Geologic Hazard Evaluation Report

Town of Scotia
Humboldt County, California

Prepared for:

Pacific Lumber Company

SHN Consulting Engineers & Geologists, Inc.

812 W. Wabash
Eureka, CA 95501-2138
707 / 441-8855

January 2006
005161.310

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QA / QC: GDS_____

Table of Contents

List of Illustrations

Abbreviations and Acronyms

g	Acceleration of gravity
mm/yr	millimeters per year
AAAS	American Association for the Advancement of Science
AAPG	American Association. of Petroleum Geologists
CDMG	California Department of Conservation, Division of Mines and Geology
FEMA	Federal Emergency Management Agency
NR	No Reference
DMG	Division of Mines and Geology
SHN	SHN Consulting Engineers & Geologists, Inc.
USGS	U.S. Geological Society
FIRM	Flood Insurance Rate Map

Introduction

This report presents the results of a geologic hazard assessment of the town of Scotia, conducted by SHN Consulting Engineers & Geologists, Inc. (SHN). The primary purpose of our investigation is to assess existing and potential geologic hazards that may affect the community. This information was requested by the Humboldt County Planning Department to supplement the environmental impact reporting for the proposed re-zoning of Scotia. Our focus is solely on geologic hazards that may affect the existing structures and facilities in Scotia, and is not intended to be applied to any new developments.

SHN conducted an evaluation of the geologic and geotechnical conditions at the site. The scope of our investigation was limited to the following items:

compilation and review of pertinent literature, maps, aerial photographs, and previously prepared reports;

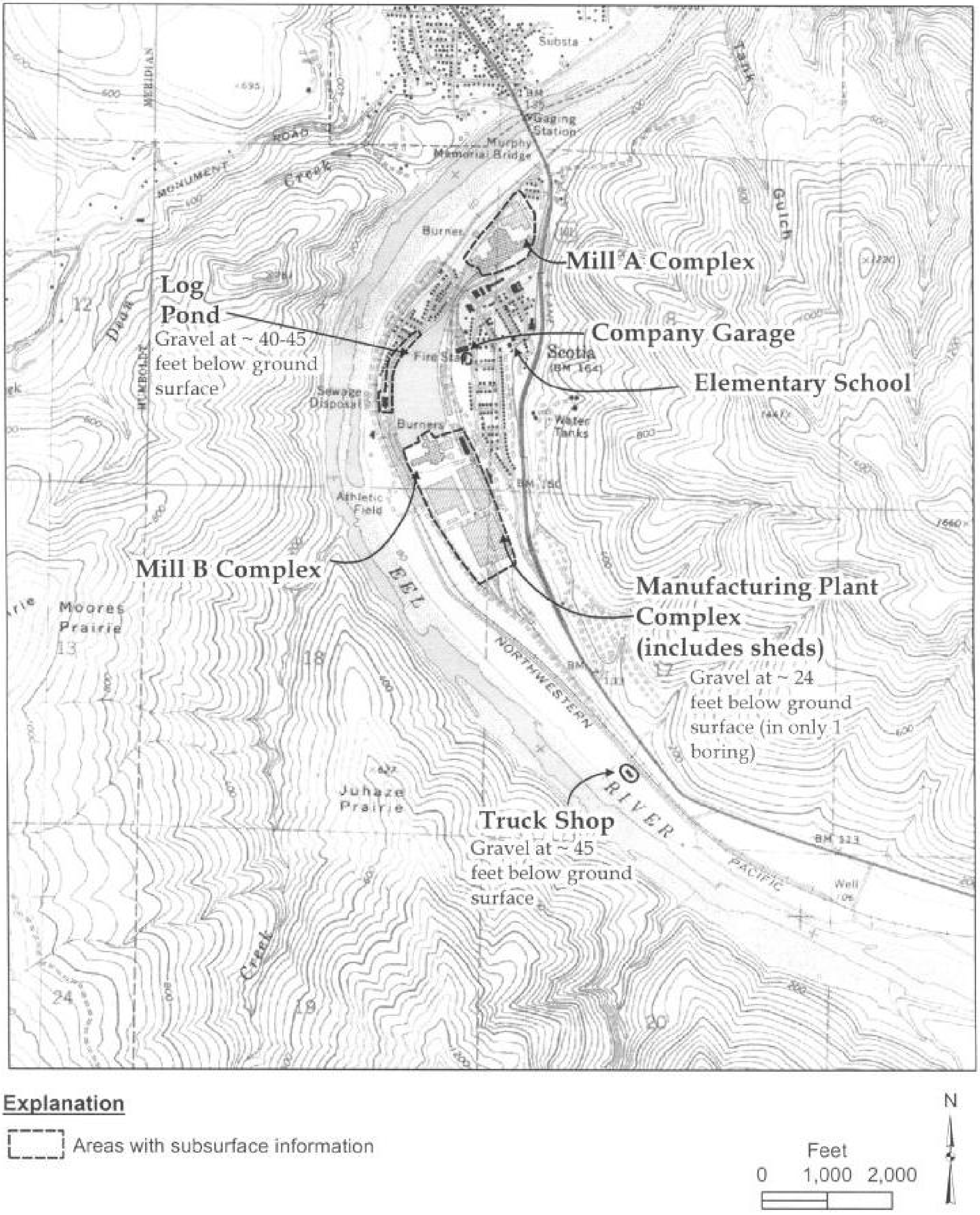
evaluation of existing geologic and soils data for the site; and

preparation of this report.

Site Conditions

Scotia is a small town located in an unincorporated part of central Humboldt County. The town is situated on a series of gently sloping fluvial terraces formed on an inside bend of the Eel River (Figure 1). These terraces are separated by steeper rises, with older terraces topographically higher than younger terraces. Residences in the eastern section of Scotia are located on the oldest fluvial terrace, with an elevation over 200 feet above mean sea level. The lowest part of Scotia, closest to the Eel River, lies at about 100 feet in elevation. Highway 101 borders the eastern part of town. Because most of the town is developed, much of the area has been previously graded and covered by varying amounts of fill. Near the old mills (Figure 1), the fill typically consists of up to 2 feet of woodwaste or sawdust. Mostly the fill is less than 5 feet thick, but may locally exceed 10 feet in thickness.

Buildings in the town of Scotia include residential structures, a hotel, offices, a shopping complex, museum, theater, former hospital, and a variety of lumber milling facilities (Figure 1). Most of the residential structures lie on the highest terrace, downslope of Highway 101, except for a series of homes along the river on the lowest terrace. Industrial facilities have been largely constructed on an intermediate age terrace below the primary residential area. These facilities include mill complexes (Mills A and B), a garage, and various equipment sheds (Figure 1). A log pond exists near the center of town; part of the embankment for this pond lies uphill of the lower residential area. A sewage treatment plant, park, soccer field, and baseball field lie on the lowest terrace surface, closest to the Eel River.



SHN Consulting Engineers & Geologists, Inc.	Scotia Geologic Hazard Report Pacific Lumber Company Humboldt County, California	Site Map Figure 1
	January 2006 FILE NAME	SHN 005161

Site Geology

Spittler (1982) mapped fluvial terrace deposits from the Eel River beneath much of Scotia (Figure 2). At least three of these terraces have topographic expression. Fluvial terrace deposits typically consist of silts, clays, and fine-grained sands overlying coarser sand and gravel. The terraces at Scotia formed during the Holocene and late Pleistocene. Gravel is deposited as bedload from the river, and finer grained material is deposited over the gravel as floodplain or overbank deposits. SHN borings near the log pond and truck shop demonstrate this depositional sequence (SHN 2000, 2000b). Thicker sections of clay are present near Mill A. The thickness of these overbank deposits may represent multiple large flood events in the past that have since weathered into clay. Two shallow borings near the elementary school (Figure 1) encountered fine sandy silt upslope of the thick clay accumulations. The transition of these deposits into clay further downslope may be the result of pedogenic processes.

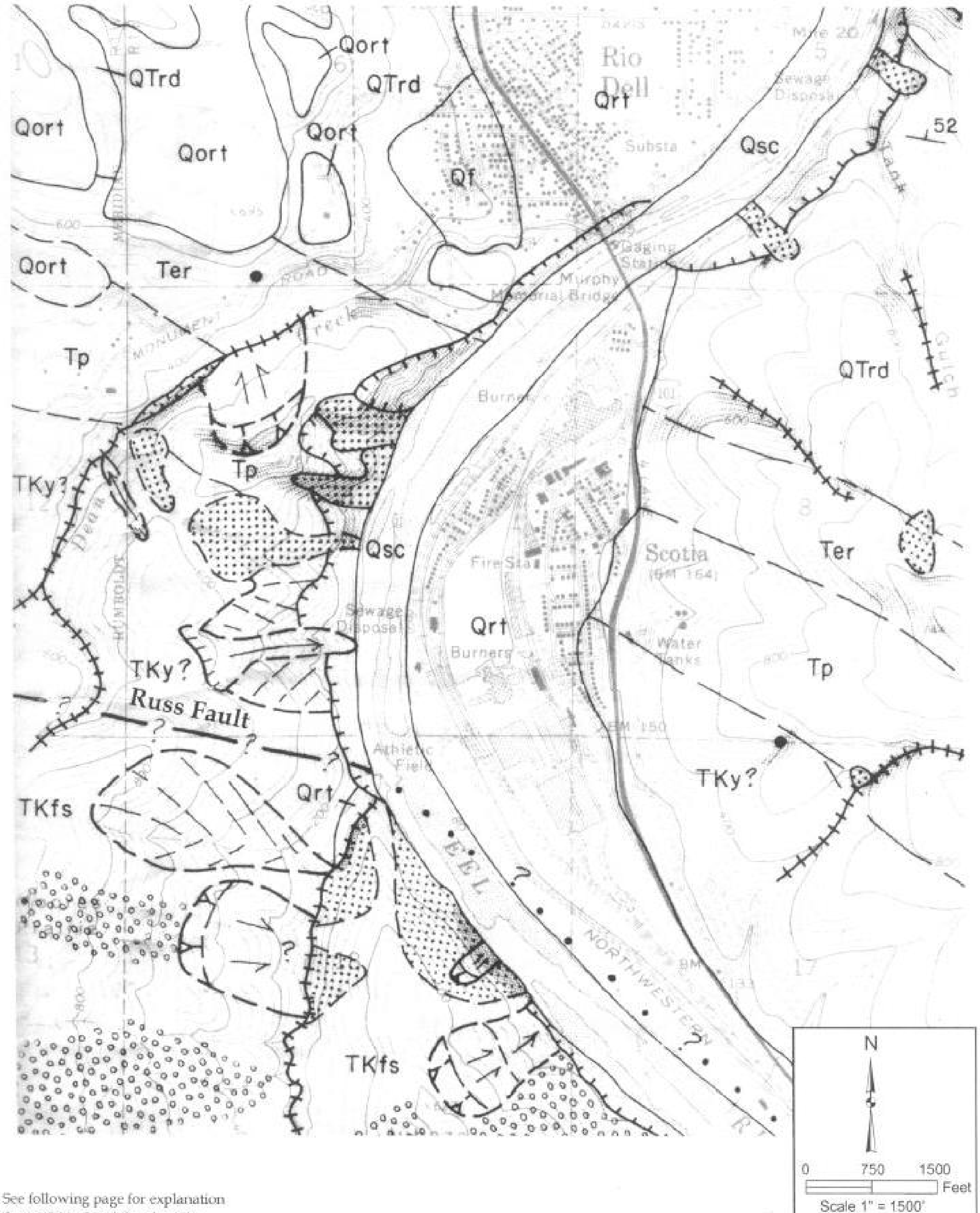
Upland areas east of Scotia are underlain by lithologic units comprising the Wildcat Group, including the Rio Dell Formation, Eel River Formation, and the Pullen Formation (Figure 2). These formations, composed of slightly indurated, interbedded marine mudstone and sandstone, are late Tertiary to early Quaternary in age (Spittler, 1982), and become progressively older to the south (Figure 2). Spittler has tentatively mapped Yager terrane near the southeastern portion of Scotia, lying unconformably beneath the much younger Pullen Formation. The Yager terrane, a subunit of the Franciscan Complex, is composed of late Cretaceous to early Tertiary siltstone, sandstone, mudstone, and conglomerate, highly sheared in places (Spittler, 1982). Scotia is less than a mile north of the Russ Fault Zone. The Russ fault is a westward-trending, southward-dipping, high angle reverse fault that juxtaposes basal Wildcat Group sediments against the underlying Coastal belt of the Franciscan Complex and defines the northern margin of the False Cape shear zone (Ogle, 1953). In the vicinity of Scotia, the Russ Fault is tentatively mapped as a fault contact between the older Franciscan Coastal terranes and the Yager terrane (McLaughlin and others, 2000).

Site Soils

Soil descriptions were compiled from logs previously prepared by SHN or other consultants. Excavation methods for these logs included truck mounted drill rigs, Geoprobes®, and hand augering. Maximum sampling depths were in excess of 50 feet. Geoprobes® were driven past 60 feet, though no samples were taken. Inferences on subsurface conditions were made based on how easily the probe penetrated the subsurface soils.

As previously mentioned, most of Scotia is located on varying amounts of fill. This fill generally consists of mixed silt, clay, and gravel. The finer grained material typically ranges from medium stiff to stiff; the river-run gravels are typically dense, well graded, and rounded, with large components of silt, sand and clay. Occasionally sawdust and woodwaste can be found in the upper 1 or 2 feet of fill. In general, the fill extends to about 5 feet or so in depth, though there are places (particularly around mills) where it exceeds 10 feet in depth.

Underlying the fill are thick accumulations of clay, silt, and fine sand, characteristic of overbank deposits. The silts and clays are typically sandy, medium-stiff to stiff, and brown in color. Occasionally sandier layers are intermixed with silt and clay. Portions of the Mill A site penetrate fine-grained sediments beyond a depth of 60 feet (SHN 2002a). Occasional increases in organics at



See following page for explanation
Scotia CDMG 7.5' Quadrangle

SHN Consulting Engineers & Geologists, Inc.	Scotia Geologic Hazard Report Pacific Lumber Company Humboldt County, California	CDMG Geologic Map (Spittler, 1982) Figure 2
	January 2006	Note: All locations approximate — SHN 005161.310

depth may indicate surfaces buried by flood events. Upslope of Mill A, at the elementary school, hand auger borings encountered native fine sandy silt below 2.5 – 3.5 feet of fill (Figure 1). A perched water table in one boring likely indicates finer material below the silt, though augering ceased at 5 feet (LACO, 2003).

Near the river, the fine-grained material overlies dense, rounded gravels with mixtures of sand, silt and clay in the matrix (Figure 1). Gravel (locally cobble-sized) is found at depths of 40 to 45 feet near the log pond and truck shop sites (SHN, 2000, 2002b). At the site of the PALCO Company Garage, two borings encountered 1 to 2.5 foot thick layers of gravel at 9 feet below the ground surface. These layers may be fill, as the gravel depths are inconsistent with gravel depths at locations closer to the river.

Seismic Setting

The north coast of California is one of the most seismically active regions in the continental United States. The area is located northeast of the Mendocino triple junction, the intersection of three crustal plates (Figure 3). More than 60 earthquakes have produced discernible damage in the region since the mid-1800s. Historic seismic and paleoseismic studies in the area suggest there are five distinct sources of damaging earthquakes in the region (Dengler et al, 1992):

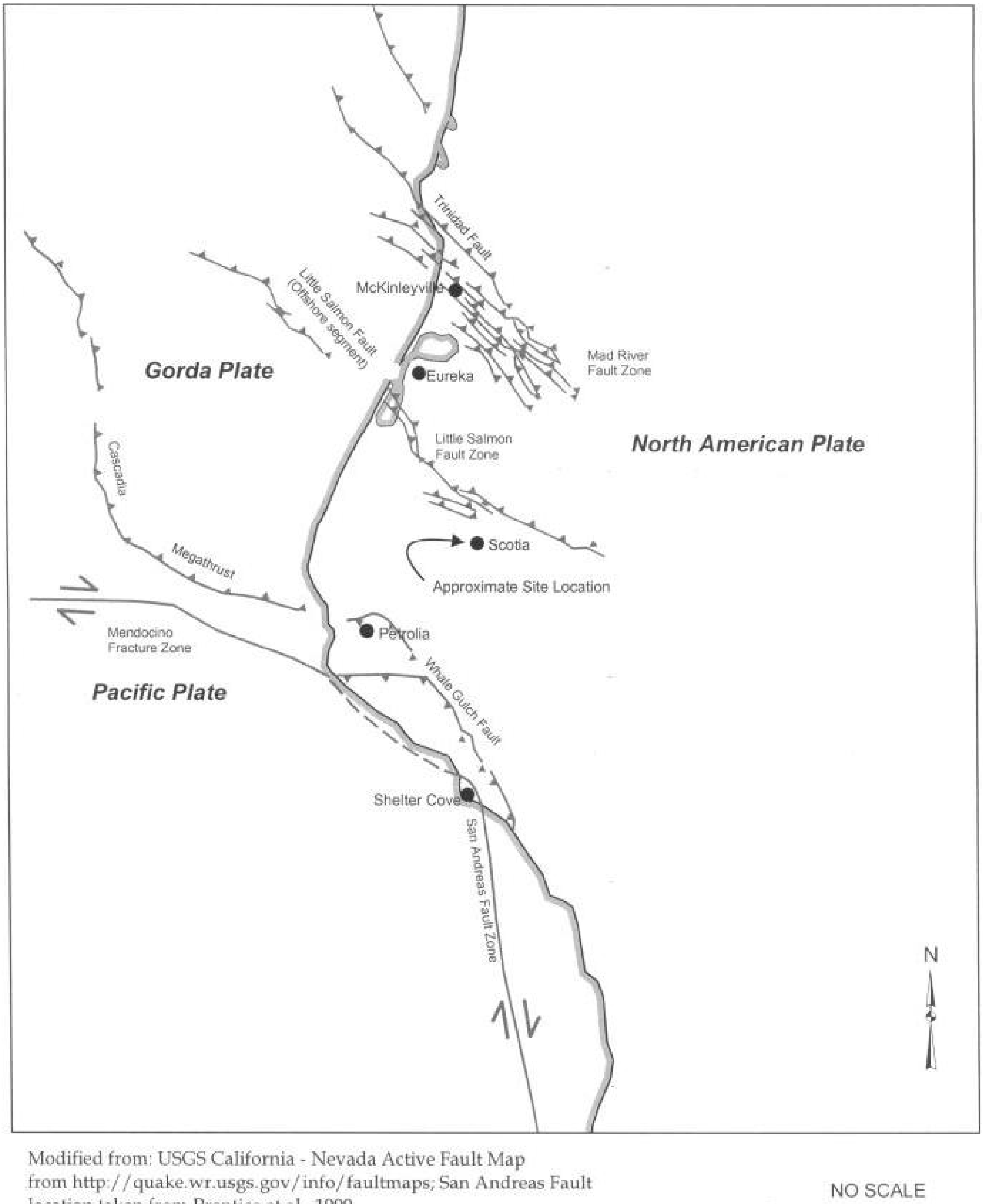
The Gorda Plate: This relatively small plate remnant is breaking up as it approaches the subduction zone. Frequent earthquakes are generated along left-lateral strike-slip faults within the plate itself. The plate is subducting in a northeastward direction.

The Mendocino Fracture Zone: This high-angle, east-west trending fault represents the plate boundary between the Gorda and Pacific plates. It generates predominantly right-lateral strike-slip earthquakes.

The Mendocino Triple Junction: Infrequent moderate magnitude earthquakes occur in the complex triple junction region. These events are generally shallow, onshore events in the magnitude 5 to 6 range.

Faults Within the North American Plate (Including the Mad River and Little Salmon Fault Zones): Along the leading edge of the North American plate where it over-rides the Gorda plate, oblique compression is manifested along a broad, northwest-trending fold-and-thrust belt. Individual faults within the belt could produce earthquakes in excess of magnitude 7.

The Cascadia Subduction Zone: This zone is the most significant potential seismic source in the region. A great subduction event, rupturing from Cape Mendocino to British Columbia could be up to magnitude 9.5. Recurrence interval estimated at 300 to 500 years. The last subduction event likely occurred 300 years ago. In general, Cascadia Subduction Zone earthquakes represent the most significant hazard to development throughout the Pacific Northwest. A great subduction event would generate very strong, long duration ground shaking that would result in significant land-level changes (several meters of uplift or subsidence may occur in many coastal areas), and is likely to trigger large-scale coseismic landsliding.



Modified from: USGS California - Nevada Active Fault Map from http://quake.wr.usgs.gov/info/faultmaps; San Andreas Fault location taken from Prentice et al., 1999.

NO SCALE

Note: All locations are approximate

SHN Consulting Engineers & Geologists, Inc.	Scotia Geologic Hazard Report The Pacific Lumber Company Humboldtr County, California	Tectonic Setting SHN 005161
	January 2006 / faultmap.mxd	Figure 3

The San Andreas Fault: This fault represents the right lateral translational boundary between Pacific and North American Plates. A magnitude 8.3 earthquake in 1906 resulted in considerable damage along North Coast, with shaking intensities possibly as high as VIII or IX in Briceland, Eureka, Fortuna, Ferndale, and Petrolia (Dengler, 1992). Large cracks were observed in the Eel River delta, subparallel to the river, and a landslide in the Scotia Bluffs north of Scotia blocked the North Coast railroad (Dengler, 1992; Reagor and Brewer, 1992).

Seismic shaking poses a significant hazard to existing residences in Scotia. Approximately 40 of the 270 clapboard homes owned by PALCO were damaged by the 1992 Petrolia Earthquake (Reagor and Brewer, 1992). Modified Mercalli Intensity Scale ground shaking values of VIII were recorded in the towns of Rio Dell and Scotia.

An array of strong motion sensors (part of the California Strong Motion Instrumentation Program) are present on the Painter Street overpass in Rio Dell, and have recorded seismic shaking from a number of moderate and large earthquakes. The presence of these instruments provides a rare opportunity to use measured acceleration values, rather than estimates based on mathematical models. Strong seismic shaking was recorded at the Rio Dell instrument station during the Petrolia earthquakes on April 25 and 26, 1992. Although a range of values was recorded, depending on the relative location on the overpass structure, the most relevant values are probably those measured away from the structure. One instrument station, located 320 feet from the overpass, recorded accelerations up to 0.55 g (acceleration of gravity) during the April 25th main shock, as well as during the first major aftershock on April 26th. Larger accelerations were recorded on the overpass (up to 1.23 g), but we assume these reflect structural response to shaking. We note here, however, that strong motion instruments near the epicenter of the 1992 earthquakes recorded accelerations approaching 2 g, illustrating the potential for very strong ground shaking throughout the north coast region.

The Little Salmon Fault is the nearest active fault to the town of Scotia (Figure 3); the main trace of the fault has been mapped approximately 5 miles northeast of town (McLaughlin and others, 2000). This particular fault is a northwest-trending, northeast-dipping thrust fault that dissects slopes along the northern valley wall of the Van Duzen River (Clarke and Carver, 1992). The Little Salmon fault appears to be the most active on-land fault in the Humboldt Bay region, and is capable of generating very large earthquakes. Offset relations within the upper Wildcat Group suggest that vertical separation exceeds 5,900 feet, representing about 4.4 miles of dip-slip motion on the Little Salmon fault since the Quaternary (that is, in the past 700,000 to 1 million years; Woodward-Clyde Consultants, 1980). The fault is associated with a slip rate in excess of 6 millimeters per year (mm/yr) (Carver and Burke, 1992). Paleoseismic studies of the Little Salmon fault indicate that the fault deforms late Holocene sediments at the southern end of Humboldt Bay (Clarke and Carver, 1992). Estimates of the amount of fault slip for individual earthquakes along the fault range from 15 to 23 feet. Radiocarbon dating suggests that earthquakes have occurred on the Little Salmon fault about 300, 800, and 1,600 years ago (Carver and Burke, 1992). Average slip rate for the Little Salmon fault for the past 6,000 years is between 6 and 10 mm/yr. Based on currently available fault parameters, the maximum magnitude earthquake for the Little Salmon fault is thought to be between 7.0 (CDMG/USGS, 1996) and 7.3 (Geomatrix Consultants, 1994).

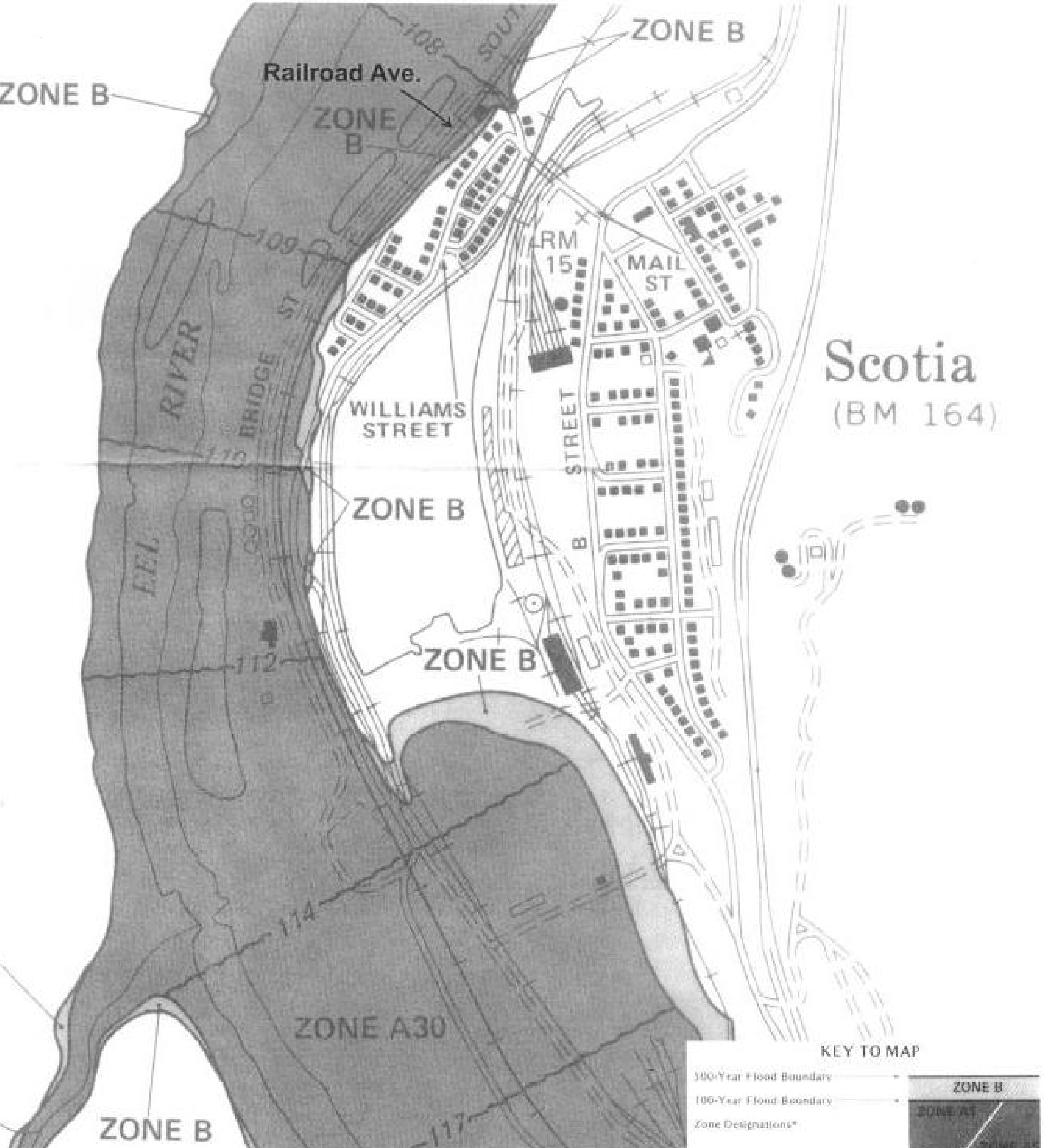
Scotia is located less than a mile from the mapped trace of the Russ fault zone (McLaughlin and others, 2000). Possible late Cenozoic movement along the Russ fault is indicated by fracturing of Wildcat deposits along its trend and offset of late Quaternary marine terraces (Clarke, 1992; Kelsey and Carver, 1988). The Russ fault eventually dies out in the Yager terrane of the Coastal belt near the northeastern flank of the southeast plunging Garberville antiform (McLaughlin and other, 2000). The apparent southwest dip of the fault suggests that this fault zone may be affiliated with the interaction between the Pacific and North American plates rather than the Cascadia margin. This fault is not considered active by the State of California under the provisions of the Alquist-Priolo Earthquake Fault Zone Act (Hart and Bryant, 1997). No active faults have been mapped as passing through Scotia.

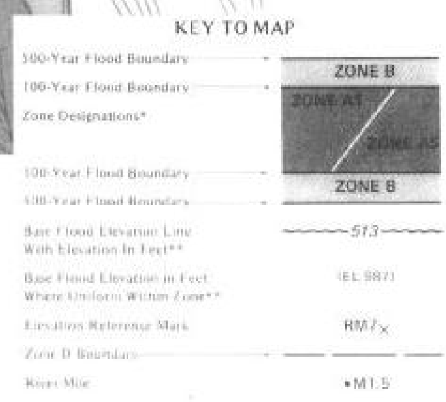
Liquefaction

Liquefaction occurs when seismic shaking of loose sands results in the upward migration of water through the pore spaces in the sand. If cracks are present above such liquefied layers, the saturated sediment can erupt to the ground surface, forming a sandblow. Structures built above liquefiable sands can sustain significant damage. Liquefaction typically occurs in young alluvial sands on an active floodplain. Most of the sediments at Scotia are silts and clays, and thus not prone to liquefaction. Sandy layers, usually at greater depths, are occasionally mixed in with the finer grained material. Boring logs indicate these sands are typically dense, though occasionally loose to medium dense layers are encountered in fill near the log pond (SHN, 2000). The variable nature of fluvial deposits allows the possibility for perched water tables in these less cohesive sandy layers, and the potential for liquefaction cannot be ruled out. Cracks were observed along the log pond embankments and spillway conduit after the 1992 Petrolia earthquakes, though these cracks could be the result of settlement and not liquefaction (SHN, 2000). No structural damage resulting from liquefaction was reported after the 1992 Petrolia earthquakes, though sandblows were observed along the active floodplains of the Mattole and Eel Rivers (Prentice, Keefer, and Sims, 1992).

Flood Hazard

The town of Scotia is located in close proximity to the Eel River. In December of 1964, an exceptionally large flood inundated the western portion of Scotia near Railroad Avenue, resulting in the loss of 3 homes, with several more inundated (Humboldt Beacon, undated). Log decks near the manufacturing plant were washed out, resulting in the loss of millions of feet of timber. The bridge to Rio Dell was also washed out (Humboldt Beacon, undated). As a result of the 1964 floods, the Federal Emergency Management Agency (FEMA)has produced Flood Insurance Rate Maps (FIRM) for communities near the Eel River. The FEMA FIRM maps (Figure 4) show that most of Scotia lies in a Zone C, or an area of minimal flooding potential. Most of the Mill B Complex lies in Zone C, though the southern edge appears to lie in Zone B, an area considered to lie between the limits of a 100 and 500-year flood. Zone B continues around the upper portion of the manufacturing plant, though most of the plant complex appears to lie in Zone A30, which represents an area where inundation will occur during a 100-year flood with a base elevation of 30 feet. Aside from the manufacturing plant complex, the lowest terrace, which includes the sewage treatment plant, lies within the 100-year flood plain. Railroad Avenue also lies in Zone A30, near the same area where houses were lost in 1964 (Figure 4). It is important to note that 100-year floods





Zone A30: Areas of 100-year flood; base flood elevations and flood hazard factors determined (30 feet).

Zone B: Areas between limits of the 100 year flood and 500-year flood; or, certain areas subject to shallow 100-year flooding

Zone C (unshaded): Areas of minimal flooding

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Slope Stability

No active landslides are mapped in the town of Scotia, and most of the town lies on low gradient ground. Steeper slopes separate the terraces; one such riser was used as the western embankment of the log pond. The embankment of the log pond was found to be stable in a report by SHN dated August 2000. High flows or strong seismic shaking may destabilize the banks along the Eel River, though only Railroad Avenue and the sewage treatment plant area would be affected. Most landsliding along the Eel River has occurred on the left bank, where the erosive potential is the highest due to the orientation of the bend in the river and the absence of terraces. Coseismic landsliding occurred during the 1992 Petrolia Earthquake at the Scotia bluffs north of Scotia (Reagor and Brewer, 1992). Few mass wasting features have been mapped on the hillsides above Scotia (Spittler, 1982), and Highway 101 would provide a significant buffer for the town should slope failures occur in these hills.

Conclusions

1. The primary geologic hazard in Scotia is seismic shaking. While most of the damage in Scotia from the 1992 Petrolia earthquake was caused by a fire, many residences experienced cracked chimneys and dislocated foundations. Earthquakes of a similar or greater magnitude can be expected to occur in the future, and would likely produce the same type of damage.
2. Because Scotia lies on older, consolidated floodplain deposits (mostly silts and clays), liquefaction remains a low hazard.
3. Lower elevation areas in Scotia are subject to inundation by large floods. Historically only the western portion of town has been inundated, and this area is at risk for large flood events in the future. Most of Scotia is located on ground high enough to be unaffected by the largest historical floods.
4. Slope failure is a low level hazard in Scotia. No historical landslides have occurred within the town, and there is no geologic no geomorphic evidence for large, catastrophic landslides that could cross Highway 101 and reach structures in Scotia. Failures are more likely to occur on the banks opposite of Scotia, where the river is directed toward the banks.

Limitations

The analyses and conclusions contained in this report are based on site conditions observed at the time of our past investigations, data from subsurface explorations and laboratory tests, our current understanding of proposed project elements, and on our experience with similar projects in similar geotechnical environments. We have assumed that the information obtained from our limited subsurface explorations is representative of subsurface conditions throughout the site. To confirm this assumption, a representative of our firm must observe and evaluate actual soil conditions encountered during future construction operations.

Subsurface conditions may differ from those disclosed by our limited investigations. If differing conditions are encountered during construction, our firm should be notified immediately so that we can reevaluate the applicability of our conclusions. Assumptions about other site characteristics, such as hazardous materials contamination, or environmentally sensitive or culturally significant areas, should not be made from this report.
Our firm has prepared this report for your exclusive use on this project in substantial accordance with the generally accepted geotechnical engineering practice as it exists in the site area at the time of our study, including time and budget constraints. No warranty is expressed or implied.

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