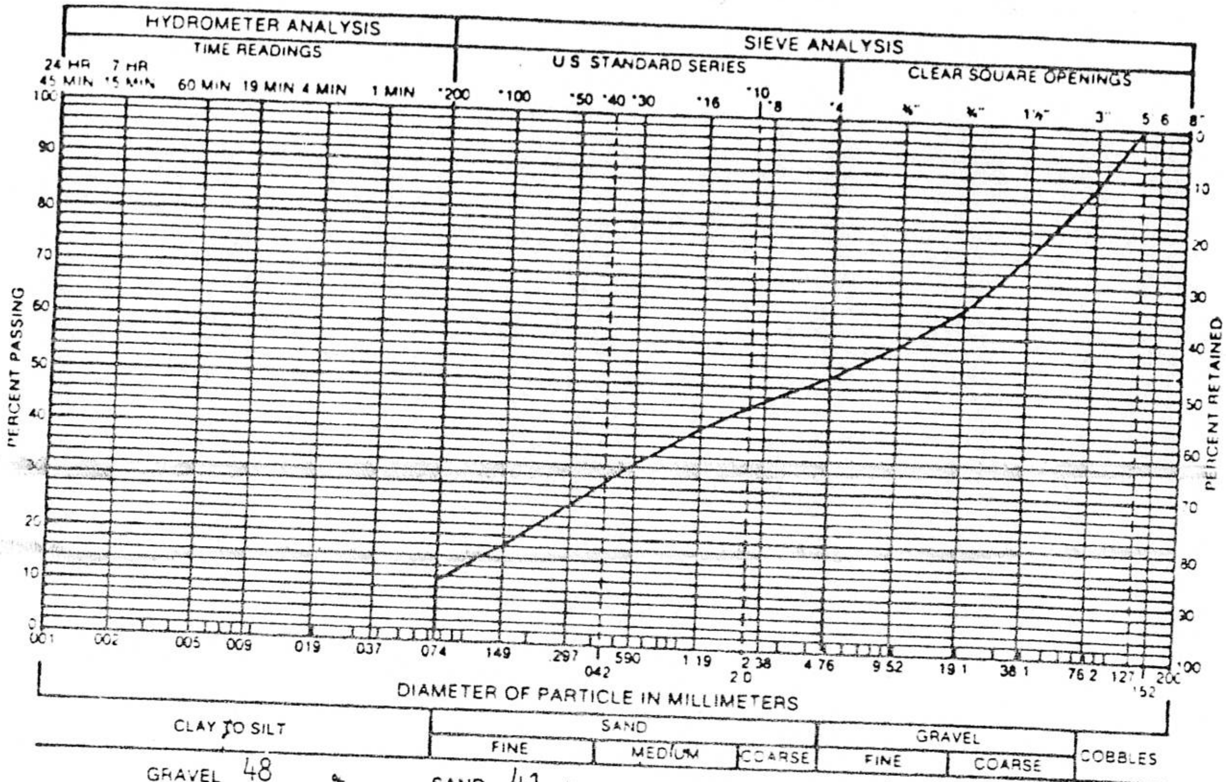


GRAVEL 54 % SAND 38 % SILT AND CLAY 8 %

LIQUID LIMIT % PLASTICITY INDEX NP %

SAMPLE OF Sandy Gravel FROM TP 2 @ 1-7'

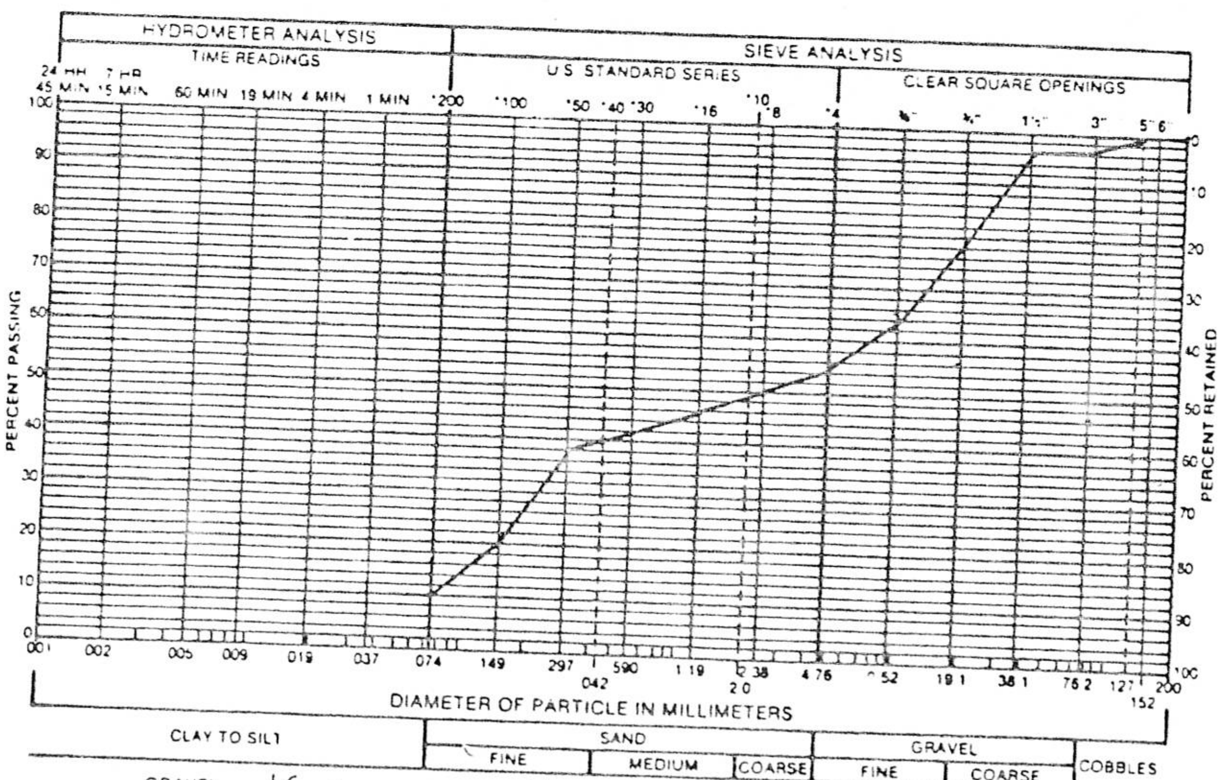
chen and associates, inc.



GRAVEL 48 % SAND 41 % SILT AND CLAY 11 %

LIQUID LIMIT % PLASTICITY INDEX NP %

SAMPLE OF Silty, Sandy Gravel FROM TP 3 @ 1-10'

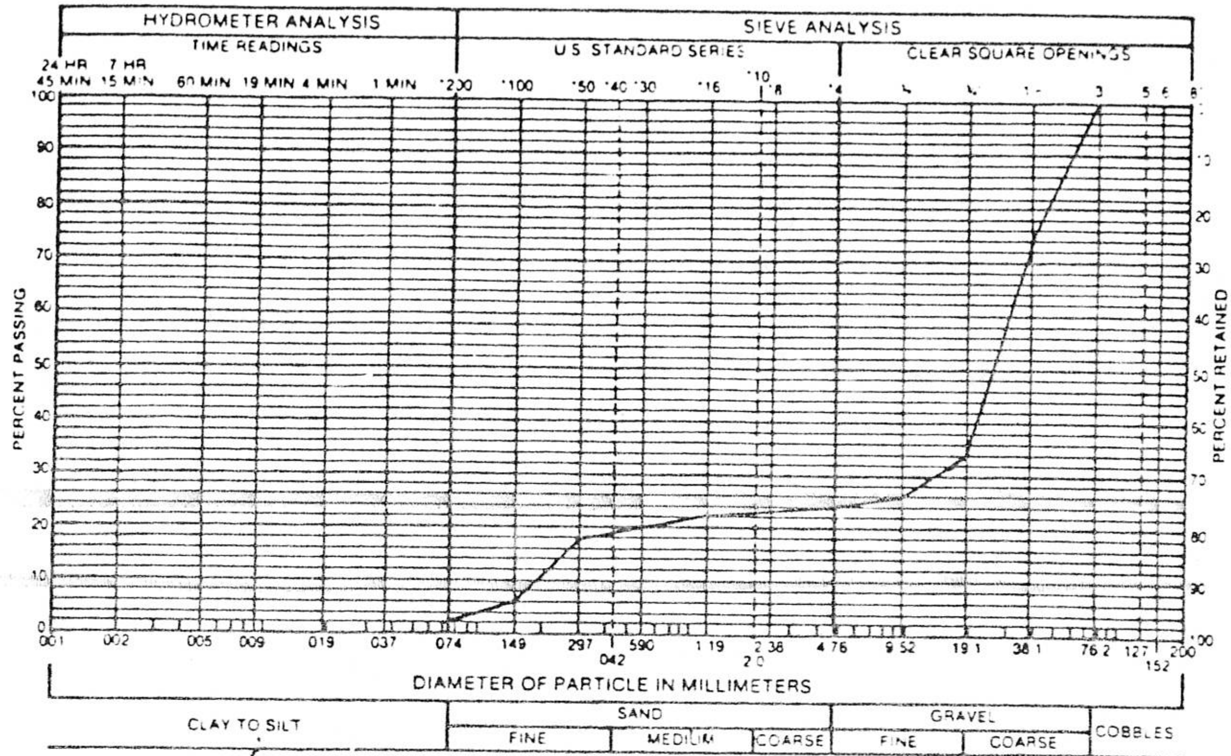


GRAVEL 46 % SAND 44 % SILT AND CLAY 10 %

LIQUID LIMIT % PLASTICITY INDEX NP %

SAMPLE OF Sandy Gravel FROM TP 6 @ 3-5'

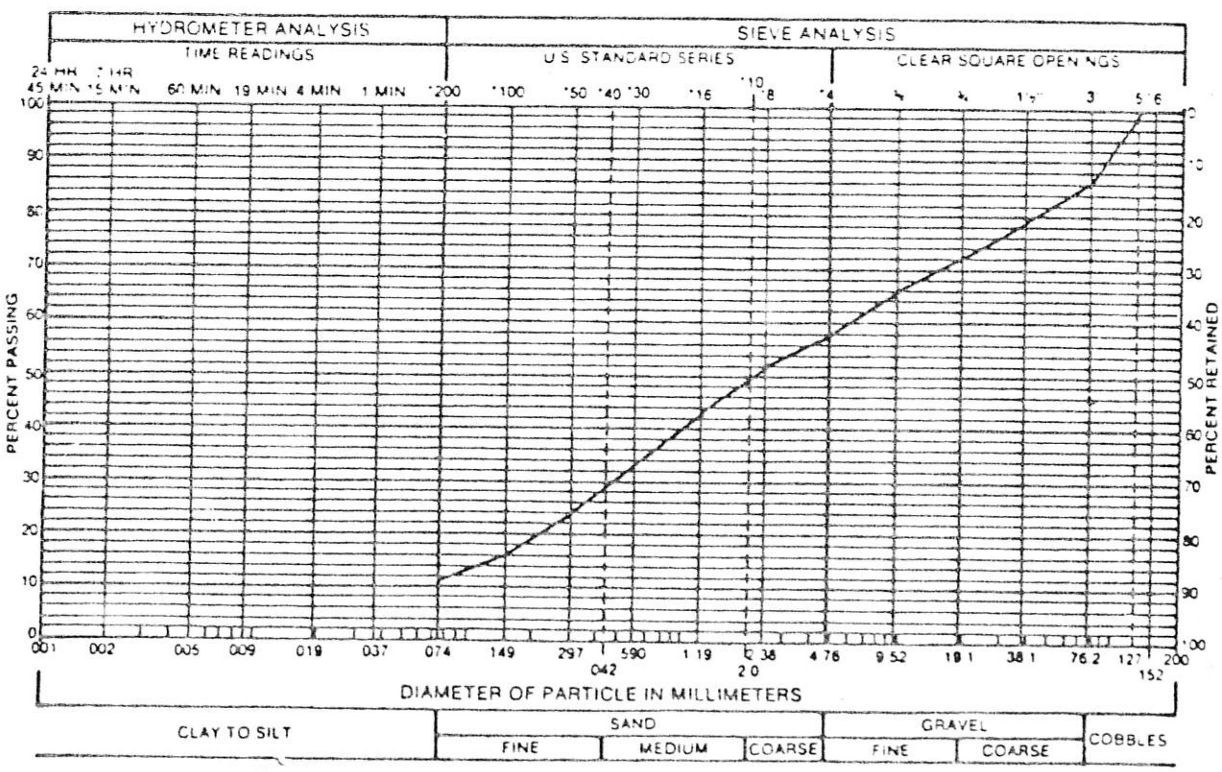
chen and associates, inc.



GRAVEL 76 % SAND 22 % SILT AND CLAY 2 %

LIQUID LIMIT % PLASTICITY INDEX NP %

SAMPLE OF Sandy Gravel FROM TP 7 @ 2-4'



GRAVEL 42 % SAND 47 % SILT AND CLAY 11 %

LIQUID LIMIT % PLASTICITY INDEX NP %

SAMPLE OF Silty, Gravelly Sand FROM TP 8 @ 2-4'