KLEINFELDER

# CAMPUS-WIDE GEOLOGIC AND SEISMIC HAZARDS ASSESSMENT
# CONTRA COSTA COLLEGE
# 2600 MISSION BELL DRIVE
# SAN PABLO, CALIFORNIA

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| Prepared For: | Contra Costa Community College District<br>500 Court Street<br>Martinez, California 94553 |
| Attention: | Ms. Teresa Greenwell |

October 7, 2005

60116 (SJO5R399) nb

**KLEINFELDER**
*An employee owned company*

October 7, 2005
File No. 60116/GEOHAZ

Ms Teresa Greenwell
Contra Costa Community College District
500 Court Street
Martinez, California 94553

**SUBJECT: Campus-Wide Geologic and Seismic Hazards Assessment for the Contra Costa College Campus, San Pablo, California**

Dear Ms Greenwell:

We are pleased to submit our campus-wide geologic and seismic hazards assessment report for Contra Costa College in San Pablo, California. The accompanying report summarizes the results of our data review, and geologic interpretation.

This geologic and seismic hazards assessment report describes the geologic setting, faulting, seismicity, geologic site characterization, geologic and seismic hazards, and near-fault issues in structural design associated with the site. The primary geologic hazard we considered in this assessment includes surface fault rupture, seismic shaking, liquefaction, dynamic compaction, landslides, seismically induced ground failure, naturally occurring asbestos, radon gas, erosion and flooding. The primary geologic hazard of concern for the campus is the location of the Hayward fault, which crosses the campus, and associated surface fault rupture, seismic shaking, liquefaction, dynamic compaction and landsliding. Conclusions regarding potential impacts of these geologic hazards are provided in the report.

If you have any questions regarding the information or recommendations presented in our report, please contact us at your convenience.

Sincerely,
**KLEINFELDER, INC.**

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# Important Information About Your

# Geotechnical Engineering Report

*Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.*

*The following information is provided to help you manage your risks.*

## Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared *solely* for the client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply the report for any purpose or project except the one originally contemplated.

## Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

## A Geotechnical Engineering Report Is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

## Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

## Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ—sometimes significantly—from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

## A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.*

## A Geotechnical Engineering Report Is Subject to Misinterpretation

Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

## Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

## Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure contractors have sufficient time* to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

## Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations" many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

## Geoenvironmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform a *geoenvironmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. *Do not rely on an environmental report prepared for someone else.*

## Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, a number of mold prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; ***none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.***

## Rely, on Your ASFE-Member Geotechncial Engineer for Additional Assistance

Membership in ASFE/The Best People on Earth exposes geotechnical engineers to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a construction project. Confer with you ASFE-member geotechnical engineer for more information.

ASFE
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## 1.0 INTRODUCTION

This report presents the results of our geologic and seismic hazards assessment for Contra Costa College (CCC) in San Pablo, California. The location of the campus is depicted on the Site Vicinity Map, Plate 1. A partial campus plan is shown on an aerial photograph as provided on Plate 2.

### 1.1 PROJECT DESCRIPTION

The proposed project consists of the construction and renovation of several buildings on the CCC campus. Currently, the college is considering construction of a new Student Services building in the lawn area south of the Vocational Arts Building. Other proposed improvements consist of renovating internal portions of the Vocational Arts Building into a new Hi Tech Center, including the construction of a new toilet room addition, and renovation of the existing Library. Structural details regarding the new buildings were not available to us at the time this report was prepared. We assume that the proposed buildings will be of similar size and design as existing buildings on the campus. Additional site improvements are anticipated to include underground utilities, sidewalks, retaining walls, pavements and landscaping. Kleinfelder is concurrently preparing subsurface fault rupture investigation reports for the Student Services Building and Vocational Arts Building Improvements (Job Numbers 59606 and 59607 respectively).

### 1.2 SITE DESCRIPTION

The CCC campus is located in San Pablo, California mostly on a level alluvial plain. The eastern portion of the campus slopes upward to the northeast. The Hayward fault, which crosses the campus, approximately separates the flat laying portion of the campus with the hillside portion of the campus. Rheem Creek flows through campus in a northwesterly direction generally parallel to the base of the hillside. Most of the academic buildings on the campus are located on the hillside portion of the campus, while the flat laying portion of the campus contains mostly athletic buildings and facilities.

The ground-surface elevation at the site ranges from about 50 feet above Mean Sea Level Datum (MSL) along the southwest margin of the campus to about 130 feet in the northeast corner along Campus Drive. Based on data presented on USGS Quad Map for Richmond 7.5 minute Quadrangle, the center of the campus coordinates are:

| Latitude: | 37.970° North | Longitude: | -122.339° West |
|---|---|---|---|

### 1.3 PURPOSE AND SCOPE OF SERVICES

The purposes of this geologic assessment are to identify and assess potential geologic hazards at or near the site in accordance with the requirements for such studies set forth by the California Education Code (Chapter 1, Section 39002) and the California Code of Regulations Title 24, and 2001 California Building Code (CBC). This report is also prepared in accordance with the guidelines established by: the 1997 California Geological Survey (CGS) (formerly California Department of Conservation Division of Mines and Geology) Special Publication 117 (Guidelines for Evaluating and Mitigating Seismic Hazards); CGS Note 48 (Checklist for Review of Engineering Geology and Seismology Reports for California Public Schools, Hospitals and Essential Services Buildings), CGS Note 42 (Guidelines to Geologic/Seismic Reports), CGS Note 44 (Recommended Guidelines for Preparing Engineering Geologic Reports), and CGS Special Publication 42 (Fault-Rupture Hazard Zones in California). Our scope of services included the following:

- Research and review available geologic, geotechnical, and seismologic reports, and FEMA publications and maps in our library that pertain to the site and vicinity;
- Review geologic and geotechnical consultant studies performed on or in the immediate site vicinity available in our library or from the College District;
- Conduct a geologic reconnaissance of the site by a Certified Engineering Geologist (CEG) to observe and document surface features indicative of possible geologic hazards;
- Review readily available trench logs and soil boring logs, from previous investigations including those on file with the CGS and listed in their database;

- Assess significant faults and site seismicity and conduct an analysis of potential earthquake impact at the site;
- Evaluate the researched data and prepare this report with conclusions and recommendations regarding possible geologic and seismic hazards affecting the campus.

This report does not address project-specific geologic issues. Each new project subject to Title 24 regulations should include a project-specific geotechnical and geologic-hazard evaluation, which could include soil borings, test pits and fault trenches, as appropriate.

This investigation excludes the assessment of environmental characteristics, particularly those involving hazardous substances. Environmental services such as chemical analysis of soil and groundwater were not included in our scope of services. Also excluded from this study was an assessment of pipeline locations within 1,500 feet of the project site (ECS 17212.5).

# 2.0 GEOLOGIC SETTING

## 2.1 REGIONAL GEOLOGY

The San Francisco Bay Area lies within the Coast Ranges geomorphic province, a more or less discontinuous series of northwest-trending mountain ranges, ridges, and intervening valleys characterized by complex folding and faulting. The general geologic framework of the San Francisco Bay Area is illustrated in studies by Schlocker (1970), Wagner et al. (1990), as well as in studies by Chin et al. (1993), and Ellen and Wentworth (1995). The Regional Geologic Map is included as Plate 3 (derived from CGS, 2002).

Geologic and geomorphic structures within the San Francisco Bay Area are dominated by the San Andreas fault (SAF). This right-lateral strike-slip fault extends from the Gulf of California in Mexico, to Cape Mendocino, on the coast of Humboldt County in northern California. It forms a portion of the boundary between two independent tectonic plates on the surface of the earth. To the west of the SAF is the Pacific plate, which moves north relative to the North American plate, located east of the fault. In the San Francisco Bay Area, movement across this plate boundary is concentrated on the SAF; however, it is also distributed, to a lesser extent across a number of other faults that include the Hayward, Calaveras, Concord-Green Valley and San Gregorio among others. Together, these faults are referred to as the SAF system. The northwest trend of the faults within this system is largely responsible for the strong northwest structural orientation of geologic and geomorphic features in the San Francisco Bay Area. Some of the significant seismic events attributed to the SAF include the 1906 (M8+) San Francisco earthquake, the 1838 and 1865 (M7) San Francisco earthquake, and the 1989 (M6.9) Loma Prieta earthquake (all on the San Andreas fault). Seismic events attributed to some nearby faults include the 1868 (M6.8) Hayward earthquake on the Hayward fault, the 1861 (M5.7) San Ramon Valley earthquake generated on the Calaveras fault, the 1980 (M5.8) Livermore Valley earthquake on the Greenville fault, and the 1955 (M5.4) Concord earthquake on the Concord fault, and.

Basement rock west of the SAF is generally granitic, while to the east it consists of a chaotic mixture of highly deformed marine sedimentary, submarine volcanic and metamorphic rocks of the Franciscan Complex. Both are typically Jurassic to Cretaceous in age (about 205 to 65 million years old). Overlying the basement rocks are Cretaceous (about 140 to 65 million years old) marine, as well as Tertiary (about 65 to 1.7 million years old) marine and non-marine sedimentary rocks with some continental volcanic rock. These Cretaceous and Tertiary rocks have typically been extensively folded and faulted as a result of a compressional component of movement along the North American/Pacific plate boundary approximately during the last 4 million years. The Jurassic and Cretaceous age rocks comprising the surrounding hills and the site area are partially blanketed by surficial deposits of alluvium, colluvium, and landslide materials.

## 2.2 AREA AND SITE GEOLOGY

Geologic maps emphasizing bedrock formations in the vicinity of the site have been prepared by Weaver (1949), Sheehan (1956), Wagner (1990), Dibblee (1980), Graymer et al. (1994), and Crane (1995) among others. Weaver (1949), Dibblee (1980), and Graymer et al. (1994) mapped the bedrock as Tertiary age (Late Miocene to Pliocen) Orinda Formation as shown on Plate 4, the Area Geologic Map taken from Graymer et al. (1994). Sheehan (1956), however, mapped the Tertiary strata near Point Pinole as undifferentiated Contra Costa Group following the suggestion of Savage, Ogle, and Creely (1951). Wagner (1978) mapped exposures of the undifferentiated Contra Costa Group in the vicinity of the site as the "Garrity Member." Graymer et al. (1994) described the Orinda Formation as non-marine, conglomerate, sandstone and siltstone with abundant rock clasts that have been derived from the Franciscan Complex and other Cretaceous age rocks. Wagner (1978) distinguished the "Garrity Member" from the Orinda Formation and other members of the Contra Costa Group by the presence of significant quantities of reworked Monterey Formation detritus such as silicious shale and chert.

Localized studies, which emphasize the Quaternary (younger than approximately 1.7 million years old) geology in the general area of the site, have been prepared by Helley et al. (1979) and Knudsen et al. (1997). Generally, the unconsolidated alluvial deposits of Pleistocene age are mapped along slightly elevated areas while the younger Holocene alluvial deposits are mapped blanketing level zones or young creek channels and drainage courses. A portion of Knudsen et al. (1997) presented as the Quaternary Geologic Map, 5.

Based on information obtained from the fieldwork at the site during previous consultants' investigations, it appears that a relatively thin veneer (approximately 1 to 8 feet thick) of fill blankets localized areas of the campus. The fill typically overlies a relatively thin section of Holocene age alluvial sediment. The Holocene alluvial soils are underlain by a thicker sequence of older (Pleistocene age) alluvium that is underlain, in turn, by the terrestrial sedimentary bedrock of the Garrity Member of the Contra Costa Group. Geologic contacts from Graymer et al. (1994) and modified by information from our field reconnaissance, overlain onto an aerial photograph of the campus, is provided as Plate 6. Subsurface conditions will be discussed further in a subsequent section of this report.

## 3.0 PREVIOUS INVESTIGATIONS

Several consultants' investigations that have relevance to the location of the Hayward fault as it traverses the campus are listed and discussed below. The reports chronicling these investigation were provided by the College or contained in our library. Locations of the various geologic trenches included in these reports are approximately shown on Plate 2.

### 3.1 WOODWARD-LUNGREN & ASSOCIATES (W-LA, 1971)

W-LA performed a literature and aerial photograph investigation for the Contra Costa College campus where they identified lineaments crossing the campus area and categorized them as "distinct," "less distinct," and "least distinct." They concluded that the "distinct" lineaments are likely to be fault-related. These "distinct" lineaments generally coincide with fault traces mapped by the CGS.

### 3.2 HARDING, MILLER, LAWSON & ASSOCIATES (HMLA, 1972)

HMLA conducted a detailed subsurface fault investigation for a proposed addition to the Physical Science Building on the college campus that included the excavation and logging of four geologic trenches. The trenches were extended across a "least distinct" lineament as was delineated by W-LA in 1971. HMLA concluded that the lineament was not fault-related. HMLA identified a fault trending 60 degrees west of north with an associated dip of 55 degrees toward the southwest in their geologic trenches. The trend of the fault appeared to be more westerly than the lineaments mapped by W-LA in 1971. The fault was observed in the siltstone bedrock but prior grading in that vicinity had resulted in the removal of the surficial soils preventing characterization of its activity. HMLA (1972) concluded that the encountered fault trace was potentially active based on the lack of surficial native soil and they considered it as a secondary eastern strand of the Hayward fault. This and subsequent HMLA reports were used by the CGS in the FER for the Hayward fault in the vicinity of Contra Costa College.

### 3.3 HARDING LAWSON AND ASSOCIATES (HLA, 1973A, B AND C)

HLA (1973a) excavated two geologic trenches along the east side of the VA Building in May 1973 and drilled seven soil borings (9)across the vacant parcel south of the VA building is currently proposed. Initially, the vacant parcel was considered for locating the then proposed Applied Arts Building. Their trenching phase revealed two fault traces that offset the bedrock/alluvial contact and were labeled "recent" by them. Trenching was discontinued due to the increased depth of alluvium encountered, proximity to underground utility lines, difficulty of installing trench shoring, and the high cost associated with trenching.

HLA (1973b) performed a fault investigation in November 1973 that included the excavation and logging of three geologic trenches totaling approximately 300 feet in length at Parking Lots 6 and 7 (to the east/southeast of the Health Sciences Building). Their trenches were extended across a "least distinct" lineament that they concluded was not fault-related. The trenches were excavated into bedrock. Three shear zones were exposed within the bedrock in one of their trenches, but the shears did not extend into the overlying alluvial, colluvial, and landslide deposits. Based on that information, they concluded that the shear zones were not fault-related.

HLA (1973c) excavated three trenches within the area situated to the northeast of the Arts Building and to the northwest of the Music Building. The trenches were extended in a generally northwestern direction and approximately parallel to the mapped trend of the Hayward fault in this vicinity. Based on the orientation of the excavated trenches it appears that they were intended to evaluate the presence of landslide deposits in that area rather than faulting. No trench logs were available for review.

## 3.4 EARTH SCIENCE AND ASSOCIATES (ESA 1976 AND 1978)

ESA performed a fault evaluation for a property to the north and northwest of the Child Development Center based on field reconnaissance, aerial photograph, and geologic literature review. They did not consider trenching and/or geophysical survey as proper investigative methods because of past grading activities at the site. Two "least distinctive lineaments" mapped across their site by W-LA (1971) were dismissed as not being fault-related. They concluded that a fault trace crossing the southwestern corner of the site is active and established a 75-foot wide setback zone. That fault trace coincided with the creeping trace mapped subsequently by Lienkaemper in 1992.

## 3.5 CALIFORNIA DIVISION OF MINES AND GEOLOGY (CDMG, 1980)

CDMG (currently known as CGS) conducted a Fault Evaluation Report (FER-101) for the Hayward fault in the Richmond and Mare Island Quadrangles. This was part of a

10-year program to evaluate and revise Alquist-Priolo Special Studies Zones maps. The CDMG conducted a comprehensive review of previous investigations performed in and around the CCC and documented observations of creep deformation. Four areas on the CCC campus and two areas on the El Portal School campus are listed by the CDMG where creep offset has occurred. All six of these locations were confirmed during our site reconnaissance. They also note that in a 1939 aerial photograph a small hill existed (see Plate 6) southeast of El Portal School along the Hayward fault which apparently is a pressure ridge that formed due to a left step over in the fault trace.

### 3.6 HERZOG ASSOCIATES (HA, 1990)

HA excavated a geologic trench at the adjacent El Portal School bordering the college campus to the south. Their 64-foot long trench was excavated to evaluate fault-related distress to a school structure caused by the mapped creeping trace. The trench, however, did not expose an apparent fault plane but did expose pond deposits, a groundwater aquitard, and disrupted soil zones that they considered as indications of active fault creep.

### 3.7 WILLIAM LETTIS & ASSOCIATES, INC. (WLA, 1999A AND B AND 2000)

WLA (1999a) performed a fault-rupture hazard evaluation for the Child Development Center (CDC) where an approximately 320-foot long trench was excavated. Their evaluation concluded that the trench is free of fault traces and that the “least distinct” lineament mapped by W-LA (1971) across the CDC site is not related to faulting. WLA established two 50-foot fault setback zones (one at each end of the trench) under the assumption that active fault traces could be present immediately beyond the trench ends.

WLA (1999b) conducted a supplemental fault-rupture hazard evaluation at the CDC site after the layout of the proposed building was revised which necessitated extending the trench to the southwest for an extra 50-foot length. No signs or features indicative of active faulting were observed in the supplemental trench. A 50-foot wide fault setback zone was established along the extended southwestern end of the trench.

WLA (2000) did not perform a subsurface investigation as part of this phase of work which was intended to evaluate other potential geologic hazards such as ground shaking, liquefaction and settlement, slope stability, flooding, volcanism, tsunami/seiche inundation, and expansive soil. Additionally, the report presented their probabilistic seismic hazard analyses performed for the CDC site.

### 3.8 KLEINFELDER, INC. (KA, 2003A)

Kleinfelder, Inc. conducted a subsurface fault investigation at the vacant parcel south of the VA building. The parcel is situated immediately to the northwest of the existing Student Activities Building beyond the seasonal creek separating both sites. Five geologic trenches totaling approximately 300 lineal feet were extended in a northeasterly direction and extending between the southwestern and the northeastern corners of the vacant parcel. The excavated trenches extended across the secondary fault mapped by the CGS in 1982 and 2000 and the "distinct" lineament mapped by W-LA in 1971. The trenches did not reveal the secondary fault trace mapped by the State or any other secondary fault traces. The site was declared fault-free based on the viewed trench exposures.

### 3.9 KLEINFELDER, INC. (KA, 2003B)

Kleinfelder, Inc. prepared a subsurface fault investigation in the area between the Student Services Building and the Humanities Building southeast of the seasonal creek. Four geologic trenches totally approximately 455 linear feet were excavated in a northeasterly direction. Two potentially active faults were encountered in the trench. A 25-foot wide setback zone (on each side of the fault) was established. One of these potentially active faults projects toward the proposed VA Building addition and prompted an additional fault trenching investigation (see Section 3.11 below) .

### 3.10 KLEINFELDER, INC. (KA, 2004)

Kleinfelder, Inc. conducted an investigation addressing distress to the Art Building. The Art Building is located within a sloping area in the northern portion of the campus. The building was constructed in about 1970 and has been experiencing distress since that time. Building movement has continued at a slow rate and most of the distress is in the south half of the building. The visible distress consists of vertical and lateral movement of the floor slab, tilting of columns in the west end of the building and cracks at door jams. Several inclinometers were installed and monitored to analyzed subsurface movement. The cause of the distress has been attributed to slope creep or settlement of the floor slab backfill. On-going slope inclinometer readings at five locations have not detected meaningful slope deformations.

## 3.11 KLEINFELDER, INC. (KA, 2005A)

Kleinfelder, Inc. conducted a fault investigation for the proposed toilet building addition to the Vocational Arts Building. A 130-foot long trench (KAT-1) was excavated along the north side of the building. The trench revealed several faults within the Garrity Member bedrock, however the overlying Pleistocene and Holocene age alluvium had been removed during the original construction of the building. It was determined based on similar trend, dip and amount of vertical offset that a north trending fault trace observed in the Trench KAT-1 was the same fault exposed in Kleinfelder's (2003b) investigation in Trench T-1 was shown to be potentially active. A 25-foot setback was established for this fault. Two other faults were observed in Trench KAT-1 that are inferred to be continuations of an inactive fault in Kleinfelder's (2003b) Trench T-2. Therefore these faults were also believed to be inactive.

## 3.12 KLEINFELDER, INC. (KA, 2005B, PENDING)

Kleinfelder has completed a supplemental field investigation in the lawn area south of the Vocational Arts building (report in preparation). A previous Kleinfelder report (Kleinfelder, September 12, 2003) concluded that the secondary fault trace postulated and mapped by the CGS on the A-P Earthquake Fault Zone map or other active fault traces were not encountered in the trenches near the center of the lawn area. This supplemental investigation was designed to address possible faulting at the south corner of the lawn area. Based on the investigation's findings, no active faults extend through the exploratory trench in the south lawn area. This investigation shows that the fault trace shown on the CGS (2000) map does not extend between Kleinfelder's trench at the south corner of the lawn area and Kleinfelder's 2003a trenches (located through the central portion of the lawn area). This investigation also shows that the potentially active fault observed in Trench T-1 (Kleinfelder, 2003b) does not extend north across the drainage channel between the Student Association Building and the Vocational Arts Building.

## 4.0 SITE INVESTIGATION

### 4.1 AERIAL PHOTOGRAPHIC REVIEW

Aerial photographic stereo pairs were reviewed as part of our geologic investigation of the site. The reviewed photographs are listed below.

| DATE | SOURCE | FLIGHTLINE/FRAMES | SCALE | COLOR |
|---|---|---|---|---|
| Sept. 6, 1946 | USGS | CS CP (S-97 & S-98 | ~1:20,000 | B&W |
| May 10, 1950 | USGS | BUU-11G (14 & 15) | ~1:20,000 | B&W |
| May 3, 1957 | PAS | AV-253-05 (4, 5 & F) | 1:12,000 | B&W |
| July 7, 1977 | PAS | AV-1377-08 (6 & 7) | 1:12,000 | B&W |

These photographs were viewed for the presence of terrain features characteristic of fault traces, particularly lineaments as well as other features that may be related to possible geologic hazards. A lineament is seen on a stereo aerial photograph pair as a feature with tonal contrast on each side. These features may be indicative of changes in soil types, vegetation, groundwater levels, sedimentary bedding characteristics or may be caused by human activity. Lineaments can be indicative of the presence of geologic structures such as folds and faults.

The 1946 and 1950 photographs show that the southwestern portion of the campus, where the athletic fields are now, contained several warehouse-type buildings. The remainder of the campus appears undeveloped in these photographs. Rheem Creek is located very close to it's current location. The residential development immediately southeast of El Portal School already existed by 1946. This is the area which the CDMG (1980) reported a "small hill." Two distinct lineaments were observed on the 1946 and 1950 photographs. The location of these lineaments, as well as the approximate location of the 1939 "small hill" are shown on Plate 6.

The 1957 photographs show the Humanities Building and the original (pre-expansion) section of the Physical Science Building along the east side of the Rheem Creek. The area to the west and north of the Rheem Creek was yet to be developed but signs of ground scaring and terracing indicative of grading activities were observed on the photographs. The Arts, Music, VA, and new Child Development Center (aka Early Learning Center) buildings have not been constructed but pad preparation appears underway for some of the noted buildings. A parking lot existed at the area of the existing Student Activities Building. The area to the south/southeast of the college campus has been developed and the original topography has been altered and/or obscured by constructed structures and roadways. The area to the northwest of the campus was occupied by the San Pablo oil tank farm. The original topography of the tank farm was also altered and no lineaments that may have been present trending toward the campus area can be detected.

The 1977 photographs show most of the above-discussed buildings except for the Child Development Center, which was built later. A prominent tree growth marks the drainage course that separates the Humanities and Student Activities buildings from the VA Building and the vacant lawn area south of the VA Building. Most of the area surrounding the campus has been developed and the oil tank farm north of the campus has been removed.

### 4.2 FIELD INVESTIGATION

Our field investigation consisted of a surface reconnaissance that included the documentation and mapping of creep features along the main trace of the Hayward fault. As shown on Plate 2, several areas display features indicative of active fault creep. These included right-lateral offset curbs, sidewalks and concrete pads, left-stepping en-echelon fractures in pavement and distortions to buildings. Our filed investigation also include the area along Rheem Creek southwest of the Library Building and in the area of the Student Association Building where a fault trace is mapped by CGS (Plate 2). No evidence of fault creep was observed in these areas.

### 4.3 SUBSURFACE CONDITIONS

Northeast of the Hayward fault, the campus is underlain by bedrock of the Garrity Member of the Contra Costa Group. This bedrock is overlain by Pleistocene alluvium which generally thickens toward the southwest. Southeast of the Hayward fault, the campus is located over Holocene alluvial deposits (Knudsen et al., 1997).

### 4.3.1 "Garrity Member" of the Contra Costa Group Bedrock

The bedrock at the campus is assigned to the Late Miocene to Pliocene Garrity Member of the Contra Costa Group. This unit, named by Wagner (1978) was originally mapped in the area of the Contra Costa College. Observations made in geologic trenches show that this unit has a general strike to the northwest and dips moderately to the northeast. Based on descriptions from trench logs, it appears that, lithologically, this formation is mostly claystone with interbedded sandstone and conglomerate beds.

During Kleinfelder's 2003 and 2005 investigations, it was observed that the claystone exhibits large concoidial fractures and can be highly weathered. This unit it typically red to green, thickly or massively bedded and likely formed as a paleosol (ancient soil formed during time of depositon). The interbedded sandstone and conglomerate beds were probably deposited in a fluvial (stream) environment. The conglomerate is reddish brown, thickly bedded and moderately weathered. The clasts are gravel sized, well rounded with common clay coatings and composed primarily of sandstone, chert and quartzite derived from the Franciscan Complex. The sandstone is moderately to highly weathered, moderately to weakly cemented and composed of fine- to coarse-grained sand with traces of gravel clasts.

### 4.3.2 Pleistocene Age Alluvium

The Pleistocene age alluvium has been observed in many trenches excavated in the area. It overlies the Garrity Member bedrock and thickens to the southwest, away from the hillside. The composition of the Pleistocene age alluvial sediments consist of interbedded layers of gravel, sand and clay. In general, the base of the exposed Pleistocene age sediments is coarser with more gravel units, while the top is finer with more clay. The clay units have been observed to be very stiff to hard with abundant black manganese oxide veinlets and staining along prismatic clay faces. Gravel clasts often appeared to be coated by reddish oxidized clay films.

### 4.3.3 Holocene Age Alluvium

Knudsen et al. (1997) maps much of the flat lying areas on the campus as Holocene fan deposits. He describes this unit as

> *"....Sediment deposited by streams emanating from the mountain canyons onto alluvial valley floors or alluvial plains as debris flows,*

> *hyperconcentrated mudflows, or braided stream flows. Alluvial fan sediment includes sand, gravel, silt, and clay, and is moderately to poorly sorted, and moderately to poorly bedded. Sediment clast size generally decreases downslope of the fan apex. Many Holocene alluvial fans exhibit levee/interlevee topography, particularly the fans associated with creeks flowing west from the eastern San Francisco Bay area hills. Alluvial fan surfaces are steepest near their apex at the valley mouth, and slope gently basinward with gradually decreasing gradient. Alluvial fan deposits are identified primarily on the basis of fan morphology. Holocene alluvial fans are relatively un-dissected, especially when compared to older alluvial fan…."*

Where observed in geologic trenches, this unit is usually only a few feet thick. However, these trenches have been mostly excavated on the hillside (northern) portion of the campus, and it is likely that the Holocene soils thicken toward the southwest in the flat laying portion of the campus.

### 4.3.4 Fill

Fill is located a various locations across the site. It is likely that when the building pads were graded into the hillside, fill was placed on the downhill side of the pads. The extent and degree of compaction of the fill is not known by us and therefore is not included on the Site Aerial Photograph and Geologic Map, Plate 6.

# 5.0 FAULTING AND SEISMICITY

## 5.1 FAULTING

Based on the information provided in Hart and Bryant (1997) and CGS (1982 and 2000), the site is located within a State-designated, Alquist-Priolo Earthquake Fault Zone and where site-specific studies addressing the potential for surface fault rupture are required (where active faults traverse the site). The site area is situated within a region traditionally characterized by numerous active faults and high seismic activity.

An active fault is a fault that has experienced seismic activity during historic time (since roughly 1800) or exhibits evidence of surface displacement during Holocene time (Hart and Bryant, 1997). Faults considered to be active are shown in orange or red on the Regional Fault Map, Plate 7 (Jennings, 1994). The definition of "potentially active" varies. A generally accepted definition of "potentially active" is a fault showing evidence of displacement that is older than 11,000 years (Holocene age) and younger than 1.7 million years (Pleistocene age). These "potentially active" faults are shown in green or purple on Plate 7. However, "potentially active" is no longer used as criteria for zoning by the CGS. The terms "sufficiently active" and "well-defined" are now used by the CGS as criteria for zoning faults under the Alquist-Priolo Earthquake Fault Act. A "sufficiently active fault" is a fault that shows evidence of Holocene surface displacement along one or more of its segments and branches, while a "well-defined fault" is a fault whose trace is clearly detectable by a trained geologist as a physical feature at or just below the ground surface. The definition "inactive" generally implies that a fault has not been active since the beginning of the Pleistocene Epoch (older than 1.7 million years old).

Locations of the significant active and potentially active faults along with symbols depicting epicenters and magnitudes are shown on Plate 8. As mentioned above, portions of the campus are within an Alquist-Priolo Earthquake fault zone for the Hayward-Rodgers Creek fault, which crosses the school site. In addition, the school site is located approximately 23 kilometers (km) to the south and 24 km to the west of the West Napa and Concord-Green Valley faults, respectively. A major seismic event on these or other nearby faults may cause substantial ground shaking at the site.

## 5.2 HAYWARD FAULT

The Contra Costa College campus is partially situated within the Alquist-Priolo Earthquake Fault Zones associated with the active Hayward fault. Such zones are delineated by the CGS on U.S. Geological Survey 7.5 Minute Quadrangles (topographic base maps) and the boundaries are generally about 500 to 650 feet wide on each side of the reported active fault trace. The width of such zones is intended to accommodate imprecise locations of the mapped faults and the potential presence of secondary active fault traces associated with the main mapped fault trace. The Alquist-Priolo Earthquake Fault Zone Act requires the implementation of programs to regulate development within established fault zones. Plates 2 and 9 show the current boundaries of the Alquist-Priolo Earthquake Fault Zone and the fault traces mapped by the State (CGS) in the vicinity of the site area. A portion of an CGS inferred fault trace shown on the Earthquake Fault Zone map southwest of the Vocational Arts building has been removed by us on Plate 2 in order to reflect our current interpretation based on recent fault trenching (Kleinfelder, 2005b, pending).

According to specific criteria of the Alquist-Priolo Fault Zone Act, no structures intended for human occupancy and habitation are permitted for construction across the trace of an active fault. Although a structure can be designed to resist severe ground shaking, it is impractical if not impossible to design a structure to withstand serious damage under the stress of fault-related surface rupture or greater than a few inches. As a result, one mitigating measure is to avoid the fault by accurately locating it and providing a reasonable building setback distance from the mapped trace. When the activity level and precise location of a fault are in question, a detailed geologic investigation can significantly reduce the risk of locating a structure across the fault. Such detailed investigations usually require subsurface exploration via trenching methods to identify the presence or absence of fault-related displacement of Holocene age (generally during the last 11,000 years) materials. If an active fault is determined to be present, buildings are usually required to be setback from it.

Published mapping, including that of the CGS (1982 and 2000), shows several northwestward-trending fault traces associated with the Hayward fault zone to the southwest of the site area. Evidence of fault slip or "creep" (slow aseismic slip) has also been observed along much of the Hayward fault (Brown, 1990 and Lienkaemper et al., 1992). A joint publication by the CGS and the U. S. Geological Survey (USGS) in

1996, lists a slip rate of 9mm per year along the northern portion of the Hayward fault in the vicinity of the college campus.

Previous maps delineating the Hayward fault on the campus were prepared by Radbruch-Hall (1974), Herd (1978), Dibblee (1980), Lienkaemper (1992), Graymer et al. (1994), Crane (1995), and the CGS (1982 and 2000). Radbruch-Hall (1974) mapped two fault traces, Herd (1978) shows a single trace traversing the campus while Dibblee (1980) shows two traces. Lienkaemper (1992) shows a single creeping trace and Crane (1995) mapped two traces. The fault traces listed above are depicted on Plate 10 while the State's (CGS) mapped fault traces are shown on Plate 9.

### 5.3 SEISMIC-SOURCE MODEL

Our seismic-source model is based on the model used in developing probabilistic seismic hazard maps by CGS (Cao et al., 2003) and by the Working Group on California Earthquake Probabilities (2003) for the San Francisco Bay Area. We have used faults within 200 km of the site in our analyses. Table 4.3-1 lists these faults and their seismic parameters within only 100 km of the site. The locations of the faults and associated parameters presented on Table 4.3-1 are based on data presented by, Jennings (1994), Wakabayashi and Smith (1994), Frankel et al. (1996, 2002), Petersen et al. (1996), ICBO (1998), Cao et al. (2003), and the Working Group on California Earthquake Probabilities (2003). The maximum earthquake magnitudes presented in this table are based on the moment magnitude scale developed by Kanamori (1977).

## TABLE 5.3-1
## SIGNIFICANT FAULTS

| Fault Name | Fault Length (km) | Closest Distance to Site (km) | Magnitude of Maximum Earthquake * | Slip Rate (mm/yr) | Recurrence Interval (yr) |
|---|---|---|---|---|---|
| Hayward – Rodgers Creek (HS + HN + RC) | 150 | 0 | 7.3 | 9 | 3524 |
| West Napa | 30 | 23 | 6.5 | 1 | 701 |
| Concord – Green Valley (CON + GVS + GVN) | 56 | 24 | 6.7 | 4 – 5 | 580 |
| San Andreas (SAS + SAP + SAN + SAO) | 473 | 28 | 7.9 | 17 – 24 | 378 |
| Mount Diablo Thrust | 25 | 29 | 6.6 | 2 | 389 |
| Calaveras (CS + CC +CN) | 123 | 29 | 6.9 | 6 – 15 | 1555 |
| San Gregorio (SGS + SGN) | 176 | 33 | 7.4 | 3 – 7 | 1202 |
| Point Reyes | 47 | 42 | 7.0 | 0.3 | 3503 |
| Great Valley (segment 5) | 28 | 43 | 6.5 | 1.5 | 501 |
| Greenville (GS + GN) | 51 | 45 | 6.9 | 2 | 1994 |
| Great Valley (segment 4) | 42 | 46 | 6.6 | 1.5 | 472 |
| Hunting Creek – Berryessa | 60 | 55 | 7.1 | 6.0 | 194 |
| Monte Vista–Shannon | 45 | 60 | 6.7 | 0.4 | 2410 |
| Great Valley (segment 7) | 45 | 74 | 6.7 | 1.5 | 622 |
| Maacama-Garberville | 182 | 74 | 7.5 | 9 | 220 |
| Great Valley (segment 3) | 55 | 78 | 6.9 | 1.5 | 718 |
| Collayomi | 29 | 95 | 6.5 | 0.6 | 1209 |

* Moment magnitude: An estimate of an earthquake's magnitude based on the seismic moment (measure of an earthquake's size utilizing rock rigidity, amount of slip, and area of rupture).

According to the Working Group on California Earthquake Probabilities (2003) study, characterizations of the Calaveras, Concord-Green Valley, Greenville, Hayward-

Rodgers Creek, San Andreas, and San Gregorio faults are based on the following fault rupture segments and fault rupture scenarios.

- The Calaveras fault includes three segments and six rupture scenarios, plus a floating earthquake. The three segments are southern (CS), central (CC), and northern (CN).
- The Concord-Green Valley fault has been characterized by three segments and six rupture scenarios plus a floating earthquake. The three segments are the Concord fault (CON), the Green Valley South (GVS), and the Green Valley North (GVN).
- The Greenville fault has been characterized by two segments and three rupture scenarios plus a floating earthquake. The two segments are Greenville South (GS) and Greenville North (GS).
- The Hayward-Rodgers Creek fault has been characterized by three segments and six rupture scenarios plus a floating earthquake. The three segments are the Rodgers Creek fault (RC), the Hayward North (HN), and the Hayward South (HS).
- The San Andreas fault has been characterized by four segments and nine rupture scenarios, plus a floating earthquake. The four segments are Santa Cruz Mountains (SAS), North Coast (SAN), Peninsula (SAP), and Offshore (SAO).
- The San Gregorio fault has been characterized by two segments and three rupture scenarios, plus a floating earthquake. The two segments are San Gregorio South (SGS) and San Gregorio North (SGN).

The recurrence intervals for these faults are listed in Table 4.3-1 and represent the rupture scenarios of all the segments. Recurrence intervals for other scenarios can be found in the Working Group on California Earthquake Probabilities (2003).

## 5.4 MAGNITUDE-FREQUENCY DISTRIBUTION

The earthquake probabilities for the faults and their segments were developed using a magnitude-frequency relationship derived from the seismicity catalogs and the fault activity based on their slip rates. In general, there are two models based on magnitude-frequency relationships. In the first, earthquake recurrence is modeled by a truncated form of the Gutenberg-Richter (G-R) (Gutenberg and Richter, 1956) magnitude-frequency relation given by:

$$\log N = a - bM$$

where N(M) is the cumulative number of earthquakes of magnitude "M" or greater per year, and "a" and "b" are constants based on recurrence analyses. The relation is truncated at the maximum earthquake. In the G-R model, it is assumed that seismicity along a given fault or fault zones satisfies the above equation. This model generally implies that seismic events of all sizes occur continually on a fault during the interval between the occurrences of the maximum expected events along the fault zone.

The second model, generally referred to as a Characteristic model (Schwartz and Coppersmith, 1984), implies that the time between maximum size earthquakes along particular fault zones or fault segments is generally quiescent except for foreshocks, aftershocks, or low level background activity.

Wesnousky (1994) has suggested that for well defined seismic sources and for practical purposes, the Characteristic model is more appropriate. In the development of the Seismic Hazard Maps for the State of California (Petersen et al., 1996, Cao et al., 2003), the CGS categorizes the faults into two classes and applies different magnitude-frequency statistical distributions for each class. Class A faults generally have slip rates greater than 5 mm/yr and well constrained paleoseismic data (i.e., the San Andreas, San Jacinto, Elsinore, Imperial, Hayward, and Rodgers Creek faults). Class B faults include all the other faults lacking paleoseismic data necessary to constrain the recurrence intervals of large events. They use the Characteristic model for class A faults, and both the Characteristic and G-R models with 0.67 and 0.33 weights, respectively, for class B faults.

We have used the CGS approach in our analyses. A b-value of 0.8 is used for all the faults in California. The most likely a-values were estimated for each seismic source based on the recurrence rates of earthquakes and events per year associated with that seismic source as reported by Petersen et al. (1996) and Cao et al. (2003).

## 5.5 BACKGROUND SEISMICITY

In addition to the individual seismogenic sources, our seismic analysis also includes background seismicity, which accounts for random earthquakes between M5 and M7 based on the methodology described by Frankel et al. (1996, 2002). Some of the local seismic sources are not included in our analysis as independent seismogenic sources because they were not considered by the CGS as independent seismogenic sources during the development of hazard maps for California. However, the seismicity of these faults was incorporated into our analysis by including background seismicity in our model. It should be noted that an overlap occurs in our source model between magnitudes M6.5 and M7 because both the background and the fault magnitude distributions may contain this range of events. However, Frankel et al. (1996) and Cao et al. (1996) indicated that this overlap causes only small differences in the calculated hazard values. The a-values are calculated using the method described in Weichert (1980). The hazard may then be calculated using this a-value, a b-value of 0.8 minimum and maximum magnitudes of M5 and M7, respectively, and by applying an exponential distribution as described by Hermann (1977).

### 5.6 HISTORICAL SEISMICITY

According to the 2001 California Building Code (CBC) Figure 16A-2 and Section 1629A.4.1, the site lies within Seismic Zone 4. The project site and its vicinity are located in an area traditionally characterized by moderate to high seismic activity. A number of large earthquakes have occurred within the site vicinity during historic time (since 1800). Some of the significant regional earthquake events include: the 1898 (M6.5) Mare Island earthquake, located approximately 26 km to the north of the site; the 1906 (M7.9) San Francisco earthquake, located about 33 km to the southwest; the 1868 (M7.0) Hayward earthquake, located approximately 37 km to the southeast; and the 1889 (M6.3) Antioch earthquake, located about 39 km to the east. Other significant regional earthquakes include: 1838 (M7.0) San Francisco Peninsula earthquake, located approximately 41 km the south of the site; the 1892 (M6.5) Vacaville earthquake, located about 57 km to the northeast; the 1892 (M6.3) Winters earthquake, located approximately 71 km to the northeast; and the 1911 (M6.5) Calaveras fault earthquake, located about 96 km to the southeast.

A recent publication prepared by the U.S. Geological Survey regarding earthquake probabilities in the Bay Area (Working Group on California Earthquake Probabilities, 2003) concludes that there is a 62 percent chance that one of the major faults within the Bay Area will experience a major (M6.7+) earthquake during the period of 2003-2032. As has been demonstrated recently by the 1989 M6.9 Loma Prieta earthquake, the 1994 M6.7 Northridge earthquake, and the 1995 M6.9 Kobe earthquake, earthquakes of this magnitude range can cause severe ground shaking and significant damage to modern urban societies.

Epicenters of some significant earthquakes (M ≥ 4.0) within the vicinity of the site are shown on Plate 8. The earthquake database used in our search contains in excess of 5,500 seismic events and covers the period from 1800 through August 2005. The earthquake database is primarily comprised of an earthquake catalog for the State of California prepared by the CGS. The original CGS catalog (Real et al., 1978) is a merger of the University of California at Berkeley and the California Institute of Technology instrumental catalogs (Hileman et al., 1973). The combined catalog contains earthquake records from January 1, 1900 through December 31, 1974. Updates prepared by the CGS in 1979 and 1982 extend the coverage through 1982. In addition to the CGS updates, the data for earthquakes that occurred during the period between 1910 through August 2005 has been obtained from a composite catalog by the Advanced National Seismic System (ANSS). The ANSS catalog is a worldwide earthquake catalog which is created by merging the master earthquake catalogs from contributing ANSS member networks and then removing duplicate events, or non-unique solutions from the same event. The ANSS network includes the Northern and Southern California Seismic Networks, the Pacific Northwest Seismic Network, the University of Nevada, Reno Seismic Network, the University of Utah Seismographic Stations, and the United States National Earthquake Information Service. The earthquake database also consists of earthquake records between 1800 and 1900 from Seeburger and Bolt (1976) and Toppozada et al. (1978, 1981). In addition, we have also utilized the data from DMG Map Sheet 49 (Toppozada et al., 2000).

The parameters used to define the limits of the historical earthquake search include geographical limits (within 100 km of the site), dates (1800 through August 2005), and magnitudes (M ≥ 4). A summary of the results of the historical search is presented below.

| | |
|---|---|
| Time Period (1800 to August 2005) | 205+ years |
| Maximum Magnitude* | 7.9 |
| Approximate distance to nearest historical M ≥ 4 earthquake | 7 km |
| Number of events exceeding magnitude 4 within search area | 164 |

*Moment magnitude

## 5.7 SITE SOIL PROFILE TYPE

In developing site-specific ground motions, the characteristics of the soils underlying the site are an important input to evaluate the site response at a given site. Based on the previous borings and test pits performed at the site during past geotechnical investigations the site is underlain by several feet of alluvial, residual, and/or man-made fill resulting from past campus development, below which is weathered claystone, sandstone, and siltstone bedrock. The alluvium/residual/fill soil material consists mostly of interbedded layers of stiff to very stiff clay/silt soils and medium dense to dense sand Groundwater varies in depth from about 10 to 15 feet below the ground surface (near low lying areas of the campus) to not encountered (near the higher elevation areas of the campus and the hillsides).

Depending on the thickness of the alluvium soil material encountered above the underlying bedrock, the site can be classified as either Soil Profile Type $S_C$ or $S_D$, per Table 16A-J of the 2001 CBC. Soil Profile Type $S_C$ is defined as very dense soil and soft rock with shear wave velocities between 360 m/s (1,200 feet/sec) and 760 m/s (2,500 feet/sec), SPT-N greater than 50 blows/foot, or Su greater than 100 kPa (2,000 psf) for the upper 30 meters (100 feet). Soil Profile Type $S_D$ is defined as very stiff soil with shear wave velocities between 180 m/s (600 feet/sec) and 360 m/s (1,200 feet/sec), SPT-N = 15 to 50 blows/foot, or Su = 50 to 100 kPa (1,000 to 2,000 psf) for the upper 30 meters.

Our assumptions for soil profile types should be verified via intrusive exploratory means as part of site-specific geotechnical engineering studies for future developments within the college campus.

## 5.8 DESIGN LEVEL EARTHQUAKE

We have developed peak ground accelerations for the Design Basis Earthquake (DBE) and the Upper Bound Earthquake (UBE). The DBE is defined as the ground motion having 10 percent probability of exceedance in 50 years (return period of about 475 years). The UBE is defined as the ground motion that has a 10% probability of being exceeded in 100 years (return period of about 950 years), or the maximum level of motion that may ever be expected at the project site within the known geological framework. It should be noted that the DBE is the same as the Maximum Probable Earthquake (MPE) as defined in Section 1631A.2 of 2001 CBC.

A probabilistic seismic hazard analysis was used to estimate the peak ground accelerations for the DBE and the UBE discussed above. This analysis involves the selection of an appropriate predictive relationship to estimate the ground motion parameters, and, through probabilistic methods, determination of peak accelerations.

## 5.9 ATTENUATION RELATIONSHIP

Site-specific ground motions can be influenced by the types of faulting, magnitudes of the earthquakes, and the local soil conditions. The attenuation relationships used to estimate ground motion from an earthquake source at some distance from the site need to consider these effects.

Many attenuation relationships have been developed to estimate the variation of peak ground surface acceleration with respect to earthquake magnitude and distance from the site to the source of an earthquake. Of these relationships, we have selected the relationships presented by Abrahamson and Silva (1997), Boore et al. (1997), Campbell and Bozorgnia (2003), and Sadigh et al. (1997), because of their wide acceptance by seismologists. Our results were obtained by averaging the individual hazard results. These relationships have also been used in developing National Seismic Hazard Maps (Frankel et al., 1996, 2002) and for the State of California (Petersen et al., 1996; Cao et al., 2003). The relationship by Boore et al. (1997) uses an estimate of the average shear wave velocity ($V_S$) of the soil profile in the analysis. Since the site can be classified as Soil Profile Type $S_C$ and/or $S_D$, per the 2001 CBC, we have used this attenuation relationship with $V_S$ values of 520 m/s and 250 m/s, as recommended by Boore et al. (1997) for $S_C$ and $S_D$ soils, respectively. For the $S_C$ case, we used rock, soft rock, and rock relationships for Abrahamson and Silva (1997), Campbell and Bozorgnia (2003), and Sadigh et al. (1997), respectively. For the $S_D$ case, we have used deep soil, firm soil, and soil relationships for Abrahamson and Silva (1997), Campbell and Bozorgnia (2003), and Sadigh et al. (1997), respectively. The predictive relationships were developed from statistical analyses of recorded earthquakes from Western North America, including the records from the 1989 Loma Prieta, the 1992 Landers, and the 1994 Northridge earthquakes. These attenuation relationships provide mean values of ground motions associated with one set of parameters: magnitude, distance, site soil conditions, and mechanism of faulting. The uncertainty in the predicted ground motion is taken into consideration by including a magnitude dependent standard error in the probabilistic analysis.

## 5.10 PROBABILISTIC ANALYSIS

A probabilistic seismic hazards analysis (PSHA) procedure was used to estimate the peak ground motions corresponding to the DBE and UBE design earthquake levels. The PSHA approach is based on the earthquake characteristics and its causative fault. These characteristics include such items as magnitude of the earthquake, distance from the site to the causative fault, and the length and activity of the fault. The effects of site soil conditions and mechanism of faulting are accounted for in the attenuation relationship(s) used for the site.

The theory behind seismic risk analysis has been developed over many years (Cornell, 1968, 1971; Merz and Cornell, 1973), and is based on the "total probability theorem" and on the assumption that earthquakes are events that are independent of time and space from one another. According to this approach, the probability of exceeding PE(Z) at a given level of ground motion, Z, at the site within a specified time period, T, is given by

$$PE(Z) = 1 - e^{-\vartheta(Z)T}$$

where $\vartheta(Z)$ is the mean annual rate of exceedance of ground motion level Z. Different probabilities of exceedance may be selected, depending on the level of performance required.

The PSHA can be explained through a four-step procedure as follows:

- The first step involves identification and characterization of seismic sources and probability distribution of potential rupture within the sources. Usually, uniform probability distributions are assigned to each source. The probability distribution of site distance is obtained by combining potential rupture distributions with source geometry.
- The second step involves characterization of seismicity distribution of earthquake recurrence. An earthquake recurrence relationship such as Gutenberg-Richter recurrence is used to characterize the seismicity of each source.
- The third step involves the use of predictive or attenuation relationships in assessing the ground motion produced at the site by considering the applicable sources and the distance of the sources to site. The variability of attenuation relationships is also included in the analysis. The effects of site soil conditions and mechanism of faulting are accounted for in these attenuation relationships.

- The last step involves combining all of these uncertainties to obtain the probability of ground motion exceedance during a particular time period.

We have used the computer program EZ-FRISK version 7.01 (Risk Engineering, 2005) for our probabilistic analysis.

# 6.0 CONCLUSIONS - GEOLOGIC HAZARDS

A discussion of specific geologic hazards that could impact the site is included below. The hazards considered include: surface fault rupture; seismic shaking; liquefaction, dynamic compaction; landslides, seismically induced ground failures, flooding, radon, naturally occurring asbestos and erosion.

## 6.1 SURFACE FAULT RUPTURE

As shown on Plates 2 and 9, much of the campus is located within an Alquist-Priolo Earthquake Fault Zone. Evidence for fault creep across the campus has been known for several decades (CDMG, 1980) and was observed and mapped during our site reconnaissance. Therefore, it is our opinion that the potential for continued fault-related surface creep rupture at the campus is inevitable. Because the Hayward fault is known to be active and has been the locus of historic earthquakes with associated ground rupture, future ground rupture during an earthquake on the Hayward along the trace of this fault within the CCC campus should be anticipated. The specific location of the associated ground ruptures is not well-defined at present on the campus because of the lack of trench exploration. Trenches to date that show the presence or absence of active fault traces cover a limited portion of the campus.

## 6.2 SEISMIC SHAKING

### 6.2.1 Peak Ground Acceleration

The estimated peak horizontal ground accelerations (in units of gravity, g) calculated using the method discussed earlier for the Design Basis Earthquake (DBE) and the Upper Bound Earthquake (UBE) are presented in Table 5.2.1-1. The corresponding return period and annual probability of occurrence are also presented in this table. Table 5.2.1-2 presents the results of our de-aggregation analysis to estimate dominant earthquake magnitudes and distances associated with the DBE and UBE events.

### TABLE 6.2.1-1
### PEAK GROUND ACCELERATION

| Soil Profile Type | Event | Return Period | Probability of Occurrence | Annual Probability of Exceedance | Peak Horizontal Acceleration (g) |
|---|---|---|---|---|---|
| $S_C$ | DBE | 475 | 10% in 50 years | 0.0021 | 0.78 |
| | UBE | 950 | 10% in 100 years | 0.0011 | 1.00 |
| $S_D$ | DBE | 475 | 10% in 50 years | 0.0021 | 0.70 |
| | UBE | 950 | 10% in 100 years | 0.0011 | 0.86 |

### TABLE 6.2.1-2
### DE-AGGREGATION ANALYSIS RESULTS

| Soil Profile Type | Event | Mean Distance (km) | Mean Magnitude* | Mode Distance (km) | Mode Magnitude* |
|---|---|---|---|---|---|
| $S_C$ | DBE | 1.0 | 6.7 | 1.3 | 6.9 |
| | UBE | 0.7 | 6.7 | 1.3 | 6.9 |
| $S_D$ | DBE | 2.0 | 6.7 | 1.3 | 6.9 |
| | UBE | 1.5 | 6.7 | 1.3 | 6.9 |

*Moment Magnitude

### 6.2.2 Near-Fault Issues in Structural Design

In recent years, many modern structures located near the seismic source have been severely damaged or collapsed. The severe damage and/or collapse is attributed to near-fault motions that are characterized by energetic unidirectional velocity pulses (Singh 1984, 1985). What makes these motions particularly damaging is the impulse (area under the acceleration multiplied by the mass). A structural system that yields during a long duration pulse (impulse loading) may experience very large permanent deformations and/or collapse. The extent of these actions depends on the strength and natural period of the structure and the structure articulation, as well as the amplitude, duration, and shape of the pulse. The near-fault pulse-type motions can be particularly damaging because they can accumulate inelastic deformations in one direction and their considerations in the near fault conditions should be properly evaluated.

Due to potential near-fault motion resulting from activity on the Hayward-Rodgers Creek fault, near-source effects should be considered in the structural design of the proposed facility. Structures with strength discontinuities, soft stories, plan irregularities, and discontinuous shear walls are particularly vulnerable to these type of motions and should either be avoided or properly evaluated.

For a code equivalent lateral force design, we recommend using the procedures provided in the 2001 CBC. The near-source factors $N_a$ and $N_v$ in the code are incorporated into the seismic coefficients $C_a$ and $C_v$, which are both used to estimate the total design lateral force or shear at the base of the building or structure. The values of these factors depend on the distance of the structure from the fault and the fault type. The near-source factors for each structure can be obtained from Tables 16A-S through 16A-U of the 2001 CBC. The seismic coefficients $C_a$ and $C_v$ can be obtained from Tables 16A-Q and 16A-R of the 2001 CBC, respectively. Alternatively, consideration should be given to dynamic analyses utilizing site-specific response that account for the types of near-source effects observed in the recent Northridge (California) and Kobe (Japan) earthquakes.

For this site, the Hayward-Rodgers Creek fault should be considered as the source for the near-fault motions, since it is the closest significant fault within 15 km of the site (the distance for near-fault considerations). Based on the information presented in Table 16A-U of the of the 2001 CBC, the Hayward-Rodgers Creek fault can be classified as Seismic Source Type A. According to Table 4.3-1 and Sheet E-17 of ICBO (1998) the Hayward-Rodgers Creek fault is located within the college campus. Based on this information, the near-source factors $N_a$ and $N_v$ are 1.5 and 2.0, respectively. The $C_a$ and $C_v$ values are 0.60 and 1.12, respectively, for Soil Profile Type $S_C$ and 0.66 and 1.28, respectively, for Soil Profile Type $S_D$. These values are summarized in Table 5.3.2-1 below. Note that the $N_a$ value may be modified in accordance with CBC Sections 1629A.4.2 or 1630A.2.3.2 or other sections as determined appropriate by the structural engineer.

### TABLE 6.2.2-1
### SUMMARY OF SEISMIC CONSIDERATIONS AT THE SITE

| **Parameter** | **Value** | |
|---|---|---|
| Site Soil Profile Type | $S_C$ | $S_D$ |
| Seismic Zone | 4 | 4 |
| Significant controlling fault, Type | Hayward-Rodgers Creek, A | Hayward-Rodgers Creek, A |
| Fault distance, Magnitude, Slip rate per year | 0 km, M7.3, 9 mm | 0 km, M7.3, 9 mm |
| $N_a$ | 1.5 | 1.5 |
| $N_v$ | 2.0 | 2.0 |
| $C_a$ | 0.60 | 0.66 |
| $C_v$ | 1.12 | 1.28 |

## 6.3 SEISMICALLY INDUCED GROUND FAILURE

### 6.3.1 Liquefaction and Lateral Spreading

Soil liquefaction is a condition where saturated, granular soils undergo a substantial loss of strength and deformation due to pore pressure increase resulting from cyclic stress application induced by earthquakes. In the process, the soil acquires mobility sufficient to permit both horizontal and vertical movements if the soil mass is not confined. Soils most susceptible to liquefaction are saturated, loose, clean, uniformly graded, and fine-grained sand deposits. If liquefaction occurs, foundations resting on or within the liquefiable layer may undergo settlements. This will result in reduction of foundation stiffness and capacities.

Lateral spreading is a potential hazard commonly associated with liquefaction where extensional ground cracking and settlement occur as a response to lateral migration of subsurface liquefiable material. These phenomena typically occur adjacent to free faces such as slopes and creek channels.

The campus lies within the Richmond quadrangle, which was partially mapped by CGS during its ongoing effort to map landslide and liquefaction related hazards throughout the San Francisco Bay Area. However, the campus does not lie within the area mapped by CGS. There are no recorded signs of ground failures associated with past earthquakes in Northern California within about 4½ km of the project site (Youd and Hoose, 1978). No historic ground failures were reported within approximately 6 km of the site in the mapped results of Holzer (1998) as a result of the 1989 M6.9 Loma Prieta earthquake. A liquefaction susceptibility map from Knudsen et al. (1997) is attached as Plate 11.

Based on the previous borings and test pits performed at the site during past geotechnical investigations, the site is underlain by several feet of alluvial, residual, and/or man-made fill resulting from past campus development, below which is weathered claystone, sandstone, and siltstone bedrock. The alluvium/residual/fill soil material consists mostly of interbedded layers of stiff to very stiff clay/silt soils and medium dense to dense sand. Groundwater varies in depth from about 10 to 15 feet below the ground surface (near low lying areas of the campus) to not encountered (near the higher elevation areas of the campus and the hillsides). Cross sections of the campus depicting subsurface conditions are shown on Plate 12. Based on our visual interpretation of the subsurface data encountered in our borings and test pits, it is our opinion that the potential for liquefaction and associated lateral spreading to impact the site is low east of Rheem Creek and east of the main trace of the Hayward fault. West of Rheem Creek the potential may be higher based on the Knudsen et al. (1997) map, but we do not have subsurface data in the western portion of the campus to generall quantify this potential. Lateral spreading may occur along the margins of Rheem Creek during an earthquake event. The liquefaction and lateral spreading potential should be further characterized where future structures are proposed on campus as part of the geotechnical engineering studies needed to develop grading, foundation, and drainage recommendations for such developments.

### 6.3.2 Dynamic Compaction

Another type of seismically induced ground failure, which can occur as a result of seismic shaking, is dynamic compaction, or seismic settlement. Such phenomena typically occur in unsaturated, loose granular material or uncompacted fill soils. The subsurface conditions encountered in the borings and test pits performed at the site are not considered conducive to such seismically induced ground failures. However, the possibility of shaking related random ground cracking affecting the site cannot be precluded.

The dynamic compaction potential should be further characterized during site-specific geotechnical engineering studies for future developments within the college campus.

### 6.3.3 Landslides and Seismically Induced Slope Failures

Most of the campus is on relatively level topography and as a result the potential for landsliding to affect the southern portion of the campus (approximately south of Rheem Creek) is considered low. Based on the contour lines on the Richmond 7.5 minute quadrangle, the hillside portion of the campus (approximately north of Rheem Creek) is on a 3.5:1 (horizontal to vertical) slope. No landslides were observed during our site reconnaissance or on aerial photographs. However, the bedrock lithology is generally weak claystone and sandstone, which may be vulnerable to instability, particularly during seismic events. We consider the potential for seismically induced slope failure to be moderate on the hillside portion of the campus.

## 6.4 FLOOD HAZARD AND EROSION

Flood hazards are generally considered from three sources, which include seismically induced waves (tsunami or seiche), catastrophic dam failure, and long-cycle storm events. The site is located approximately 6,000 feet from San Pablo (San Francisco) Bay at an elevation ranging from about 50 feet to 130 feet above mean sea level. The only historical account of tsunamis impacting the San Francisco Bay area is the "Good Friday" earthquake of 1964 (generated off the coast of Alaska), which caused only minor damage at Monterey and Moss Landing Harbors (CGS, 1972). Run-up at the Golden Gate Bridge was measured at 7.4 feet from the Good Friday earthquake and generally less further south. Based upon the site's distance to San Pablo Bay, elevation, and the lack of historically damaging tsunamis and seiches, we judge that the potential for a seismically induced wave to impact the site is low.

With respect to the 100-year storm events, ESRI/FEMA (Project Impact Information and Awareness Site [http://www.esri.com/hazards] and FEMA Flood Insurance Rate Map, Community-Panel Number 060337-0640 D, August 1982) indicate the area adjacent to San Pablo Creek and Wildcat Creek (over 3,000 feet south of the campus) are prone to flooding from 100-year storm events (Plate 13). This flooding is not shown to intrude onto the school campus.

With respect to flooding due to inundation caused by dam failure, the campus could be affected by failure of three dams as shown on Plate 14. The Briones Dam, San Pablo Dam and North Dam are all located upstream from the campus. The San Pablo Dam is the largest of these dams and is located approximately 4.5 miles southeast of the campus. It should be noted that on Plate 14, the location of North Reservoir dam and other features are erroneously located.

No evidence of excessive soil erosion was observed during our site reconnaissance.

### 6.5 NATURALLY OCCURRING ASBESTOS

California has experienced a rising concern over potential public exposure to naturally occurring asbestos in recent years. Medical studies have shown there is a connection between certain diseases (asbestosis, lung cancer, and mesothelioma) and asbestos exposure. Because the asbestos minerals are naturally occurring, and may be present in a variety of geologic environments, concern has been raised over possible environmental exposure of the public to asbestos minerals in California (Clinkenbeard et al., 2002). The geologic units that underlie the site (Contra Costa Group, alluvium) are not generally known to contain naturally occurring asbestos. However, the Contra Costa Group contains many conglomerate beds which received sediment from Franciscan sources during its time of deposition. Therefore, the presence of occasional clasts made up of rock types which may contain naturally occurring asbestos (such as serpentinite) cannot be ruled out. The closest mapped formation, which may contain naturally occurring asbestos is ultramafic rock located approximately 2 km to the south (Graymer et al., 1994; Plate 4). We believe that the potential for naturally occurring asbestos to impact the site is low.

### 6.6 RADON

Radon is a naturally occurring colorless, tasteless, and odorless radioactive gas that forms in soils from the decay of trace amounts of uranium that are naturally present in soils. Radon enters buildings from the surrounding soil through cracks or other openings in foundations, floors over crawlspaces, or basement walls. Once inside a building, radon can become trapped and concentrate to become a health hazard unless the building is properly ventilated to remove radon. Long-term exposure to elevated levels of radon increase one's risk of developing lung cancer (Blood, 2002).

Geologic formations which may contain uranium in concentrations above the crustal average (such as the Monterey Formation, asphaltic rocks, marine phosphatic rocks, granitic rocks, felsic volcanic rocks and certain metamorphic rocks) do not directly underlie the site (Churchill, 2000; Graymer et al., 1994).

The United States Environmental Protection Agency recommends that individuals avoid long-term exposures to radon concentrations above 4 picocuries per liter (pCi/L). Blood (2002) indicates that of 5 tests within the 94806 zip code area, within which the CCC is located, no tests had levels equal to or greater than 4 pCi/L. Therefore the potential for radon gas to impact the site is considered low.

## 6.7 EXPANSIVE SOILS

Moderately expansive clay soils were observed at the site surface during our site reconnaissance. The soil expansion at the site was characterized via laboratory testing of the surficial soils as part of our concurrent geotechnical investigations for the site. Pertinent mitigation measures addressing the potential presence of expansive soils should be presented in a site-specific geotechnical reports.

## 7.0 RECOMMENDATIONS

From a geologic-hazards perspective, it is our opinion that CCC campus developments and improvements can occur if the following recommendations are incorporated in the project design, plans, and construction.

- Site-specific geologic hazard assessments and design-level geotechnical investigation should be carried out for each building, cluster of buildings or specified development areas. Recommendations contained therein should be incorporated into the proposed development.
- Structures proposed within the Alquist-Priolo fault zone should have subsurface fault investigations conducted and analysis of fault rupture potential. This may incude review of existing fault trench data, site reconnaissance or new fault trenching. .
- Procedures from the 2001 CBC at a minimum should be implemented for a code-equivalent lateral-force design of structures within the project area. Near-Source Factors $N_a$ and $N_V$ to be used at the project site are 1.5 and 2.0, respectively.
- Structures built on the hillside portion of the campus (approximately north of Rheem Creek) should include an evaluation of slope stability.
- The campus is within a zone which could flood from dam failure of North Dam, San Pablo Dan and Briones Dam. The college's Civil Engineer should evaluate the potential for campus flood inundation and make appropriate recommendations.
- Due to the potential for severe seismic shaking at the campus, geotechnical investigations should address liquefaction and dynamic compaction possibilities where susceptible soils and fill may be present on campus.

## 8.0 LIMITATIONS

This report may be used only by the Contra Costa Community College District for the proposed development and by members of the design team as the School's representatives, and only for the purposes stated, within a one year from its issuance. Land use, site conditions (both on site and off site) or other factors may change over time, and additional work may be required with the passage of time. Any party other than the Contra Costa Community College District and its design team who wishes to use this report shall notify Kleinfelder of such intended use. Based on the intended use of the report, Kleinfelder may require that additional work be performed and that an updated report be issued. Non-compliance with any of these requirements by the clients or anyone else will release Kleinfelder from any liability resulting from the use of this report by any unauthorized party.

The conclusions and recommendations in this report are for the proposed campus development and only for that proposed development as described in the text of this report. The extent and nature of subsurface soil and groundwater variations may not become evident until construction begins. It is possible that variations in soil conditions and depth to groundwater could exist beyond the points of exploration that may require additional studies, consultation, and possible design revisions. If conditions are encountered in the field during construction, which differ from, those described in this report, our firm should be contacted immediately to provide any necessary revisions to these recommendations.

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# PLATES