Utah County Planning Commission Packet
Rocky Mountain Power / PacifiCorp CUP Application,
Spanish Fork–Mercer 345 kV Transmission Project

Prepared Findings of Law and Fact, Decision Flowchart, Conditions, and Recommendations

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Submitted by:
Protect Salem Park Residents & Wildlife Coalition
Representing 1,200+ Concerned Residents

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Executive Overview

To the Utah County Planning Commission:

You are entrusted—as *our* land-use authority—with a vital responsibility: upholding the aims of the **County Land Use, Development, and Management Act**. That law mandates you preserve public health, safety, and general welfare, enhance aesthetics, ensure fairness, and **safeguard property values**[1].

These core duties are your legal and ethical foundation. If any proposed action fails to advance these purposes—or, worse, directly undermines them—it cannot stand. Utah Code also permits you to consider community and private property interests, balancing them with statutory and constitutional protections.

Key Concerns with Rocky Mountain Power/PacifiCorp's Conditional Use Permit (CUP) Application

1. Notice Violations Are Fatal

Utah law requires strict compliance with notice requirements[2].

Rocky Mountain Power/PacifiCorp failed to comply with these strict notice requirements in multiple ways. They never notified dozens of directly affected property owners[3], including at least 40 homes within the Salem Park neighborhood[4] that lie in the 250 ft corridor. Even the notices[5] they claim to have sent were legally deficient because they omitted the required project contact address and a specific corridor map[6], not just a study map. That means residents were either never notified at all—or, if they had been, the notice still would not have satisfied the law.

To compound matters, in their own August 22, 2025 letter to Salem Park residents, Rocky Mountain Power listed newspapers where notice was supposedly published[7]. Yet according to those very newspapers, no such notices ever appeared in their papers[8]. This is to say that **no one along the proposed line has received their duly required legal notice** of this project.

Because the statutory notice was defective, the **public workshops held under that defective notice are also invalid[9]**. Proper notice must be issued first, and only then may public workshops be held. Until both are corrected and completed, notice cannot be considered legally sufficient.

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[1] Exhibit A - Utah State Code Chapter 27a County Land Use, Development, and Management Act
[2] Exhibit B - Utah Code 54-18-301(3)(4)
[3] Exhibit C - Utah Code 54-18-102
[4] Exhibit S - Resident's Affidavits
[5] Exhibit D - Mercer 60 Day Notice
[6] Exhibit B - Utah Code 54-18-301
[7] Exhibit E - Aug 22 2025 RMP Letter
[8] Exhibit F 1, 2, 3 - Daily Herald Email, Deseret News Email, Salt Lake Trib Email
[9] Exhibit G - Utah Code 54-18-302

The Utah Supreme Court in *Springville Citizens v. Springville* (1999) held that when an ordinance or statute uses the words “shall” or “must,” compliance is **mandatory—not optional**[10]. The **Utah County Land Use, Development, and Management Act (LUDMA)** reinforces this rule by requiring counties to strictly comply with notice provisions in Part 2 and by declaring that a land use decision is **illegal if it conflicts with statutory authority or is based on an incorrect interpretation of law**

Because notice is the foundation of due process, the Commission has **no discretion** to excuse or overlook defective notice. If statutory notice is not fully and lawfully given, the County lacks jurisdiction to proceed, and any conditional use permit issued under those circumstances is **invalid and void as a matter of law**.

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2. Unmitigated Detrimental Effects

Under **Utah Code § 17-27a-506**, the Commission must:

1. Identify all detrimental effects created by the CUP, and

2. **Deny** the CUP if those effects cannot be reasonably mitigated with enforceable conditions.

Rocky Mountain Power has the burden to prove—**by a preponderance of the evidence on the record**—that all impacts are substantially mitigated[11]. They have not met this standard. The application fails to sufficiently address at least 13 adverse impacts under UCLUO 16.94(C):

[10] Exhibit H - Springville Citizens v. The City of Springville -Utah Supreme Court
[11] Exhibit I - UCLUO 16.94 Rules

Unmitigated Detrimental Effects

Effect	Evidence	Mitigation Status
(5) Bodily injury	EMF fields as low as **0.4 µT** linked to **doubling childhood leukemia risk**; line expected to produce **>3.0 µT**, more than **7× higher**.[12]	**No shielding, setbacks, or monitoring proposed.**
(5) Property damage	Homes within 100 ft of high-voltage lines typically lose **10–15% value**,[13] legally recognized as property damage[14] & inverse condemnation.	**No compensation, easements, or offsets offered.**
(13) Creeks, ponds, wetlands	Route crosses wetlands and a pond; vegetation removal and erosion likely.	**No environmental study or wetland mitigation submitted.**
(14) Natural environment of site	Dust, soil disturbance, and vegetation clearing will impact air and water quality.	**Only generic "dust control" noted; no enforceable plan.**
(14) Natural environment of surrounding areas	Tall monopoles (90–135 ft) immediately abut dense wetlands, creating extreme disharmony.	**No setback or compatibility plan.**
(14) Wildlife, wildlands	The Applicant offers only general assurances of avoidance, with no wildlife surveys or species-specific mitigation measures.	**Without studies or enforceable plans, impacts to raptors and wildlife remain unmitigated.**

[12] Exhibit J - Mercer Magnetic Field Levels at Salem Park
[13] Exhibit R - Home Values Damage
[14] Exhibit L - Utah Code 78B-6-511- Property Damage as Loss in Market Value

(15) Buffering/screening of objectionable site features	Towers and 345 kV wires create industrial visual blight.	**No screening, fencing, or vegetative buffers proposed.**
(15) Disharmony with existing land uses	Adjacent land use is an established large neighborhood of single-family housing.[15]	**No setbacks to reduce disharmony.**
(15) Proximity of incompatible uses	Transmission corridor directly abuts children's play areas, backyards and homes.[16]	**No protective measures provided.**
(18) Noise	Construction equipment and ongoing line "humming" create nuisance noise.	**No noise analysis or limits offered.**
(18) Electromagnetic disturbances	Chronic EMF exposure at unsafe levels for residences.[17]	**No monitoring, shielding, or reduction measures.**
(18) Radiation	Applicant relies on irrelevant short-term standards (<0.2 seconds exposure).[18]	**No chronic exposure mitigation proposed.**
(20) Federal, constitutional & State compliance	**The 5th Amendment**[19] & Utah Constitution Article 1.22[20] prohibit taking property without just compensation; 20% equity loss = inverse condemnation.[21]	**No compensation mechanism offered.**

[15] Exhibit Q - Neighborhood Adjacent Land Use
[16] Exhibit K - Children's play areas & Transmission Lines
[17] Exhibit J - Mercer Magnetic Field Levels at Salem Park
[18] Exhibit P - Institute of Electrical and Electrons Engineers Standard for Safety Levels (IEEE) pg 17
[19] Exhibit N - U.S. Constitution - Fifth Amendment
[20] Exhibit O -Utah Constitution Article 1, Section 22
[21] Exhibit M - Colman v. Utah State Land Bd.__ Utah Supreme Court Decisions

3. Misleading or Incomplete Representations

- Rocky Mountain Power/PacifiCorp's "medical expert" relied on standards meant only for **short bursts of EMF exposure**[22], which are irrelevant to the **chronic, long-term exposure** families would face in their homes. He also claimed that "typical daily EMF exposure" is not harmful. But that statement is misleading: daily background exposure usually measures only **0.01–0.1 μT**, while a 345 kV transmission line produces **several microteslas (μT)—orders of magnitude higher**[23] than ordinary daily levels. Comparing those two scenarios is not scientifically or legally valid.

- Records from the **Deseret News, Salt Lake Tribune, and Daily Herald** show **no published notices**[24], despite Rocky Mountain Power/PacifiCorp's claims.

- Rocky Mountain Power/PacifiCorp claimed undergrounding is infeasible and would cost "20x more," while simultaneously admitting they have **no engineering studies and no knowledge of how to build underground lines**—two irreconcilable positions.

- They repeatedly stated a preference to follow existing rights-of-way, **yet omitted mention of the nearby corridors** by Salem Park that could be used instead of forcing new lines against family neighborhoods.

Overall, the record is incomplete and misleading, failing the legal burden of substantial evidence.

Recommendation

Deny Rocky Mountain Power/PacifiCorp's CUP application in its current form, because:

- **Legal Deficiencies** – Statutory notice requirements were not met.

- **Unmitigated Harms** – Numerous serious impacts remain unaddressed.

- **Misrepresentation** – The record is unreliable and fails the required evidentiary burden.

If continued consideration is deemed necessary, impose these minimum conditions:

- Full, corrected notice and a re-set public hearing timeline.

[22] Exhibit P - Institute of Electrical and Electrons Engineers Standard for Safety Levels (IEEE) pg 17
[23] Exhibit J - Mercer Magnetic Field Levels at Salem Park
[24] Exhibit F 1, 2, 3 - Daily Herald Email, Deseret News Email, Salt Lake Trib Email

- Independent, third-party EMF, environmental, and engineering studies.
- A feasible underground routing analysis with cost verification.
- ≥300 ft setbacks, shielding, fencing, and visual screening for all residential-adjacent areas.
- Wetlands and wildlife protection measures, with U.S. Fish & Wildlife Service input.

Conclusion

Your mandate is to protect the public's welfare and property rights. Approval of Rocky Mountain Power's application—absent full compliance and credible mitigation—is **legally unsupportable and ethically indefensible**.

Suggested Motion for Denial:

"I move that the Commission deny the conditional use permit filed by Rocky Mountain Power for the 345 kV transmission line route due to insufficient notice to affected landowners, failure to mitigate significant detrimental effects as required by Utah law (including EMF exposure, property value loss, environmental and nuisance impacts), and reliance on misleading information. In the alternative, we may reopen the application only upon complete compliance and credible mitigation documentation."

Or

Alternative Motion for Approval With Conditions:

"Chair, I move that we approve the Conditional Use Permit for Rocky Mountain Power only on the condition that the Applicant satisfies every requirement in the Conditions Sheet before beginning construction. These include corrected statutory notice, independent third-party studies, enforceable setbacks and performance standards, property value and environmental protections, and continuous compliance monitoring. If any single condition is not met, the permit shall be considered invalid."

(conditions sheet on next page)

Conditions Sheet – Rocky Mountain Power CUP Application

Spanish Fork–Mercer 345 kV Transmission Line

A. Notice & Process

☐ Corrected notice mailed to all affected owners (with **contact address** & **specific corridor map**)

☐ Proof of publication in required newspapers (tear sheets / affidavits)

☐ Complete mailing list and affidavits of mailing filed

☐ Statutory 60-day re-notice period restarted if defects found

☐ Hold new public workshops with corrected notice, including mailed, published, and posted notices, to ensure affected residents have a fair opportunity to participate.

B. Independent Studies (3rd-Party, County-Directed)

☐ EMF exposure modeling & spot measurements (with chronic exposure analysis)

☐ Property value impact analysis by certified appraiser/economist

☐ Alternatives analysis (use of existing ROWs, route shifts, no-build)

☐ Underground feasibility report (engineering basis + verified cost estimates)

☐ Wetlands/waters delineation & wildlife survey (raptors, migratory birds, pond)

☐ Noise & vibration study (construction + operational hum)

☐ Traffic/construction plan (haul routes, hours, road protection)

C. Setbacks, Buffers & Performance Standards

☐ Residential setback: **≥300 ft from homes** (or greater to meet standards)

☐ Environmental setback: **≥100 ft from wetlands, ponds, and critical wildlife habitat**

☐ EMF at property line ≤ **0.3 µT (3 mG)**

☐ Noise ≤ **55 dBA day / 45 dBA night** at dwellings

☐ Buffering/screening plan (fences, vegetative screens, pole finish)

D. Environmental Protections

☐ Wetlands & water permits (USACE, state) obtained and filed

☐ Wildlife protections (raptor timing, collision risk mitigation)

☐ SWPPP & dust control plan with specific triggers and water source

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E. Property & Community Protections

☐ Property Value Protection Program (easements, compensation fund, or value-guarantee for 0–500 ft homes)

☐ Construction damage/road repair bond posted

☐ Decommissioning bond & plan for structure removal/restoration

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F. Compliance & Enforcement

☐ Independent compliance monitor (county-retained, utility-funded)

☐ Continuous EMF & noise monitoring with public dashboard

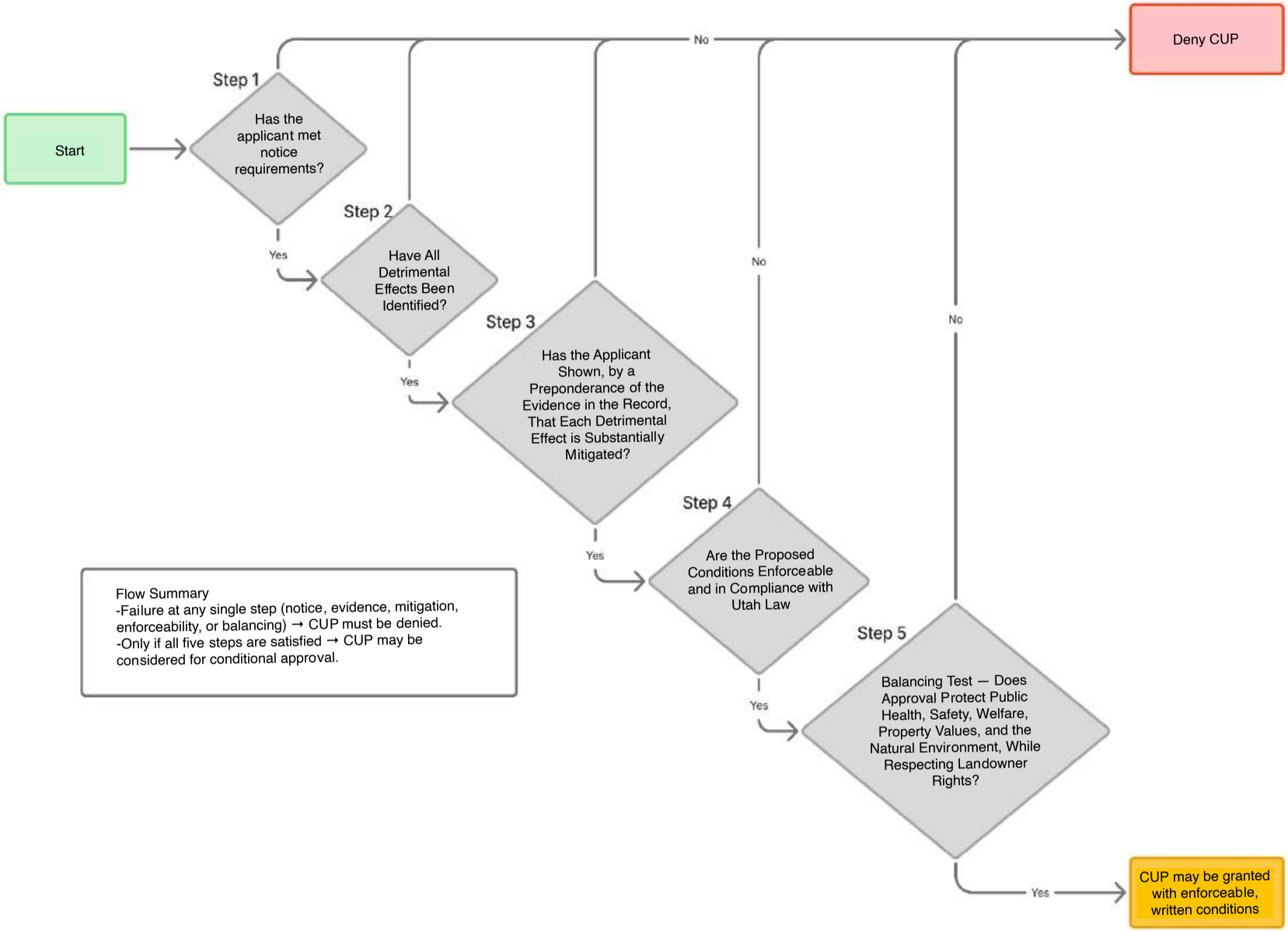
☐ Enforcement triggers: exceedance = immediate corrective action

☐ CUP phasing & expiration schedule adopted

Commission Guidance:

- **All boxes must be checked** before the CUP can lawfully proceed.
- Failure on any single condition = grounds for **denial**.

CUP Decision Flowchart



Flow Summary
-Failure at any single step (notice, evidence, mitigation, enforceability, or balancing) → CUP must be denied.
-Only if all five steps are satisfied → CUP may be considered for conditional approval.

Findings of Law & Fact

I. Notice Defects (Jurisdictional Findings)

Finding 1

Law/Requirement:

Utah Code requires counties to provide **statutory notice** before acting on a conditional use permit application (§ 17-27a-205, § 17-27a-801). The Utah Supreme Court in *Springville Citizens v. Springville* (1999) held that when an ordinance or statute uses “shall” or “must,” compliance is **mandatory—not discretionary**.[25]

Evidence in Record:

The Applicant has not demonstrated that the required statutory notices were provided in full compliance with law.

Finding:

The Commission has **no discretion to overlook or excuse defective notice**. Without strict compliance, the County lacks jurisdiction to consider the application.

Finding 2

Law/Requirement:

Utah Code § 54-18-301 requires mailed notice to “each affected landowner” and directly affected property owners. Notice is jurisdictional; without it, proceedings cannot lawfully move forward.[26]

Evidence in Record:

At least **40 homes in the Salem Park neighborhood**—located directly adjacent to the proposed transmission corridor—received no mailed notice. Affidavits from homeowners confirm this.[27]

Finding:

Because dozens of directly affected property owners were not notified, the statutory requirement was not met, and the CUP application is invalid as a matter of law.

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[25] Exhibit H - Springville Citizens v. The City of Springville -Utah Supreme Court
[26] Exhibit B - Utah Code 54-18-301(3)(4)
[27] Exhibit S - Resident's Affidavits

Finding 3

Law/Requirement:

Notices must include sufficient detail to inform property owners of the proposal, including **a contact person and address** and the **specific corridor map** (Utah Code § 54-18-301).[28]

Evidence in Record:

The notices PacifiCorp claims to have sent omitted the required project contact address and included only a broad study area, not the **specific corridor alignment**.[29]

Finding:

Even if notices were mailed, they were **legally deficient** and did not meet statutory content requirements. Therefore, notice was not validly given.

Finding 4

Law/Requirement:

Utah Code § 54-18-301 requires publication of notice in a newspaper of general circulation.[30]

Evidence in Record:

In its August 22, 2025 letter to Salem Park residents, PacifiCorp identified the **Deseret News, Salt Lake Tribune, and Daily Herald** as newspapers where notice was supposedly published.[31] Each of these outlets confirmed that **no such legal notices ever appeared**.[32]

Finding:

Because newspaper publication requirements were not satisfied, statutory notice has not been completed.

Finding 5

Law/Requirement:

[28] Exhibit B - Utah Code 54-18-301(3)(4)
[29] Exhibit D - Mercer 60 Day Notice
[30] Exhibit B - Utah Code 54-18-301(3)(4)
[31] Exhibit E - Aug 22 2025 RMP Letter
[32] Exhibit F 1, 2, 3 - Daily Herald Email, Deseret News Email, Salt Lake Trib Email

Utah Code Title 54, Chapter 18 (High Voltage Power Line Siting Act) requires both proper notice and public workshops as part of the CUP process. Public workshops are valid only if they follow lawful notice.[33]

Evidence in Record:

The Applicant held several public workshops in 2024. However, because the statutory notice was defective, those workshops did not satisfy legal requirements.

Finding:

The Applicant must first provide **corrected statutory notice** and then hold **properly noticed public workshops**. Until both are completed, the application cannot lawfully proceed.

Conclusion (Notice):

Strict statutory notice is a threshold requirement under both LUDMA and *Springville Citizens*. Because mailed notice, content requirements, and newspaper publication all failed—and because public workshops were therefore invalid—the County **lacks jurisdiction** to consider this CUP. Any approval issued would be **illegal and void**.

II. Unmitigated Detrimental Effects (Substantive Findings)

Utah Code § 17-27a-506 and UCLUO 16.94 require the Planning Commission to:

1. Identify all detrimental effects of a conditional use; and

2. Deny the permit if those effects cannot be reasonably mitigated through enforceable conditions.

The burden is on the **Applicant** to prove, by a preponderance of substantial evidence in the record, that all effects are mitigated.[34]

Finding 6 — Bodily Injury (EMF Exposure)

Law/Requirement:

UCLUO 16.94(C)(5) requires mitigation of bodily injury risks to persons in the affected area.

Evidence in Record:

[33] Exhibit G - Utah Code 54-18-302
[34] Exhibit I - UCLUO 16.94 Rules

Peer-reviewed studies show that EMF exposure at **0.4 µT doubles childhood leukemia risk**.[35] The proposed 345 kV line will generate **>3.0 µT at property lines**, far above ordinary background exposure of 0.01–0.1 µT.[36] The Applicant submitted **no shielding, setback, or monitoring plan**.

Finding:

The Applicant failed to mitigate health and safety risks. CUP cannot be approved under subsection (5).

Finding 7 — Property Damage (Property Values)

Law/Requirement:

UCLUO 16.94(C)(5) also requires mitigation of property damage risks. Loss of market value is recognized under Utah and federal law as a compensable injury.[37]

Evidence in Record:

Homes within 100 ft of transmission lines typically lose **10–15% of market value**.[38] For Salem Park families, this equals catastrophic losses in the hundreds of thousands of dollars. The Applicant offered **no compensation, easements, or property value protection program**.

Finding:

The Applicant failed to mitigate property damage. CUP cannot be approved under subsection (5).

Finding 8 — Natural Features & Environment (Wetlands & Wildlife)

Law/Requirement:

UCLUO 16.94(C)(13)–(14) requires mitigation of effects on natural features (wetlands, ponds, creeks) and the natural environment (wildlife, vegetation, erosion, water quality).

Evidence in Record:

The proposed alignment cuts directly through wetlands and over a pond. Bald eagles and falcons are known to nest and hunt in this corridor. No wetlands delineation, wildlife survey, or environmental impact study has been conducted. No erosion or dust control plan specific to the corridor was provided.

Finding:

[35] Exhibit T - Childhood leukemia risk in the California Power Line Study
[36] Exhibit J - Mercer Magnetic Field Levels at Salem Park
[37] Exhibit L - Utah Code 78B-6-511- Property Damage as Loss in Market Value
[38] Exhibit R - Home Values Damage

The Applicant failed to provide evidence of mitigation for wetlands, water, or wildlife. CUP cannot be approved under subsections (13) and (14).

Finding 9 — Land Use Compatibility & Buffers

Law/Requirement:

UCLUO 16.94(C)(15) requires buffering and screening to reduce disharmony with existing and future land uses and to separate incompatible uses.

Evidence in Record:

The proposed line places 90–135 ft steel monopoles directly adjacent to residential backyards [39] and play areas.[40] No setbacks, fencing, or vegetative screening are proposed. The Applicant's submission acknowledges "landscape screening" as a possible mitigation , but none was provided in the narrative or plans.

Finding:

The Applicant failed to provide buffers or setbacks to make the project compatible with surrounding residential land uses. CUP cannot be approved under subsection (15).

Finding 10 — Nuisance Factors (Noise & EMF Disturbance)

Law/Requirement:

UCLUO 16.94(C)(18) requires mitigation of nuisance factors including noise, vibration, dust, and electromagnetic disturbances.

Evidence in Record:

Corona hum and construction noise will directly impact nearby homes. EMF levels exceed internationally recognized thresholds for safe long-term exposure. The International Agency for Research on Cancer (IARC) classifies extremely low frequency magnetic fields as **Group 2B ("possible carcinogen").** No noise study, EMF monitoring plan, or nuisance control measures were submitted.

Finding:

The Applicant failed to mitigate nuisance effects. CUP cannot be approved under subsection (18).

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[39] Exhibit Q - Neighborhood Adjacent Land Use
[40] Exhibit K - Children's play areas & Transmission Lines

Finding 11 — Constitutional Protections (Inverse Condemnation)

Law/Requirement:

UCLUO 16.94(C)(20) requires mitigation consistent with federal and state law. The U.S. Constitution, Fifth Amendment[41], and Utah Constitution Article 1.22[42] prohibits taking private property for public use without just compensation .

Evidence in Record:

Property owners adjacent to the line will lose 10–15% of their home values [43] without compensation. This constitutes **inverse condemnation**. No compensation mechanism was proposed by the Applicant.

Finding:

The Applicant failed to address constitutional property protections. CUP cannot be approved under subsection (20).

Conclusion (Detrimental Effects):

The Applicant has not provided substantial evidence that the project mitigates bodily injury, property damage, environmental harm, land use conflicts, nuisance impacts, or constitutional takings. Each failure is independently sufficient to require denial under UCLUO 16.94.

III. Deficient Record & Misrepresentation (Evidentiary Findings)

Under Utah's Land Use Development and Management Act (LUDMA), a land use decision is **illegal** if it is not supported by substantial evidence in the record, or if it is based on an incorrect interpretation of law . The Applicant bears the burden of producing credible, reliable, and complete evidence to demonstrate mitigation of detrimental effects.

Finding 12 — Misuse of EMF Standards

Law/Requirement:

The Applicant must provide credible scientific evidence relevant to the specific impacts of the proposed project. Evidence must be applicable and not misleading.

Evidence in Record:

[41] Exhibit N - U.S. Constitution - Fifth Amendment
[42] Exhibit O -Utah Constitution Article 1, Section 22
[43] Exhibit R - Home Values Damage

The Applicant's "medical expert" cited only **short-term EMF exposure standards** [44], which apply to fractions of a second, not chronic exposure in homes and schools. He also claimed that "typical daily EMF exposure" is harmless, even though typical background levels are **0.01–0.1 µT**, while a 345 kV line produces **>3 µT**[45] — orders of magnitude higher.

Finding:

The Applicant relied on misleading and irrelevant testimony. The record does not contain substantial evidence of EMF safety for chronic residential exposure.

Finding 13 — Undergrounding Claims Without Evidence

Law/Requirement:

Applicants must provide engineering studies or cost analyses to support claims of infeasibility or cost-prohibitive alternatives.

Evidence in Record:

The Applicant asserted that undergrounding the line is both infeasible and "20 times more expensive." Yet in the same presentation, the Applicant admitted they have **no engineering studies and no knowledge of how to construct underground transmission lines**. No third-party cost estimate was submitted.

Finding:

The Applicant's conflicting statements are unsupported and undermine credibility. Without evidence, claims of infeasibility or excessive cost cannot be relied upon.

Finding 14 — Omission of Existing Right-of-Way Alternatives

Law/Requirement:

Applicants must demonstrate consideration of alternatives and provide complete information about routing options (Utah Code Title 54, Chapter 18).

Evidence in Record:

The Applicant repeatedly stated it would prefer to use existing rights-of-way. However, in the Salem Park segment, no such options were disclosed or analyzed, even though nearby corridors exist.

Finding:

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[44] Exhibit P - Institute of Electrical and Electrons Engineers Standard for Safety Levels (IEEE) pg 17
[45] Exhibit J - Mercer Magnetic Field Levels at Salem Park

The omission of relevant right-of-way alternatives renders the application incomplete and prevents the Commission from considering less harmful routes.

Finding 15 — Newspaper Notice Misrepresentation

Law/Requirement:

Applicants must demonstrate compliance with publication requirements by providing affidavits or tear sheets. Failure to provide proof, or misrepresenting publication, undermines the record.

Evidence in Record:

In its August 22, 2025 letter to Salem Park residents, the Applicant claimed notice was published in the **Deseret News, Salt Lake Tribune, and Daily Herald**. Each paper confirmed no such notice ever appeared.[46]

Finding:

The Applicant misrepresented compliance with notice requirements. The record is incomplete and unreliable.

Conclusion (Record & Misrepresentation):

The Applicant's record is riddled with omissions, contradictions, and misleading testimony. Because the evidence provided is not substantial, reliable, or complete, the Applicant has failed to meet its burden under LUDMA. The Commission therefore has no lawful basis to approve the CUP.

Overall Conclusion

- **Any one defect** (notice, unmitigated effects, or deficient record) requires denial.
- Taken together, the application is **fatally flawed**. The Commission must deny the CUP.

[46] Exhibit F 1, 2, 3 - Daily Herald Email, Deseret News Email, Salt Lake Trib Email

Recommendation

The Utah County Planning Commission has a clear legal mandate under the Land Use, Development, and Management Act (LUDMA) and the Utah County Land Use Ordinance:

- Protect public health, safety, welfare, property values, and the environment.
- Ensure statutory notice is strictly followed before considering any conditional use permit.
- Require applicants to prove, by substantial evidence in the record, that all detrimental effects are reasonably mitigated.
- Deny a conditional use permit when these standards are not met.

Based on the **Findings of Law and Fact** presented in this packet:

1. **Notice Defects:** Statutory notice was not provided. At least 50 homes in Salem Park were not notified. The notices that were sent were legally deficient, and required newspaper publications never occurred. Because notice was defective, the County lacks jurisdiction to even consider this application.
2. **Unmitigated Detrimental Effects:** The Applicant failed to mitigate numerous adverse impacts — including health risks from EMF, property value loss, harm to wetlands and wildlife, land use incompatibility, nuisance factors, and constitutional property protections.
3. **Deficient Record & Misrepresentation:** The Applicant relied on misleading testimony, unsupported claims, and incomplete data. The record lacks the substantial evidence required under LUDMA.

Recommendation

For these reasons, the Commission has no legal or factual basis to grant this permit.

Primary Recommendation:

> *The Planning Commission should deny the Conditional Use Permit (CUP) application submitted by Rocky Mountain Power/PacifiCorp for the Spanish Fork–Mercer 345 kV transmission line, on the grounds that notice requirements were not met, detrimental effects remain unmitigated, and the record is incomplete and unreliable.*

Alternative (if denial is deferred):

In the alternative, the Commission should continue the matter and require Rocky Mountain Power/PacifiCorp to meet all conditions outlined in the Conditions Sheet — including corrected notice, properly noticed public workshops, independent third-party studies, enforceable setbacks and performance standards, property value protections, environmental safeguards, and compliance monitoring — before the application may return for further consideration.

Final Note:

The Commission has **no discretion** to excuse defective notice or to approve a CUP without substantial mitigation supported by credible evidence. To do so would not only violate Utah law but also expose the County to legal challenge. The only lawful and defensible action at this stage is **denial**.

"Chair and Commissioners, under Utah law this permit cannot stand. Notice was defective and never properly given, dozens of families were left uninformed, and even the published notice requirement was not met. The Applicant has also failed to mitigate serious detrimental effects — including health risks, property value loss, and environmental harms — and has not provided substantial evidence in the record to meet its burden. The law gives you no discretion to overlook these failures. The only lawful and defensible action today is to deny this conditional use permit."

"Chair and Commissioners, if the Commission is not prepared to deny this permit outright, then at minimum the law requires that it be conditioned on strict compliance with notice requirements and every safeguard in the Conditions Sheet. That means corrected notice, properly noticed public workshops, independent third-party studies, enforceable setbacks, property value protections, and continuous monitoring. Without full satisfaction of these conditions, the permit cannot be considered valid. Any lesser action would place the County outside the bounds of Utah law."

Source Materials

- Exhibit A - Utah State Code Chapt 27a - County Land Use, Development and Management Act, pg 1-2
- Exhibit B - Utah Code 54-18-301
- Exhibit C - Utah Code 54-18-102
- Exhibit D - Mercer 60 Day Notice
- Exhibit E - Aug 22 2025 RMP Letter
- Exhibit F 1 - Daily Herald Email
- Exhibit F 2 - Deseret News Email
- Exhibit F 3- Salt Lake Trib Email Thread
- Exhibit G - Utah Code 54-18-302
- Exhibit H - Springville Citizens v. The City of Springville -Utah Supreme Court
- Exhibit I - UCLUO 16.94 Rules
- Exhibit J - Mercer Magnetic Field Levels at Salem Park
- Exhibit K - Children's play areas & Transmission Lines
- Exhibit L - Utah Code 78B-6-511- Property Damage as Loss in Market Value
- Exhibit M - Colman v. Utah State Land Bd.__ Utah Supreme Court Decisions
- Exhibit N - U.S. Constitution - Fifth Amendment
- Exhibit O -Utah Constitution Article 1, Section 22
- Exhibit P - Institute of Electrical and Electrons Engineers Standard for Safety Levels (IEEE) Short Term Limits
- Exhibit Q - Neighborhood Adjacent Land Use
- Exhibit R - Home Values Damage
- Exhibit S - Resident's Affidavits
- Exhibit T - Childhood leukemia risk in the California Power Line Study

Exhibit A

Chapter 27a
County Land Use, Development, and Management Act

Part 1
General Provisions

17-27a-101 Title.

This chapter is known as the "County Land Use, Development, and Management Act."

Renumbered and Amended by Chapter 254, 2005 General Session

17-27a-102 Purposes -- General land use authority -- Limitations.

(1)

(a) The purposes of this chapter are to:

(i) provide for the health, safety, and welfare;

(ii) promote the prosperity;

(iii) improve the morals, peace, good order, comfort, convenience, and aesthetics of each county and each county's present and future inhabitants and businesses;

(iv) protect the tax base;

(v) secure economy in governmental expenditures;

(vi) foster the state's agricultural and other industries;

(vii) protect both urban and nonurban development;

(viii) protect and ensure access to sunlight for solar energy devices;

(ix) provide fundamental fairness in land use regulation;

(x) facilitate orderly growth, allow growth in a variety of housing types, and contribute toward housing affordability; and

(xi) protect property values.

(b) Subject to Subsection (4) and Section 11-41-103, to accomplish the purposes of this chapter, a county may enact all ordinances, resolutions, and rules and may enter into other forms of land use controls and development agreements that the county considers necessary or appropriate for the use and development of land within the unincorporated area of the county or a designated mountainous planning district, including ordinances, resolutions, rules, restrictive covenants, easements, and development agreements governing:

(i) uses;

(ii) density;

(iii) open spaces;

(iv) structures;

(v) buildings;

(vi) energy-efficiency;

(vii) light and air;

(viii) air quality;

(ix) transportation and public or alternative transportation;

(x) infrastructure;

(xi) street and building orientation and width requirements;

(xii) public facilities;

(xiii) fundamental fairness in land use regulation; and

(xiv) considerations of surrounding land uses to balance the foregoing purposes with a landowner's private property interests and associated statutory and constitutional protections.

(2) Each county shall comply with the mandatory provisions of this part before any agreement or contract to provide goods, services, or municipal-type services to any storage facility or transfer facility for high-level nuclear waste, or greater than class C radioactive waste, may be executed or implemented.

(3)

(a) Any ordinance, resolution, or rule enacted by a county pursuant to its authority under this chapter shall comply with the state's exclusive jurisdiction to regulate oil and gas activity, as described in Section 40-6-2.5.

(b) A county may enact an ordinance, resolution, or rule that regulates surface activity incident to an oil and gas activity if the county demonstrates that the regulation:

(i) is necessary for the purposes of this chapter;

(ii) does not effectively or unduly limit, ban, or prohibit an oil and gas activity; and

(iii) does not interfere with the state's exclusive jurisdiction to regulate oil and gas activity, as described in Section 40-6-2.5.

(4)

(a) This Subsection (4) applies to development agreements entered into on or after May 5, 2021.

(b) A provision in a county development agreement is unenforceable if the provision requires an individual or an entity, as a condition for issuing building permits or otherwise regulating development activities within an unincorporated area of the county, to initiate a process for a municipality to annex the unincorporated area in accordance with Title 10, Chapter 2, Part 8, Annexation.

(c) Subsection (4)(b) does not affect or impair the enforceability of any other provision in the development agreement.

Amended by Chapter 385, 2025 General Session
Amended by Chapter 399, 2025 General Session

17-27a-103 Definitions.

As used in this chapter:

(1) "Accessory dwelling unit" means a habitable living unit added to, created within, or detached from a primary single-family dwelling and contained on one lot.

(2) "Adversely affected party" means a person other than a land use applicant who:

(a) owns real property adjoining the property that is the subject of a land use application or land use decision; or

(b) will suffer a damage different in kind than, or an injury distinct from, that of the general community as a result of the land use decision.

(3) "Affected entity" means a county, municipality, special district, special service district under Title 17D, Chapter 1, Special Service District Act, school district, interlocal cooperation entity established under Title 11, Chapter 13, Interlocal Cooperation Act, specified property owner, property owner's association, public utility, or the Department of Transportation, if:

(a) the entity's services or facilities are likely to require expansion or significant modification because of an intended use of land;

(b) the entity has filed with the county a copy of the entity's general or long-range plan; or

54-18-301 Notice of intent to file -- Content -- Prefiling procedures.

(1) If a public utility conducts any field work in preparation of establishing a target study area before a notice of intent is filed in accordance with Subsection (2)(a), the public utility shall first notify the local land use authority of the public utility's work.

(2)

(a) At least 90 days before the day on which a public utility files a land use application in a city or county that requires a permit for the construction of a high voltage power line or an upgraded high voltage power line, the public utility shall submit a notice of intent to the land use authority of each affected entity.

(b) The notice of intent described in Subsection (2)(a) shall include:

(i) the name and mailing address of the public utility, including:

(A) the name of a contact person; and

(B) an address and telephone number for the contact person;

(ii) the purpose and need for the high voltage power line;

(iii) a map showing the target study area;

(iv) a description of environmentally sensitive areas in the target study area;

(v) the timing of construction; and

(vi) a list of affected entities.

(c) The land use authority of an affected entity may provide written comments to the public utility within 30 days after the day on which the notice of intent is mailed under Subsection (2)(a).

(3) At least 60 days before filing a conditional use permit application with a local land use authority, the public utility shall send a notice to:

(a) an affected entity;

(b) the land use authority of an affected entity; and

(c) an affected landowner.

(4) The notice required under Subsection (3) shall include:

(a) the name and mailing address of the public utility, including:

(i) the name of a contact person; and

(ii) an address and telephone number for the contact person;

(b) a description of the proposed corridor, including:

(i) location maps of:

(A) the target study area; and

(B) the public utility's proposed corridor within the target study area;

(ii) the width of the proposed route needed for the high voltage power line;

(iii) a description of the website described in Subsection (6); and

(iv) an explanation of:

(A) the land use application process;

(B) how an affected landowner may participate in a land use authority's land use application process; and

(C) the rights of an affected land owner under Title 78B, Chapter 6, Part 5, Eminent Domain.

(5)

(a) For purposes of Subsection (3), a county, at the public utility's request, shall provide a certified list of the most recent county tax records showing all affected landowners within 30 days after the day on which the public utility submits the request.

(b) A public utility may not be required to restart the notification process if:

(i) the county information provided under Subsection (5)(a) is insufficient or incorrect; and

(ii) the public utility fails to send an affected landowner a notice of intent based on the insufficient or incorrect information.

(6) Within one week of filing the notice of intent with a land use authority in accordance with Subsection (2), the public utility shall:

(a)

(i) create and update a website to dispense information about the proposed high voltage power line; and

(ii) on the website:

(A) designate a public utility point of contact; and

(B) explain how the public utility will respond to requests for information from the public and public officials; and

(b)

(i) publish a public notice in a daily or weekly newspaper of general circulation at least once per week for two weeks in each county where the target study area is located disclosing that the public utility has filed a notice of intent with an affected entity; and

(ii) describe in the public notice:

(A) the proposed high voltage power line, including a map of the target study area; and

(B) how readers may obtain more information from the website or locations listed in Subsection (3).

Enacted by Chapter 316, 2009 General Session

54-18-102 Definitions.

As used in this chapter:

(1) "Affected entity" means an entity as defined in Sections 10-9a-103 and 17-27a-103.

(2) "Affected landowner" means an owner of a property interest, as reflected in the most recent county or city tax records as receiving a property tax notice, whose property is located within a proposed corridor.

(3)

(a) "Construction" means the excavation, construction, and installation of a high voltage electric power line or upgraded high voltage transmission line.

(b) "Construction" does not include:

(i) the temporary use of sites; or

(ii) studies and tests for:

(A) requirements of this chapter;

(B) state regulations;

(C) federal regulations;

(D) securing geological and survey data; or

(E) any other actions taken by a public utility reasonably necessary to determine the location of a target study area or proposed corridor.

(4) "High voltage power line" means:

(a) an electrical high voltage power line with a nominal voltage of 230 kilovolts or more; and

(b) an upgraded high voltage power line.

(5) "Land use application" has the same meaning as provided in Sections 10-9a-103 and 17-27a-103.

(6) "Land use authority" has the same meaning as provided in Sections 10-9a-103 and 17-27a-103.

(7) "Land use permit" has the same meaning as Sections 10-9a-103 and 17-27a-103.

(8) "Legislative body" has the same meaning as provided in Sections 10-9a-103 and 17-27a-103.

(9) "Proposed corridor" means the transmission line route within a target study area selected by the public utility as the public utility's proposed alignment for a high voltage power line.

(10) "Proposed route" means the right-of-way needed for construction of the high voltage power line.

(11) "Public utility" has the same meaning as provided in Section 54-2-1.

(12) "Target study area" means the geographic area for a new high voltage transmission line or an upgraded high voltage power line as proposed by a public utility.

(13) "Upgraded high voltage power line" means increasing the voltage of an existing transmission line to 230 kilovolts or more.

Enacted by Chapter 316, 2009 General Session

ROCKY MOUNTAIN POWER®
A DIVISION OF PACIFICORP

May 31, 2024

RE: Property Owner Notification of Local Land Use Applications for an Electric Power Transmission Line

Dear Property Owner:

Rocky Mountain Power (Company) proposes to permit, construct, operate and maintain a new transmission line in southern Utah Valley between its existing Spanish Fork Substation and Mercer Substation near Eagle Mountain. The proposed Spanish Fork to Mercer Transmission Line Project (Project) will improve transmission-system reliability for customers and meet increased electrical demand. The Project will be approximately 45 miles of new 345-kilovolt, single-circuit transmission line requiring a 125-foot-wide right-of-way.

The Company has conducted a study to develop and evaluate alternative routing options to identify a route for the transmission line that has the least impact on communities, land uses, and the environment while also meeting engineering and safety standards. The affected entities in the Spanish Fork to Mercer Transmission Line Project area include Utah County, Eagle Mountain, Genola, Goshen, Mapleton, Payson, Salem, Santaquin, and Spanish Fork. Attachment A to this notice is a map that depicts the Project area and alternative routes.

The Company is beginning the process of permitting the Project. You are receiving this letter because, according to our records, your property may be crossed by or in the vicinity of one of the alternative routes. This letter is to inform you that a Conditional Use Permit application and any other required land use permits will be filed with your local land use authority. Pursuant to Utah Code Chapter 54-18-301 Siting of High Voltage Power Line Act, regarding regulatory and community engagement processes, we are sending this notice.

As we begin the permitting process, the Company will host four public open house meetings—three in-person meetings and one live virtual meeting online—for the public to review the alternative routes and provide input on a route to be carried forward into the permitting process.

Please join us at our public open house meetings!

June 18, 2024
5:30 p.m. to 7:30 p.m.
Goshen Senior Center
79 S Center St. Goshen, UT

June 19, 2024
5:30 p.m. to 7:30 p.m.
Salem Junior High School Cafeteria
598 N Main Street
Salem, UT

June 20, 2024
5:30 p.m. to 7:30 p.m.
Spanish Fork Fairgrounds High Chaparral Room
475 S Main Street Spanish Fork, UT

June 25, 2024
5:30 p.m. to 6:30 p.m.
https://us06web.zoom.us
Passcode: 638010

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The land use approval process involves a Conditional Use Application or other required land use permit to be filed with your local land use authority (Agency). This application is subject to review and approval by

the Agency and will be reviewed by the Agency's Planning Commission. The Agency will conduct a public hearing to review the application and accept public comments. Notice will be provided to potentially affected residents and landowners by the Agency pursuant to the provisions of the Agency's code procedures. You also may be receiving letters from your local Agency about applications filed, upcoming public hearing dates and locations, and how to provide comments on the application.

During the land use approval process for the Project, you may be contacted by a representative of the Company to request entry onto your property to conduct certain land and environmental surveys to help inform the process. If studies are desired on your property, you will receive a separate letter explaining the request with contact information.

Finally, receiving this letter does not necessarily mean the Project will be sited on or across your property. If it is determined a right of way is needed on your property for the transmission line, you will be contacted by a representative of the Company to meet on your property, discuss the Project in detail and negotiate for the purchase of a right-of-way easement. The Company prefers—and makes every effort to—acquire right-of-way easements for its transmission lines through voluntary good faith negotiations without using the power of eminent domain granted to it by the State of Utah. The vast majority of easements acquired by the Company are through voluntary means. However, Utah Code requires Rocky Mountain Power to notify an affected landowner of the rights they have under Title 78B, Chapter 6, Part 5, Eminent Domain, as follows:

- You are entitled to receive just compensation for your property.
- You are entitled to an opportunity to negotiate with Rocky Mountain Power over the amount of just compensation.
    - You are entitled to an explanation of how the compensation offered for your property was calculated.
    - If an appraiser is asked to value your property, you are entitled to accompany the appraiser during an inspection of the property.
- You are entitled to discuss this case with the attorneys at the Office of the Property Rights Ombudsman. The office may be reached at (801) 530-6391, or at Heber M. Wells Building, 160 East 300 South, Salt Lake City, Utah, 84111.
- The Office of the Property Rights Ombudsman is a neutral state office staffed by attorneys experienced in eminent domain. Their purpose is to assist citizens in understanding and protecting their property rights.
- If you have a dispute with Rocky Mountain Power over the amount of just compensation due to you, you are entitled to request free mediation or arbitration of the dispute from the Office of the Property Rights Ombudsman. As part of mediation or arbitration, you are entitled to request a free independent valuation of the property.
- Oral representations or promises made during the negotiation process are not binding upon the entity seeking to acquire the property by eminent domain.

Requests for information may be directed to Delynn Rodeback at (801) 597-4465 or Delynn.Rodeback@pacificorp.com or Dan Forbes at 801-220-2248 or Daniel.Forbes@PacifiCorp.com.

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A website has been established that provides a description of the Project, the need for the Project and the anticipated Project timeline. This website will be updated with information throughout the Project. The website may be accessed at:

https://www.pacificorp.com/transmission/transmission-projects/spanish-fork-to-mercer.html

Thank you for your time and consideration. If you have any questions about the Project, please contact us.

Sincerely,

Brandon Smith
Director of Project Delivery, PacifiCorp VP Transmission and Delivery PacifiCorp

Enclosure: Map

Cc: Todd Jensen, VP Transmission and Delivery, PacifiCorp
Richard Bardauskas, Project Manager, PacifiCorp
Tami Moody, Regulatory Permitting Project Manager, PacifiCorp

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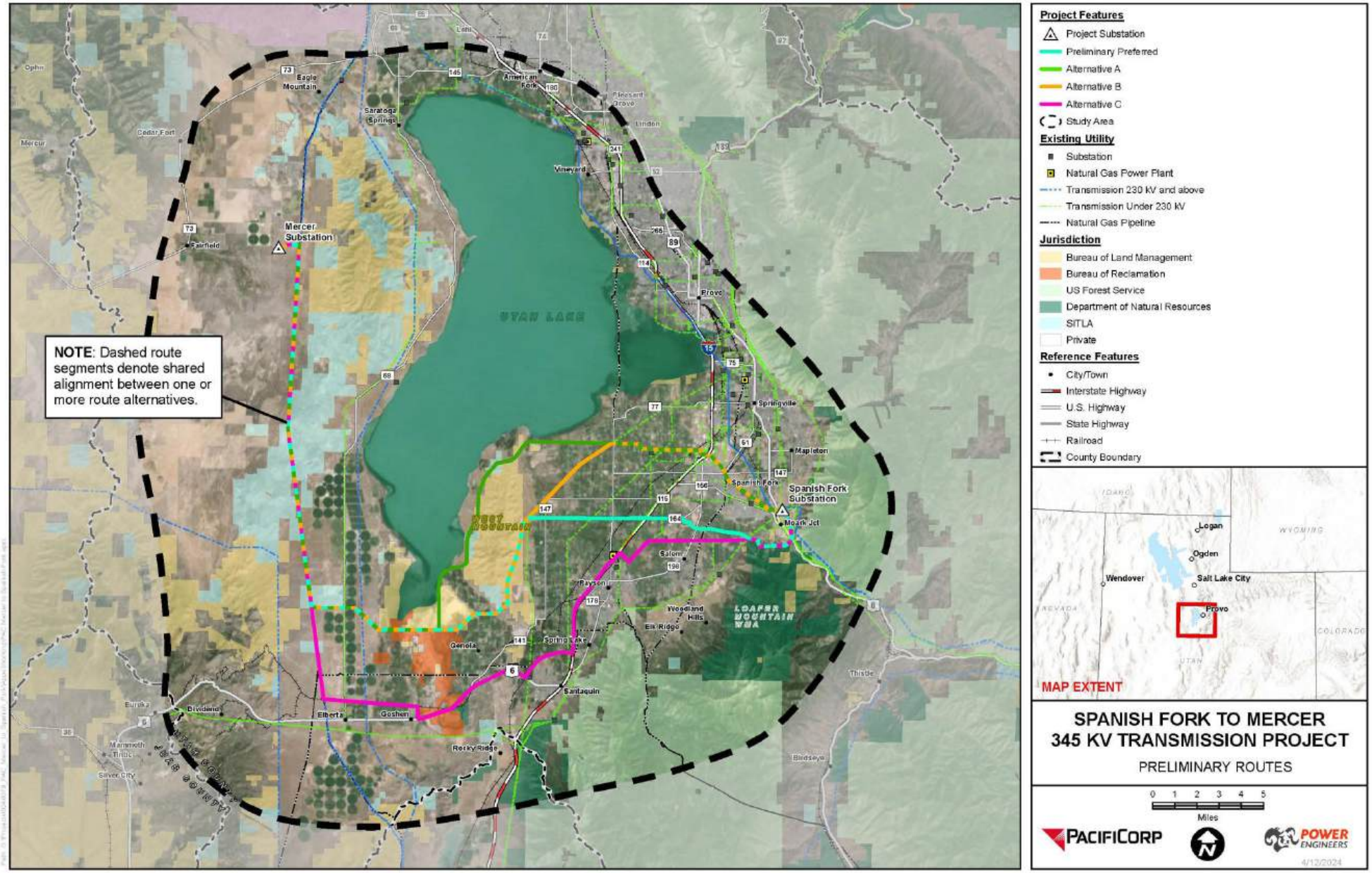

ROCKY MOUNTAIN POWER.
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1407 W. North Temple
Salt Lake City, UT 84116

August 22, 2025

Joseph and Mary Ybarra
273 East Snowy Egret Drive
Salem, Utah 84653

Dear Joseph and Mary Ybarra,

Thank you for reaching out with your comments and concerns on the Spanish Fork to Mercer Transmission line. This is an important project that will serve the communities of Utah County as they continue to grow and develop.

The project team understands your concerns and hopes to be able to provide information to add clarification about the project.

In addition to PacifiCorp's own standards for public outreach, this project worked through compliance with Utah State Code, Title 54, Chapter 18, Siting of High Voltage Power Line act. This code specifies requirements for public noticing and workshops for public involvement. The following were conducted for this project: 1) A 90-day notice to all local land use authorities about the proposed transmission line and study area was mailed on April 29, 2024. 2) A 60-day notice to all local jurisdictions where a conditional use application will be filed, and to affected landowners within the study corridor (250 ft on each side of the preferred centerline) was mailed on July 1, 2024. The mailing list was created based on county records. 3) A total of four (4) in-person public workshops and one (1) virtual public workshop were held. The workshop information was provided in the notices, as well as through media notifications that included the Salt Lake Tribune, Deseret News, and the Daily Herald. The workshops were open to the public and held in person on June 18, 19, 20, 2024, July 15, 2024, and virtually on June 25, 2024. The virtual open house has also been placed on the project website for continuous viewing. Rocky Mountain Power has complied with all aspects of Utah State Code 54-18.

As a Conditional Use Application, we submit application to Utah County, who is responsible for following noticing procedures and requirements in conformance with their adopted code for scheduling public hearings on land use applications. As far as PacifiCorp is aware, notices were sent out to all property owners and adjacent properties according to Utah County Code, notifying their public meeting.

Concerns have been mentioned regarding health and safety risks for the public. PacifiCorp has developed and follows wildfire mitigation plans in coordination with the State of Utah. Our projects are also developed to follow Federal, State, and local regulations and requirements for health and safety. We understand the concerns expressed around high-voltage transmission lines and health. The designs for high-voltage transmission lines, like those operating at 345-kV, account for electromagnetic fields to

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1407 W. North Temple
Salt Lake City, UT 84116

help protect people from any potential harmful effects, and studies indicate that normal exposure levels near high-voltage lines are far below World Health Organization established limits.

Rocky Mountain Power, PacifiCorp has evaluated the undergrounding of high voltage transmission lines in several areas and found them not feasible for this project due to cost, engineering constraints, and long-term operations risks. Undergrounding of larger lines comes with substantially greater installation, maintenance, and repair costs, and in the event of line outages, repairs will generally take a significantly longer period of time compared to overhead lines.

Engaging with the community is important to us, and through public outreach, public open house events, and meeting with the various landuse authorities, we have gained a good understanding of how much the area is growing, and the increased amount of development continues to take place. It is the growth which has increased the need to provide additional transmission line capacity to strengthen the grid and assist in serving the load growth, increasing the overall system reliability.

If you would like to learn more about the project, or remain up to date on project activities, please visit our website at http://www.pacificorp.com/transmission/transmission-projects/spanish-fork-to-mercer.html where you will find an interactive map, as well as project information, and a link to the Virtual Open House that was held last summer.

We appreciate you taking the time to provide feedback and are happy to address any additional questions you may have.

Thank you,

Tami Moody

Tami Moody
Principal Regulatory Permitting Mgr, Project Delivery, Transmission PMO
Office: (801) 220-2217 pmopac@PacifiCorp.com

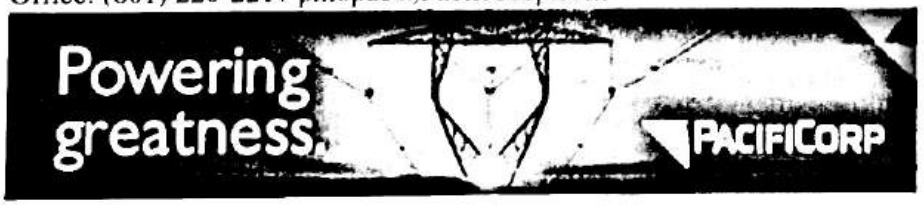


Exhibit F1

Gmail

Salem Residents and Wild Life Coalition <srwcoalition@gmail.com>

Request for Legal Notice Records – Rocky Mountain Power / PacifiCorp (2024–2025)

Jamie Rivera <jrivera@standard.net> Wed, Sep 3, 2025 at 8:13 AM
To: Salem Residents and Wild Life Coalition <srwcoalition@gmail.com>
Cc: dhlegals@heraldextra.com

Hello,

Thank you for reaching out to us.

I have checked our records thoroughly and was unable to locate any legal or public notices published by Rocky Mountain Power or PacifiCorp during 2024 or 2025 that relate to the Spanish Fork–Mercer 345 kV transmission project or any associated transmission line or conditional use permit notices in Utah County.

Please be aware that all of our legal notices are published and subsequently uploaded to the Utah Legal Notices website. You may be able to find the information you are looking for by searching directly on that platform: https://utnewspaper.utahlegals.com/Public-Notices/View-PublicNotices.aspx

We hope this information helps with your community's review of the project's public notification process.

Sincerely,
Jamie

Thank You,

Jamie Rivera
Legal Department/Inside Sales
jrivera@standard.net
STANDARD EXAMINER/www.standard.net
DAILY HERALD/www.heraldextra.com
PYRAMID/www.heraldextra.com/sanpetecounty
332 Standard Way, Ogden, UT 84404
Office: (801) 625-4302

[Quoted text hidden]

Exhibit F2

Gmail **Salem Residents and Wild Life Coalition <srwcoalition@gmail.com>**

Request for Legal Notice Records – Rocky Mountain Power / PacifiCorp (2024–2025)

2 messages

Salem Residents and Wild Life Coalition <srwcoalition@gmail.com> Tue, Sep 2, 2025 at 6:52 PM
To: legals@deseretnews.com

Dear Deseret News Legal Notices Department,

On behalf of the Protect Salem Park Residents and Wildlife Coalition, I am writing to request confirmation of any legal/public notices published by Rocky Mountain Power / PacifiCorp during 2024 or 2025 related to:

• The Spanish Fork–Mercer 345 kV transmission project, or
• Any related transmission line or conditional use permit notices in Utah County.

If such notices were published, could you please provide:
1. An Affidavit of Publication (official proof of publication).
2. A copy or tear sheet of the notice showing the exact text and publication date(s).

This information is very important to our community's review of the project's public notification process.

Thank you in advance for your assistance. Please feel free to contact me at 810-793-4966 or by email at srwcoalition@gmail.com if additional details are needed.

Sincerely,
Christine Blythe
Protect Salem Park Residents & Wildlife Coalition

Lenea Tapusoa <ltapusoa@deseret.com> Wed, Sep 3, 2025 at 11:26 AM
To: Salem Residents and Wild Life Coalition <srwcoalition@gmail.com>

Hello,

We don't have a record of running this.

Lenea Tapusoa | Account Executive - Obituaries & Legal Notices | ltapusoa@deseret.com | m: 801-204-6245 | deseret.com

DeseretNews.

[Quoted text hidden]

Exhibit F3

Gmail **Salem Residents and Wild Life Coalition <srwcoalition@gmail.com>**

Request for Legal Notice Records – Rocky Mountain Power / PacifiCorp (2024–2025)

3 messages

Salem Residents and Wild Life Coalition <srwcoalition@gmail.com> Tue, Sep 2, 2025 at 6:51 PM
To: legals@sltrib.com

Dear Salt Lake Tribune Legal Notices Department,

On behalf of the Protect Salem Park Residents and Wildlife Coalition, I am writing to request confirmation of any legal/public notices published by Rocky Mountain Power / PacifiCorp during 2024 or 2025 related to:

- The Spanish Fork–Mercer 345 kV transmission project, or
- Any related transmission line or conditional use permit notices in Utah County.

If such notices were published, could you please provide:
1. An Affidavit of Publication (official proof of publication).
2. A copy or tear sheet of the notice showing the exact text and publication date(s).

This information is very important to our community's review of the project's public notification process.

Thank you in advance for your assistance. Please feel free to contact me at 810-793-4966 or by email at srwcoalition@gmail.com if additional details are needed.

Sincerely,
Christine Blythe
Protect Salem Park Residents & Wildlife Coalition

Salem Residents and Wild Life Coalition <srwcoalition@gmail.com> Wed, Sep 3, 2025 at 11:40 AM
To: legals@sltrib.com

My last email (see below) seemed to bounce back. Would you please confirm the receipt. Thank you for your time.
[Quoted text hidden]

---

lwhitmer@sltrib.com <lwhitmer@sltrib.com> Wed, Sep 3, 2025 at 2:21 PM
To: Salem Residents and Wild Life Coalition <srwcoalition@gmail.com>, legals@sltrib.com

Hello Christine,

Thank you for reaching out to The Salt Lake Tribune Legal Notices Department.

I do not have an Account for Rocky Mountain Power / PacifiCorp.

All legal/public notices published in The Salt Lake Tribune can be found online at www.utahlegals.com . That site includes every notice we publish and allows you to narrow your search by using keywords, dates, counties, and other filters.

If you are able to locate the notice on www.utahlegals.com , please send me the publication details (notice title, date(s) published, and any identifying information). With that information, I can have the affidavit emailed over to you.

I hope this helps with your review process. Please let me know if you have any other questions.

Kind regards,

The Salt Lake Tribune
The Times-Independent

LaRee Whitmer

lwhitmer@sltrib.com

Manager, Legals, Recruitment and Obituaries

[Quoted text hidden]

54-18-302 Public workshops.

After a public utility files the notice of intent in accordance with Subsection 54-18-301(3) and before it files a land use application, the public utility shall:

(1) conduct informal public workshops at locations along the proposed corridor to provide information about:

(a) the high voltage power line; and

(b) the process for obtaining a land use permit; and

(2) provide notice of the public workshops at least 14 days before a public workshop to:

(a) a newspaper of general circulation in the target study area;

(b) radio stations in the target study area; and

(c) an affected entity.

Enacted by Chapter 316, 2009 General Session

Exhibit H

JUSTIA

Springville Citizens, et al v. The City of Springville, et al

Springville Citizens for a Better Community v. City of Springville
This opinion is subject to revision before final publication in the Pacific Reporter.

IN THE SUPREME COURT OF THE STATE OF UTAH

----ooOoo----

Springville Citizens for a Better Community, including Leland and LaJean Davies, Keith and Joanne Haeffele, Michael and Linda Krau, Blaine and Shirley Robertson, Brian and Marsha Ryder, and Russel and Nancy Weiser, and High Line Ditch Water Users, including Bryan and Belinda Adams, Bert and Debra Bartholomew, Lynn and Maxine Bartholomew, Darrell and Dorothy Bickmore, Merlene Bona, Carl and Rebecca Burrows, Donald and Debra Bushman, Walter and Manita Fowler, David and Ruth Fuller, Donald and Laura Gage, Michael and
LaRae Hill, Dale and Melba Jarman, Glendon and Leila C. Johnson, Linda Powers, Blaine and Shirley Robertson, Ronald and Utawna Witney,
Plaintiffs and Appellants,

v.

The City of Springville, a municipality under Utah law (aka Springville City, a municipal corporation or Springville City, a municipality), Mayor Hal Wing, in his official capacity, and John and Jane Does I-XV,
Defendants and Appellees.

No. 980028

F I L E D
March 19, 1999
1999 UT 25

Fourth District, Utah County
The Honorable Anthony W. Schofield

Attorneys:
Matthew Hilton, Springville, for plaintiffs
Jody K. Burnett, Salt Lake City, for defendants

--- RUSSON, Justice:

¶1 This action arises from a land use decision made by Springville City, granting T. Roger Peay approval to develop a Planned Unit Development ("P.U.D."). Plaintiffs, owners of property neighboring the P.U.D., filed suit against the City challenging the P.U.D.'s approval. The district court granted summary judgment in favor of the City. We reverse the district court's grant of summary judgment and remand for further proceedings consistent with this opinion.

FACTS

¶2 Roger Peay sought approval to develop a P.U.D. in the foothills of Springville, Utah. To obtain approval, Peay had to follow the procedure outlined in the Springville City ordinances. See Springville City Code §§ 11-4-304, 11-4-202. These ordinances require P.U.D. applicants to submit numerous documents regarding the proposed development. A process then commences in which first the city planning commission and then the city council review the development plans, with each entity imposing modifications and conditions, if necessary, on those plans. The council is authorized to grant final P.U.D. approval, which is evidenced by the adoption of an ordinance amending the City's zoning map.

¶3 On July 11, 1995, Peay appeared before the planning commission seeking sketch plan approval for a thirty-three-acre, forty-eight-lot P.U.D. called Powerhouse Mountain Estates. Between July of 1995 and May of 1996, Peay attended five planning commission meetings and three city council meetings. At each meeting, Peay sought either sketch plan approval or preliminary approval for the P.U.D. On each occasion, the commission and the council imposed modifications on Peay's plans in order to meet the City's P.U.D.

requirements. There was considerable public participation at these meetings, including input from those who are plaintiffs herein. Ultimately, the council rejected Peay's proposal.

¶4 On May 28, 1996, Peay started anew before the planning commission. In response to the previously expressed concerns of the council and the commission, the proposed P.U.D. now consisted of thirty-five lots, contained no "deep lots," provided for curbs and gutters on each side of the P.U.D. road and a sidewalk on the downhill side of the road, and provided for an entrance road forty-six feet wide and an interior road forty-one feet wide. The commission voted to give the P.U.D. sketch plan approval and to recommend approval of the preliminary plan.

¶5 Thereafter, on July 16, 1996, Peay sought city council approval for the P.U.D. After extended public comment, the council voted four to one to give the P.U.D. preliminary approval subject to twenty-nine conditions. On September 10, 1996, Peay then appeared before the planning commission seeking final approval for the P.U.D., which was now called Stonebury Estates. The commission reviewed the twenty-nine conditions and, contrary to the city code, voted to send the matter to the council without a recommendation, positive or negative.

¶6 In a letter to the city attorney dated September 19, 1996, Peay detailed the specific actions he had taken in response to the twenty-nine conditions. On September 30, 1996, the city attorney submitted to the mayor and the city council his review of Peay's compliance with the conditions. He opined that Peay had not complied with many aspects of the conditions and that final approval should therefore be withheld.

¶7 On October 1, 1996, Peay sought final approval from the council for what he called the "first phase" of the P.U.D., which consisted of seventeen of the thirty-five lots. After a detailed discussion of each of the conditions imposed, the council voted to meet with Peay for a work session, the purpose of which was to evaluate Peay's compliance with the conditions.

¶8 Prior to the work session, at the council's request, Peay responded in writing to the city attorney's concerns and conclusions regarding the twenty-nine conditions. Thereafter, with this information before it, the council concluded that sixteen conditions had been met entirely, seven conditions had been met partially or were ready to be met, and six conditions required council action. These six conditions were the focus of the work session.

¶9 On October 15, 1996, the council then voted to adopt nine additional conditions, which modified some of the previous twenty-nine conditions. Among other things, these

additional conditions (1) allowed the thirty-five-lot P.U.D. to be developed in phases, (2) allowed four of the lots to have less than 20,000 square feet but not less than 17,000 square feet, (3) required Peay to cover the highline ditch through the entire development, and (4) provided that the homeowners' association would own the spring protection area as a common area. Peay agreed to comply with all nine conditions. The council, however, did not refer these additional conditions to the commission for its review, recommendation, or approval, as mandated by the city code.

¶10 At a council meeting on November 5, 1996, Peay sought final approval for the seventeen lots comprising the first phase of the P.U.D. After more discussion of the conditions, the council voted to give the first phase "tentative final approval." Then, on November 11, 1996, the council adopted ordinance 19-96, which amended the City's zoning map and gave final approval to the first phase of the P.U.D. This ordinance specifically required compliance with "approved plans, plats, documents, conditions of approval and agreements." Peay ultimately complied with all the conditions imposed by the council.

¶11 Plaintiffs thereafter commenced this action against the City in district court, challenging the council's approval of the P.U.D. pursuant to Utah Code Ann. § 10-9-1001, which states: Any person adversely affected by any decision made in the exercise of the provisions of this chapter may file a petition for review of the decision with the district court within 30 days after the local decision is rendered. The courts shall: (a) presume that land use decisions and regulations are valid; and

(b) determine only whether or not the decision is arbitrary, capricious, or illegal. Utah Code Ann. § 10-9-1001(2) & (3) (1996) (emphasis added).

¶12 Plaintiffs alleged that the City's approval of the P.U.D. was arbitrary, capricious, and illegal because the City failed to strictly follow its own ordinances, which, under the City's own code, were mandatory. Plaintiffs also alleged violations of state statutory requirements and of the state and federal constitutions. Plaintiffs sought declaratory and injunctive relief and monetary damages.

¶13 After conducting discovery, the City moved for summary judgment. The district court held that the City had substantially complied with the ordinances governing approval of the P.U.D. and, on that basis, granted the City's motion for summary judgment. This appeal followed.

¶14 On appeal, plaintiffs argue that summary judgment was improper because the City's decision to approve the P.U.D. was arbitrary, capricious, and illegal.(1) According to

plaintiffs, the decision was illegal because the City failed to comply strictly with several of the ordinances governing P.U.D. approval, many of which include the terms "shall" and "must." Plaintiffs emphasize that under the City's own statutory standard of interpretation, the "[w]ords 'shall' and 'must' are always mandatory." Springville City Code § 11-10-101(4). Plaintiffs claim that a number of such mandatory procedures outlined as subsections of City Code § 11-4-202 were not satisfied by the City, as well as several other mandatory requirements concerning P.U.D. improvements and documentation under City Code §§ 11-4-301 to -308.

¶15 In addition, plaintiffs contend that the City violated City Code § 11-5-7(4), which states that the "Planning Commission shall not approve any preliminary plat for any subdivision" unless the irrigation company or persons entitled to use the irrigation ditches "certify that the drawing [showing the location of all irrigation ditches] is a true and accurate representation." (Emphasis added.) Plaintiffs argue that this ordinance was violated when such a certification had not been made prior to the commission's granting the P.U.D. preliminary approval or considering its final approval.

¶16 Plaintiffs further assert that the City ran afoul of City Code § 11-5-9, which provides, "The Planning Commission shall review the final plat, final engineering drawings and documents, and shall act to approve the plan [or] disapprove the plan," and Utah Code Ann. § 10-9-204(5), which states, "The planning commission shall . . . (5) recommend approval or denial of subdivision applications as provided in this chapter." (Emphasis added.) Plaintiffs argue that the commission violated this ordinance and statute when, after reviewing the plans submitted for final approval, it voted simply to send the matter to the council without a recommendation, either positive or negative. Plaintiffs contend that the lack of such a recommendation cannot be construed as an implicit approval of the plans because certain amendments to those plans did not exist at the time and, after the amendments were made, the plans were not remanded to the commission for its review.

¶17 Plaintiffs also argue that the City breached section 11-5-10 of its code, which states, "If modifications are required [by the city council], such modifications must be referred to the Planning Commission and be approved by the Commission." (Emphasis added.) Plaintiffs assert that this ordinance was violated when the additional nine conditions imposed by the council on October 15, 1996, were not sent to the commission for its review, recommendation, or approval.

¶18 In addition to these alleged violations, plaintiffs charge that the City violated certain provisions of state statutory law. They claim the City breached Utah Code Ann. §§ 10-9-703 and 10-9-707(2)(a) by, in essence, granting variances which, under these statutes, should

have been decided by the board of adjustments. Plaintiffs also posit that the City allowed certain plats to be recorded in violation of both Utah Code Ann. § 10-9-811(1)(b) and some of the conditions of approval imposed on the P.U.D., such as the requirement of eliminating flag lots and tendering water rights. Plaintiffs further claim that the City breached Utah Code Ann. § 10-9-704(1)(a) by not allowing certain grievances to be presented to the board of adjustments.

¶19 Finally, plaintiffs contend that the City's decision to approve the P.U.D. was arbitrary and capricious because (1) it was illegal, on the grounds set forth above, and (2) it was not supported by substantial evidence because some of the required documents, which plaintiffs claim were mandatory for the decision making process, were not before the city council or planning commission when they made their respective decisions.

¶20 The City responds that its approval of the P.U.D. was not arbitrary, capricious, or illegal because it substantially complied with its ordinances in approving the P.U.D. According to the City, strict compliance with the ordinances was not necessary because the ordinances are procedural in nature and because less than complete compliance with such ordinances did not prejudice plaintiffs. The City emphasizes that the approval process for the P.U.D. spanned more than a year, during which time Peay attended seven planning commission meetings and six city council meetings wherein various concerns were discussed, by both city officials and plaintiffs, and numerous conditions imposed. The City stresses that all of the requirements complained about by plaintiffs were eventually met or substantially satisfied.

¶21 The issue before us, therefore, is whether the City's approval of the P.U.D. was arbitrary, capricious, or illegal.(2)

STANDARD OF REVIEW

¶22 Summary judgment is appropriate only when there are no genuine issues of fact and the moving party is entitled to judgment as a matter of law. See Utah R. Civ. P. 56(c). In reviewing a grant of summary judgment, we do not defer to the legal conclusions of the district court, but review them for correctness. When reviewing a municipality's land use decision, our review is limited to determining "whether . . . the decision is arbitrary, capricious, or illegal." Utah Code Ann. § 10-9-1001(3)(b) (1996).

ANALYSIS

¶23 A municipality's land use decisions are entitled to a great deal of deference. See Xanthos v. Board of Adjustment, 685 P.2d 1032, 1034 (Utah 1984); Triangle Oil, Inc. v.

North Salt Lake Corp., 609 P.2d 1338, 1339-40 (Utah 1980); Cottonwood Heights Citizen Ass'n v. Board of Comm'rs, 593 P.2d 138, 140 (Utah 1979); Naylor v. Salt Lake City Corp., 410 P.2d 764 (Utah 1965). Therefore, "the courts generally will not so interfere with the actions of a city council unless its action is outside of its authority or is so wholly discordant to reason and justice that its action must be deemed capricious and arbitrary and thus in violation of the complainant's rights." Triangle Oil, 609 P.2d at 1340. Indeed, the statute that forms the basis of this appeal requires the courts to "presume that land use decisions and regulations are valid." Utah Code Ann. § 10-9-1001(3)(a). However, this discretion is not completely unfettered, and the presumption is not absolute. If a municipality's land use decision is arbitrary, capricious, or illegal, it will not be upheld. See id. § 10-9-1001(3)(b).

¶24 In the present case, plaintiffs argue that the City's decision to approve the P.U.D. was arbitrary and capricious. A municipality's land use decision is arbitrary and capricious if it is not supported by substantial evidence. See Patterson v. Utah County Bd. of Adjustment, 893 P.2d 602, 604 (Utah Ct. App. 1995). In evaluating the City's decision under this standard, we review the evidence in the record to ensure that the City proceeded within the limits of fairness and acted in good faith. See id. We also determine whether, in light of the evidence before the City, a reasonable mind could reach the same conclusion as the City. See id.; see also 2 Young, Anderson's American Law of Zoning § 11.11, at 461 (4th ed. 1996) (noting that when reviewing an ordinance that approves a P.U.D., courts determine whether there is support for the approval and whether the decision was reasonable). We do not, however, weigh the evidence anew or substitute our judgment for that of the municipality. See Patterson, 893 P.2d at 604; see also Xanthos, 685 P.2d at 1035.

¶25 In the case at bar, the undisputed facts demonstrate that the City's decision was not arbitrary or capricious but was the result of careful consideration and was supported by substantial evidence. Of significant import, consideration of the P.U.D. spanned nearly a year and a half and involved more than a dozen separate meetings wherein public input was heard, objections voiced, and modifications to the P.U.D. imposed. Although certain materials were not timely submitted, the majority of the required documentation was before the planning commission and the city council when the P.U.D. ultimately was approved. That documentation, as well as the other evidence before the commission and the council, supported approval of the P.U.D. Moreover, throughout the approval process and in an effort to meet the P.U.D. requirements, the city council required Peay to satisfy numerous conditions concerning the proposed development, all of which Peay eventually fulfilled. In short, the undisputed evidence reveals without question that substantial evidence supported the City's decision and that a reasonable person could have reached the

same decision as the City. We conclude, therefore, that the City's decision to approve the P.U.D. was not arbitrary or capricious.

¶26 This conclusion does not end our inquiry, however. Under Utah Code Ann. § 10-9-1001(3)(b), we must also determine whether the City's decision was illegal. Plaintiffs argue convincingly that the City's decision to approve the P.U.D. was illegal because the City violated its own ordinances during the approval process. Plaintiffs highlight that compliance with the city ordinances at issue was, under the City's own legislatively enacted standard, mandatory. Plaintiffs point to Springville City ordinance 11-10-101, which states, "For purposes of this Title, certain words and terms are defined as follows: . . . (4) Words 'shall' and 'must' are always mandatory." (Emphasis added.)

¶27 Title 11 of the Springville ordinances, entitled "Development Code," details the procedures and requirements for P.U.D. approval, including those that plaintiffs contend the City violated. Those procedures and requirements, as indicated in the ordinances quoted above, frequently are prefaced by the words "shall" and "must." Thus, according to the City's own rule of interpretation, compliance with the P.U.D. procedures and requirements containing these words was mandatory.

¶28 In its ruling granting summary judgment in favor of the City, the district court appeared to recognize the mandatory nature of the city ordinances but concluded nonetheless that substantial compliance with those ordinances was sufficient. In fact, one of the express legal principles upon which the district court premised its ruling was that "[t]he city's actions approving the PUD must be upheld if those actions are in substantial compliance with the city's ordinances."

¶29 The district court's use of the substantial compliance doctrine in the face of ordinances that are expressly mandatory was erroneous. While substantial compliance with matters in which a municipality has discretion may indeed suffice, it does not when the municipality itself has legislatively removed any such discretion. The fundamental consideration in interpreting legislation, whether at the state or local level, is legislative intent. See Board of Educ. v. Salt Lake County, 659 P.2d 1030, 1030 (Utah 1983). Application of the substantial compliance doctrine where the ordinances at issue are explicitly mandatory contravenes the unmistakable intent of those ordinances.

¶30 Municipal zoning authorities are bound by the terms and standards of applicable zoning ordinances and are not at liberty to make land use decisions in derogation thereof. See Thurston v. Cache County, 626 P.2d 440, 444-45 (Utah 1981). The irony of the City's position on appeal is readily apparent: the City contends that it need only "substantially

comply" with ordinances it has legislatively deemed to be mandatory. Stated simply, the City cannot "change the rules halfway through the game." Brendle v. City of Draper, 937 P.2d 1044, 1048 (Utah Ct. App. 1997). The City was not entitled to disregard its mandatory ordinances. Because the City did not properly comply with the ordinances governing P.U.D. approval, we conclude that under Utah Code Ann. § 10-9-1001(3)(b), the City's decision approving the P.U.D. was illegal.

¶31 The City's failure to pass the legality requirement of section 10-9-1001(3)(b), however, does not automatically entitle plaintiffs to the relief they request. Rather, plaintiffs must establish that they were prejudiced by the City's noncompliance with its ordinances or, in other words, how, if at all, the City's decision would have been different and what relief, if any, they are entitled to as a result. See, e.g., Board of Ed. v. Salt Lake County, 659 P.2d 1030, 1035 (Utah 1983) (noting that recovery for failure of county to follow mandatory statutory requirements required showing of prejudice from such failure); see also Anderson's American Law of Zoning § 11.24 (explaining that party challenging approval of P.U.D. must show "actual injury").

¶32 With respect to the City's alleged violations of state statutory requirements, namely, Utah Code Ann. §§ 10-9-204, 10-9-703, 10-9-704(1)(a), 10-9-707(2)(a), and 10-9-811(1)(b), as outlined herein, it appears that the district court summarily dismissed these claims without analysis. With the exception of the alleged violation of section 10-9-703, the district court articulated no basis for rejecting these claims, thus preventing us from reviewing the correctness of those rulings. As to section 10-9-703, the district court simply concluded that plaintiffs could not appeal the overall approval of the P.U.D. to the board of adjustments; this, however, overlooked the nature of plaintiffs' claims under that section, namely, that certain City actions apart from the final P.U.D. approval were appealable to the board of adjustments, i.e., the City's issuance of building permit 03675 and the recording of Plat 4. Thus, whether section 10-9-703 was violated, as well as the other enumerated sections, must be addressed as part of the proceedings on remand.

CONCLUSION

¶33 The district court's grant of summary judgment is therefore reversed, and this matter is remanded for further proceedings.

¶34 Chief Justice Howe, Associate Chief Justice Durham, Justice Stewart, and Justice Zimmerman concur in Justice Russon's opinion.

1. We note our disapproval of plaintiffs' methods of circumventing the fifty-page limit for appellate briefs, see Utah R. App. P. 24(f). Plaintiffs' brief contains numerous, lengthy footnotes that set forth key arguments (the opening brief contains 104 footnotes, some of which consume up to three- fourths of a page). Also, plaintiffs' discussion of central points is cursory and incomplete, and many of their citations to the record are simply references to arguments made to the district court.

2. Plaintiffs also raise a panoply of constitutional issues. We do not address these issues because plaintiffs have failed to brief them adequately. See Utah R. App. P. 24(i) ("All briefs under this rule must be concise, presented with accuracy, logically arranged with proper headings and free from burdensome, irrelevant, immaterial and scandalous matters. Briefs which are not in compliance may be disregarded or stricken, on motion or sua sponte by the court . . . .") and Utah R. App. P. 24 (a)(9) ("The argument shall contain the contentions and reasons of the appellant with respect to the issues presented . . . with citations to the authorities . . . relied on."). Plaintiffs' brief on these issues is poorly organized, confusing, and difficult to follow. It is frequently difficult to determine exactly what assertions are being made and the substance of the accompanying arguments. We can certainly comprehend the district court's observation that "plaintiffs spent considerable effort wandering in fields of irrelevancy." Furthermore, many of plaintiffs' constitutional arguments are premised on the existence of constitutional liberty and property interests which plaintiffs fail to define and which are not supported by any authority. Their bald assertion that the interests are "self-evident" is insufficient. See also State v. Carver, 776 P.2d 886, 888 (Utah 1989) ("[T]his Court need not analyze and address in writing each and every argument, issue, or claim raised. . . . Rather, it is a maxim of appellate review that the nature and extent of an opinion rendered by an appellate court is largely discretionary with that court.").

16.94 Rules For Hearing And Deciding Conditional Use Applications

A. When the Planning Commission acts under its power to hear and decide applications for Conditional Uses, the Conditional Use shall be approved if reasonable conditions are proposed, or can be imposed, to substantially mitigate the reasonably anticipated detrimental effects of the proposed use in accordance with the standards in this section and other relevant sections of this land use ordinance. If the reasonably anticipated detrimental effects of a proposed Conditional Use cannot be substantially mitigated, the Conditional Use may be denied.

B. The Planning Commission shall ensure compliance with the following procedures:

1. The applicant shall have submitted a properly completed application form signed by the property owner.
2. The land use ordinance specifically identifies the Conditional Use in question as one which the Planning Commission is empowered to approve.
3. The use shall comply with all of the terms and requirements of the land use ordinance, including but not limited to UCLUO 4, UCLUO 6, UCLUO 8, and UCLUO 12.
4. The applicant has the burden of proving by a preponderance of the evidence that all conditions for granting a Conditional Use have been met and must meet that burden based on the facts presented for the record; expressions of support or protest alone shall not constitute the basis of approval or denial.
5. A grant of a Conditional Use permit requires the concurring vote of a majority of Planning Commission Members participating in the deliberations.
6. Conditional Uses run with the land, subject to UCLUO 16.84(E).

C. The Planning Commission may attach conditions to mitigate any anticipated detrimental effects of the proposed use and may consider the following standards in doing so. When considering the effects, the Planning Commission may consider the reasonably anticipated detrimental effects in the context of current conditions and, to the extent supported by law, the policy recommendations of the applicable General Plan.

1. Mitigate injury, loss of life, and property damage to firefighting and emergency medical service agencies.
2. Mitigate injury, loss of life, and property damage for the county sheriff's office or the need for added peace keeping activities.
3. Mitigate any disproportionate demand for government services generally, including, but not limited to, firefighting; emergency medical services; policing; Schools and School busing; water, sewer and stormwater facilities; and garbage removal.
4. Mitigate injury, loss of life, or property damage from any known geologic or Flood hazard if credible evidence of such a detrimental effect is present.
5. Substantially mitigate the likelihood that the proposed use or facility may cause bodily injury or property damage to potential persons or property in the area.
6. Mitigate the creation of traffic hazards, right-of-way conflicts, or undesirable vehicle or pedestrian traffic patterns or volumes.
7. Mitigate onsite vehicle or pedestrian circulation inefficiencies and provide for adequate onsite parking given the unique specificities of the proposed use or the proposed site plan.

8. Mitigate material degradation of the level of service of any storm water drainage facility or infrastructure, and adequately provide for storm water drainage from the site.
9. Mitigate material degradation of the level of service of any culinary, secondary, or irrigation water facility or infrastructure, and, if applicable, provide adequate culinary, secondary, or irrigation water service to the site.
10. Mitigate material degradation of the level of service of any sanitary sewer service, and, if applicable, provide adequate sanitary sewer service to or septic system on the site.
11. Mitigate material degradation of the level of service of any other utility, and, if applicable, adequately provide such utility services to the site.
12. Mitigate material degradation of the level of service, functionality, capacity, or usability of the existing open spaces, public features, or recreational amenities in the area, and, if applicable, adequately provide additional open spaces, public features, or recreational amenities.
13. Mitigate detrimental effects on the natural features of the site and the surrounding affected areas if credible evidence of such a detrimental effect is present; including, but not limited to, rivers and creeks, lakes, ponds, reservoirs, wetlands, drainage ways, groundwater protection, and Slopes.
14. Mitigate detrimental effects on the natural environment of the site and the surrounding affected areas if credible evidence of such a detrimental effect is present; including, but not limited to, wildlife, air quality, water quality (including erosion control), local natural resources, natural vegetation (including protection against noxious or invasive species), and wildland areas.
15. Provide buffering, screening, or fencing of the use or site, or provide other landscape features sufficient to mitigate the proximity of incompatible uses, objectionable site features, and disharmony with existing and future land uses in the area.
16. Provide hours of operation appropriate for the general nature and character of existing land uses in the area to mitigate conflict or incompatibility with surrounding uses.
17. Provide reclamation, restoration, cleanup, or beautification of the site as the use evolves or as the use is terminated in order to mitigate aesthetic and nuisance effects.
18. Mitigate nuisance factors, including, but not limited to, light and glare, noise, vibrations, smoke, dust, dirt, odors, gases, noxious matter, heat, electromagnetic disturbances, and radiation, if credible evidence of such a nuisance is present.
19. Mitigate potential noncompliance or poor performance by requiring regular review or monitoring of certain specified detrimental effects by an appropriately qualified professional.
20. Provide appropriate mitigation of detrimental effects as required in standards found elsewhere in this land use ordinance and any other federal, state, or local regulation, as may be applicable.

D. Voluntary contributions providing satisfactory compliance with applicable standards. When considering a Conditional Use, the Land Use Authority has discretion to determine satisfactory compliance with any applicable standard, requirement, provision, or restriction of this chapter if the applicant has voluntarily offered a more desirable alternative to mitigate the reasonably anticipated detrimental effects of the use than those otherwise specified here. The Land Use Authority may require a Development agreement to execute the voluntary alternative.

E. Within fifteen (15) days after a decision has been made, the Planning Commission shall file a written notice of its decision in its offices and mail a copy of the notice to the applicant at the address supplied in the application form. The decision of the Planning Commission shall be deemed final at the time it is filed in its offices.

F. The Planning Commission shall record all final decisions with the Utah County Recorder.

G. If a request for a Conditional Use is approved, the notice shall also contain the date such approval terminates if a Building permit (or other permit or license, if applicable) is not obtained pursuant thereto. Such termination shall automatically be three (3) years from the date of the decision of the Planning Commission. The Planning Commission may, as a condition of approval, set a different termination date for a Conditional Use on a finding that a different date is necessary for substantial justice to be done.

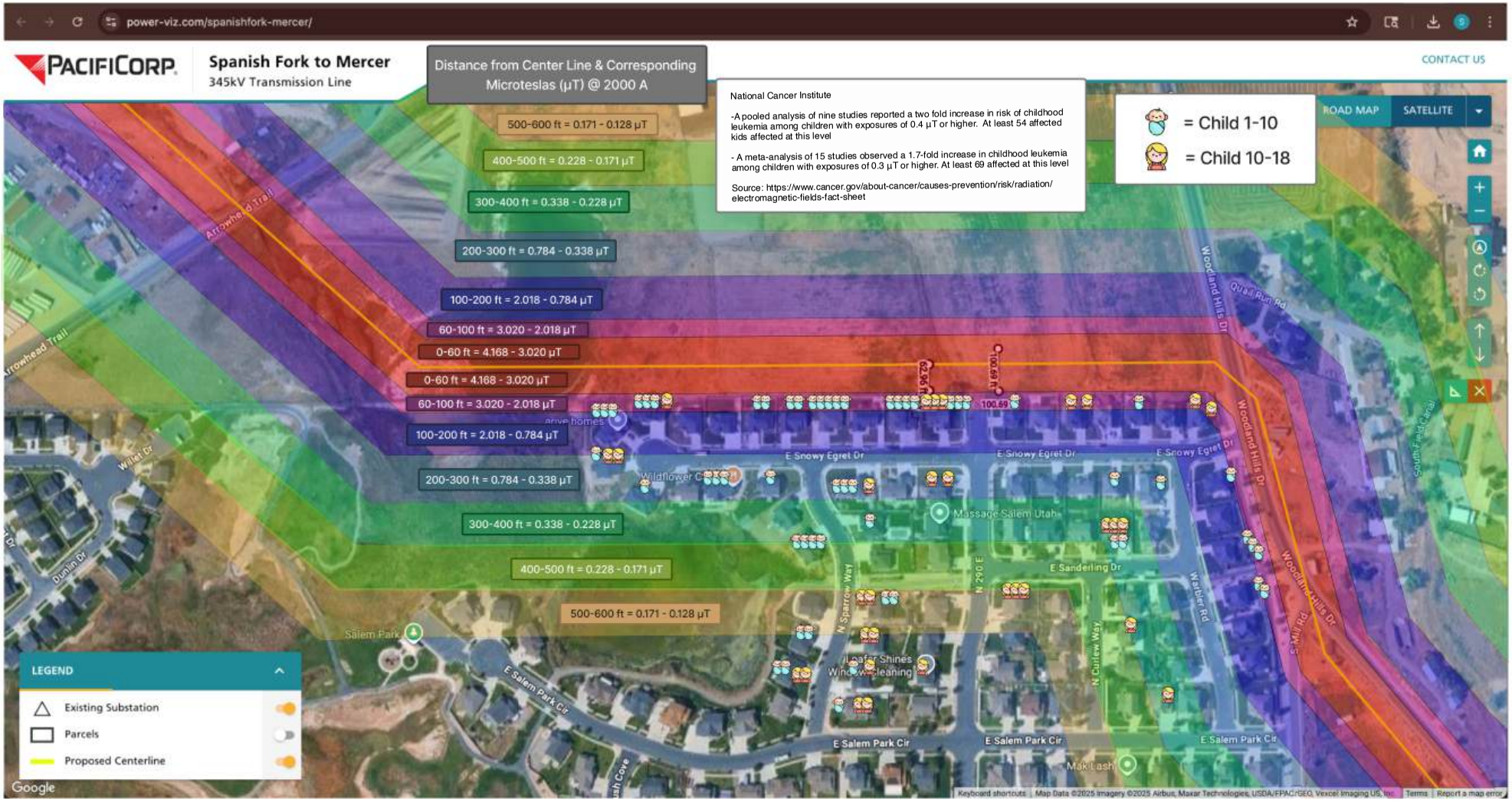
H. After the hearing, the Planning Commission may order the termination date for a Conditional Use enlarged if a request is made in writing, the request is made before the expiration of the period originally prescribed, and a different date is necessary for substantial justice to be done. A Conditional Use may be enlarged only one (1) time for a maximum of five (5) years. Any request for an enlargement of time shall comply with the applicable notice requirements for a Conditional Use. This request for an enlargement of time shall not be considered a rehearing under UCLUO 16.

I. Conditional Uses are subject to abandonment as follows:

1. Conditional Uses which are rendered unoccupiable or otherwise unusable by the destruction of a fire, Flood, or other calamity or act of nature may be restored and the preexisting use resumed provided that a Building permit for reconstruction is obtained within one year from the date of destruction and construction is diligently prosecuted to completion and re-occupancy. Such restoration shall not increase the Conditional Use previously approved by the Land Use Authority. If a Building permit is not issued within one year from the date of destruction or if the Building permit is so issued but construction is not diligently prosecuted to completion and re-occupancy, then the Conditional Use shall be conclusively deemed abandoned, and the Conditional Use shall terminate.

2. Conditional Uses which are not occupied or not used for a continuous period of one year or longer, shall not thereafter be relicensed, reoccupied or used anew. The Conditional Use shall be conclusively deemed abandoned, and the Conditional Use shall terminate.

HISTORY
Amended by Ord. 2024-57 Updated Conditional Use on 2/8/2024
Amended by Ord. 2025-412 Updated ALJ on 5/29/2025


power-viz.com/spanishfork-mercer/
PACIFICORP
Spanish Fork to Mercer
345kV Transmission Line
Distance from Center Line & Corresponding Microteslas (μT) @ 2000 A
CONTACT US
National Cancer Institute
-A pooled analysis of nine studies reported a two fold increase in risk of childhood leukemia among children with exposures of 0.4 μT or higher. At least 54 affected kids affected at this level
- A meta-analysis of 15 studies observed a 1.7-fold increase in childhood leukemia among children with exposures of 0.3 μT or higher. At least 69 affected at this level
Source: https://www.cancer.gov/about-cancer/causes-prevention/risk/radiation/electromagnetic-fields-fact-sheet
= Child 1-10
= Child 10-18
ROAD MAP
SATELLITE
500-600 ft = 0.171 - 0.128 μT
400-500 ft = 0.228 - 0.171 μT
300-400 ft = 0.338 - 0.228 μT
200-300 ft = 0.784 - 0.338 μT
100-200 ft = 2.018 - 0.784 μT
60-100 ft = 3.020 - 2.018 μT
0-60 ft = 4.168 - 3.020 μT
0-60 ft = 4.168 - 3.020 μT
60-100 ft = 3.020 - 2.018 μT
100-200 ft = 2.018 - 0.784 μT
200-300 ft = 0.784 - 0.338 μT
300-400 ft = 0.338 - 0.228 μT
400-500 ft = 0.228 - 0.171 μT
500-600 ft = 0.171 - 0.128 μT
62.95 ft
100.69 ft
100.69
Arrowhead Trail
Willet Dr
Dunlin Dr
Salem Park
E Salem Park Cir
E Snowy Egret Dr
Wildflower Cir
Massage Salem Utah
N Sparrow Way
N 290 E
E Sanderling Dr
N Curlew Way
Warbler Rd
Woodland Hills Dr
Quail Run Rd
E Mill Rd
South Field Canal
Maki Lash
LEGEND
Existing Substation
Parcels
Proposed Centerline
Google
Keyboard shortcuts
Map Data ©2025 Imagery ©2025 Airbus, Maxar Technologies, USDA/FPAC/GEO, Vexcel Imaging US, Inc.
Terms
Report a map error

Effective 5/12/2020

78B-6-511 Compensation and damages -- How assessed.

(1) The court, jury, or referee shall hear any legal evidence offered by any of the parties to the proceedings, and determine and assess:

(a)

(i) the value of the property sought to be condemned as a whole, including all improvements pertaining to the property; and

(ii) the value of each separate interest in the property;

(b) if the property sought to be condemned constitutes only a part of a larger parcel, the damages which will accrue to the portion not sought to be condemned by reason of its severance from the portion sought to be condemned and the construction of the improvement in the manner proposed by the plaintiff;

(c) if the property, though no part of it is taken, will be damaged by the construction of the proposed improvement, and the amount of the damages;

(d) separately, how much the portion not sought to be condemned, and each estate or interest in it, will be benefitted, if at all, by the construction of the improvement proposed by the plaintiff , provided that if the benefit is equal to the damages assessed under Subsection (1)(b), the owner of the parcel shall be allowed no compensation except the value of the portion taken; but if the benefit is less than the damages assessed, the former shall be deducted from the latter, and the remainder shall be the only damages allowed in addition to the value of the portion taken;

(e) if the property sought to be condemned consists of water rights or part of a water delivery system or both, and the taking will cause present or future damage to or impairment of the water delivery system not being taken, including impairment of the system's carrying capacity, an amount to compensate for the damage or impairment; and

(f) if land on which crops are growing at the time of service of summons is sought to be condemned, the value that those crops would have had after being harvested, taking into account the expenses that would have been incurred cultivating and harvesting the crops.

(2) In determining the market value of the property before the taking and the market value of the property after the taking to assess damages in partial takings cases as described in Subsection (1)(b), the court, jury, or referee:

(a) may consider everything a willing buyer and a willing seller would consider in determining the market value of the property after the taking; and

(b) may not consider the assessed value on the property tax assessment for the property unless the court determines that the assessed value on the property tax assessment constitutes an admission by a party opponent.

Amended by Chapter 290, 2020 General Session

Colman v. Utah State Land Bd.

795 P.2d 622 (1990)

William J. COLMAN, Plaintiff and Appellant, v. UTAH STATE LAND BOARD; Ralph Miles, Director, Utah Division of State Lands and Forestry, Utah Department of Natural Resources; and Southern Pacific Transportation Company, a Delaware corporation, Defendants and Appellees.

No. 860331.

Supreme Court of Utah.

April 12, 1990.

Rehearing Denied July 20, 1990.

*623 Carol Clawson, Gary Bendinger, Salt Lake City, for Colman.

R. Paul Van Dam, Dallin W. Jensen, Michael M. Quealy, R. Douglas Credille, Salt Lake City, for State appellees.

L. Ridd Larson, Thomas L. Kay, Craig L. Taylor, Salt Lake City, for Southern Pacific.

STEWART, Justice:

William J. Colman filed an action against the Utah State Land Board and against Ralph Miles, Director of the Utah Division of State Lands and Forestry of the Department of Natural Resources (referred to collectively as "the State"), and against Southern Pacific Transportation Company for the destruction of an underwater brine canal Colman maintained on the bed of the Great Salt Lake. The trial court dismissed the complaint, and Colman appealed.

I. FACTS

This case arose out of the breach of the Great Salt Lake causeway on August 1, 1984. The causeway is a raised bed of fill which crosses the lake in an east-west direction. Southern Pacific runs a railroad line over the causeway. The causeway was constructed in 1959 by Southern Pacific after obtaining a right-of-way for its construction from the state of Utah.

The Great Salt Lake Causeway Act (the "Act"), 1984 Utah Laws ch. 32, enacted during the 1984 budget session of the Utah legislature, authorized breaching the causeway as a response to the rapid rise of the water level in the lake. During this same session, the legislature amended the Utah Governmental Immunity Act to limit the liability of governmental entities for management of flood waters. Utah Code Ann. § 63-30-3; 1984 Utah Laws ch. 33, § 1.

Prior to the breach of the causeway by the State and Southern Pacific, Colman operated and maintained a five-mile-long underwater *624 brine canal running parallel to and approximately 1,300 feet north of the causeway. The canal was authorized by a lease and easement granted by the State. The brine canal was used in Colman's business of extracting minerals from deep lake brines.

On July 20, 1984, Colman filed a complaint in the Third District Court seeking (1) to enjoin the State and Southern Pacific from breaching the causeway, and (2) to recover monetary damages for the damage the breach would cause his property if the court did not grant the injunction.

Colman's mineral extraction operation was located on the western shore of the lake. The canal began near that point and ran five miles eastward into the lake. Colman alleged that for his mineral extraction operation to be economically feasible, it was necessary for him to draw brines from the deeper strata of the lake, where the brines are more dense. His complaint alleged that he had dredged and maintained the canal so that its bottom was at a constant elevation. Colman alleged that the canal made it possible for him to pump the deep-water brines into his mineral extraction operation.

Colman alleged that the breach of the causeway would cause water from the south arm of the lake to flow through the breach under great pressure and cut through the canal banks. He also claimed that the breach would create turbidity and sedimentation, making the use of the canal as a brine conduit impossible.

The trial court denied Colman's motion for a preliminary injunction on July 31, 1984, after an evidentiary hearing, and the causeway was breached the following day. On August 20,

1984, the State filed a motion to dismiss Colman's damage claims. That motion was granted by the trial court May 2, 1986. The trial court concluded that (1) the Utah Governmental Immunity Act immunized the State from liability, (2) the breach of the causeway was a valid exercise of the police powers of the State, (3) the breach of the causeway was in furtherance of the State's public trust responsibilities, and (4) there was no compensable taking of a property interest.

II. STANDARD OF REVIEW

A dismissal is a severe measure and should be granted by the trial court only if it is clear that a party is not entitled to relief under any state of facts which could be proved in support of its claim. Liquor Control Comm'n v. Athas, 121 Utah 457, 460, 243 P.2d 441, 443 (1952). The courts are a forum for settling controversies, and if there is any doubt about whether a claim should be dismissed for the lack of a factual basis, the issue should be resolved in favor of giving the party an opportunity to present its proof. Baur v. Pacific Fin. Corp., 14 Utah 2d 283, 284, 383 P.2d 397, 397 (1963). On this appeal, we look solely to the material allegations of Colman's complaint, not to the evidence presented at the preliminary injunction hearing. In their briefs and at oral argument, the State and Southern Pacific rely extensively on the evidence presented at the preliminary injunction hearing to support their position. We do not, however, consider this evidence on this appeal. See Utah R.Civ.P. 12(b). Colman's complaint was dismissed on a rule 12 motion to dismiss. When reviewing a dismissal based on rule 12, an appellate court must accept the material allegations of the complaint as true, Petersen v. Jones, 16 Utah 2d 121, 122, 396 P.2d 748, 748 (1964), and the trial court's ruling should be affirmed only if it clearly appears that Colman can prove no set of facts in support of his claim. Arrow Industries, Inc. v. Zions First Nat'l Bank, 767 P.2d 935, 936 (Utah 1988); Freegard v. First Western Nat'l Bank, 738 P.2d 614, 616 (Utah 1987); Wells v. Walker Bank & Trust Co., 590 P.2d 1261, 1263 (Utah 1979).

The State argues in its supplemental brief that "[t]here is no virtue in rigid adherence to a technical rule that has no practical bearing on the proper outcome of a particular case." We decline to follow the State's suggestion that we should ignore the Utah Rules of Civil Procedure. The "technical rule" the State refers to is found in rule 12(b), which provides that a *625 motion to dismiss for failure to state a claim upon which relief can be granted shall be treated as a motion for summary judgment under rule 56 if matters outside the pleadings are presented to and not excluded by the court. However, the rule provides that if a motion to dismiss is converted to a motion for summary judgment, it must only be done so as to not create procedural prejudice to one of the parties. The rule states, "[A]ll parties

shall be given reasonable opportunity to present all material made pertinent to such a motion by Rule 56." Utah R.Civ.P. 12(b). This rule gives the opposing party an opportunity to gather evidence to rebut the movant's evidence. Without such a rule, one party could have the benefit of significant, supporting evidence while the other party would be left to rely solely on the unsubstantiated pleadings.

This rule has much "practical bearing on the proper outcome" of this case. The State and Southern Pacific moved for dismissal based on Colman's failure to state a claim upon which relief could be granted. Colman responded to these motions with a memorandum opposing the motions to dismiss, which focused exclusively on points of law. Colman appears to have assumed at that point that the rule 12 standard would be followed. His memorandum began by stating, "For purposes of a motion to dismiss, the truth of the Complaint's fact allegations must be assumed." Colman was not given reasonable opportunity to present additional evidence pursuant to rule 12(b). Had Colman known that the State would rely on the preliminary injunction evidence, he could have submitted other evidence to the trial court rebutting that evidence.

Furthermore, the trial court treated the motion to dismiss only under rule 12 and not under rule 56. The trial court did not make any factual findings in denying Colman's motion for a preliminary injunction. The trial court specifically stated that it only ruled that plaintiff had not met his burden of proof for a preliminary injunction and that its ruling was not dispositive of any other issues. The trial court also refused to order Colman to order the transcript of the preliminary injunction proceedings for this appeal. In granting the State's motion to dismiss, the trial court only entered conclusions of law.

Finally, if a trial court cannot on its own motion convert a rule 12 motion to dismiss to a Rule 56 motion for summary judgment, Hill v. Grand Central, Inc., 25 Utah 2d 121, 123, 477 P.2d 150, 151 (1970), then certainly we should not allow the moving party to do so on appeal.

III. TAKING OR DAMAGING PROPERTY A. Was Colman's canal "property" for purposes of article I, section 22?

Article I, section 22 of the Utah Constitution provides, "Private property shall not be taken or damaged for public use without just compensation." A claimant must possess some protectible interest in property before that interest is entitled to recover under this provision. Colman alleged that the Utah Division of State Lands and Forestry granted him, as part of a lease with the state, an easement for the maintenance and operation of the canal. It has always been accepted in this state that even an implied easement is a property

interest protectible under article I, section 22. Utah State Road Comm'n v. Miya, 526 P.2d 926, 928-29 (Utah 1974); Hampton v. State ex rel. Road Comm'n, 21 Utah 2d 342, 345, 445 P.2d 708, 710 (1968); Dooly Block v. Salt Lake Rapid Transit Co., 9 Utah 31, 37, 33 P. 229, 231-32 (1893). An express easement, such as that alleged by Colman, is also "private property" for the purposes of article I, section 22. See Whiterocks Irrigation Co. v. Mooseman, 45 Utah 79, 79-80, 141 P. 459, 460 (1914); Utah Code Ann. § 78-34-2(2) (Supp. 1989). Nichols on Eminent Domain states, "An easement is an interest in land, and it is taken in the constitutional sense when the land over which it is exercised is taken; but if it is only destroyed and ended, a destruction for public purposes may also be an appropriation for the same purpose." 2 Nichols on Eminent Domain § 5.14, at 5-186 (3d ed. 1989) (citing United States v. *626 Welch, 217 U.S. 333, 339, 30 S. Ct. 527, 54 L. Ed. 787 (1910)).

A lessee holding under a valid lease also has a property interest protected by the takings clause of the constitutional provisions:

It has been judicially established that lessees for years or from year to year, holding under a valid devise, grant, or lease, have such an interest in property as to be classed as "owners" in the constitutional sense, and to be entitled to compensation for the taking of their interest... .

2 Nichols on Eminent Domain § 5.06, at 5-97 to 101 (3d ed. 1989).

We conclude that Colman has alleged a property interest protectible under article I, section 22 of the Utah Constitution. We emphasize again that we regard the allegations of the complaint as true. We do not look to evidence presented at the preliminary injunction hearing. Colman cannot recover if the State proves that in fact there was no canal or that Colman had no legal rights in the canal. Colman can only recover for the taking of property to the extent that property exists and to the extent he has legal rights in that property.

B. Was Colman's canal "taken or damaged" for purposes of article I, section 22?

Article I, section 22 of the Utah Constitution provides, "Private property shall not be taken or damaged for public use without just compensation." This Court has previously outlined what constitutes a taking and what constitutes damage under this constitutional provision.

In State ex rel. State Road Commission v. District Court, Fourth Judicial District, 94 Utah 384, 78 P.2d 502 (1937), the Court stated that a "taking" is "any substantial interference with private property which destroys or materially lessens its value, or by which the owner's right to its use and enjoyment is in any substantial degree abridged or destroyed."

94 Utah at 394, 78 P.2d at 506 (quoting Stockdale v. Rio Grande Western Ry. Co., 28 Utah 201, 211, 77 P. 849, 852 (1904)); see Hampton v. State Road Comm'n, 21 Utah 2d 342, 347, 445 P.2d 708, 711-12 (1968). This Court has also defined the term "damage" for the purpose of article I, section 22 and for the purpose of the eminent domain statute in Board of Education of Logan City School District v. Croft, 13 Utah 2d 310, 373 P.2d 697 (1962). In that case, the Court cited article I, section 22 and stated:

Damages to land, by the construction of a public or industrial improvement, though no part thereof is taken as provided for under 78-34-10(3), contrary to the rule for severance damages, is limited to injuries that would be actionable at common law, or where there has been some physical disturbance of a right, either public or private, which the owner enjoys in connection with his property and which gives it additional value, and which causes him to sustain a special damage with respect to his property in excess of that sustained by the public generally.

13 Utah 2d at 313-14, 373 P.2d at 699; see State ex rel. Road Comm'n v. Williams, 22 Utah 2d 331, 334, 452 P.2d 881, 883-84 (1969); Twenty-Second Corporation of Church of Jesus Christ of Latter-Day Saints v. Oregon Short Line R.R., 36 Utah 238, 247, 103 P. 243, 246 (1909) ("[T]o bring the case within the damage clause of the Constitution, there must be some physical interference with the property itself or with some easement which constitutes an appurtenant thereto."). The Court went on to explain that such "damage" requires a "definite physical injury cognizable to the senses with a perceptible effect on the present market value." Croft, 13 Utah 2d at 314, 373 P.2d at 699. The Court listed various types of injuries that would be compensable as "damage" under the constitutional provision. These included "drying up wells and springs," "destroying lateral supports," "preventing surface waters from running off adjacent lands or running surface waters onto adjacent lands," or "depositing of cinders and other foreign materials on neighboring lands by the permanent operation of the business or improvement established on the adjoining *627 lands." Croft, 13 Utah 2d at 314, 373 P.2d at 699-700.

In our recent case of Rocky Mountain Thrift Stores, Inc. v. Salt Lake City Corp., 784 P.2d 459 (Utah 1989), we stated: "Plaintiffs alleged that damages [from the flooding] resulted from a temporary, one-time occurrence and not a permanent, continuous, or inevitably recurring interference with property rights usually associated with and requisite in a compensable taking." 784 P.2d at 465 (citing Sanguinetti v. United States, 264 U.S. 146, 149, 44 S. Ct. 264, 265, 68 L. Ed. 608 (1924); Accardi v. United States, 220 Ct.Cl. 347, 356-57, 599 F.2d 423, 429 (1979); Miotke v. City of Spokane, 101 Wash. 2d 307, 334, 678 P.2d

803, 818 (1984)). See also Loretto v. Teleprompter Manhattan CATV Corp., 458 U.S. 419, 428, 102 S. Ct. 3164, 3172, 73 L. Ed. 2d 868 (1982).

Colman alleged in his complaint that the breach would result in the total destruction of at least a 300-foot segment of the canal. He also alleged that the breach would create such turbidity in the area of the canal that the remaining portions of the canal would be filled with sediment over much of its course. Colman alleged that the breach would require that he move the canal and pumps to another location free from the current caused by the breach. We conclude that Colman has alleged a permanent or recurring interference with property rights. Thus, Colman has alleged sufficient facts to constitute a "taking" or "damage" under article I, section 22.

C. Was Colman's property "taken or damaged" or merely regulated under the State's general police powers?

The State suggests that because the breach of the causeway was a valid exercise of the State's police powers, it is not liable for the damage caused to Colman. However, in Utah State Road Commission v. Miya, 526 P.2d 926 (Utah 1974), we plainly stated, "The constitutional guarantee of just compensation for the taking or damaging of private property for public use is in no way affected by the fact that the expropriator ... exercis[ed] the police power." 526 P.2d at 928.

The State seems to have misled itself on this point by relying on isolated language from discussions of a related but different issue. It is true that the courts will not disturb the legislature's judgment in the exercise of the general police powers as long as it does not violate constitutional limits. Salt Lake City v. Young, 45 Utah 349, 355, 145 P. 1047, 1048-49 (1915). The police powers are not, however, beyond the limitations established by the constitution. Bountiful City v. De Luca, 77 Utah 107, 125-26, 292 P. 194, 202 (1930).

The emphasis the State places on the police powers is often made when there is a close issue that turns on the difference between a taking or damage under article I, section 22 and mere regulation of property and activities on property. Many statutes and ordinances regulate what a property owner can do with and on the owner's property. Those regulations may have a significant impact on the utility or value of property, yet they generally do not require compensation under article I, section 22. Only when governmental action rises to the level of a taking or damage under article I, section 22 is the State required to pay compensation.

Previous cases of this Court have wrestled with the issue. In Bountiful City v. De Luca, the Court stated:

Broad and comprehensive as are the police powers of the state, still we think it may not successfully be contended that the power may be so exercised as to infringe upon or invade rights safeguarded and guaranteed by constitutional provisions... . The cases are numerous to the effect that ... the state may without compensation regulate and restrain the use of private property when the health, safety, morals, or welfare of the public requires or demands it; ... that the exercise of proper police regulations may to some extent prevent enjoyment of individual rights in property or cause inconvenience or loss to the owner, does not necessarily render the police law unconstitutional, for the reason that *628 such laws are not considered as appropriating private property for a public use, but simply as regulating its use and enjoyment, and if the owner through a lawful exercise of the power suffers inconvenience, injury, or a loss, it is regarded as damnum absque injuria, provided always, that constitutional mandates have not been invaded by a confiscation, destruction, or deprivation of property, unless it is per se injurious or obnoxious or a menace to public health or public safety or morals or general welfare, or unless under conditions similar to tearing down a building to prevent spreading of a conflagration; but however broad the scope of the police power, it is always subject to the rule that the Legislature may not exercise any power expressly or impliedly forbidden by constitutional provisions.

77 Utah at 119-121, 292 P. at 199-200 (emphasis added). In Salt Lake City v. Young, 45 Utah 349, 362, 145 P. 1047, 1051 (1915), we held that "a landowner cannot complain because he is inconvenienced in the use of his property, where such inconvenience arises out of the proper enforcement of the police power to protect the public health, and where such enforcement does not amount to a taking or destruction of his property."

Here, Colman argues that the State's actions were not a mere regulation of property, but constituted an actual physical taking. It is not relevant that the State's action in this case was a valid exercise of its police power. Rather, the issue is whether sufficient facts were alleged to show a taking of property.

It is not alleged that Colman was causing a nuisance on the property. Thus, the case does not fall into the exception for the abatement of nuisances.

D. Does the State avoid liability because its action was in response to an emergency?

The State argues that no liability should be imposed on it because the breach destroyed the canal to avert an overwhelming destruction of property. Colman argues, however, that that

principle only applies when the plaintiff's property would have been destroyed by the emergency condition irrespective of the governmental action.

Colman correctly states that many of the cases involve situations where the plaintiff's property would have been destroyed by the emergency even if there had been no governmental action. See United States v. Caltex (Philippines), Inc., 344 U.S. 149, 73 S. Ct. 200, 97 L. Ed. 157 (1952); Sanguinetti v. United States, 264 U.S. 146, 149, 44 S. Ct. 264, 265, 68 L. Ed. 608 (1924). Colman argues that the "emergency" created by the higher lake waters did not affect the operation of the canal. However, the trial court must determine whether Colman's canal would have been in danger without the breach.

Other cases dealing with emergencies and eminent domain can be distinguished because they involve questions of proper regulation and the use of the police power as discussed above. See Miller v. Schoene, 276 U.S. 272, 48 S. Ct. 246, 72 L. Ed. 568 (1928); Teresi v. State, 180 Cal. App. 3d 239, 225 Cal. Rptr. 517 (1986). These cases do not involve a direct physical taking, as is alleged in this case.

However, all of the cases dealing with this emergency doctrine cannot be distinguished on these bases. The State argues correctly that in some cases there is no liability where property is destroyed by a governmental entity to prevent imminent public catastrophe. The privilege to take or damage private property without compensation arises from the necessity of sacrificing some property to prevent overwhelming damage or loss of life. This privilege is based on the privilege of any individual to take immediate action that harms property so as to prevent loss of life or great destruction of property. City of Rapid City v. Boland, 271 N.W.2d 60, 65 (S.D. 1978). This exception to the general requirement of just compensation for property taken is explained in 1 Nichols on Eminent Domain §§ 1.43[1] and 1.43[2]:

More closely allied to the power of eminent domain is the power of destruction *629 from necessity. In the case of fire, flood, pestilence or other great public calamity, when immediate action is necessary to save human life or to avert an overwhelming destruction of property, any individual may lawfully enter another's land and destroy his property, real or personal, providing he acts with reasonable judgment. ... . If the individual who enters and destroys private property happens to be a public officer whose duty it is to avert an impending calamity, the rights of the owner of the property to compensation are no greater than in the case of a private individual. The most familiar example of the exercise of this right is seen in case of fire. The neighbors and fireman freely trespass on the adjoining land, and houses are even blown up to prevent the spread of the conflagration. The danger of flood or the existence of a pestilence may call for equally drastic action. However, the

permanent appropriation of private property without the payment of compensation therefor cannot be justified under the power.

1 Nichols on Eminent Domain §§ 1.43[1], 1.43[2], at 1-841 to 843 (3d ed. 1989) (footnotes omitted). This exception only applies where there is an extreme, imperative, or overwhelming necessity. Mere expediency is insufficient. Boland, 271 N.W.2d at 66. There must be "circumstances of imminent necessity." Srb v. Board of County Comm'rs, 43 Colo. App. 14, 18, 601 P.2d 1082, 1085 (1979), cert. denied as improvidently granted, 199 Colo. 496, 618 P.2d 1105 (1980). This exception must be narrowly construed. Almost every act of taking property under the eminent domain powers involves some degree of public necessity. This exception could overcome the rule of just compensation if it is not limited to only the most extreme emergencies. In McKell v. Spanish Fork City, 6 Utah 2d 92, 305 P.2d 1097 (1957), this Court outlined how a governmental entity or any riparian owner could protect itself against extraordinary floods without liability:

However, it is generally recognized that riparian owners may embank and protect their lands against the overflow of extraordinary floods, even though damage to the lands of others is caused thereby. An extraordinary flood is one which is not foreshadowed by the usual course of nature, and is of such a magnitude and destructiveness as could not have been anticipated or provided against by the exercise of ordinary foresight.

McKell, 6 Utah 2d at 95-96, 305 P.2d at 1099 (emphasis in original). McKell involved an extraordinary flood. Here, it is a question of fact whether the rising water level constituted an "extraordinary flood" and whether there were otherwise circumstances of overwhelming necessity. These questions cannot be decided on the basis of the pleadings and will have to be decided at trial.

Also involved in this case is the State's role in creating the emergency. Colman alleged that Southern Pacific is the owner of a right-of-way granted by the State over the bed of the lake for the construction of the causeway. It appears that the State played some role in the construction of the causeway, and the causeway seems to be the major factor in causing the "emergency" the State is now claiming. It is more difficult to find an emergency of overwhelming necessity when the State played a part in creating the circumstances causing the emergency. See McKell, 6 Utah 2d at 96-97, 305 P.2d at 1099-1100.

Nichols on Eminent Domain makes clear that the permanent appropriation of property without compensation does not fit into this exception. 1 Nichols on Eminent Domain § 1.43[2], at 1-843 (3d ed. 1989); see Short v. Pierce County, 194 Wash. 421, 435-36, 78 P.2d

610, 616 (1938). In this case, Colman alleges a permanent taking of his property. This is another question of fact for the trial court to determine.

On remand, the trial court must determine whether the emergency exception applies in this instance. To fall within this exception, the trial court must find that the flooding created a situation of extreme, imperative, or overwhelming necessity. In *630 addition, the exception is not applicable if the State played a foreseeable role in causing the emergency.

IV. SOVEREIGN IMMUNITY

Colman's complaint states a cause of action for inverse condemnation of his property. Colman alleged that the destruction of his canal constitutes a taking of his property without just compensation in violation of article I, section 22 of the Utah Constitution. The State and Southern Pacific claim that they are immune from this inverse condemnation claim under the Utah Governmental Immunity Act. Utah Code Ann. § 63-30-1 to -38. (1989).[1] The issue is whether an inverse condemnation claim under article I, section 22 is subject to the limitations found in the Governmental Immunity Act.

This Court has struggled since the turn of the century to reconcile the doctrine of sovereign immunity with article I, section 22 of the Utah Constitution, which provides simply that " [p]rivate property shall not be taken or damaged for public use without just compensation." Early and recent cases provide valuable insight into the meaning of this provision.

The delegates to the Constitutional Convention in 1895 spent a great deal of time formulating and debating the language of article I, section 22. The debates show that the delegates believed that the provision limited state government and was not merely advice that the legislature could choose to follow if it wished. See Proceedings and Debates of the Constitutional Convention, 326-344, 623-53 (1898). The specific issue of the relation between sovereign immunity and article I, section 22 never arose in these debates. However, the more general issue of the role of the constitution in relation to the role of legislature was frequently discussed during the debates on article I, section 22. Throughout these discussions, the delegates assumed that article I, section 22 would be a limitation on the state and that further legislation would provide no less protection than that mandated by article I, section 22. Proceedings and Debates of the Constitutional Convention, 625, 629-33 (1898) (indicating that the delegates saw the constitutional provision as the minimum expected of the state and the legislature). The framers of the Utah Constitution expected it to act as a real limit on the powers of the state. The framers certainly did not

intend to allow state government to override the constitutional guarantee with a legislative enactment.

This Court originally held that article I, section 22 was self-executing. Webber v. Salt Lake City, 40 Utah 221, 224, 120 P. 503, 504 (1911). Later, the Court switched to a position that the state was immune from suit for damages under the doctrine of sovereign immunity and that article I, section 22 was not self-executing. Fairclough v. Salt Lake County, 10 Utah 2d 417, 354 P.2d 105 (1960). We now reaffirm that article I, section 22 is self-executing. In doing so, clarity requires that we specify the cases that the Court overrules.

The question of whether article I, section 22 is self-executing involves the issue of whether the constitutional provision requires a legislative enactment to be enforced in the courts. As the law developed in this state, the question of whether article I, section 22 is self-executing gave rise to the specific issue of whether the legislature can block enforcement of article I, section 22 against the state or its political subdivisions by a grant of immunity.

In Stockdale v. Rio Grande Western Ry. Co., 28 Utah 201, 77 P. 849 (1904), the *631 Court stated that "a party whose property is about to be specially damaged in any substantial degree for public use has the same rights and is given the same remedies for the protection of his property from the threatened injury as would be accorded him if his property was actually taken and appropriated for such use." 28 Utah at 213, 77 P. at 853. See State ex rel. State Road Commission v. District Court, Fourth Judicial Dist., 94 Utah 384, 393, 78 P.2d 502, 506 (1937). In Stockdale, the Court referred to the discussions in the Constitutional Convention to support that proposition. 28 Utah at 213, 77 P. at 853. Nevertheless, the Court later ignored the principle that "takings" and "damages" should be afforded the same remedies.

In Webber v. Salt Lake City, 40 Utah 221, 120 P. 503 (1911), the Court explicitly held that article I, section 22 was self-executing and the right to recover consequential damages for damage to property did not rely on legislative enactment. 40 Utah at 224, 120 P. at 504; see Coalter v. Salt Lake City, 40 Utah 293, 298, 120 P. 851, 853 (1912) ("Consequential damages to property which are caused by making public improvements are recoverable under the Constitution of this state, and not by virtue of a statute.").

Wilkinson v. State, 42 Utah 483, 134 P. 626 (1913), did not deal with article I, section 22, but it seems to have led to confusion in subsequent decisions dealing with sovereign immunity in the context of that provision. See Fairclough v. Salt Lake County, 10 Utah 2d 417, 425, 354 P.2d 105, 110-11 (1960) (Wade, J., dissenting). In Wilkinson, the plaintiff sought recovery from a state fund for damage to his property caused by flooding from a

canal the state had constructed. The Court stated that without the consent of the state an action against the sovereign could not be maintained: "We have neither a statute nor a constitutional provision authorizing a suit against the state." 42 Utah at 492, 134 P. at 630.

Eight years later, the Court again stated that article I, section 22 was binding on the state as sovereign. In Croft v. Millard County Drainage District No. 1, 59 Utah 121, 202 P. 539 (1921), the Court stated:

Even the state itself, when acting within the scope of its sovereign powers, cannot take or damage private property for public use without making just and adequate compensation to the person to whom the property belongs. This is a fundamental law of the commonwealth, binding upon every department of the state government. It is the duty of the courts to give it full force and effect whenever it is properly invoked by one claiming its protection, even as against the sovereign power of the state.

59 Utah at 126, 202 P. at 541 (emphasis added).

Campbell Building Co. v. State Road Commission, 95 Utah 242, 70 P.2d 857 (1937), was like Wilkinson in holding that an action could not be maintained against the state without its consent. It was also like Wilkinson in that it did not deal with article I, section 22.

State ex rel. State Road Commission v. District Court, Fourth Judicial District, 94 Utah 384, 78 P.2d 502 (1937), held that the individual commissioners of the State Road Commission could be enjoined from pursuing a highway project until payments for consequential damage were made to property owners. Because this action was brought before the improvement was constructed, the property owners sought an injunction, not damages. Because of this, the Court did not consider in depth the relation of sovereign immunity to article I, section 22. The Court simply stated that the state could not be sued without its consent and cited Wilkinson and Campbell as authority. 94 Utah at 389, 78 P.2d at 504. As mentioned above, neither of those cases dealt with sovereign immunity in the context of an article I, section 22 claim.

The Court did state, however, that "it is clear that the framers of the Constitution did not intend to give the rights granted by section 22, and then leave the citizen powerless to enforce such rights." 94 Utah at 397, 78 P.2d at 508. The Court then stated in dicta that if an injunction would not *632 adequately protect the constitutional right, then the state could be found to have consented to suit against itself under article I, section 22. 94 Utah at 399, 78 P.2d at 509.

Nevertheless, this and other similar dicta were soon ignored in the later cases. Anderson Investment Corp. v. State, 28 Utah 2d 379, 503 P.2d 144 (1972); Hjorth v. Whittenburg, 121 Utah 324, 241 P.2d 907 (1952). In Hjorth, the Court held that the road commissioners individually could not be sued for consequential damages done to property in regrading for a highway project. 121 Utah at 330, 241 P.2d at 909. Chief Justice Wolfe concurred and stated that Hjorth overruled State ex rel. State Road Commission v. District Court, Fourth Judicial District, 94 Utah 384, 78 P.2d 502 (1937). Hjorth, 121 Utah at 331, 241 P.2d at 910.

In Springville Banking Co. v. Burton, 10 Utah 2d 100, 349 P.2d 157 (1960), the plaintiff tried to circumvent sovereign immunity and the holding in Hjorth by seeking a writ of mandamus to compel the members of the State Road Commission to initiate eminent domain proceedings to assess consequential damages to the plaintiff's property. The Court held that sovereign immunity could not be circumvented in that way. Springville Banking, 10 Utah 2d at 103, 349 P.2d at 159.

In Fairclough v. Salt Lake County, 10 Utah 2d 417, 354 P.2d 105 (1960), we held that "Art. I, Sec. 22 of our Constitution is not self-executing, nor does it give consent to be sued, implied or otherwise; and that to secure such consent is a legislative matter... ." 10 Utah 2d at 419, 354 P.2d at 106 (footnotes omitted). Fairclough was followed in State ex rel. Road Commission v. Parker, 13 Utah 2d 65, 368 P.2d 585 (1962), and in Holt v. Utah State Road Commission, 30 Utah 2d 4, 511 P.2d 1286 (1973).

In Hampton v. State ex rel. Road Commission, 21 Utah 2d 342, 445 P.2d 708 (1968), the Court took a less restrictive position on the issue of compensation from the state. In Hampton, the plaintiffs' right of access to their property was interfered with by the construction of Interstate 15. The Court held that the state had given its consent to be sued for the taking of property under Utah Code Ann. § 78-11-9 (1953). The Court held that if the action of the state amounted to a "substantial and material impairment of access to their property," then it constituted a taking requiring compensation from the state. 21 Utah 2d at 348, 445 P.2d at 712. Thus, the Court made it possible for the plaintiff to recover by classifying the plaintiffs' damages as a taking, for which immunity had been waived by statute, rather than as damage, for which the plaintiff could not recover under Fairclough.

Andrus v. State, 541 P.2d 1117 (Utah 1975), held the state liable because the state's conduct, which led to the damages sustained by the plaintiffs, fell within the Governmental Immunity Act, Utah Code Ann. § 63-30-9 (1953), although Judge Bullock, sitting pro tempore, dissented and argued that article I, section 22 was self-executing and should be applied. 541 P.2d at 1122 (Bullock, D.J., dissenting). In dissent in separate cases, Justice Wade and Judge Bullock both cited many cases from other states holding that similar state

constitutional provisions are self-executing. See Andrus v. State, 541 P.2d at 1123 n. 6 (Bullock, D.J., dissenting); Springville Banking Co. v. Burton, 10 Utah 2d at 105-09, 349 P.2d at 159-62 (Wade, J., dissenting). Today the overwhelming majority of states with similar constitutional provisions hold them to be self-executing.[2]*633

*634 The history of these cases shows that for a time the Court's concentration on the doctrine of sovereign immunity caused it to neglect this constitutional provision, which was designed to protect individual rights. This elevation of legislation and common law principles over a clear constitutional limitation strikes at the heart of constitutional government. The people of Utah established the Utah Constitution as a limitation on the power of government. It can hardly be maintained that the doctrine of sovereign immunity, alone among all doctrines, is outside of the limitations the people *635 established. In Dean v. Rampton, 556 P.2d 205 (Utah 1976), we stated:

The purpose of a constitution is to provide an orderly foundation for government and to keep even the sovereign ... within its bounds. Therefore, the legislative power itself must be exercised within the framework of the constitution. Accordingly, it has been so long established and universally recognized, as to be hardly necessary to state, that if a statutory enactment contravenes any provision of the constitution, the latter governs.

556 P.2d at 206-07 (citing Marbury v. Madison, 1 Cranch 137, 2 L. Ed. 60 (1803)).

In sum, article I, section 22 needs no legislation to activate it; it is mandatory and obligatory as it is. See Utah Const. art. I, § 24.

The trial court concluded that Southern Pacific acted as the State's contractor on the causeway breach project and was therefore protected by the State's immunity. Since we hold that the State is not immune, Southern Pacific can no longer depend on the State's immunity. We express no opinion as to Southern Pacific's argument of derivative immunity based on its status as the State's contractor for the project.

V. PUBLIC TRUST DOCTRINE

The trial court held that the breaching of the causeway was in furtherance of the State's public trust responsibilities and that the State could not be liable for the damage allegedly done to Colman's canal. The State maintains that it can take any action relating to the lake that is in the public interest and be immune from liability for that action. Colman argues that the public trust doctrine does not apply to flood control, but only to certain limited purposes, such as commerce, fishing, navigation, and perhaps recreational use and preservation of ecological integrity.

The controlling case on this issue is Illinois Central R.R. Co. v. Illinois, 146 U.S. 387, 13 S. Ct. 110, 36 L. Ed. 1018 (1892), where the United States Supreme Court discussed the public trust doctrine and held that the Illinois legislature's earlier grant to the railroad of lands submerged under Lake Michigan could be revoked by a later legislature because the earlier grant was in violation of the public trust the state held over the waters.

The essence of this doctrine is that navigable waters should not be given without restriction to private parties and should be preserved for the general public for uses such as commerce, navigation, and fishing. Recent cases have examined this doctrine in deciding whether the state could grant uses of public waters to private parties. See, e.g., Kootenai Envtl. Alliance, Inc. v. Panhandle Yacht Club, Inc., 105 Idaho 622, 671 P.2d 1085 (1983).

This case, however, presents a different problem. The State has already exercised its powers under the public trust in leasing the canal on the bed of the lake to Colman. Now, the State wishes to revoke that grant without compensation to Colman. The State maintains that it can do so since it holds the waters of the lake under the public trust. In taking such a position, the State essentially argues that it originally acted without authority in granting the lease to Colman.

Illinois Central provides some guidance on this question. The Supreme Court stated:

But the decisions are numerous which declared that such property is held by the State, by virtue of its sovereignty, in trust for the public. The ownership of the navigable waters of the harbor and of the lands under them is a subject of public concern to the whole people of the State. The trust with which they are held, therefore, is governmental and cannot be alienated, except in those instances mentioned of parcels used in the improvement of the interest thus held, or when parcels can be disposed of without detriment to the public interest in the lands and waters remaining.

146 U.S. at 455-56, 13 S. Ct. at 119 (emphasis added). The Supreme Court made clear that a state can grant certain rights in navigable waters if those rights can be disposed of without affecting the public *636 interest in what remains. 146 U.S. at 453, 13 S. Ct. at 118. At this point in the litigation, there is nothing to show that Colman's canal impaired the public interest in any way at the time the State granted him the right to conduct his operation. This is a question of fact to be decided by the trial court.

VI. SPECIAL LEGISLATION

Colman argues on appeal that the Great Salt Lake Causeway Act (the "Act") was beyond legislative authority and constituted special legislation in violation of article VI, section 26

of the Utah Constitution. Article VI, section 26 provides, "No private or special law shall be enacted where a general law can be applicable." In this case, the Act provided indemnity to Southern Pacific for actions arising out of the breach of the causeway.

The fact that legislation benefited one individual does not prove a violation of article VI, section 26. Hulbert v. State, 607 P.2d 1217, 1223 (Utah 1980). The standards for judging challenged legislation under this provision were stated by this Court in Utah Farm Bureau Insurance Co. v. Utah Insurance Guaranty Association, 564 P.2d 751 (Utah 1977):

A general law applies to and operates uniformly upon all members of any class of persons, places, or things requiring legislation peculiar to themselves in the matters covered by the laws in question. On the other hand, special legislation relates either to particular persons, places, or things or to persons, places or things which, though not particularized, are separated by any method of selection from the whole class to which the law might, but for such legislation, be applied. ... [A] law is general when it applies equally to all persons embraced in a class founded upon some natural, intrinsic, or constitutional distinction. It is special legislation if it confers particular privileges or imposes peculiar disabilities, or burdensome conditions in the exercise of a common right; upon a class of persons arbitrarily selected, from the general body of those who stand in precisely the same relation to the subject of the law. The constitutional prohibition of special legislation does not preclude legislative classification, but only requires the classification to be reasonable.

564 P.2d at 754 (following State v. Kallas, 97 Utah 492, 505, 94 P.2d 414, 420 (1939); People v. Western Fruit Growers, Inc., 22 Cal. 2d 494, 506, 140 P.2d 13, 19-20 (1943)).

In the Act, the legislature found that extreme weather conditions had caused the water level in the lake to rise sharply, causing severe flood damage. 1984 Utah Laws ch. 32, § 1. It also found that the causeway had caused the water level in the south arm of the lake to be significantly higher than the water level in the north arm. The legislature declared it to be in the public interest to breach the causeway and authorized the Division of State Lands and Forestry to do so. The legislature then stated: "In order to obtain the cooperation of the Southern Pacific Railroad which is necessary for the timely accomplishment of the objectives of this act, the division is authorized to enter into formal agreement with the railroad for indemnification as follows... ." 1984 Utah Laws ch. 32, § 2.

This legislation makes a reasonable classification to accomplish its purposes of preventing widespread flood damage to public lands, major transportation routes, and other public facilities. Southern Pacific owns the causeway. This statute does not discriminate against anyone since Southern Pacific is the owner of the causeway and the operator of the railway

that crosses the causeway. The Act is not special legislation in violation of article VI, section 26.

VII. CONCLUSION

The trial court's dismissal of plaintiff's complaint is reversed, and the case is remanded to the trial court for further proceedings consistent with this opinion.

HALL, C.J., and HOWE, Associate C.J., concur.

*637 ZIMMERMAN, Justice: (concurring).

I join in all of Justice Stewart's opinion. However, as to part IIIB, which holds that the allegations of Colman's complaint are sufficient to state a claim for a taking or damaging under article I, section 22 of the Utah Constitution, I would observe that the precise limits of a taking or damaging have yet to be carefully or consistently spelled out by this court. Three D Corp. v. Salt Lake City, 752 P.2d 1321, 1324-25 (Utah Ct.App. 1988). There will be time enough for us to carefully consider this question in future cases.

DURHAM, J., concurs in the concurring opinion of ZIMMERMAN, J.

NOTES

[1] In 1987, the legislature waived its asserted immunity by adding § 63-30-10.5 to the Utah Governmental Immunity Act. 1987 Utah Laws ch. 75, § 3. That section provides:

(1) Immunity from suit of all governmental entities is waived for the recovery of compensation from the governmental entity when the governmental entity has taken or damaged private property without just compensation.

(2) Compensation and damages shall be assessed according to the requirements of Chapter 34, Title 78.

However, this provision was not in place at the time this cause of action arose and does not apply here.

[2] The following states hold their constitutional provisions requiring just compensation for taking or damaging private property to be self-executing or otherwise binding on the state.

ALABAMA. Ala. Const. art. I, § 23 ("[B]ut private property shall not be taken for, or applied to public use, unless just compensation be first made therefor... ."); City of Fairhope v.

Raddcliffe, 48 Ala.App. 224, 229, 263 So. 2d 682, 686 (1972) (authority to sue for damage caused by negligent construction of sewer system arises from Alabama constitution, not from statutory waiver of sovereign immunity).

ALASKA. Alaska Const. art. I, § 18 ("Private property shall not be taken or damaged for public use without just compensation."); State, Dept. of Highways v. Crosby, 410 P.2d 724, 728-29 (Alaska 1966) (basis of action was article I, section 18 of the Alaska constitution).

ARIZONA. Ariz. Const. art. II, § 17 ("No private property shall be taken or damaged for public or private use without just compensation having first been made... ."); Pima County v. Bilby, 87 Ariz. 366, 370, 351 P.2d 647, 649 (1960) ("This Court has previously held section 17, article 2, of the Arizona Constitution to be self-executing (County of Mohave v. Chamberlin, 78 Ariz. 422, 281 P.2d 128 (1955)), and it is perfectly clear that the absence of enabling legislation cannot deprive plaintiff of his constitutional right to just compensation for any of his private property which is `taken or damaged' by the County.").

CALIFORNIA. Cal. Const. art. I, § 19 ("Private property may be taken or damaged for public use only when just compensation, ascertained by a jury unless waived, has first been paid to, or into court for, the owner."); Pacific Outdoor Advertising Co. v. City of Burbank, 86 Cal. App. 3d 5, 9, 149 Cal. Rptr. 906, 909 (1978) ("[Article I, section 19] requires no statutory implementation, since it is self-executing."); Rose v. State, 19 Cal. 2d 713, 726, 123 P.2d 505, 513 (1942) ("Immunity from suit cannot avail in this instance, and, if no statute exists, liability still exists, because as to this provision the Constitutions are self-executing.") (quoting Chick Springs Water Co. v. State Hwy. Dept., 159 S.C. 481, 157 S.E. 842 (1931)).

COLORADO. Colo. Const. art. II, § 15 ("Private property shall not be taken or damaged, for public or private use, without just compensation."); Srb v. Bd. of County Commissioners, 43 Colo App. 14, 19, 601 P.2d 1082, 1085 (1979) (the just compensation clause of the Colorado constitution creates an exception to the doctrine of governmental immunity), cert. denied as improvidently granted, 199 Colo. 496, 618 P.2d 1105 (1980).

GEORGIA. Ga. Const. art. I, § 3, ¶ 1 ("[P]rivate property shall not be taken or damaged for public purposes without just and adequate compensation being first paid."); Fulton County v. Baranan, 240 Ga. 837, 838, 242 S.E.2d 617, 619 (1978) (action for damage done to private property by county not barred by statute granting counties immunity from liability).

ILLINOIS. Ill. Const. art. I, § 15 ("Private property shall not be taken or damaged for public use without just compensation as provided by law."); People ex rel. Alexander v. City of Mount Vernon, 404 Ill. 58, 66, 88 N.E.2d 45, 49 (1949) ("The provision of the constitution guaranteeing compensation if property is taken or damaged for public use is self-executing, requires no legislation for its enforcement, and cannot be impaired by legislation or ordinance.").

KENTUCKY. Ky. Const. § 13 ("[N]or shall any man's property be taken or applied to public use without the consent of his representatives and without just compensation being previously made to him."); Holloway Constr. Co. v. Smith, 683 S.W.2d 248 (Ky. 1984) (state waives immunity for suits under takings clause); Kentucky Bell Corp. v. Commonwealth, 295 Ky. 21, 25, 172 S.W.2d 661, 663 (1943) (the constitutional provisions "support the rule that ... where a trespass ... amounts to [a] taking, the state's immunity from suit is waived ...").

LOUISIANA. La. Const. art. I, § 4 ("Property shall not be taken or damaged by the state or its political subdivisions except for public purposes and with just compensation... ."); Reymond v. State ex rel. Dep't. of Highways, 255 La. 425, 447, 231 So. 2d 375, 383 (1970) (constitutional provision supports suit for inverse condemnation by property owner); Angelle v. State, 212 La. 1069, 1076, 34 So. 2d 321, 323 (1948) ("This provision, which is similar to that appearing in other State Constitutions, has been generally regarded as self-executing.").

MINNESOTA. Minn. Const. art. I, § 13 ("Private property shall not be taken, destroyed or damaged for public use without just compensation therefor, first paid or secured."); State v. Prow's Motel, Inc., 285 Minn. 1, 171 N.W.2d 83 (1969) (property owner is entitled to damages for constitutional taking).

MISSISSIPPI. Miss. Const. art. III, § 17 ("Private property shall not be taken or damaged for public use, except on due compensation being first made to the owner or owners thereof...."); State Highway Comm'n v. Mason, 192 Miss. 576, 593, 4 So. 2d 345, 349 (1941) ("It would be a mockery for the Constitution to guarantee a right to the property owner, and a duty on the taker thereof, and leave the enforcement of both dependent upon the legislative will.").

MISSOURI. Mo. Const. art. I, § 26 ([P]rivate property shall not be taken or damaged for public use without just compensation."); Page v. Metropolitan St. Louis Sewer Dist., 377 S.W.2d 348, 354 (Mo. 1964) ("While the state cannot be sued without its consent, and there is no statutory provision authorizing such suits, nevertheless, `if the injury alleged is a

damage within the constitutional provision, that provision is self-enforcing.'") (quoting Anderson v. Inter-River Drainage & Levee Dist., 309 Mo. 189, 274 S.W. 448, 455 (1925)).

MONTANA. Mont. Const. art. II, § 29 ("Private property shall not be taken or damaged for public use without just compensation to the full extent of the loss... ."); City of Three Forks v. State Highway Comm'n, 156 Mont. 392, 398, 480 P.2d 826, 830 (1971) (the constitutional provision prohibiting the taking or damaging of private property without just compensation waives the immunity of the state where that provision applies).

NEBRASKA. Neb. Const. art. I, § 21 ("The property of no person shall be taken or damaged for public use without just compensation therefor."); Kula v. Prososki, 219 Neb. 626, 629, 365 N.W.2d 441, 443 (1985) ("[Article I, section 21] of the Constitution is self-executing, and legislative action is not necessary to make the remedy available.").

NEW MEXICO. N.M. Const. art. II, § 20 ("Private property shall not be taken or damaged for public use without just compensation."); McClure v. Town of Mesilla, 93 N.M. 447, 448, 601 P.2d 80, 81 (Ct.App. 1979) (citing Summerford v. Board of Commr's of Dona Ana County, 35 N.M. 374, 379, 298 P. 410, 413 (1931) (plaintiff property owner could base suit on article II, section 20)).

NORTH DAKOTA. N.D. Const. art. I, § 16 ("Private property shall not be taken or damaged for public use without just compensation... ."); Jamestown Plumbing & Heating Co. v. City of Jamestown, 164 N.W.2d 355, 358 (N.D. 1968) ("We have held on numerous occasions that under this constitutional provision the owner may maintain an action to recover damages for the taking of his property and for consequential damages to his property resulting from a public use.").

SOUTH DAKOTA. S.D. Const. art. VI, § 13 ("Private property shall not be taken for public use, or damaged, without just compensation... ."); Hurley v. State, 82 S.D. 156, 170, 143 N.W.2d 722, 729 (1966) ("In the absence of an adequate remedy provided by the legislature which condemnees may invoke in such cases, Section 13, Article VI of our Constitution is deemed to be self-executing granting them a right of trial by jury in the circuit courts of our state.").

TEXAS. Tex. Const. art. I, § 17 ("No person's property shall be taken, damaged or destroyed for or applied to public use without adequate compensation being made... ."); San Antonio River Authority v. Lewis, 363 S.W.2d 444, 449 (Tex. 1962) ("The provisions of Section 17, Article I of the Constitution of Texas applies as well to the State and its agencies as to private corporations.").

VIRGINIA. Va. Const. art. I, § 11 ("[N]or any law whereby private property shall be taken or damaged for public uses, without just compensation... ."); Heldt v. Elizabeth River Tunnel Dist., 196 Va. 477, 482, 84 S.E.2d 511, 515 (1954) ("It is well settled that such a constitutional provision is self-executing and the landowner may enforce his constitutional right to compensation in a common-law action.").

WASHINGTON. Wash. Const. art. I, § 16 ("No private property shall be taken or damaged for public or private use without just compensation having been first made... ."); Kincaid v. City of Seattle, 74 Wash. 617, 621, 134 P. 504, 506 (1913) ("The city is bound to make compensation under a compact no less formal than the constitution itself, and it cannot defeat this constitutional right by a charter provision or an ordinance, nor can the legislature take it away by any arbitrary requirement... .").

WEST VIRGINIA. W. Va. Const. art. III, § 9 ("Private property shall not be taken or damaged for public use, without just compensation... ."); Johnson v. City of Parkersburg, 16 W. Va. 402, 422-23 (1880) ("I have nowhere seen it contended that the clause of a Constitution, which declares, that `private property shall not be taken for public use without just compensation,' requires legislation to put it in force. It has always been regarded as self executing. It is a limitation, not only upon the rights of individuals and corporations, but also upon the Legislatures of the States." The court proceeds to hold that the result is the same if the constitutional provision covers damages as well.).

WYOMING. Wyo. Const. art. I, § 33 ("Private property shall not be taken or damaged for public or private use without just compensation."); State Highway Comm'n v. Peters, 416 P.2d 390, 395 (Wyo. 1966) ("However, the legislature cannot infringe upon or take from property owners the right to be compensated, according to the requirement of art. I, § 33.").

The law in three states differs from the positions of these courts.

ARKANSAS. Ark. Const. art. II, § 22 ("[A]nd private property shall not be taken, appropriated or damaged for public use, without just compensation therefor.") (law on this issue is unclear).

OKLAHOMA. Okla. Const. art. II, § 24 ("Private property shall not be taken or damaged for public use without just compensation."); State ex rel. Department of Transp. v. Hoebel, 594 P.2d 1213, 1214-15 (Okla. 1979) (under the Oklahoma constitution, a claim in inverse condemnation for a taking for a public use is not subject to sovereign immunity, but a claim for damages is).

PENNSYLVANIA. Pa. Const. art. I, § 10 ("[N]or shall private property be taken or applied to public use, without authority of law and without just compensation being first made or secured."). The law on this issue is not clear in Pennsylvania, but a recent case indicates that the Pennsylvania Supreme Court would hold it to be self-executing. Hughes v. Commonwealth Dept. of Transp., 514 Pa. 300, 306, 523 A.2d 747, 750 (1987) ("What is `just compensation' cannot be determined by the exclusive fiat of the General Assembly, for like all others they cannot be the judge in their own case. The determination of what is `just' between the Commonwealth and a condemnee is the function of the judiciary.").

Exhibit N

CONSTITUTION ANNOTATED
Analysis and Interpretation of the U.S. Constitution

Constitution of the United States

Fifth Amendment

Fifth Amendment Explained

No person shall be held to answer for a capital, or otherwise infamous crime, unless on a presentment or indictment of a Grand Jury, except in cases arising in the land or naval forces, or in the Militia, when in actual service in time of War or public danger; nor shall any person be subject for the same offence to be twice put in jeopardy of life or limb; nor shall be compelled in any criminal case to be a witness against himself, nor be deprived of life, liberty, or property, without due process of law; nor shall private property be taken for public use, without just compensation.

Article I, Section 22 [Private property for public use.]

Private property shall not be taken or damaged for public use without just compensation.

IEEE Std C95.6™-2002

IEEE Standards

C95.6™

IEEE Standard for Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 0–3 kHz

IEEE Standards Coordinating Committee 28

IEEE International Committee on
Electromagnetic Safety on Non-Ionizing Radiation

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IEEE Standard for Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 0–3 kHz

Sponsor

IEEE International Committee on Electromagnetic Safety
(Standards Coordinating Committee 28) on Non-Ionizing Radiation

Approved 12 September 2002
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IEEE-SA Standards Board

Abstract: Recommendations are given to prevent harmful effects in human beings exposed to electromagnetic fields in the frequency range of 0–3 kHZ. The recommendations are intended to apply to exposures of the general public, as well as to individuals in controlled environments. They are not intended to apply to the purposeful exposure of patients by or under the direction of practitioners of the healing arts and may not be protective with respect to the use of medical devices or implants. A rationale that describes how the recommendations were arrived at, and the factors taken into account in formulating them, is included.
Keywords: contact currents, electric fields, electrical excitation, electromagnetic fields, electrostimulation, exposure limits, magnetic fields, non-ionizing radiation protection, safety levels

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Introduction

(This introduction is not part of IEEE Std C95.6-2002, IEEE Standard for Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 0–3 kHz.)

In 1960, the American Standards Association approved the initiation of the Radiation Hazards Standards project under the co-sponsorship of the Department of the Navy and the Institute of Electrical and Electronics Engineers.

Prior to 1988, C95 standards were developed by accredited standards committee C95 and submitted to the American National Standards Institute (ANSI) for approval and issuance as ANSI C95 standards. Between 1988 and 1990, the committee was converted to Standards Coordinating Committee 28 under sponsorship of the IEEE Standards Board, and in 2001, became also known as the International Committee on Electromagnetic Safety (ICES). In accordance with policies of the IEEE, C95 standards will be issued and developed as IEEE standards, as well as being submitted to ANSI for recognition.

The present scope of ICES is:

"Development of standards for the safe use of electromagnetic energy in the range of 0 Hz–300 GHz relative to the potential hazards due to exposure of such energy to man, volatile materials, and explosive devices. The committee will coordinate with other committees whose scopes are contiguous with ICES."

ICES is responsible for this standard. There are five subcommittees concerned with:

I Techniques, Procedures, Instrumentation, and Computation,

II Terminology, Units of Measurements, and Hazard Communication,

III Safety Levels with Respect to Human Exposure, 0–3 kHz,

IV Safety Levels with Respect to Human Exposure, 3 kHz–300 GHz,

V Safety Levels with Respect to Electro-Explosive Devices.

Two standards, two guides, and three recommended practices have been issued. Current versions are:

IEEE Std C95.1™-1999 Edition, IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz–300 GHz (Replaces IEEE Std C95.1-1991).

IEEE Std C95.2™-1999, IEEE Standard for Radio Frequency Energy and Current Flow Symbols (Replaces ANSI C95.2).

IEEE Std C95.3™-1991 (Reaff 1997), IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields—RF and Microwave (Replaces ANSI C95.3-1973 and ANSI C95.1-1981).

ANSI C95.5-1981, American National Standard Recommended Practice for the Measurement of Hazardous Electromagnetic Fields—RF and Microwave.

IEEE Std 1460™-1996, IEEE Guide for the Measurement of Quasi-Static Magnetic and Electric Fields.

ANSI C95.4-1978, American National Standard Safety Guide for the Prevention of Radio-Frequency Radiation Hazards in the Use of Electric Blasting Caps.

This standard was developed by an ICES Subcommittee 3 (SC 3) formed in 1991 to address the frequency range from 0–3 kHz (SC 3). In the early years, the subcommittee discussed the science relating to both long-

term and short-term exposures and concluded that the effects of long-term (chronic) exposure were not convincingly established as were effects of short-term exposures.

Disclaimer

This IEEE standard was developed through the collaborative effort of an international group of volunteers with expertise in many disciplines ranging from medicine to engineering. While this standard represents a consensus among this volunteer group, it is not the only view on the safety issues addressed herein. As with any guidance, use of this standard, does not provide proof of or guarantee of absolute safety. Use and compliance with this IEEE standard is wholly voluntary.

Participants

At the time this standard was completed, SCC 28 Subcommittee 3 had the following membership:

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James Daly, *Secretary*

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The following members of the balloting committee voted on this standard. Balloters may have voted for approval, disapproval, or abstention.

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Grateful appreciation is expressed to J. Patrick Reilly for his major contributions to this standard through technical development, his chairmanship of the Working Group responsible for its development, his drafting of this standard, and his gracious permission to adapt the material in this standard from his own numerous publications on this subject.

The Committee also recognizes the contributions to this standard by the previous Subcommittee co-chairs, John A. Bergeron and William E. Feero.

In memoriam, we wish to recognize Matthew Mingoia, who served as Secretary of Subcommittee 3 from its formation in 1991 until his death in 2000, for his total dedication and support of the activities of the Subcommittee and his contributions to the development of this standard.

Contents

IEEE Standard for Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 0–3 kHz

1. Overview

This standard is divided into six clauses. Clause 1 defines the scope and purpose of the standard. Clause 2 lists references to other standards that are useful in applying this standard. Clause 3 provides definitions that are either not found in other standards or have been modified for use with this standard. Clause 4 defines the protected population and the mechanisms of interaction. Clause 5 defines the exposure limits. Clause 6 details the rationale used in developing this standard.

1.1 Scope

This standard defines exposure levels to protect against adverse effects in humans from exposure to electric and magnetic fields at frequencies from 0–3 kHz. This standard was developed with respect to *established* mechanisms of biological effects in humans from electric and magnetic field exposures. It does not apply to exposures encountered during medical procedures. The defined exposure limits do not necessarily protect against interference of medical devices or problems involving metallic implants (see 6.12).

Established human mechanisms fall within the category of short-term effects. Such effects are understood in terms of recognized interaction mechanisms. Exposure limits defined in this standard are not based on the potential effects of long-term exposure because:

a) There is not sufficient, reliable evidence to conclude that long-term exposures to electric and magnetic fields at levels found in communities or occupational environments are adverse to human health or cause a disease, including cancer.
b) There is no confirmed mechanism that would provide a firm basis to predict adverse effects from low-level, long-term exposure.

The Subcommittee is aware of reported epidemiological associations between long-term exposure to magnetic fields and disease, including childhood leukemia in residential environments and chronic lymphocytic leukemia in occupational environments. The interpretation of these associations is unclear, especially since exposure to magnetic fields does not appear to initiate or advance the development of leukemia or other forms of cancers and other diseases in animals exposed over much of their lifetime. This is

consistent with the findings of interdisciplinary panels of scientists that have evaluated the literature on long-term exposures for scientific and governmental organizations. The most recent of these major reviews include the Advisory Group on Non-Ionizing Radiation of the UK National Radiological Protection Board (AGNIR [B3][1]), the Health Council of the Netherlands (Netherlands [B63]), the U.S. National Institute of Environmental Health Sciences (NIEHS [B64]; Olden [B68]), the Institution of Electrical Engineers (IEE [B45]), the International Agency for Research on Cancer (IARC [B42]), the International Commission on Non-Ionizing Radiation Protection (ICNIRP) [B43], and the U. S. National Research Council (NRC [B65]).

Because none of the above reviews concluded that any hazard from long-term exposure has been confirmed, this standard does not propose limits on exposures that are lower than those necessary to protect against adverse short-term effects. The Subcommittee will continue to evaluate new research and will revise this standard should the resolution of present uncertainties in the research literature identify a need to limit long-term exposures to values lower than the limits of this standard. The Subcommittee will also continue to evaluate new research on short-term effects and modeling. As stated below, this standard makes reasonable assumptions based upon available data. As new data becomes available, the committee will revisit these assumptions for future revisions.

1.2 Purpose

The IEEE has previously defined safety standards for human exposure to electromagnetic fields in the frequency regime from 3 kHz–300 GHz (IEEE [B46]). The purpose of this standard is to define exposure standards for the frequency regime 0–3 kHz. For pulsed or nonsinusoidal fields, it may be necessary to evaluate an acceptance criterion at frequencies outside this frequency regime as explained in 5.2.4.2.

2. References

This standard shall be used in conjunction with the following publications:[2]

Accredited Standards Committee C2-1997, National Electrical Safety Code® (NESC®).[3]

IEEE Std 644™-1994, IEEE Standard Procedures for Measurement of Power Frequency Electric and Magnetic Fields from AC Power Lines.[4]

IEEE Std 1460™-1996, IEEE Guide for the Measurement of Quasi-Static Magnetic and Electric Fields.

3. Definitions, acronyms, and symbols

3.1 Definitions

For the purposes of this standard, the following terms and definitions apply. *The Authoritative Dictionary of IEEE Standards Terms,* Seventh Edition [B47], shall be referenced for terms not defined in this clause.

3.1.1 action potential: A response of a nerve cell to a stimulus involving a propagating rapid depolarization of the potential across the cell membrane.

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[1]The numbers in brackets correspond to those of the bibliography in Annex A.

[2]The IEEE standards referred to in Clause 2 are trademarks of the Institute of Electrical and Electronics Engineers, Inc.

[3]The NESC is available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (http://standards.ieee.org/).

[4]IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (http://standards.ieee.org/).

3.1.2 adverse effect: An effect detrimental to the health of an individual due to exposure to an electric or magnetic field, or a contact current.

3.1.3 adverse reaction factor (F_a): A multiplier used to derive maximum permissible exposure (MPE) levels, which converts from a threshold reaction to an adverse one.

3.1.4 averaging distance: The distance over which the *in situ* electric field is averaged when determining compliance with basic restrictions.

3.1.5 averaging time: The appropriate time period over which exposure is averaged for purposes of determining compliance with a maximum permissible exposure (MPE) or Reference Level.

3.1.6 axial cross section: A cross section of the body taken in a plane perpendicular to its long axis.

3.1.7 axial exposure: Exposure by a magnetic field perpendicular to the axial cross section.

3.1.8 basic restrictions: Limitations on the *in situ* electrical forces that avoid adverse effects, and with an acceptable safety factor.

3.1.9 biphasic: A waveform that has a reversal of polarity.

3.1.10 cardiac excitation: The electrical stimulation of a cardiac contraction.

3.1.11 central nervous system (CNS): The portion of the vertebrate nervous system consisting of the brain and spinal cord, but not including the peripheral nerves.

3.1.12 cerebral cortex: The convoluted thin layer of brain cells (gray matter) forming the outer surface of each cerebral hemisphere.

3.1.13 conductivity: A property of materials that determines the magnitude of the electric current density when an electric field is impressed on the material, expressed in units of siemens per meter (S/m); the inverse of resistivity.

3.1.14 contact current: Current passed into a biological medium via a contacting electrode or other source of current.

3.1.15 controlled environment: An area that is accessible to those who are aware of the potential for exposure as a concomitant of employment, to individuals cognizant of exposure and potential adverse effects, or where exposure is the incidental result of passage through areas posted with warnings, or where the environment is not accessible to the general public and those individuals having access are aware of the potential for adverse effects.

3.1.16 corona (air): A luminous discharge due to ionization of the air surrounding a conductor caused by a voltage gradient exceeding a certain critical value.

3.1.17 coronal cross section: A cross section taken through the long axis of the body in a plane parallel to its front view.

3.1.18 coronal exposure: Exposure by a magnetic field perpendicular to the coronal cross section.

3.1.19 depolarization (cellular): The reduction of the resting potential across a cellular membrane.

3.1.20 direct electrostimulation: Stimulation via the electric field within the biological medium induced by an external electric or magnetic field without direct contact with other conductors or spark discharges.

3.1.21 electric field strength (*E*): Force exerted by an electric field on an electric point charge, divided by the electric charge. Electric field strength is expressed in newtons per coulomb or volts per meter (N/C = V/m).

3.1.22 electrostimulation: Induction of a propagating action potential in excitable tissue by an applied electrical stimulus; electrical polarization of presynaptic processes leading to a change in post synaptic cell activity.

3.1.23 environmental field: An electric or magnetic field external to the body and measured in the absence of the body.

3.1.24 established mechanism: A bioelectric mechanism having the following characteristics: (a) can be used to predict a biological effect in humans; (b) an explicit model can be made using equations or parametric relationships; (c) has been verified in humans, or animal data can be confidently extrapolated to humans; (d) is supported by strong evidence; and (e) is widely accepted among experts in the scientific community.

3.1.25 extra systole: An induced cardiac contraction, usually a premature contraction that interrupts the normal sinus rhythm; a forced heartbeat.

3.1.26 general public: All individuals who may experience exposure, except those in controlled environments.

3.1.27 grasping contact: An electrical connection with a large energized conductor made by firmly holding the conductor in the hand. In this standard, a contact area of 15 cm^2 is assumed for such contact.

3.1.28 Hall-effect voltage: The voltage developed between two points within a conductive medium due to the redistribution of moving charges in a magnetic field.

3.1.29 indirect electrostimulation: Stimulation through contact with a conducting object under the influence of an electric or magnetic field, including spark discharges.

3.1.30 induction: An electric or magnetic field in a conducting medium caused by the action of a time-varying external (environmental) electric or magnetic field.

3.1.31 *in situ*: Within biological tissue.

3.1.32 let-go current: The threshold current level at which involuntary muscular contraction prevents release of a grip on an energized conductor.

3.1.33 lognormal distribution: A statistical distribution in which the logarithm of the statistical variate is normally distributed.

3.1.34 Lorentz force: The force on a moving charge within a magnetic field.

3.1.35 magnetic field strength (*H*): The magnitude of the magnetic field vector; expressed in units of amperes per meter (A/m).

3.1.36 magnetic flux density (*B*): A vector quantity that determines the force on a moving charge or charges (electric current). Magnetic flux density is expressed in teslas (T). One gauss (deprecated unit) equals 10^{-4} T.

3.1.37 magnetohydrodynamic effect: A force or potential imparted on a fluid volume arising from its motion in the presence of a magnetic field.

3.1.38 maximum permissible exposure (MPE): The rms and peak electric and magnetic fields and contact currents to which a person may be exposed without an adverse effect and with acceptable safety factors. The MPE for magnetic field exposure in this standard may be exceeded if it can be demonstrated that the basic restrictions are not exceeded.

3.1.39 mean: The arithmetic average of a series of measurements or other data.

3.1.40 median: The value within a statistical distribution at which 50% of data are above and below.

3.1.41 median threshold: The threshold value within a statistical distribution at which 50% of subjects have greater thresholds and 50% have lesser thresholds.

3.1.42 monophasic: A waveform not reversing in polarity.

3.1.43 motor neuron: (a) A central neuron that initiates excitation of a peripheral nerve; (b) a peripheral nerve that innervates muscle. Definition (b) is generally used in this standard.

3.1.44 myelinated nerve: A nerve fiber containing insulating myelin sheaths that are interrupted by uninsulated segments called *nodes of Ranvier.*

3.1.45 nerve: A bundle of axons.

3.1.46 nerve fiber: A single nerve axon.

3.1.47 neuron: A single cellular unit usually consisting of an axon, cell body, and dendritic tree.

3.1.48 nonuniform field: A field that is not constant in amplitude, direction, and relative phase over the dimensions of the body or body part under consideration. In the case of electric fields, the definition applies to an environmental field undisturbed by the presence of the body.

3.1.49 normal load conditions: The maximum operating voltage and current of an electric power transmission line under conditions that exclude outages, or other emergency operating conditions.

3.1.50 open-circuit voltage: The potential difference between two conducting objects without a current load being applied to the objects.

3.1.51 peripheral nerve: Nerve found outside the central nervous system and leading to and from the central nervous system.

3.1.52 phase duration (t_p): The time between zero crossings of a waveform having zero mean. For a sinewave of frequency f, $t_p = 1/(2f)$. For an exponential waveform, t_p is interpreted as the duration measured from the waveform peak to a point at which it decays to 0.37 (e^{-1}) of its peak value.

3.1.53 phosphene: Visual sensation caused by nonphotic stimuli. Electro-phosphenes are induced by electric currents; magneto-phosphenes are induced magnetically.

3.1.54 polarization (cellular): The electric potential formed across a cell membrane.

3.1.55 postsynaptic cell: The cell receiving excitation in a synaptic junction between two nerve cells.

3.1.56 presynaptic cell: The cell that provides excitation at a synapse, usually by release of a neurotransmitter.

3.1.57 probability factor (F_p): A multiplier used in the derivation of maximum permissible exposure (MPE) or reference levels, which converts a median threshold to a low probability one (≤ 1%).

3.1.58 proposed mechanism: A bioelectric mechanism lacking the characteristics of an established mechanism. **(See also:** *established mechanism.*)

3.1.59 relative phase: The phase angle of a sinusoidal waveform relative to the phase angle of another waveform measured at a different point within the conductive medium or with respect to a stated reference waveform.

3.1.60 rheobase: The minimum threshold intensity in a strength-duration relationship (applicable to a stimulus duration that is long in comparison with the strength-duration time constant). Also applied to the minimum plateau in a strength-frequency relationship.

3.1.61 root-mean-square (rms): A mathematical operation on a series of measurements (or a temporal sequence of data) in which the square root of the arithmetic mean of the squares of the measurements or data is taken.

3.1.62 safety factor (F_s): A multiplier (≤ 1) used to derive maximum permissible exposure (MPE) levels, which provides for the protection of exceptionally sensitive individuals, uncertainties concerning threshold effects due to pathological conditions or drug treatment, uncertainties in reaction thresholds, and uncertainties in induction models.

3.1.63 sagittal cross section: A cross section along the long axis of the body, parallel to its side view.

3.1.64 sagittal exposure: Exposure by a magnetic field perpendicular to the sagittal cross section.

3.1.65 short-term response: A biological response to an electric or magnetic stimulus manifested within a few seconds after the exposure begins.

3.1.66 spark discharge: The transfer of current through an air gap requiring a voltage high enough to ionize the air, as opposed to direct contact with a source.

3.1.67 specific absorption rate (SAR): The time derivative of the incremental energy absorbed by (dissipated in) an incremental mass contained in a volume element of given density. SAR is expressed in watts per kilogram (W/kg).

3.1.68 strength-duration curve: The functional relationship between the threshold of excitation and the duration of an excitatory stimulus.

3.1.69 strength-duration time constant (τ_e): The functional parameter in a strength-duration curve that describes the temporal inflection point between the rheobase and the rising threshold segment.

3.1.70 strength-frequency curve: The functional relationship between the threshold of excitation and the frequency of an excitatory stimulus.

3.1.71 synapse: The site of functional apposition between two neurons at which an electrical signal from one neuron is transmitted to another by either electrical or chemical means. In the typical synapse, the impulse is transmitted by a chemical substance called a *neurotransmitter.*

3.1.72 systole: Contraction of the heart.

3.1.73 threshold: The level of a stimulus marking the boundary between a response and a nonresponse.

3.1.74 touch contact: A contact of small area made between the human body and an energized conductor. In this standard, a contact area of one cm^2 is the assumed touch contact area.

3.1.75 uniform field: A field that is constant in amplitude, direction, and relative phase over the dimensions of the body or body part under consideration. In the case of electric fields, the definition applies to an environmental field undisturbed by the presence of the body.

3.1.76 ventricular fibrillation: Arrhythmia of the ventricles of the heart characterized by rapid uncoordinated contractions.

3.1.77 visual evoked potential (VEP): An endogenous potential ensuing in the brain and measured on the scalp in response to a visual stimulus.

3.1.78 voxel: A three-dimensional computational element.

3.1.79 waveform: The variation of an electrical amplitude with time. Unless otherwise stated, in this standard the term *waveform* refers to values (or measurements) at sites within the biological medium.

3.2 Acronyms and abbreviations

B-field Magnetic flux density

CNS Central nervous system

E-field Electric field strength

ECT Electroconvulsive therapy

EMC Electromagnetic compatibility

IARC International Agency for Research on Cancer

ICNIRP International Commission on Non-Ionizing Radiation Protection

IEE Institute of Electrical Engineers (United Kingdom)

MPE Maximum permissible exposure

MRI Magnetic resonance imaging

NIEHS National Institute of Environmental Health Sciences (USA)

NRC National Research Council (USA)

rms Root-mean-square

SAR Specific absorption rate

S-D Strength-duration (time constant, curve, etc.)

VEP Visual evoked potential

VF Ventricular fibrillation

3.3 Symbols

a, b Semi-major and semi-minor axes of elliptical representation of exposed body part.

A_i The magnitude of the ith Fourier component of a waveform.

B Magnetic flux density, expressed in tesla (T). Tesla and gauss (G) units are related by 1 G = 10^{-4} T.

B_o The minimum flux density in a strength-duration or strength-frequency relationship (T).

$\dot{B}$ Time rate of change of magnetic flux density, *dB/dt*, expressed as teslas-per-second (T/s).

$\dot{B}_p$ Peak allowable limit on the time derivative of flux density.

d_a Averaging distance used to determine compliance with an *in situ* electric field basic restriction.

d_e Spatial extent of an *in situ* electric field.

E Electric field strength, expressed in volts-per-meter (V/m).

E_o The minimum (rheobase) electric field strength in a strength-duration or strength-frequency relationship (V/m).

E_{ot} Rheobase threshold electric field strength.

E_{ob} Rheobase basic restriction.

E_i *In situ* electric field (V/m).

f Frequency, expressed in hertz (Hz).

f_e Upper transition frequency in a strength-frequency relation (Hz).

f_i Frequency of the ith Fourier component of a waveform.

F_a Adverse reaction factor.

F_p Probability factor.

F_s Safety factor.

h Height of standing person, expressed in meters (m).

H Magnetic field intensity, expressed in amperes-per-meter (A/m). Related to flux density by $B = \mu H$.

I_c Contact current, expressed in amperes (A).

J Current density, expressed in amperes-per-square meter (A/m^2).

ME_i Maximum allowable exposure of either the *in situ* electric field, the environmental field, or the contact current at frequency f_i.

μ Magnetic permeability, expressed in henries-per-meter (H/m).

μ_o Magnetic permeability in a vacuum or in air: $\mu_o = 4\pi \times 10^{-7}$ H/m.

σ Conductivity of medium, expressed in siemens-per-meter (S/m).

τ_e Transition duration in a strength-duration relationship, expressed in seconds (s).

τ_h Time constant of the leakage of charge applied to a human subject.

t_p Phase duration (s).

4. Protected population and mechanisms of interaction

4.1 Protected population

Protection is to be afforded to individuals in the general population and to groups in controlled environments. It is assumed that for the controlled environment, education and various mitigating measures can be taken to reduce the probability of adverse reactions of exposed individuals, although the exposure limits should protect against adverse effects for almost all people, with the possible exception of spark discharges within electric fields in the controlled environment. However, if adverse effects under some circumstances are anticipated, they can be mitigated with precautionary measures that are appropriate to the anticipated exposure situation. Examples of such measures include protective gloves or clothing, awareness programs designed to alert personnel to the possibility of effects, or specific work practices that lessen the frequency or intensity of exposure. For the general public accessibility is unconstrained and may include individuals uninformed of the potential for exposure or of possible adverse effects. Such exposure may occur in living quarters, areas open to the general public, workplaces where individuals do not anticipate exposure, or workplaces where workers are not aware of exposure conditions or prevention and mitigation procedures.

4.2 Mechanisms of biophysical reactions

An established human mechanism is one having the following characteristics:

a) It can be used to predict biological effects in humans; (b) an explicit model can be made using equations or parametric relationships.
b) It has been verified in the intact human, or animal data can be confidently extrapolated to humans.
c) It is supported by strong evidence.
d) It is widely accepted among experts in the scientific community.

Mechanisms not having these characteristics are classified as *proposed.* Progress in research on proposed mechanisms should be monitored and evaluated as to whether any can be included in the list of established mechanisms.

Established mechanisms have been identified based on these criteria (Reilly [B75], [B76], [B77]). One class of mechanisms relates to membrane polarization, i.e., the alteration of the cellular membrane's natural resting potential by the *in situ* electric field. Depolarization of the membranes of nerve and muscle can lead to their excitation *herein referred to as electrostimulation*; these effects are responsible for the minimum thresholds of reaction at frequencies from about 1 Hz to above 3 kHz (the limit of this standard). Magnetohydrodynamic effects, which apply to forces on moving charges in fluids, dominate biological reactions below 1 Hz. These mechanisms produce short-term effects, i.e., they result in reactions to electric and magnetic fields that are manifested within seconds, (usually a fraction of a second) after the exposure begins. Thermal effects are well-understood, but are not dominant at frequencies below 100 kHz, and therefore do not affect the exposure limits defined in this document.

The fundamental force responsible for electrostimulation effects is the *in situ* electric field, rather than the internal current density (see 6.1). More accurate limits for electrostimulation effects can be derived as a function of the *in situ* electric field rather than internal current density as has been a common practice in the past (Bernhardt [B11]; ICNIRP [B43]; IEEE [B46]). The distribution within the body of *in situ* electric fields differs from the distribution of current density, and the calculation of the *in situ* electric field is less sensitive to assumptions of tissue conductivities compared to internal current density.

Mechanisms of interaction that are classified as *proposed* relate to long-term or chronic exposure effects (Olden [B68]; Reilly [B76]). These mechanisms are typically mentioned in connection with hypotheses concerning effects of chronic exposure to low-level electric and magnetic fields, including cancer, reproductive effects, nervous system effects, etc. While these mechanisms cannot be dismissed as being irrelevant, the body of knowledge concerning them is presently insufficient to establish a confirmed mechanism that would provide a firm basis for deriving human exposure limits.

4.3 Adverse biological effects

Maximum exposure limits are based on avoidance of the following short-term reactions:

a) Aversive or painful stimulation of sensory or motor neurons
b) Muscle excitation that may lead to injury while performing potentially hazardous activities
c) Excitation of neurons or direct alteration of synaptic activity within the brain
d) Cardiac excitation
e) Adverse effects associated with induced potentials or forces on rapidly moving charges within the body, such as in blood flow

5. Exposure limits

5.1 Basic restrictions

Basic restrictions refer to limitations on the *in situ* electrical forces that adequately avoid adverse effects. Such restrictions are derived with consideration of adverse electrical thresholds, their distribution among the population, and safety factors (see Clause 6).

Table 1 lists basic restrictions for particular areas of the body in terms of the electric field within the biological medium. Two parameters are listed in the table: the rheobase *in situ* field, E_o, and a frequency parameter, f_e. Limits are determined from Table 1 as shown in Equation (1a) and Equation (1b):

$$E_i = E_0 \quad \text{for } f \le f_e \tag{1a}$$

$$E_i = E_0 (f / f_e) \quad \text{for } f \ge f_e \tag{1b}$$

where E_i is the maximum permissible induced *in situ* electric field. The basic restrictions on the *in situ* electric field apply to an arithmetic average determined over a straight line segment of 0.5 cm length oriented in any direction within the tissue identified in Table 1.

In addition to the listed *in situ* electric field restrictions of Table 1, the *in situ* magnetic field below 10 Hz should be restricted to a peak value of 167 mT for the general public and 500 mT in the controlled environment. For frequencies above 10 Hz, a basic restriction on the *in situ* magnetic field is not specified in this standard.

Table 1—Basic restrictions applying to various regions of the body[a, b]

Exposed tissue	f_e (Hz)	General public	Controlled environment
		E_0 - rms (V/m)	E_0 - rms (V/m)
Brain	20	5.89×10^{-3}	1.77×10^{-2}
Heart	167	0.943	0.943
Hands, wrists, feet and ankles	3350	2.10	2.10
Other tissue	3350	0.701	2.10

[a]Interpretation of table is as follows: $E_i = E_0$ for $f \le f_e$; $E_i = E_0\,(f / f_e)$ for $f \ge f_e$.
[b]In addition to the listed restrictions, exposure of the head and torso to magnetic fields below 10 Hz shall be restricted to a peak value of 167 mT for the general public, and 500 mT in the controlled environment.

5.2 Maximum permissible exposure (MPE) values: Magnetic flux density

5.2.1 Exposure of the head and torso to sinusoidal fields

Table 2 lists maximum permissible magnetic field limits (flux density, *B*, and magnetic field strength, *H*) for exposure of the head and torso. The averaging time for an rms measure is 0.2 seconds for frequencies above 25 Hz. For lower frequencies, the averaging time is such that at least 5 cycles are included in the average, but with a maximum of 10 seconds.

Table 2—Magnetic maximum permissible exposure (MPE) levels: exposure of head and torso[a, b]

Frequency range (Hz)	General public		Controlled environment	
	B - rms (mT)	*H* - rms (A/m)	*B* - rms (mT)	*H* - rms (A/m)
< 0.153	118	9.39×10^4	353	2.81×10^5
0.153–20	$18.1/f$	$1.44 \times 10^4/f$	$54.3/f$	$4.32 \times 10^4/f$
20–759	0.904	719	2.71	2.16×10^3
759–3000	$687/f$	$5.47 \times 10^5/f$	$2060/f$	$1.64 \times 10^6/f$

[a]f is frequency in Hz.
[b]MPEs refer to spatial maximum.

Compliance with Table 2 ensures compliance with the basic restrictions of Table 1. However, lack of compliance with Table 2 does not necessarily imply lack of compliance with the basic restrictions, but rather that it may be necessary to evaluate whether the basic restrictions have been met. If the basic restrictions in Table 1 are not exceeded, then the MPE values in Table 2 can be exceeded. Consequently, it is sufficient to demonstrate compliance with either Table 1 or Table 2.

For purposes of demonstrating compliance with this standard, Table 2 and Table 4 shall be considered separately, and not additively.

Entries in Table 1 and elsewhere in this standard are sometimes given to three significant digits. This degree of precision is provided so that the reader can follow the various derivations and relationships presented in this standard and does not imply that the numerical quantities are known to that precision.

5.2.2 Nonuniform exposure to sinusoidal magnetic fields

When the magnetic field is not constant in magnitude, direction, or relative phase over the head and torso, the maximum field over the head and torso shall be limited to the levels in Table 2. Alternatively, it shall be permitted to demonstrate adherence to the basic restrictions.

5.2.3 Exposure of the arms or legs

Maximum permissible exposure (MPE) levels for the arms or legs are listed in Table 3. Compliance with Table 3 ensures compliance with the basic limitations of Table 1. However, lack of compliance with Table 3 does not necessarily imply lack of compliance with the basic restrictions, but rather that it may be necessary to evaluate whether the basic restrictions are met.

Table 3—Magnetic flux density maximum permissible exposure levels: exposure of arms or legs[a]

Frequency range (Hz)	General public *B* - rms (mT)	Controlled environment *B* - rms (mT)
< 10.7	353	353
10.7–3000	3790/*f*	3790/*f*

[a]*f* is frequency in Hz.

5.2.4 Pulsed or nonsinusoidal fields

When the magnetic flux density waveform is nonsinusoidal, maximum permissible exposure shall conform to the *rms* limits of Table 1 or Table 2. In addition, maximum exposure limits shall conform to either 5.2.4.1 or 5.2.4.2. (Since both criteria are conservative, adherence to either is sufficient to demonstrate compliance with maximum permissible exposure limits or the basic restrictions.)

5.2.4.1 Restriction based on peak field

Demonstration of compliance with either of the following two subclauses is sufficient to demonstrate compliance with restrictions based on the peak field. Subclause 5.2.4.1.1 applies to the *in situ* induced electric field. Subclause 5.2.4.1.2 applies to the environmental field.

5.2.4.1.1 Peak *in situ* field

The peak *in situ* electric field shall be restricted to a value obtained by multiplying the rms limits of Table 1 by $\sqrt{2}$. To interpret this table for nonsinusoidal waveforms, frequency, *f*, is defined as $f = 1/(2t_p)$, where t_p is the phase duration of a peak excursion of the *in situ* electric field. Phase duration is defined as time between zero crossings of a waveform having zero mean. For an exponential waveform, t_p is interpreted as the duration measured from the waveform peak to a point at which it decays to 0.37 (e^{-1}) of its peak value. Peak

limits apply to instantaneous values measured through a bandwidth from zero to the highest frequency applicable to the waveform under consideration.

5.2.4.1.2 Peak environmental field

The peak environmental magnetic field, *B*, shall be limited according to the following procedure, where *B* is a time-varying flux density waveform whose compliance is under question.

a) Determine the time derivative of the environmental field, $dB/dt = \dot{B}$.
b) Identify the peak and phase duration of any excursion of $\dot{B}$. Phase duration shall be determined as in 5.2.4.1.1.
c) Determine the allowable peak limit on $\dot{B}$ from Table 2 as $\dot{B}_p = \sqrt{2}\, MPE_B(2\pi f)$, where $\dot{B}_p$ is the maximum permissible value of $\dot{B}$, MPE_B is the flux density consistent with Table 2 and Table 3, $f = 1/(2t_p)$, and t_p is the phase duration of $\dot{B}$.

5.2.4.2 Restriction based on Fourier components

For an exposure waveform consisting of multiple frequencies, a test for compliance of the exposure waveform shall satisfy the following criterion:

$$\sum_{0}^{5\text{MHz}} \frac{A_i}{ME_i} \le 1 \qquad (2)$$

where

A_i is the magnitude of the *i*th Fourier component of the exposure waveform,
ME_i is the maximum permissible exposure or the basic *in situ* field restriction with a single sinusoidal waveform at a frequency f_i.

The summation is carried out from the lowest frequency of the exposure waveform, to a maximum frequency of 5 MHz. Note that A_i and ME_i must measure the same quantity, as well as be in the same units. For instance, if A_i is the magnitude of a flux density waveform, then ME_i must also be a measure of flux density. Alternatively, both A_i and ME_i could be measures of the time derivative of the field, the induced *in situ* electric field, or induced current density.

It may be necessary to evaluate Equation (2) at frequencies outside the limits of this standard. For purposes of such evaluation, the ME_i values applying to frequencies greater than 3 kHz shall be determined as follows.

a) *Basic restrictions* (Table 1). Rheobase values of the *in situ* electric field (E_{ob}) shall be assumed for frequencies from f_e to 5 MHz.
b) *Magnetic field MPEs* (Table 2 and Table 3). The MPE value of *B* or *H* shall be determined to a maximum frequency of 3350 Hz using the formulae listed in the last row of the table. From 3350 Hz–5 MHz, the MPE value shall equal that at 3350 Hz.
c) *Electric field MPEs* (Table 4). The MPE value applicable to 3000 Hz shall be assumed to a maximum frequency of 5 MHz.
d) *Induced and contact current MPEs* (Table 5). The MPE value listed at 3000 Hz shall be extrapolated to a maximum frequency of 5 MHz using the relationship: $MPE_i = MPE_{3000}\,(f/3000)$ where MPE_i is the limit at the appropriate frequency between 3 kHz and 5 MHz, MPE_{3000} is the limit at 3000 Hz, and *f* is the frequency in Hz.

5.3 Maximum permissible exposure values: environmental electric fields

5.3.1 Constant whole-body exposure to sinusoidal electric fields

Table 4 lists maximum electric field limits in terms of the undisturbed (absent a person) environmental field, *E*. It is assumed that the undisturbed field is constant in magnitude, direction, and relative phase over a spatial extent that would fit the human body. The averaging time for an rms measure shall be 0.2 seconds for frequencies above 25 Hz. For lower frequencies, the averaging time is such that at least 5 cycles are included, with a maximum of 10 seconds. For a controlled environment in which an exposed individual is not within reach of a grounded object, it may be acceptable to exceed the limits listed in Table 4. This standard does not specify limits for situations involving contact with ungrounded objects.

For purposes of demonstrating compliance with this standard, Table 2 and Table 4 shall be considered separately, and not additively.

Table 4—Environmental electric field MPEs, whole body exposure

General public		Controlled environment	
Frequency range (Hz)	***E* - rms (V/m)**	**Frequency range (Hz)**	***E* - rms (V/m)**
1–368[c]	5000[a,d]	1–272[c]	20 000[b,e]
368–3000	$1.84 \times 10^6/f$	272–3000	$5.44 \times 10^6/f$
3000	614	3000	1813

[a]Within power line rights-of-way, the MPE for the general public is 10 kV/m under normal load conditions.
[b]Painful discharges are readily encountered at 20 kV/m and are possible at 5–10 kV/m without protective measures.
[c]Limits below 1 Hz are not less than those specified at 1 Hz.
[d]At 5 kV/m induced spark discharges will be painful to approximately 7% of adults (well-insulated individual touching ground).
[e]The limit of 20 000 V/m may be exceeded in the controlled environment when a worker is not within reach of a grounded conducting object. A specific limit is not provided in this standard.

5.3.2 Nonuniform or partial body exposure to sinusoidal electric fields

When the environmental electric field is not constant in magnitude, direction, and relative phase over the dimensions of the human body, the average environmental field shall be restricted to the levels in Table 4. For a controlled environment in which an exposed individual is not within reach of a grounded conducting object, it may be acceptable to exceed the limits listed in Table 4. This standard does not specify limits for such cases. In no case shall the basic limitations of Table 1 or the contact current limits of Table 5 be exceeded.

5.3.3 Pulsed or nonsinusoidal fields

When the waveform of the electric field is nonsinusoidal, such as with pulsed or mixed frequency waveforms, MPE limits shall conform to the rms limits of Table 4 and also to either of the criteria stated in 5.2.4.1 and 5.2.4.2. For this application, the environmental magnetic field is replaced by the undisturbed electric field, A_i is understood to represent the magnitude of the *i*th Fourier component of the environmental electric field waveform, and ME_i is the maximum permissible electric field magnitude at frequency f_i.

With respect to electric field exposure, 5.2.4.1.2 and 5.2.4.2 shall apply to frequencies from 368–3000 Hz for the general public, and from 272–3000 Hz in controlled environments. Below those frequencies and above

1 Hz, peak electric fields shall not exceed 7100 and 28 000 V/m for the general public and controlled environments, respectively, and 14 100 V/m for the general public within powerline rights-of-way.

5.4 Contact and induced current maximum permissible exposure limits

5.4.1 Sinusoidal current

Contact current shall be limited as indicated in Table 5, subject to the following conditions:

a) Table 5 limits for freestanding individuals without contact with metallic objects shall not exceed the values listed in the rows labeled “Both feet” and “Each foot.”

b) Contact limits in Table 5 assume a freestanding individual who is insulated from ground while touching a conductive path to ground. The criteria do not necessarily protect against aversive sensations from spark discharges just prior to and just after the moment of direct contact with the ground path.

c) The averaging time for rms current measurements shall be 0.2 seconds for frequencies above 25 Hz. For lower frequencies, the averaging time shall include at least 5 cycles, with a maximum of ten seconds. The limits for peak exposure refer to instantaneous values measured through a bandwidth from zero to the highest frequency of interest.

d) In controlled environments, limits for grasp contacts apply where personnel are trained to make grasping contact and to avoid touch contacts with conductive objects that present the possibility of painful contact current. A grasp contact area is assumed to be 15 cm^2. The use of protective gloves, the prohibition of metallic objects, or training of personnel may be sufficient to assure compliance with contact current MPE in controlled environments. For the general public, it is assumed that access, methods of contact, and protective measures are unconstrained.

e) For the general public, a touch contact is assumed to have a contact area of 1 cm^2.

Table 5— Induced and contact current MPEs (mA-rms) for continuous sinusoidal waveforms, 0–3 kHz[a, b]

Condition	General public (mA, rms)	Controlled environment (mA, rms)
Both feet	2.70	6.0
Each foot	1.35	3.0
Contact, grasp	—	3.0
Contact, touch	0.50	1.5

[a]Grasping contact limit pertains to controlled environments where personnel are trained to effect grasping contact and to avoid touch contacts with conductive objects that present the possibility of painful contact.

[b]Limits apply to current flowing between body and grounded object that may be contacted by the person.

5.4.2 Nonsinusoidal (pulsed or mixed frequency) current

When the current waveform is nonsinusoidal, such as with pulsed or mixed frequency waveforms, MPE limits shall conform to the rms limits of Table 5 and also to either of the criteria stated in 5.2.4.1 and 5.2.4.2. For this application, the environmental field is replaced by the applied current, A_i is understood to represent the magnitude of the ith Fourier component of the current waveform, and ME_i is the maximum permissible current magnitude at frequency f_i.

6. Rationale

6.1 Excitation thresholds: strength-duration and strength-frequency laws

The parameter that drives the process of electrostimulation is the depolarization of the excitable cellular membrane (nerve or muscle) (Reilly [B75]). This modification of the cellular resting potential by an applied electrical stimulus is determined by the electric field in the medium surrounding the excitable tissue (the component of the field parallel to the long axis of the cell), or equivalently, the change in electric potential exterior to the cell. Knowledge of either the electric field or its spatial gradient is required to assess electrostimulation. Of course, the electric field can be derived from the current density by taking the ratio J/σ, where σ is the conductivity of the medium. But basing a standard on current density rather than the *in situ* electric field introduces an additional parameter, and that introduces an uncertainty beyond that which already existed in deriving the electric field itself. Thus, the *in situ* electric field is used as the fundamental metric in this standard.

An *in situ* electric field strength-duration curve, which defines thresholds for monophasic stimulus waveforms, is defined by two parameters: the minimum *(rheobase)* excitation threshold, E_o, and the strength-duration time constant, τ_e. Values of E_o and τ_e differ considerably for nerve excitation, muscle excitation, and synaptic activity alteration. Table 6 lists median threshold assumptions on E_o and τ_e underlying these standards. Peak electric field thresholds are determined from Table 6 and Equation (3a) and Equation (3b) as follows:

Table 6—Models for established thresholds of reaction: median *in situ* E-field thresholds[a, b]

Reaction	E_o pk (V/m)[c]	τ_e (ms)	f_e (Hz)
Synapse activity alteration, brain	0.075	25.0	20
10-µm nerve excitation, brain	12.3	0.149	3350
20-µm nerve excitation, body	6.15	0.149	3350
Cardiac excitation	12.0	3.00	167

[a]Interpretation of table as follows: $E_i = E_0$ for $t_p \geq \tau_e$; $E_i = E_0\,(\tau_e/t_p)$ for $t_p \leq \tau_e$.
Also, $E_i = E_0$ for $f \leq f_e$; $E_i = E_0\,(f/f_e)$ for $f \geq f_e$.
[b]Adapted from Reilly [B75].
[c](*V/m-pk*) refers to the temporal peak of the electric field.

$$E_i = E_0 \qquad \text{for } t_p \geq \tau_e \tag{3a}$$

$$E_i = E_0\,(\tau_e/t_p) \quad \text{for } t_p \leq \tau_e \tag{3b}$$

where

t_p is the phase duration of the E_i waveform

Alternatively, the limits can be determined in terms of sinusoidal frequency as shown in Equation (4a), Equation (4b), and Equation (4c):

$$E_i = E_0 \qquad \text{for } f \leq f_e \tag{4a}$$

$$E_i = E_0\,(f/f_e) \quad \text{for } f \geq f_e \tag{4b}$$

$$f_e = 1/(2\tau_e) \tag{4c}$$

Relationship (4c) has been determined using a theoretical model of myelinated nerve (Reilly [B75]). Because of the nonlinear electrodynamics of excitable tissue, Equation (4c) differs from linear systems for which a relationship $\tau = 1/(2\pi f)$ would be anticipated.

Nerve excitation thresholds follow a U-shaped curve, with a low-frequency upturn at about 10 Hz and a high frequency upturn at a frequency f_e. The plateau between the upper and lower transition frequencies is the rheobase. Theoretical models suggest that the strength-duration time constant and upper transition frequency are related by $f_e = (2\tau_e)^{-1}$ (Reilly [B75], [B77]; Reilly and Diamant [B79]). The low-frequency upturn occurs for *in situ* sinusoidal waveforms initiated at a zero crossing because the slow rate of rise of the sinusoid allows the nerve to accommodate to the stimulus—a feature absent in the square wave stimulus or the sinewave initiated at a peak. To allow for worst-case conditions, the induced field waveform is assumed to be initiated at a peak. Because the induced field is proportional to the derivative of the environmental field at frequencies affecting this standard, this assumption is equivalent to assuming an environmental field initiated at a zero crossing. Above f_e, thresholds converge to a slope that is proportional to frequency.

For a given stimulus duration, a monophasic square-wave current provides the lowest threshold of electrostimulation. Brief biphasic current wave shapes in general have higher thresholds of excitation. The increase in threshold due to a biphasic current reversal becomes greater as the phase duration becomes shorter (i.e., as the frequency content of the event becomes higher). However, for repeated biphasic waves (e.g., a repeated sinusoid), thresholds converge to a value that is approximately that for a single monophasic square wave of the same phase duration (Reilly [B75]). Consequently, thresholds pertaining to monophasic square-wave stimuli, which establish a lower limit, have been applied to biphasic waves with the same phase duration. For a single biphasic event of brief duration the excitation threshold may be higher than that for a monophasic stimulus, and therefore this approach is conservative. However, in the frequency regime of this standard, the degree of conservatism is small.

6.1.1 Nerve excitation

Excitation of nerve and muscle requires depolarization of the membrane resting potential by about 15–20 mV—the exact amount depends upon the stimulus waveshape and other factors. In the region of a locally constant electric field, excitation is initiated where a nerve is terminated, or undergoes a rapid bend, such as may occur at a motor neuron end plate or at sensory receptors (Reilly [B71], [B75]). Under these conditions the threshold of excitation is inversely proportional to the diameter of the nerve axon.

In this standard the assumption has been made that the fiber diameter is at the outer limit of the distribution of fiber sizes found in humans. Accordingly, a maximum diameter of 20 μm is assumed for a peripheral nerve and 10 μm for a CNS neuron. Theoretical models predict E_o = 6.15 V/m and 12.3 V/m for stimulation of 20- and 10-μm nerve fibers, respectively, and τ_e = 128 μs for either fiber size (Reilly [B75]).

These values correspond well to experimental data. Median experimental values of τ_e with magnetic stimulation are reported in the range 146–152 μs (Barker et al. [B4]; Bourland et al. [B13]; Mansfield and Harvey [B59]); although larger values have also been reported (Bourland et al. [B16]; Havel [B39]; Nyenhuis et al. [B66]). Values of τ_e with contact current stimulation encompass a fairly wide range that includes the values observed with magnetic stimulation.

To determine basic restrictions, it is conservative to assume a small value of τ_e, rather than a large one. Consequently, Table 6 adopts a value of τ_e = 149 μs as suggested by an average of the lower experimental values mentioned above. The theoretical value of E_o = 6.15 V/m is considered a median within a distribution of thresholds in healthy adults. Although adequate statistical data is lacking, sufficient data on E_o is available to suggest that the assumption is reasonable. Where the induced E-field could be determined, rheobase for pulsed magnetic stimulation of the forearm was found to be 5.9 V/m (Havel et al. [B39]). In addition, an underlying neural excitation assumption of 6.15 V/m correctly reproduces the distribution of let-go current thresholds in adults (Sweeney [B94]). Furthermore, thresholds of excitation with pulsed magnetic

stimulation calculated with E_o = 6.15 V/m are reasonably consistent with experimentally determined thresholds (6.3).

The most sensitive means of exciting skeletal muscle is via electrostimulation of the motor neurons that innervate it. Consequently, thresholds for muscle stimulation follow those for nerve excitation. An exception to this occurs with cardiac stimulation, as described below.

6.1.2 Cardiac excitation

Cardiac excitation, which refers to electrical stimulation of a contraction (systole), follows strength-duration and strength-frequency laws like those for nerve excitation, except with much greater values of τ_e (smaller values of f_e). Experimental data demonstrate that τ_e depends on the focality of the stimulus. For focal stimuli, as with a small electrode near the excitable tissue, time constants can be much smaller than when the stimulus is more diffuse, as it would be for magnetically induced *in situ* electric fields. An S-D time constant τ_e = 3 ms has been assumed, which applies to large contact electrodes or diffuse stimulation of cardiac tissue; E_o = 12 V/m has been assumed as a median rheobase for excitation based on experimental data (Reilly [B73], [B75]).

Cardiac excitation is not necessarily hazardous, although ventricular fibrillation (VF) is a serious life-threatening condition. Minimum thresholds for VF typically exceed those for excitation by a factor of 50 or more. However, if the heart is repeatedly excited, the VF threshold drops such that the margin between VF and excitation thresholds may be reduced to a factor as little as two if the stimulus is applied during the vulnerable period within the cardiac cycle.

Cardiac excitation would not be an exposure issue under most circumstances since with exposure of the torso the limits on peripheral nerve excitation would prevail. However, particular circumstances of nonuniform exposure that result in strong induced fields around the heart could conceivably require the application of the cardiac excitation criterion.

6.1.3 Synaptic activity alteration

Whereas the nerve cell requires membrane depolarization of approximately 15–20 mV to initiate an action potential, synaptic processes can be affected by altering the presynaptic membrane potential by less than 1 mV, and possibly as little as 60 μV, as with electrical stimulation of synapses in the retina (Knighton [B53], [B54])—a factor 250 times lower than minimum neural excitation thresholds. Consequently, the synapse is a potentially sensitive site for neural interaction with applied electrical stimuli. An important property of the synapse is that a relatively small change in presynaptic potential can have a much larger percentage change in postsynaptic potentials (Katz and Miledi [B50]). Since the postsynaptic cell sums the presynaptic inputs from several cells, a small change in presynaptic potential can have a significant postsynaptic effect, and can be either inhibitory or excitatory, i.e., could result in the excitation of a neuron that would otherwise not have been excited, or could inhibit excitation of a neuron that would otherwise have been excited.

An example of a synaptic polarization effect is attributed to the phenomenon of electro- and magneto-phosphenes, which are visual effects resulting from electric currents or magnetic fields applied to the head (Adrian [B2]; Barlow [B5], [B6]; Baumgart [B7]; Bergeron et al. [B10]; Budinger et al. [B19]; Carstensen [B21]; Clausen [B24]; Lövsund et al. [B57], [B58]; Silny [B92]). Experimental evidence suggests that phosphenes result from modification of synaptic potentials in the receptors and neurons of the retina (Knighton [B53], [B54]; Lövsund et al. [B57]), rather than excitation of the optic nerve or the visual cortex, although visual sensations with stimulation of the visual cortex have been demonstrated with much stronger stimuli (Brindley and Lewin [B17]; Brindley and Rushton [B18]; Ronner [B83]).

Using data from magnetophosphenes (Lövsund et al. [B57], [B58]) the corresponding induced E-field in the head at the most sensitive frequency tested (20 Hz) is 0.079 V/m-rms as calculated with an ellipsoidal model

of the head (see Annex B). At the retina, where the electrical interaction is thought to take place, the calculated field is 0.053 V/m-rms, which is consistent with the current density threshold of 0.008 A/m^2 at the retina determined for electro-phosphenes (Lövsund et al. [B58]) assuming the conductivity of the brain is 0.15 S/m. The internal E-field corresponding to phosphene perception at the optimum frequency is a factor of 100 or so below rheobase thresholds for neural stimulation.

Experimental strength-duration data show that τ_e for phosphenes using electrodes on the temples is approximately 14 ms (Baumgart [B7]; Bergeron et al. [B10]) and for electrically evoked potentials in the frog's eye, τ_e is in the range 14–36 ms (Knighton [B53], [B54]). These values are consistent with the phosphene data described above, but are about 100 times greater than corresponding values for peripheral nerves.

Relatively few data exist on synaptic polarization effects by applied electric fields. Considering this dearth of data, reasonable assumptions are made based on the available synaptic effects experimental data and on assumed parallels with nerve excitation properties. One class of these properties concerns strength-duration and strength-frequency characteristics. An average strength-duration time constant for synapse effects is τ_e = 25 ms. Using the relationships noted for nerve excitation, a strength-frequency constant of f_e = 20 Hz is expected above which *in situ* electric field thresholds should rise. This rise is indeed observed in the case of electrophosphene thresholds, although the rate of rise is greater than that observed with nerve excitation (Adrian [B2]; Clausen [B24]). Magneto-phosphene strength-frequency curves reported by Lövsund and colleagues ([B57], [B58]) show a minimum at 20 Hz, and rising thresholds at lower frequencies, in accord with electrophosphene data. Thresholds above 20 Hz vary somewhat with the experimental parameters (background illumination and wavelength, subject visual acuity). Considering electro- and magneto-phosphene strength-frequency and strength-duration curves in total, it is reasonable to adopt a threshold curve similar to that found in electrostimulation of nerve and muscle, but with a much lower strength-frequency constant (or equivalently, a larger strength-duration time constant), and with lower rheobase. Additional study of CNS synaptic interaction effects is needed to clarify these assumptions.

Frequency sensitive thresholds for phosphenes have been experimentally tested only to a maximum frequency of about 75 Hz. The Subcommittee makes the conservative assumption that synaptic polarization thresholds follow a frequency-proportional law above 20 Hz to a frequency of at least 760 Hz (above which peripheral nerve excitation limits dominate the magnetic field MPEs).

In connection with phosphene threshold experiments, Lövsund and colleagues ([B57], p. 330) state: “Virtually all the volunteers noted tiredness and some reported headaches after the experiment. Some experienced afterimages which were generally of only short duration following exposure to the magnetic field. In one case, however, they persisted up to ten minutes after the experiment. Individual volunteers reported spasms of the eye muscles, probably arising from stimulation by the field.” These findings were similar to those of Silny [B92], who reported headaches, indisposition, and persistent visual evoked potential (VEP) alterations at flux density levels above phosphene thresholds, but still well below nerve excitation thresholds (by a factor of 23).

Clearly adverse reactions that may be attributable to CNS reactions (tiredness, headaches, muscle spasms, persistent afterimages) are reported in connection with phosphene threshold experiments. It is unlikely that the phosphenes themselves were causing the reported adverse reactions. A plausible explanation is that the adverse effects were due to electrostimulation of brain neurons in accord with the synapse mechanism discussed previously.

The ability of sub-excitation fields to alter neuronal response has also been reported after exposure of hippocampal slices from the rat brain to magnetic fields (Bawin et al., [B8, B9]) in which induced E-field intensities were as low as 0.75 V/m peak—a factor of 16 below the threshold of 12.3 V/m for excitation of a 10-μm neuron. The rate of maze learning in living mice was significantly reduced by exposure to flux densities at and below 0.75 mT at 50 Hz (Sienkiewicz et al. [B90], [B91]). Although the cited studies did not

establish a synaptic mechanism, they do support the view that CNS effects, including adverse ones, are possible well below thresholds of excitation of brain neurons.

The spinal cord also contains synapses. Spinal functions are important to the organism (e.g., control of posture; reflex activity). Tests have been conducted with human subjects whose torsos were subjected to the strong switched gradient fields of experimental MRI systems (see 6.1.1 and 6.3.2). Perception was sometimes preferentially reported in the small of the back at stimulus levels corresponding to nerve stimulation thresholds in accord with expectations from an elliptical induction model (see 6.3.2 and Annex B). These tests showed no observable effects below the neural threshold for perception. The lack of an observable effect below electrical perception thresholds suggests one of three possible explanations. One is that spinal synapse interactions did occur, but they were imperceptible to the subject. Another is that the induced field in the spinal column was below synapse interaction thresholds, even though the levels just outside of the spinal column were roughly two orders of magnitude above synapse thresholds. A third is that stimulation thresholds are significantly greater than what has been assumed for synaptic effects in brain neurons (Table 6).

Considering that the Subcommittee could find no data to suggest observable effects from stimulation of the spinal cord at the levels attributed to synapse thresholds, protection in this standard is focused on the brain, rather than the spinal cord.

6.1.4 Averaging time

The rms metrics specified in Table 1, Table 2, Table 3, Table 4, and Table 5 require the specification of an averaging time. For sinusoidal stimulus waveforms, thresholds of nerve excitation evaluated at half-cycle increments oscillate between gradually falling maxima at odd numbers of half cycles, and minima at even number of half cycles, and converge to a single minimum threshold at about 1.3 ms of stimulus duration (Reilly [B75]). The time constants of excitation threshold versus duration for muscle and nerve synapse stimulation exceed that for nerve stimulation by factors of 20 and 168, respectively (Table 7). Consequently, a measurement averaging duration of 200 ms ($\cong 168 \times 1.3$) would encompass the maximum integration duration needed to characterize minimum nerve, muscle, and synapse excitation thresholds. For sufficiently low frequencies, the variation of threshold with the number of cycles above one is trivial, and a measurement averaging time of a few cycles appears adequate. For frequencies below 0.1 Hz, a maximum averaging time of 10 seconds (one cycle) is considered adequate.

6.1.5 Spatial averaging

When determining compliance with the basic restrictions (Table 1), an important parameter is the averaging distance, d_a, over which the *in situ* electric field should be measured. A related question is the required distance over which the electric field must exist for efficient electrostimulation. For cases of practical interest involving unintended electrical exposure, the most sensitive means of exciting a nerve fiber is via an *in situ* electric field oriented with the long axis of the nerve fiber, and acting at its terminus (Reilly [B75]). An exception to this statement might occur when a small stimulus electrode is situated near the nerve, but such cases would normally be found only in medical applications, rather than chance electrical encounters.

The relationship between the threshold of excitation and the distance over which the field exists (d_e) has been determined using a nonlinear model of a myelinated nerve (Reilly and Diamant [B80]). With this model, a minimum threshold was obtained with d_e of seven or more internodal spaces. With d_e of one internodal space, the threshold was twice the minimum value. With d_e = 2, 3, 4, and 5 internodal spaces, the threshold exceeded the minimum value by 34, 14, 7, and 3%, respectively. For a nerve axon diameter of 20 μm (the size assumed in this standard for peripheral nerves), the internodal distance is 2 mm. If an averaging distance (d_a) of 5 mm is used, and assuming a field just at the threshold of excitation corresponding to d_e, the measured average field with $d_e \leq 2$ internodal spaces would be within 19% of the basic restriction value (Table 1). For larger d_e and with a corresponding threshold field, the measured average field over 5 mm approaches the basic restriction value within a few percent. It appears that 5 mm

represents a reasonable averaging distance, which is neither overly conservative nor permissive. Consequently, the Subcommittee specifies that the *in situ* electric field be determined as the average over a distance d_a = 5 mm, which can be readily determined from the potential difference at a spacing of 5 mm.

6.2 Adverse reaction criteria

The purpose of basic restrictions and MPE limits is to avoid adverse reactions, not just perceptible ones. Aversive or painful electrostimulation is considered an adverse effect. Painful sensations from magnetic stimulation of peripheral nerves are reported at multiples above perception thresholds of 1.3 (Budinger et al. [B20]), 1.6 (Bourland et al. [B15]), and 1.48 (Nyenhuis et al. [B67]; Schaefer et al. [B88])—an average multiple of 1.45. The mean threshold for intolerable pain was observed at a perception multiple of 2.05 (Schaefer et al. [B88]). The median rheobase threshold for painful sensations is taken as $E_o = 6.15 \times 1.45 =$ 8.92 V/m (peak). Based on a log-normal probability model of human perception thresholds of electrical stimuli (see 6.8), a conservative estimate of a one-percentile pain reaction threshold for healthy adults would be a factor of 3 below the median, resulting in a rheobase of 2.97 V/m.

In the case of contact current stimulation, unpleasant and painful sensations are elicited at greater multiples above perception than with magnetic stimulation. Based on experimental data from several sources (Reilly, [B75], Table 7.3), painful stimulation is estimated to occur at a multiple of 2.4 above the perception threshold; unpleasant sensations are estimated to occur at a multiple of 1.7; the ratio of pain to unpleasantness thresholds is about 1.4.

That smaller pain-to-perception ratios are found with magnetic stimulation than with contact current stimulation may be explained by the fact that in magnetic stimulation, the distribution of induced current varies only gradually with respect to body dimensions. Consequently, at a field level where some neurons first begin to be excited, a small increase in the field may excite neurons over a large area. If pain is magnetically induced in some area of the body, it is likely to be in an extended area. In contrast, cutaneous stimulation is more focal. Suprathreshold stimulation in a large area may be more painful than in a small area, and that might account for the differences in pain-to-perception ratios between magnetic induction and small-area contact current.

Cardiac excitation is considered adverse. Although not necessarily life threatening in itself, it is potentially dangerous if it is repeated in close succession, such as can be the case with sinusoidal or repeated pulse stimulation of the heart (see 6.1.2).

With synaptic effects, the Subcommittee treats any alteration of brain activity as a result of electrical stimulation of brain neurons via the induced *in situ* electric field as a potentially adverse outcome. Such conservatism is motivated by the adverse reactions (tiredness, headaches, muscle spasms, persistent after-images) reported in laboratory experiments using magnetic field exposures near the threshold of synapse effects (see 6.1.3).

With magnetohydrodynamic effects and forces on charges due to rapid body motion in strong static and quasi-static fields, a variety of biological effects have been observed (see 6.4). In light of these observations, adverse reactions are assumed at 1.06 T-rms (1.5 T-peak) in 50% of human subjects at frequencies below 1 Hz, which possibly include nausea, vertigo, and taste sensations associated with head movement.

6.3 Threshold limits for magnetic field exposure

To derive an environmental magnetic field from allowable *in situ* E-field magnitudes, it is necessary to apply an induction model. Traditional methods used to predict whole body energy absorption during magnetic field exposure include the use of ellipsoid shapes arranged to mimic an animal or man (Reilly [B72]). During the past several years, high-resolution anatomical models have been developed to enhance the capability to predict localized energy absorption, such as within a single organ or part of an organ.

6.3.1 Detailed anatomical induction models

The development of the high-resolution models has enhanced tremendously the understanding of energy absorption during electromagnetic field exposure. However, this development has also revealed several inadequacies in present knowledge regarding dosimetry. Hurt and colleagues [B41] demonstrated how variability in published permittivity values influence specific absorption rate (SAR) calculations. Although SAR values are pertinent only at the higher frequencies, the influence of permittivity values on predicted induced internal fields produced by the lower exposure frequencies should also be determined. Mason and associates [B60] evaluated the influence of voxel size on the predicted energy absorption during electromagnetic field exposure. Increasing voxel size could either increase or decrease the predicted amount of energy absorbed within a voxel. In general, there was usually a decrease in the amount of energy absorbed, but this was not always the rule. It appears that the better solution is to use the highest-resolution model available, and then average the amount of energy absorbed amongst the voxels. However, even if a model has a small voxel size, this does not necessarily imply that the high-resolution anatomy or separation of anatomical components has been adequately incorporated.

A comparison of induced electric field calculations obtained by several investigators using a similarly detailed anatomical model and similar numerical techniques (Dawson and Stuchly [B28]; Dimblylow [B30]; Gandhi [B37]) showed differences of over 5:1 in the maximum field in critical organs; organ averages were usually reasonably consistent, although differences as great as 2:1 were noted. Since the basic restrictions of this standard depend on the maximum field in particular organs, large variations in reported maximum values make it difficult to apply presently available detailed models to standards.

An important missing element in high resolution modeling is validation. Simply producing a model is insufficient for declaring that the results produced by using this model are accurate. Substantial laboratory testing on biological tissue should be incorporated into any model development. Comparison of the theoretical and empirical results and the subsequent refining of a model are essential in order to earn the credibility essential when using these models to establish or revise exposure standards.

6.3.2 Ellipsoidal induction model

Limits on environmental magnetic fields in this standard have been based on an ellipsoidal model of the head and torso of a large individual, with uniform conductivity, and a constant magnitude and relative phase of the field over the body dimensions as described in Annex B. In all calculations, a worst-case assumption has been made for the direction of the field relative to the body.

Using this model, an *in situ* field of 6.15 V/m (the presumed median nerve excitation threshold among subjects) has been calculated to be induced in the periphery of the torso with whole-body exposure to *dB/dt* = 37.5T/s (see Annex B and Table B.1). That theoretical value applies to conditions of exposure that minimize the excitation threshold, namely: a very large adult; constant magnitude, direction, and relative phase of the incident field over the dimensions of the body; a monophasic square-wave shape of the *in situ* electric field. In most cases, experimental conditions deviate from the optimal parameters resulting in greater thresholds than the minimum ones.

One of the cited optimal conditions was a monophasic square-wave shape for the induced electric field. Note that the *in situ* field follows the waveform of the time derivative of flux density, *dB/dt*, which is necessarily biphasic for a magnetic pulse; the mean is zero if the rise and fall magnitudes of flux density are equal, although the rise and fall times need not be equal. If the induced waveform is such that the phase reversal is either delayed or is gradual, then the threshold can be effectively the same as would apply to a monophasic waveform.

The conservatively derived theoretical value of 37.5 T/s may be compared with experimental thresholds conducted with pulsed magnetic field exposure of the human torso in MRI studies (Bourland et al. [B12], [B13], [B14], [B15]; Budinger et al. [B20]; Cohen et al. [B25]; Mouchawar et al. [B61]; Nyenhuis et al.

[B66]; Schaefer et al. [B86], [B87]; Yamagata et al. [B98]), as previously reviewed (Reilly [B75], Sect. 9.7). Mean perception thresholds of 60 T/s were reported by two investigators (Budinger et al. [B20]; Cohen et al. [B25]), and a minimum threshold of 45 T/s was reported by another (Bourland et al. [B12]). Higher thresholds were reported by others, but, like the above cited studies, these involved sub-optimum waveforms or conditions not conducive to minimum rheobase values.

Simulated MRI fields used in experiments discussed above varied considerably in amplitude and relative phase over the dimensions of the human torso. The optimum field metric for electrostimulation is not clear when such nonuniformity exists. Recent studies report perception thresholds in terms of the spatially averaged exposure, rather than the spatial peak as in most of the studies mentioned above. Using a spatial average metric, an average rheobase value of the perception threshold was reported at 25 T/s in one study involving 65 subjects (Hebrank [B40]), and 28.8 T/s in another study involving 84 subjects (Nyenhuis et al. [B66]).

Cardiac excitation thresholds using magnetic stimulation have been determined in dogs. Early results (Mouchawar et al. [B62]; Yamaguchi et al. [B99]) indicated *dB/dt* thresholds in excess of what would be predicted from the models used here (Table 7 and Table B.1), although this could be explained by the use of sub-optimum exposure conditions in the cited studies (Reilly [B73]). More recent test results with dogs (Schaefer et al. [B88]) conformed well with the models used in this standard when scaled from animal to human dimensions. It was also established that the addition of a 1.5 T static field to the time-varying excitatory field does not alter cardiac excitation thresholds (Bourland et al. [B16]).

With consideration of theoretical and experimental data, the Subcommittee adopts as median thresholds the peak *dB/dt* ($\dot{B}$) values listed in Table 7. Annex B describes the methods whereby the external field thresholds of Table 7 are derived from the *in situ* parameters of Table 6.

Table 7—Models for established magnetic dB/dt thresholds of reaction: whole body exposure; median thresholds[a]

Reaction	$\dot{B}_o$ - pk (T/s)[b]	τ_e (ms)	f_e (Hz)
Synapse activity alteration, brain	1.45	25.0	20
10-µm nerve excitation, brain	237	0.149	3350
20-µm nerve excitation, body	37.5	0.149	3350
Cardiac excitation	88.7	3.00	167

[a]Interpretation of table as follows: $\dot{B} = \dot{B}_o$ for $t_p \geq \tau_e$; $\dot{B} = \dot{B}_o\,(\tau_e/t_p)$ for $t_p \leq \tau_e$.

Also, $\dot{B} = \dot{B}_o$ for $f \leq f_e$; $\dot{B} = \dot{B}_o\,(f/f_e)$ for $f \geq f_e$.

[b](*T/s-pk*) refers to the temporal peak of the magnetic flux density.

Thresholds are computed from the parameters of Table 7, and as shown in Equation (5a) and Equation (5b) as

$$\dot{B} = \dot{B}_o \qquad \text{for } t_p \geq \tau_e \tag{5a}$$

$$\dot{B} = \dot{B}_o\ (\tau_e/t_p) \qquad \text{for } t_p \leq \tau_e \tag{5b}$$

where

t_p is the phase duration of the $\dot{B}_o$ waveform

Alternatively, the limits can be determined as shown in Equation (6a) and Equation (6b)

$$\dot{B} = \dot{B}_o \quad \text{for } f \le f_e \tag{6a}$$

$$\dot{B} = \dot{B}_o \, (f / f_e) \quad \text{for } f \ge f_e \tag{6b}$$

Flux density, *B*, listed in Table 8 can be computed from the Table 7 criteria using the relationships for sinusoidal fields as shown in Equation (7) and Equation (8)

$$\dot{B} = \dot{B}_o / (2\pi f_e) \tag{7}$$

$$B_O(rms) = B_o(peak) / (\sqrt{2}) \tag{8}$$

where

$\dot{B}_o$ is the minimum (rheobase) threshold value of *dB/dt*
B_o is the minimum threshold value of *B*.

Median flux density thresholds are computed from Table 8, and Equation (9a) and Equation (9b) as

$$B = B_o \quad \text{for } f \ge f_e \tag{9a}$$

$$B = B_o \, (f_e / f) \quad \text{for } f \le f_e \tag{9b}$$

Table 8—Median magnetic flux density thresholds; whole body exposure[a]

Reaction	B_0 - rms (mT)	H_0 - rms (A/m)	f_e (Hz)
Synapse activity alteration, brain	8.14	6.48×10^3	20
10-μm nerve excitation, brain	7.97	6.34×10^3	3350
20-μm nerve excitation, body	1.27	1.00×10^3	3350
Cardiac excitation	59.8	4.76×10^4	167

[a]Interpretation of table as follows: $B = B_o$ for $f \ge f_e$; $B = B_o \, (f_e/f)$ for $f \le f_e$.

Considering the procedures discussed above, it is apparent that the flux density limits in Table 8 are based on the assumed *in situ* limits of Table 6 evaluated at the site of interaction. For instance, the brain exposure limits are based on the estimated field induced in the outer perimeter of the cerebral cortex; cardiac excitation applies to the field induced in the apex of the heart; and peripheral nerve limits are based on the maximum induced field in the periphery of the torso.

6.4 Static or quasi-static magnetic field exposure

Whereas Equation (9b) indicates that flux density thresholds would increase to infinity as the frequency approaches zero, an upper limit on flux density is required to avoid adverse effects from magnetohydrodynamic forces on moving charges within a magnetic field. Such movement is typically

associated with the vascular system, although observable effects can also result from the rapid movement of the body or eyes within a strong static field. The physical effects are *Hall* voltages or *Lorentz* forces.

With static magnetic fields, reactions under laboratory conditions include a 17% increase in human cardiac cycle length at 2 T (Jehesen et al. [B49]). The authors gave the opinion that the observed effect is probably harmless in healthy subjects, but that its safety in dysrhythmic patients was not certain. Other observations included a 0.2–3% change in blood velocity between 1–10 T (Dorfman [B31]; Keltner [B52]). A host of adverse effects were noted at 1.5 T, including: vertigo, difficulty with balance, nausea, headaches, numbness and tingling, phosphenes, and unusual taste sensations. Much more marked reactions were noted at 4 T (Schenck et al. [B89]). Other effects include benign enhancement of the cardiac T-wave in rats at 4 T (Gaffey and Tenforde [B36], Tenforde et al. [B95]).

The studies of Schenck and colleagues report adverse effects in a significant number of subjects at 1.5 T, which the Subcommittee adopts as a median threshold for adverse effects. A peak value of 1.5 T is associated with a slowly varying sinusoidal field of 1.06 T-rms. A statistical model has been assumed for the distribution of thresholds that follows the same lognormal distribution found in other electrical thresholds (see 6.8). Consequently, at a factor of 3 below the median, namely, 353 mT (the value listed in Table 2 for the lowest frequencies), the affected population of sensitive individuals is estimated to be less than 1% of exposed individuals. For the general public the Subcommittee applies an additional safety factor of 3, which leads to the value of 118 mT (as listed in Table 2).

6.5 Nonsinusoidal or pulsed fields

The basic restrictions and MPE levels in Table 1, Table 2, Table 3, Table 4, and Table 5 are expressed as a function of frequency assuming a sinusoidal exposure waveform. In many practical situations, however, the applicable waveform may not be sinusoidal, such as with a waveform having harmonic distortion, or with pulsed waveforms. Subclause 5.2.4 expresses tests for determining the compliance of a nonsinusoidal waveform (pulsed or mixed frequency) based on previous studies (Reilly [B74], Reilly and Diamant [B79]). One of these tests is required to be met in addition to satisfying the rms limits of Table 1 or Table 2.

The criteria in 5.2.4.1 are based on the temporal peak and phase duration of either the *in situ* field (or contact current), or the derivative of the environmental field. Alternatively, Equation (2) in 5.2.4.2 uses Fourier components of the test waveform. Since criteria in either subclause are conservative, either may be used to test for compliance. The choice may be dictated by the relative ease of obtaining the requisite data to implement the test (Fourier components versus temporal peak and phase duration).

In some cases the compliance tests may be overly conservative. Such cases may occur when the waveform appears as a low frequency wave on which is superimposed a short duration impulse. The degree of conservatism would increase as the impulse becomes shorter in duration, and greater in amplitude. A more precise test would require evaluation of the threshold of a specific waveform with a neural excitation model, such as the one used in the cited study (Reilly and Diamant [B79]).

The maximum frequency used in Equation (2) is 5 MHz, which is outside the limits of this standard. However, it is possible that a particular waveform does not respect the frequency division between this standard and IEEE Std C95.1 that treats higher frequencies. Since it is not meaningful to truncate the summation of Equation (2) at 3 kHz, the summation is shown as applying to the maximum frequency of demonstrable electrostimulation.

6.6 Exposure to environmental electric fields

Since environmental electric fields induce *in situ* electric fields and body currents, it might seem logical to conclude that the induced field should be limited so as to preclude direct electrostimulation effects. In practice, however, contact current and spark discharge criteria (indirect electrostimulation) limit

environmental electric fields to values significantly lower than what is required to directly induce *in situ* electric fields at the levels in Table 1 and Table 6. For example, the basic restriction for the *in situ* electric field in the brain is 17.7 mV/m at 60 Hz for the general public (Table 1). To induce this field in a grounded, erect person would require an environmental field of about 59 kV/m (Carstensen [B22]). Considering that the undisturbed field is enhanced at body surfaces—18 times, for example, on the head of an erect person (Kaune [B51]), and even greater enhancements are possible on extended fingertips—parts of the body could be in a state of corona at environmental field levels necessary to induce the cited E-field within the brain.

Indirect stimulation effects occur through charge transfer between a person and a conducting object within the field. With sufficiently strong fields, an individual can perceive spark discharges just prior to the moment of direct contact and just after breaking contact with conducting objects that are well insulated from ground. It is also possible to perceive current through direct contact with such objects.

The contact current component, I_c, for an erect person touching a grounded conductor in a vertically polarized electric field is shown in Equation (10) (Reilly [B75])

$$I_c = 9.0 \times 10^{-11} h^2 f E \tag{10}$$

where

h is the height of the person
f is the frequency of the field
E is the environmental field strength

For fields with frequencies within the limits of this standard, in which the environmental field magnitude varies over the area that would be occupied by the body, the field strength in Equation (10) may be replaced with the average environmental field over the area in which the body is placed (Deno and Zaffanella [B29]; Kaune [B51]).

Exposure limits on environmental electric fields in Table 4 are intended to avoid aversive or painful contact currents or spark discharges when an erect person touches a conductive path to ground. In this instance, the individual is the induction object if that person is insulated from ground (rubber sole shoes, standing on an insulated surface, etc.). The limits may not protect grounded individuals from adverse electrostimulation when touching large conductive objects that are insulated from ground.

The field limitations in Table 4 that provide protection against adverse contact current vary in inverse proportion to frequency. If this law were to extended to zero frequency, the electric field limit would approach infinity. An upper limit is placed on the maximum permissible E-field to limit the probability of an adverse reaction to a spark discharge.

The maximum permissible field in Table 4 is 5 kV/m for the general public. It is estimated that spark discharges would be painful to approximately 7% of adults who are well insulated and who touch a grounded object within a 5 kV/m field. Unpleasant spark discharges can also occur when a grounded person touches a large conductive object that is well-insulated from ground situated within a strong field. It is not possible to absolutely protect against all possibility of adverse stimulation without mitigating the induced charge on the object when very large (or long) objects are situated near sources that produce electric fields that are very extended spatially, such as is the case with high-voltage power transmission lines. For instance, one might postulate a long fence wire on insulated posts running parallel to a high-voltage transmission line. In such cases, it is preferable to restrict electrostimulation by properly grounding the conducting object (as stated in other safety codes), rather than by limiting the electric field to an impractically small level.

In the controlled environment where the MPE is limited to 20 kV/m, painful spark discharges, but not contact currents, can be readily encountered at the stated limit for an insulated person at ground level

touching a grounded conductive object. In such strong fields, workers should limit the probability of painful spark discharges by appropriate use of protective clothing, grounding measures, contacting techniques, or other work practices that consider these environmental electric field effects. In the controlled environment, conductive suits can be worn that shield the body from high environmental electric fields, thereby greatly reducing indirect electrostimulation. Currents conducted to the body of individuals wearing protective clothing shall not exceed those in Table 5.

Power line rights-of-way fall somewhere between the definitions of “controlled” and “uncontrolled” environments for the general public in that public activity can be circumscribed by the utility, but that public access is often allowed for the public benefit. Consequently, this standard specifies a limit of 5 kV/m for the general public in regions off the right-of-way, but allows an intermediate field of 10 kV/m within the right-of-way under normal load conditions. (If the powerline right-of-way conforms to the requirements of a controlled environment, then the controlled environment limits apply.) Experimental data using spark discharge stimuli on human subjects (Reilly [B75]; Reilly and Larkin [B81]) can be applied to this exposure. In a field of 10 kV/m, about 50% of adult subjects (1.8 m tall) who are well insulated from ground would experience painful discharges when contacting a grounded conductor. The stated probability would increase with taller subjects and decrease with shorter ones. It is also decreased by imperfect insulation of the person with respect to ground.

Maximum electric fields permitted within and off power transmission line rights-of-way are subject to limitation from other agencies or requirements, such as the U.S. National Electrical Safety Code and other electric utility regulations. The National Electrical Safety Code® (NESC®) (Accredited Standards Committee C2-1997) specifies a safety limit of 5 mA short circuit current (i.e., the current into a low-impedance connection to earth) from objects within the electric field of a high-voltage transmission line. The intent of this provision is to limit contact currents to the “let-go” level of a few percent of sensitive children under worst case conditions, rather than to avoid aversive or painful perception of contact current or spark discharges.

In the absence of indirect stimulation, environmental E-fields can sometimes be perceived through vibration of body hair caused by the interaction of the field and charged hair follicles. With a sufficiently strong field the sensation can be annoying to some people. For instance, at 20 kV/m in an outdoor environment, 50% of standing adults can perceive a 60 Hz field, and about 5% will consider the sensation annoying (Deno and Zaffanella [B29]; Reilly [B69]). Although 20% of subjects perceived a 60-Hz electric field at 9 kV/m, less than 5% could detect electric fields of 2 or 3 kV/m (Reilly [B69]). With hands raised above the body, the median perception threshold is 7 kV/m.

When an exposed individual is not within reach of a grounded conducting object, such as with a live power line worker in an insulated bucket, the maximum exposure limits in Table 4 may not apply. In such cases, the magnitude of contact current and spark discharges will be determined by the potential difference between the individual and the touched object, and their capacitances. The Subcommittee recommends adherence to the limits of Table 4 for the general public, however, the limits of Table 4 may be exceeded in controlled environments in which workers are not within reach of grounded conducting objects. The Subcommittee does not have a specific recommendation at this time for this situation. Regardless of the size and proximity of conducting objects that may be touched by the exposed individual, an absolute upper limit on acceptable exposure will be determined by the need to prevent corona on body surfaces. It is unlikely that exposures in excess of 30 kV/m (undisturbed field) would be acceptable on any exposed body part.

6.7 Static or quasi-static electric fields

The maximum permissible environmental electric field has been capped to limit the probability of painful spark discharges. This limit could, in principle, be extended to arbitrarily low frequencies since even a single discharge can be painful. However, at a sufficiently low frequency, the time constant, τ_h, at which a human can maintain a charge will begin to limit the magnitude of the induced charge. The time constant is given by

the product of the capacitance and resistance to ground of the person. For example, consider a resistance of 1000 MΩ, which is applicable to 10% of people with normal footwear on dry ground (Reilly [B70], [B75]), and a capacitance of 150 pF. These assumptions result in a time constant of 150 ms, which is equivalent to a frequency of 1 Hz below which the induced voltage in a given field would fall, and the permissible exposure could rise. However, for people on well-insulated surfaces, longer time constants would be possible. The validity of this observation is apparent considering that one may experience an unpleasant carpet spark a second or more after the charge has been acquired.

These observations may be applied to the standards of Table 4 as follows. For leakage resistance of 1000 MΩ, the allowable maximum limits below 1 Hz could be increased approximately in inverse proportion to frequency; for greater resistances, the applicable frequency would become lower.

6.8 Statistical variations in thresholds of reaction

Large variations in electrical thresholds are observed from one person to another. The statistical distribution of electrical reaction thresholds is typically represented by a *lognormal* distribution, i.e., one in which the logarithm of a statistical variate has a normal distribution. The mean of a lognormal distribution always exceeds the median. The mean-to-median ratio, ρ, is expressed as shown in Equation (11) (Hastings and Peacock [B38])

$$\rho = \exp\left(\frac{\sigma^2}{2}\right) \tag{11}$$

where

σ is the variance of the natural logarithm of the statistical variate.

For a distribution in which the ratio of 50% to 1% values equals three, the mean-to-median ratio is 1.12, i.e., the mean exceeds the median by 12%. This relationship is useful in cases where an experimental mean is given, rather than a median.

Experimental thresholds correspond well to the lognormal distribution in many instances of electrostimulation, although it is often necessary to replot published data on lognormal coordinates to demonstrate this. The lognormal distribution is found in: human perception of contact current (Larkin et al.[B56]); bovine perception of contact current (Reinemann et al. [B82]); human “let-go” thresholds (Dalziel [B26]); human perception of electric fields (Reilly [B69]); human perception of and pain from time-varying magnetic fields (Nyenhuis et al. [B67]); human electroconvulsive therapy (ECT) seizure thresholds (Weaver and Williams [B97]); and cardiac VF thresholds in dogs (Reilly [B75]).

A lognormal slope can be expressed as the ratio of the median to the one-percentile thresholds. Approximate slope parameters from experimental data can be summarized as: human perception of contact current on the forearm: 3.0; human perception, fingertip: 2.0; VF thresholds, dogs: 2.1; bovine contact current perception: 2.3; human ECT seizure thresholds: 2.0; human perception of time varying magnetic fields: 1.9. It can be seen that a slope parameter of 3 represents an observed maximum slope applied in this standard, although a more typical condition would have a slope parameter of about 2.

Table 9 provides examples of log normal models (medians normalized to 1.0) applicable to sensory stimulation of the forearm of healthy adult humans, and to ventricular fibrillation (VF) in healthy dogs (Reilly [B75]). Experimental data for fingertip perception more closely follow the VF values. Compared with data from healthy animals, a much broader distribution of VF thresholds has been reported for direct electrode contact to the hearts of human patients undergoing open-heart surgery for valve replacement (Watson et al. [B96]). Thresholds for persons in a pathological state or under drug treatment have not been otherwise tested.

Table 9—Normalized distribution of electrical reaction thresholds using lognormal model for healthy adult population (male and female)[a, b]

Percentile rank (%)	Threshold multiplier perception and pain	Threshold multiplier ventricular fibrillation
99.5	3.45	2.33
99.0	3.11	2.14
95.0	2.24	1.67
90.0	1.85	1.51
75.0	1.40	1.24
50.0	1.00	1.00
25.0	0.72	0.80
10.0	0.54	0.66
5.0	0.45	0.60
1.0	0.32	0.47
0.5	0.29	0.43

[a]Perception distribution based on human experimental data for arm contact. Ventricular fibrillation distributions from healthy dog hearts.
[b]Source: Reilly [B75].

It is tempting to extrapolate the distribution model of Table 9 to arbitrarily small percentile ranks. However, experimental evidence is insufficient to support extrapolation much below the rank of about 1% due to limitations in the numbers of subjects represented in available experimental data. The Subcommittee adopts a factor of three to convert median thresholds to a sensitive individual. This would encompass at most one percent of most sensitive individuals, but generally a much smaller percentile would be affected for most reactions treated in this standard.

Variations in thresholds from one individual to another are not well understood. The only significant physiological parameter that has been correlated with electrical thresholds is body size and related parameters, such as gender and age (Larkin et. al. [B56] and Reilly [B75], [B81]). The correlation is such that small individuals tend to have lower thresholds. A body size relationship is found in sensory reactions, let-go thresholds, and ventricular fibrillation. Experimental evidence indicates that thresholds of pain in humans and VF thresholds in animals vary approximately with the square-root of body weight, although other relationships have been proposed (Reilly [B75]). Let-go thresholds in humans vary approximately in proportion to body weight. Consequently, small individuals, especially children, would be most susceptible to electrical stimulation effects. On the other hand, the magnitude of current induced by electric or magnetic fields diminishes with decreasing subject size. And with contact current, the small individual typically has a greater inter-limb resistance than a larger person. Because of these compensating factors, the effect of body size is not expected to be great. Indeed, a study of the relationship between magnetic field perception thresholds and morphological factors (subject gender, girth, weight, and age) demonstrated a lack of significant correlation with any of these factors (Nyenhuis [B67]).

Subclause 6.11.2 provides an example of the application of the lognormal statistical model.

6.9 Acceptance criteria

6.9.1 Basic restrictions

Maximum permissible exposure levels listed in Table 1 were derived from the median thresholds of Table 6 by applying multipliers that convert from a median threshold of excitation to an adverse reaction threshold with low probability in healthy adults and with an adequate safety factor. Table 10 summarizes multipliers used to derive the basic restrictions: column A lists the reaction under consideration; column B lists the locus of stimulation; column C lists median rheobase excitation thresholds, E_{ot}, from Table 6, but converted from peak to rms values using the conversion E(rms) = E(peak)/$\sqrt{2}$; column D lists multipliers, F_a, applied to column C that convert from a median excitation threshold to a median adverse reaction threshold; column E lists multipliers, F_p, that convert from a median threshold to a low-probability one; column F lists safety factors, F_s, applied to the general public and in the controlled environment, respectively; column H lists rheobase *in situ* fields, $E_{ob} = E_{ot}F_aF_pF_s$, which are the rheobase basic restrictions in Table 1.

Basic restrictions listed in Table 1 are in terms of *in situ* induced electric fields; the mode of induction, however, can be through the action of the environmental magnetic or electric field. In addition to induced electric field specifications, it is also necessary to restrict the *in situ* magnetic field to avoid adverse reactions due to magnetohydrodynamic effects from very low frequency magnetic fields (see 6.4). Table 1 specifies such restrictions below 10 Hz. It is not necessary to specify magnetic field basic restrictions at greater frequencies, because potential adverse effects would be related to the induced electric field, rather than the *in situ* magnetic field itself.

The following paragraphs summarize the rationale for the multipliers appearing in Table 10.

Table 10—Factors for converting median thresholds to MPE values

A	B	C	D	E	F Safety factor (F_s)		G Basic restrictions (E_{ob})	
Reaction	**Locus**	**Threshold E_{ot} (50%) (V/m, rms)**	**Adverse mult. (F_a)**	**Prob. mult. (F_p)**	**General public**	**Contr. environ**	**General public (V/m, rms)**	**Contr. environ. (V/m, rms)**
Synapse alter.	Brain	0.053	1.0	0.333	0.333	1.000	5.89×10^{-3}	1.77×10^{-2}
10-µm neuron excite	Brain	8.70	1.0	0.333	0.333	1.000	0.970	2.90
20-µm neuron pain	Body	4.35 (percept.)	1.45 (pain)	0.333	0.333	1.000	0.700	2.10
20-µm neuron pain	Hands, feet, wrists, ankles	4.35 (percept.)	1.45 (pain)	0.333	1.000	1.000	2.10	2.10
Cardiac excite	Heart apex	8.49	1.0	0.333	0.333	0.333	0.943	0.943

6.9.1.1 Adverse reaction factor

Pain is considered an adverse response with peripheral nerve excitation. An adverse reaction multiplier of F_a = 1.45 is applied to the nerve excitation threshold to derive a pain threshold (see 6.2). With synaptic effects, brain stimulation, and cardiac excitation, excitation itself is considered adverse as noted in 6.1.2 and 6.1.3; hence the adverse reaction multiplier of F_a = 1.0 is applied to the excitation threshold for these reactions.

6.9.1.2 Probability factor

A probability factor, F_p, is applied to convert from a median threshold to a low-probability one. For a lognormal distribution in which the slope parameter (median-to-one-percentile ratio) is 3, the multiplier of 0.333 applied to the median threshold corresponds to a one-percentile most sensitive subject. Whereas a slope parameter of 3 is observed in some cases (e.g., contact current perception on the forearm), with other reactions of critical application to this standard (magnetic field perception, cardiac VF, brain ECT thresholds), the slope parameter is very close to 2.0 (see 6.8). With a slope parameter of 2, a multiplier of 0.333 applied to the median threshold results in a 0.01% probability rank.

6.9.1.3 Safety factor

A safety factor multiplier of F_s = 0.333 allows for protection of exceptionally sensitive individuals, uncertainties concerning threshold effects due to pathological conditions or drug treatment, uncertainties in the reaction thresholds, and uncertainties in the induction models. In the case of the hands, wrists, feet, and ankles, F_s = 1 for the general public in recognition of the narrow cross sections and preponderance of low conductivity tissue that tend to enhance the *in situ* E-field in these areas in comparison with other areas of the body. Because these regions lack critical function when compared with the vital organs, a greater localized electric field is permitted. In the case of the controlled environment, F_s = 1 for all of the reaction types except for cardiac excitation under the assumption that a small probability of discomfort is acceptable in the controlled environment for some mechanisms, but that cardiac excitation is unacceptable for all individuals. The safety factor F_s = 1 can be justified for the indicated exposures because this standard is based on avoidance of short-term reactions that are immediately apparent to the exposed individual, rather than chronic exposure health effects at sub-perception levels, and where cumulative exposure might be significant. It is assumed that, because the short-term reactions are apparent to exposed individuals, they can remove themselves from the environment, modify their activities, or can take other action to avoid the exposure entirely.

If the safety factor F_s = 0.333 is to be compared with that applied at higher frequencies of IEEE Std C95.1, note that a divisor of 3 applied to the magnitude of the induced field is equivalent to a divisor of 9 in the SAR because SAR is proportional to the square of the induced field.

6.9.2 Maximum permissible exposure levels

Sophisticated computational capabilities may sometimes be required to assess whether basic restrictions are met. Consequently, it is desirable to define MPE values which are reference levels in terms of the environmental field, rather than the induced *in situ* field. The MPEs listed in Table 2 incorporate conservative assumptions such that adherence to them insures that the basic restrictions are not exceeded. However, since the MPEs are conservatively derived, it is possible that one may exceed them and still be within the basic restrictions.

Figure 1 illustrates the derivation of MPE levels for magnetic fields. The figure shows median thresholds of adverse reaction (broken lines), and MPEs (solid lines) with whole body exposure. The MPEs are derived from the minimum adverse thresholds at each frequency, decremented by the appropriate probability and safety factors in Table 10. The curve for synapse alteration has been extended to 1000 Hz. The MPE curves have been derived from the lowest adverse reaction threshold across the frequency spectrum as follows: 0– 0.153 Hz, magnetohydrodynamic effects; 0.153–759 Hz, synapse alteration;

above 759 Hz, peripheral nerve pain. Note that the MPEs in the controlled environment correspond to low probability reaction thresholds (≤ 1%). The limits applicable to the general public are lower by a factor of three. Table 2 expresses the MPE reference values.

For purposes of demonstrating compliance with this standard, Table 2 and Table 4 shall be considered separately, and not additively. This is because the *in situ* electric field induced by environmental electric and magnetic fields are maximized in disjoint regions of the body under the conditions represented in Table 2 and Table 4.

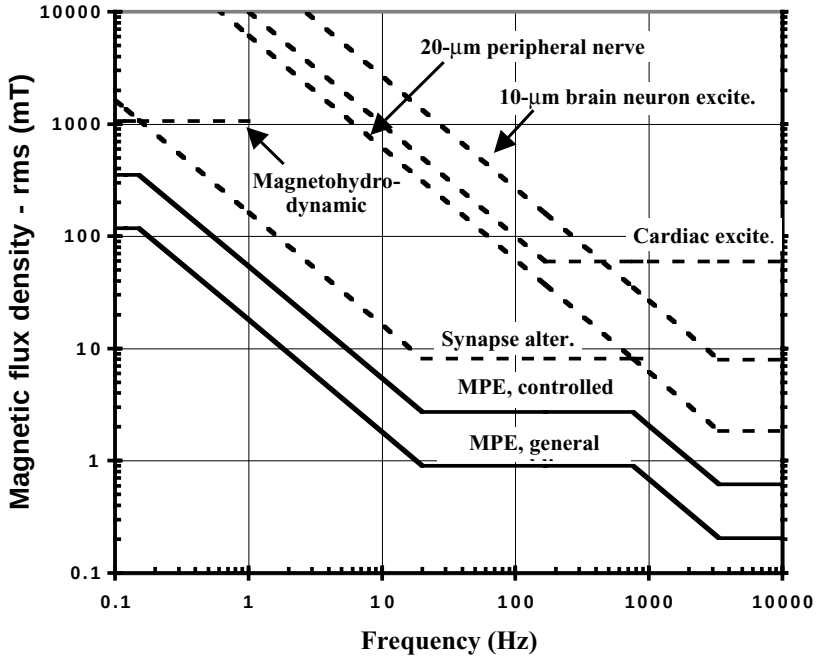

Figure 1— Median thresholds for adverse stimulation from magnetic field exposure (broken lines) and recommended maximum permissible exposure limits (solid lines); whole-body exposure to spatially constant field

6.10 Partial or nonuniform exposure

The limits of Table 2 are designed to avoid adverse reactions with whole body exposure to magnetic fields that are relatively constant in magnitude and relative phase over the entire body. Because the contribution of the *in situ* electric field within the head and torso due to exposure of the arms and legs is not great, the limits also apply to a constant field over only the head and torso. However, when a magnetic field is not constant over the head and torso, a conservative approach for magnetic fields would be to limit the spatial peak of the actual field in accordance with Table 2. It is possible that such an approach might be unduly restrictive. An acceptable alternative would be to limit the external magnetic field such that the *in situ* E-fields do not exceed the basic restrictions of Table 1. To determine compliance with Table 1, it would be necessary to model the induction process using the actual field values (direction, magnitude, and relative phase), and an appropriate physiological model (computational or physical), along with the orientation of the model with respect to the direction of the field.

For situations where there is a significant disparity in magnetic field exposure of the head and torso, the MPE flux density limits needed to meet the basic restrictions (Table 1) can change considerably. To illustrate this point, consider a 60 Hz field where only the torso is exposed versus one where both the head and torso are exposed. If only the torso were exposed, the MPE would be limited by peripheral nerve stimulation,

rather than by brain synapse effects. For torso exposure, the MPE at 60 Hz would be 34.8 mT—roughly 13 times the limit of 2.71 mT for both head and torso exposure (Table 2).

The electric field reference levels in Table 4 are not based on the *in situ* electric field limits of Table 1; rather these limits are based on indirect electrostimulation. Spark discharge and contact currents will be acceptable if the average environmental electric field over the dimensions of the body does not exceed the Table 4 limits. These limits are based on the assumptions that the exposed person is insulated from ground, is much closer to the ground than the field source, and is within reach of a grounded conducting object.

6.11 Induced and contact current

6.11.1 General relationships

Strength-duration and strength-frequency curves characterize thresholds of nerve stimulation for contact currents. The rheobase threshold value of current into a contact electrode varies inversely with the contact area. A touch contact area of 1 cm^2 is assumed for the area of a light fingertip contact, whereas a much larger contact area ($\cong$15 cm^2) can apply to a grasped contact. Consequently, separate values are cited in Table 5 for grip and touch contacts. The grasping contact limit in controlled environments pertains where personnel are trained to effect grasping contact and to avoid touch contacts with potentially energized conductors or grounded conductors when the person is the induction object. It is assumed that the general public is not aware of the possibility of conducted current from energized objects, and the method of contact is unconstrained. Specified limits reduce the probability that inadvertent contact with energized objects could lead to tiny localized burns of the outer layer of skin (with spark discharges), painful sensations, or startle reactions that, while not hazardous per se, could lead to an accident.

Numerous experiments with perception of sinusoidal current reveal a strength-frequency law with a minimum plateau below a critical frequency, f_e, above which thresholds converge to a frequency-proportional law when the current is of a continuous nature (Reilly [B75]). With continuous sinusoidal stimulation, frequency-proportional thresholds have been demonstrated in humans to a frequency of 100 kHz, above which thermal perception thresholds dominate (Chatterjee et al. [B23]; Dalziel and Mansfield [B27]). However, for pulsed sinusoidal waveforms, the frequency-proportional relationship can be extended into the MHz region as suggested by neurostimulation experiments in rats (LaCourse et al. [B55]), and in human experiments using brief ($\cong$ 0.1 μs) pulses (Reilly [B75]).

Based on nerve excitation models, strength-duration and strength-frequency constants are connected by $f_e = 1/(2\tau_e)$. Consequently, factors leading to small values of τ_e would increase f_e. Experimental values of f_e vary significantly, although the factors accounting for this variation are not well understood. The Subcommittee has adopted the assumption that f_e for contact current is 3 kHz, allowing extrapolation to lower frequencies from thresholds determined at higher frequencies using a slope of f with a minimum threshold at and below 3 kHz. Further research will be needed to understand the variation of experimental constants observed in strength-duration and strength-frequency laws.

6.11.2 Illustration of statistical relationships

Pain levels with touch contact can be extrapolated from Chatterjee et al. [B23] to a frequency of 3.0 kHz, which is the postulated corner frequency (above which there is a frequency-proportional slope). At 10 kHz (the lowest frequency tested by Chatterjee), the mean pain level is 8.0 mA for adults (males and females mixed) and 6.0 mA for 10-year-old children. Those values may be converted to median thresholds by dividing by the factor 1.12 as noted in 6.8. The 10 kHz thresholds are extrapolated to a 3 kHz rheobase by applying the multiplier 0.3 (the ratio 3 kHz/10 kHz). The result is a median pain threshold of 2.14 mA for adults and 1.6 mA for 10-year-old children. Using a discomfort-to-pain ratio of 0.7 for contact current (see 6.2), the median discomfort rheobase level is estimated to be 1.5 mA for adults, and 1.12 mA for children. Applying these median values to the lognormal model with a median-to-one-percentile ratio of 3.0, the

following reaction probabilities are determined. At a touch contact level of 0.5 mA (the MPE for the general public) in children: the probability of discomfort is 5%, and the probability of pain is 1%. In adults: the probability of discomfort is 1%, and the probability of pain is 0.1%. At a touch contact current level of 1.5 mA in adults: the probability of pain is 23%, and the probability of discomfort is 50%.

Current thresholds for perception and pain are considerably greater if contact is made with a grasping contact rather than a touch. A mean perception level for a grasping contact at 10 kHz is 13 mA for adults (Chatterjee et al. [B23]). Extrapolating to a frequency of 3 kHz, a median perception threshold of 3.48 mA is determined. The median discomfort or pain threshold is determined by applying the multipliers 2.4 and 1.7 respectively (see 6.2), resulting in a median rheobase discomfort level at 5.92 mA and a pain level at 8.35 mA. At a grasping contact current of 3 mA (specified in Table 5 for grasping contact MPE in controlled environments), the probability of discomfort in adults is estimated at 8%, and the probability of pain at 1.6%.

The contact current levels in Table 5 do not contain safety factors. The omission of safety factors is justified by noting that the reaction levels for contact current are better understood than are the other reaction thresholds addressed in this standard.

6.12 Medical devices and metallic implants

Medical devices and metallic implants may involve special health and safety problems when the individual using them is exposed to electric and magnetic fields. This standard does not necessarily provide protection against interference with such devices or hardware. The recipient or provider of these devices should be aware of the potential for hazards and precautions that may be necessary with such devices.

Electrically powered medical devices can be susceptible to interference from many different sources of electrical energy. Interference with medical devices can occur with exposures below those cited as thresholds for electrostimulation effects. While several types of medical devices have been designed for immunity to electrical interference (e.g., cardiac pacemakers), many devices in use have not been designed or tested for immunity. Even with reasonable immunity to interference, serious patient consequences may occur if the immunity is exceeded. The concerns for device interference extend over a broad range of electrically powered medical devices. Examples of such devices where there are concerns for interactions include, but are not limited to: pacemakers, defibrillators, drug delivery pumps, neurostimulators, hearing aids, apnea monitors, hospital beds, and powered wheelchairs. When deemed necessary, advice should be sought from the manufacturer of the device and/or from the patient’s medical practitioner.

There are a few standards that address electromagnetic compatibility (EMC) of medical devices and the device performance during exposure. The most widely recognized medical device standard published by the International Electrotechnical Commission (IEC [B44]) covers many, but not all, medical devices. There are also general standards for active implantable medical devices that contain EMC requirements (ECES [B33]; IEC [B44]; ISO [B48]). In addition, work is underway to update the IEC medical equipment EMC standard and to develop more consistent standards for pacemakers and implantable defibrillators which include EMC requirements, such as in the United States (AAMI [B1]) and Europe (ECES [B34], [B35]).

Metallic implants comprise another class of medical implants, such as metallic stints, staples, and orthopedic rods and plates. In some cases, metallic implants may contact sensitive tissue, as with cardiac staples. Unlike the medical device, such implants may not have a failure mode due to electrical interference. Nevertheless, metallic hardware implanted in the body can enhance induced electric fields either by providing a magnetic induction loop, or a high conductivity region that can locally enhance the induced electric field, and thereby enhance the possibility of electrical stimulation in localized regions near the implant (Reilly and Diamant [B78]).

Annex A

(informative)

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Annex B

(normative)

Magnetic induction model

The magnetic induction model used in developing this standard treats an exposed cross section of the body as an elliptical shape, with homogeneous conductivity. A solution for this model, applicable to situations where the wavelength of the field is much greater than body dimensions was published by Durney et al., [B32], and expressed in applied form by Spiegel [B93]. The present form used here is the one expressed by Reilly [B72]. A general expression for the induced E-field due to an incident B-field that is constant in magnitude and relative phase over the ellipse is shown in Equation (B.1)

$$E = -\dot{B}_w \left| \frac{a^2 u \boldsymbol{a}_v - b^2 v \boldsymbol{a}_u}{a^2 + b^2} \right| \tag{B.1}$$

where $\boldsymbol{a}_u$ and $\boldsymbol{a}_v$ are unit vectors along the minor and major axes, respectively, (a, b) are the semi-major and semi-minor axes, respectively, (u, v) is the location within the exposed area, and $\dot{B}_w$ is the time rate of change of the magnetic flux density in a direction perpendicular to the cross section. In the calculations that follow, the magnitude of the induced field, E, is expressed, rather than its vector components. The coordinate system is such that the minor axis of the ellipse is along the u-direction, and the major axis is along the v-direction.

Table B.1 summarizes the exposure conditions used to determine $\dot{B}_o$ data expressed in Table 7. The entries of Table B.1 are interpreted as follows. The second column expresses the exposure condition. For instance, the entry in the first row is interpreted as excitation of a 10 μm neuron located in the brain, with a magnetic field perpendicular to the sagittal cross section. The third column gives the semi-minor and semi-major axes of the ellipse. The fourth column gives the location within the cross section where the E-field is evaluated. The fifth column is the assumed rheobase value of E_o (from Table 6). The last column gives the values of $\dot{B}_o$ determined from Equation (B.1). In this formulation, it is assumed that an ellipse is fitted to the torso, body,

Table B.1—Elliptical exposure model used to compute magnetic induction[a, b]

Item	Exposure	*b, a* (cm, cm)	*u, v* (cm, cm)	E_o (V/m-pk)	$\dot{B}_o$ (T/s-pk)
1	10-μm nerve, brain, sagittal	9, 10.5	9, 0	12.3	237
2	Synapse, brain, sagittal	9, 10.5	9, 0	0.075	1.45
3	20-μm nerve, body, sagittal	17, 90	17, 0	6.15	37.5
4	20-μm nerve, torso, coronal	20, 40	20, 0	6.15	38.4
5	Heart, body, sagittal	17, 90	14, 18	12.0	88.7
6	Heart, torso, sagittal	17, 40	14, 18	12.0	98.6
7	Leg	9, 42	9, 0	6.15	71.5

[a] *b,a* represent semi-minor and semi-major axes, respectively, of ellipse fitted to particular body part, *viz:* the brain in items 1 and 2, the torso in item 4, and the whole body in items 3 and 5.

[b] (*u,v*) represents the location within the ellipse where the induced field was evaluated, where *u* and *v* are measured along the minor and major axes, respectively.

or head in one of three orientations. Consequently, the reference system (*u, v*) is tied to the fitted ellipse and not to one specific reference system with respect to the body.

In items (1) and (2), the assumed ellipse is not supposed to represent the actual size of the brain, but rather the size of an ellipse that encloses its outer perimeter (the cerebral cortex) where the magnitude of the induced E-field is greatest. The ellipse enclosing the brain has semi-major and semi-minor axes that are 1.5 cm smaller than the assumed head size to account for the distance of 1.5 cm between the cortex and the scalp. Items (3) and (5) treat the exposure as uniformly covering the entire body; items (4) and (6) assume only the torso is exposed. The latter points are included to demonstrate that there is but a modest difference (about 10%) between worst-case exposure of the entire body versus exposure of only the torso with respect to peripheral nerve and cardiac stimulation.

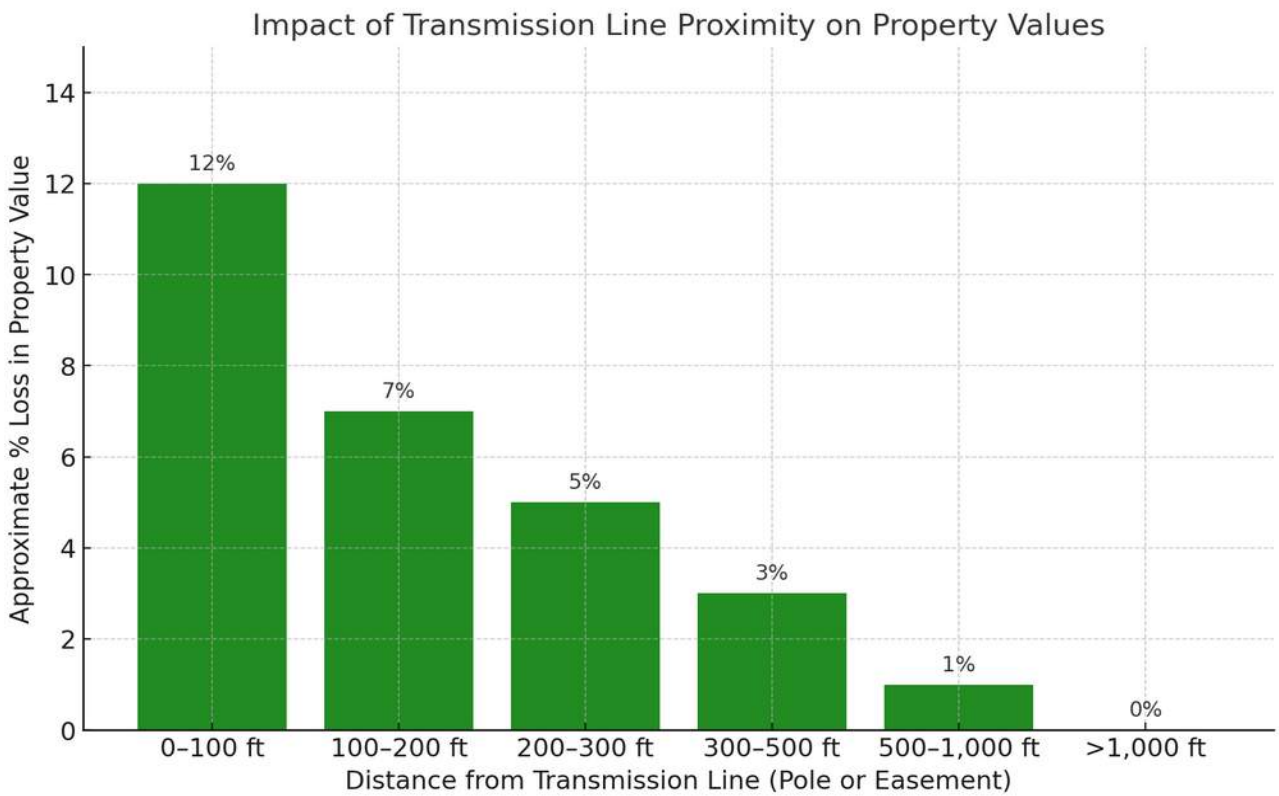
The points *u,v* are selected to correspond to the worst-case exposure point for each of the assumed scenarios. In the case of the brain [items (1) and (2)], the cortex is where the induced E-field is greatest, and sagittal exposure provides the greatest magnetic induction loop. For items (3) and (5), an ellipse is fitted to the entire body viewed in the sagittal cross section. In the case of the heart, the point of greatest sensitivity to electrical stimulation is its apex (Roy et. al. [B84]), and the greatest induced field at that location is found with sagittal exposure (Reilly [B72]). The points (*u,v*) in items (5) and (6) correspond to the apex of the heart.

The exposure ellipses in Table B.1 correspond to a large (but not extreme) body size for adults based on anthropomorphic data (SAE [B85]). It is conservative to assume large body dimensions.

High-Voltage Transmission Lines and Property Value Impacts

This briefing document summarizes peer-reviewed research on the relationship between high-voltage transmission lines (HVTLs) and nearby property values. Studies consistently show that proximity to large (230–735 kV) lines correlates with measurable reductions in home prices, with the strongest impacts within 0–200 feet of the right-of-way (ROW). Impacts taper off with distance and are usually negligible beyond 1,000 feet.

Estimated Property Value Loss by Distance



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Voltage: 315 kV and 735 kV (Québec). Proximity: Within 100 ft, homes lost 9.6–14.8%. Diminished after 300 ft; negligible by 500 ft. Relevance: Shows steep penalty at adjacency for 735 kV.

Hamilton, Stanley W., & Schwann, Gregory M. (1995). Do High Voltage Electric Transmission Lines Affect Property Value? *Land Economics, 71*(4), 436–444.

Voltage: 230, 287, 500 kV (Vancouver). Proximity: Adjacent (0–200 ft) lost ~6.3%; 200–500 ft lost ~1%; none beyond. Relevance: Landmark study proving adjacency depresses values.

Chalmers, James A., & Voorvaart, Frank A. (2013). High-Voltage Transmission Lines: Proximity, Visibility, and Encumbrance Effects. *The Appraisal Journal, 81*(3), 227–245.

Voltage: 500 kV (Chino Hills, CA). Proximity: ROW-encumbered lost ~4.9%; abutting lost ~3.1%. Minimal beyond 300 ft. Relevance: U.S. case showing strongest impact for encumbered lots.

Sterling, Julie, & Colwell, Richard. (1993). Power Lines and Property Values: The Stigma Effect. *Journal of Real Estate Research, 8*(2), 289–303.

Voltage: 138 & 345 kV (Illinois). Proximity: 3–7% loss within ~200 ft; little beyond. Relevance: Demonstrates stigma effect even without health risk evidence.

Jackson, Thomas O., & Pitts, John M. (2001). The Effects of Electric Transmission Lines on Property Values: A Literature Review. *Journal of Real Estate Literature, 9*(2), 171–193.

Voltage: 115–735 kV (various). Proximity: 2–9% loss within 200–500 ft; strongest <200 ft. Negligible beyond 1,000 ft. Relevance: Consensus overview.

Kroll, Cynthia A., & Priestley, John D. (1992). The Effects of Transmission Lines on Property Values: A Literature Review and Survey of Homeowners. California Department of Real Estate.

Voltage: 230–500 kV (California). Proximity: 2–10% losses within few hundred ft; diminished by 500 ft. Relevance: Shows both perceived and measured impacts.

■ Voltage–Distance–Impact Pattern

-735kV super-HVTLs (Des Rosiers):9–15% lossat100≤ft, diminished by 300–500 ft. - 500 kV corridors (Chalmers & Voorvaart; Hamilton & Schwann; Kroll & Priestley): 3–7% loss at adjacency (0–200 ft), gone by ~500 ft. ROW encumbrance creates higher loss (~5%). - 345 kV lines (Sterling & Colwell): 3–7% loss at adjacency (0–200 ft). - 230–287 kV lines (Hamilton & Schwann; Kroll & Priestley): 2–6% loss adjacent, diminishing quickly by 500 ft. - Consensus: Strongest impact occurs within 0–200 ft of ROW, measurable but smaller impacts may persist to ~500 ft, negligible beyond ~1,000 ft.

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Christine Blythe

Property Address: 144 e snowy egret Dr.

City/ZIP: 84653

Email / Phone (optional): 801-793-4966

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- **I did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 8-17-25

Signature: CBlythe

Printed Name: Christine Blythe

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Maria Jose Rodriguez

Property Address: 1782 N SPARROW CIR UT

City/ZIP: Salem UT

Email / Phone (optional): 801 800 3510

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- **I did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 8-17-25

Signature: Maria MR

Printed Name: Maria M Rodriguez

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Kevin & Garnet Kuttever

Property Address: 254 E Snowy Egret Dr.

City/ZIP: Salem, UT 84653

Email / Phone (optional): kooterk@gmail.com

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- I **did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 8/17/2025

Signature: Kevin G Kuttever

Printed Name: Kevin G. Kuttever

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Kevin & Rebekah Frost

Property Address: 208 E. Snowy Egret Dr.

City/ZIP: Salem, UT 84653

Email / Phone (optional): 801-368-6375

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- I **did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 08/17/2025

Signature: [signature]

Printed Name: Rebekah Frost

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Joseph + Mary Ybarra

Property Address: 273 S. Egret Dr

City/ZIP: Salem 84653

Email / Phone (optional): josephybarra88@gmail.com

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- **I did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: Aug 17 2025

Signature:

Printed Name: Joseph Ybarra

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Ryan & Carlie Nelson

Property Address: 145 E. Snowy Egret Drive

City/ZIP: Salem, 84653

Email / Phone (optional): carliehaslem@gmail.com

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- **I did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 8/17/25

Signature: Carlie Nelson

Printed Name: Carlie Nelson

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Boydell Brown

Property Address: 317 E Snowy Egret

City/ZIP: 84653

Email / Phone (optional): _____

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- **I did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: Aug 17, 2025

Signature: Anne Brown

Printed Name: Anne Brown

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Kevin and Ashley Brickson

Property Address: 1558 N. 290 E.

City/ZIP: Salem, 84653

Email / Phone (optional): 385-447-3303

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- **I did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: Aug-17-2025

Signature: Kevin & Brickson

Printed Name: Kevin Brickson

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Michael & Tauscha Johanson

Property Address: 359 E Snowy Egret Dr.

City/ZIP: 84653

Email / Phone (optional): tauscha.johanson@gmail.com

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- **I did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 8/17/25

Signature: Tauscha C Johanson

Printed Name: Tauscha Johanson

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Jonathan Sullivan

Property Address: 388 E. Snowy Egret Dr.

City/ZIP: 84653

Email / Phone (optional): 801-319-5340

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- I **did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 8/17/25

Signature:

Printed Name: Jonathan Sullivan

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Quinlan & Allison DRAPER

Property Address: 149 E SNOWY EGRET DR.

City/ZIP: SALEM

Email / Phone (optional): Quinlan.James1119@gmail.com

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- **I did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 8/17/2025

Signature:

Printed Name: Quinlan Draper

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Brian Rowe

Property Address: 243 E Snowy Egret Dr.

City/ZIP: Salem

Email / Phone (optional): _____

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- **I did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 8/17

Signature: B

Printed Name: Brian Rowe

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Paul - Angela Madsen

Property Address: 17960 N. Warbler Rd

City/ZIP: Salem, Ut 84653

Email / Phone (optional): pamadsen@comcast.net

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- **I did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: Aug 17, 2025

Signature: Angela Madsen / Paul Madsen

Printed Name: Angela Madsen / PAUL MADSEN

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): AARon + Shellee ANDERSON

Property Address: 1782 N WARBLER RD

City/ZIP: 84653

Email / Phone (optional): AARandav34@gmail.com

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- **I did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 8-17-2025

Signature: AARon Anderson

Printed Name: AARON ANDERSON

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Blake Francom

Property Address: 1765 N. Warbler Rd.

City/ZIP: Salem / 84653

Email / Phone (optional): x

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- **I did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 6/17/25

Signature:

Printed Name: Blake Francom

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Ashley Page

Property Address: 1787 N Sparrow Hawk Way

City/ZIP: 84653

Email / Phone (optional): _____

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- **I did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 8/17/25

Signature: Ashley Page

Printed Name: Ashley Page

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): TODD + KARLEEN WRIGHT

Property Address: 1749 N WARBLER RD

City/ZIP: SALEM 84653

Email / Phone (optional): 801-380-7223 TODDW@NATR.COM

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- **I did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 8-17-2025

Signature: [signature]

Printed Name: TODD WRIGHT

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Mike Beagley

Property Address: 1730 N Wasatch

City/ZIP: 84058

Email / Phone (optional): _____

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- **I did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 8-17-2025

Signature: _____

Printed Name: Mike Beagley

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Jessica & Aaron Zahn

Property Address: 1811 N. 290 E.

City/ZIP: Salem, 84653

Email / Phone (optional): jessicazahn@gmail.com

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- **I did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 8/17/25

Signature:

Printed Name: Jessica Zahn

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Josh & Kelli vidmar

Property Address: 235 E. Snowy egret Dr.

City/ZIP: 84653

Email / Phone (optional): N/A

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- I **did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 8/17/25

Signature: Kelli Vidmar

Printed Name: Kelli vidmar

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Rachel Ricks

Property Address: 1794 N. Sparrow Way

City/ZIP: Salem 84653

Email / Phone (optional): rachelricks10@gmail.com

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- **I did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 8/17/25

Signature: Rachel Ricks

Printed Name: Rachel Ricks

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Chris Tanalca

Property Address: 1803 N Sparrow Way

City/ZIP: Salem 84653

Email / Phone (optional): _____

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- I **did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 08/17/25

Signature: _____

Printed Name: Chris Tanalca

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Goran + Melinda Hunter

Property Address: 152 E Snowy Egret

City/ZIP: Salem 84653

Email / Phone (optional): _____

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- I **did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 17 Aug 2025

Signature: _____

Printed Name: Goran Hunter

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): _____

Property Address: 1H E Salem Park

City/ZIP: 84653

Email / Phone (optional): 801 884-8068

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- **I did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 17 Aug 2025

Signature: Deborah Stringham Randal Stringham

Printed Name: Deborah Stringham Randal Stringham

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Thomas Bennett

Property Address: 412 E. Salem Park Cir

City/ZIP: Salem, UT 84653

Email / Phone (optional): _____

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- **I did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 8-17-25

Signature: [signature]

Printed Name: Thomas Bennett

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Luce M. Rivera

Property Address: 1748 N Waibler Rd

City/ZIP: 84653

Email / Phone (optional): rivera.lucem@hotmail.com

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- **I did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: Aug 17, 2025

Signature: 

Printed Name: Luce M. Rivera

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Paul J. Patrick

Property Address: 398 E Salem Park Circle ~~Salem Ut 84653~~

City/ZIP: Salem, 84653

Email / Phone (optional): _____

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- **I did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 8/17/25

Signature: [signature]

Printed Name: Paul Jed Patrick

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): _____

Property Address: 1748 N. Curlew Way

City/ZIP: 84653

Email / Phone (optional): (801)866-2573

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- I **did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 8/17/25

Signature: _____

Printed Name: Nancy Johnson

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Philip and Candace Munoa

Property Address: 351 E Snowy Egret Dr.

City/ZIP: Salem, UT 84653

Email / Phone (optional): _____

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- **I did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 8-17-25

Signature: Candace Munoa

Printed Name: Candace Munoa

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Mark and Melanie Jensen

Property Address: 338 E. Snowy Egret Dr. Salem, UT 84653

City/ZIP: _____

Email / Phone (optional): _____

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- **I did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 8-17-2025

Signature: Melanie Jensen

Printed Name: Melanie Jensen

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Adam & Maleena Edwards

Property Address: 354 E Snowy Egret Drive

City/ZIP: Salem, 84653

Email / Phone (optional): 801.857-0540, 801-404-8863

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- **I did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 8-17-25

Signature: Maleena Edwards

Printed Name: Maleena Edwards Adam Edwards

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Kent Sorensen

Property Address: 373 E Snowy Egret Dr.

City/ZIP: 84653

Email / Phone (optional): 801-602-4799

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- **I did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 8/17/25

Signature: Kent Sorensen

Printed Name: Kent Sorensen

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Rochell & Gordon Madsen

Property Address: 384 E Salem Park Cir

City/ZIP: Salem, UT 84653

Email / Phone (optional): rgates@baav@yahoo.com 801-680-7347

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- **I did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 8-17-25

Signature: Rochell Madsen

Printed Name: Rochell Madson

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Jeff & Marlyn Kartchner

Property Address: 1734 N. Curlew Way Salem, UT

City/ZIP: 84653

Email / Phone (optional): Jeffmarlyn1028@gmail.com

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- **I did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 9/17/2025

Signature: Marlyn J. Kartchner

Printed Name: Marlyn J Kartchner

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Tyson Peterson

Property Address: 355 E. Sanderlin Dr.

City/ZIP: Salem 84653

Email / Phone (optional): _____

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- **I did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 8/12/25

Signature: _____

Printed Name: Tyson Peterson

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Taylor & Mikki Hogan

Property Address: 304 E. Snowy Egret Dr.

City/ZIP: Salem 84653

Email / Phone (optional): 801-979-6311

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- **I did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 8/17/2025

Signature:

Printed Name: Donald Taylor Hogan

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Dustin Peterson

Property Address: 1781 N 290 E

City/ZIP: 84663

Email / Phone (optional): oneless4jesus@yahoo.com

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- **I did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 8/17/25

Signature: [signature]

Printed Name: Dustin Peterson

Landowner Declaration of Non-Receipt of Notice

Regarding Proposed High-Voltage Power Lines by Rocky Mountain Power (PacifiCorp) also known as the Mercer Project

Property Owner(s): Tasha & Jonathan Fox

Property Address: 387 E. Snowy Egret drive

City/ZIP: Salem, UT 84653

Email / Phone (optional): tashafox81@gmail.com

Declaration

I am an owner of the property identified above. To the best of my knowledge and belief:

- I **did not receive** any **written or personal notice** about the above project from **Rocky Mountain Power (PacifiCorp)** or its contractors.

I understand this declaration may be provided to Utah County, the Planning Commission, and other relevant authorities to document lack of notice.

Unsworn Declaration (Utah)

I declare **under penalty of perjury under the laws of the State of Utah** that the foregoing is true and correct.

Date: 8/17/2025

Signature: Tasha Fox Jonathan Fox

Printed Name: Tasha Fox Jonathan Fox

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Childhood leukemia risk in the California Power Line Study: magnetic fields versus distance from power lines

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[4]UCLA Fielding School of Public Health, Department of Epidemiology, 650 Charles E. Young Drive South, Los Angeles, CA, 90095, USA

Abstract

Pooled analyses have suggested a small increased risk of childhood leukemia associated with distance and with exposure to high magnetic fields from power transmission lines. Because magnetic fields are correlated with distance from lines, the question of whether the risk is due to magnetic fields exposure or to some other factor associated with distance from lines is unresolved. We used data from a large records-based case-control study to examine several research questions formulated to disentangle the relationships among magnetic fields, distance from high voltage lines, and childhood leukemia risk. In models examining an interaction between distance and magnetic fields exposure, we found that neither close proximity to high voltage lines alone nor exposure to high calculated fields alone were associated with childhood leukemia risk. Rather, elevated risk was confined to the group that was both very close to high voltage lines (<50 m) and had high calculated fields (≥0.4 μT) (odds ratio 4.06, 95% CI 1.16, 14.3). Further, high calculated fields (≥0.4 μT) that were due solely to lower voltage lines (<200 kV) were not associated with elevated risk; rather, risk was confined to high fields attributable to high voltage lines. Whilst other explanations are possible, our findings argue against magnetic fields as a sole explanation for the association between distance and childhood leukemia and in favor of some other explanation linked to characteristics of power lines.

[*]Corresponding author. Phone: 310-206-9364; fax: 310-206-3566.

HUMAN SUBJECTS REVIEW
The California Power Lines Study was reviewed and approved by University of California, Los Angeles Office for the Protection of Research Subjects.

Keywords

Childhood leukemia; epidemiologic study; magnetic fields; power transmission lines; voltage

1. Introduction

The possibility that the electric power transmission and distribution system could pose a risk for childhood leukemia has been a concern for several decades, beginning with the study of Wertheimer and Leeper (1979) that found an association with electrical wiring configurations. Since that time, over 40 epidemiologic studies have investigated the association of childhood leukemia with residential exposure to magnetic fields or surrogates of magnetic fields (Kheifets and Swanson, 2014; Swanson et al., submitted). Analyses that have pooled data from multiple studies (Ahlbom et al,. 2000; Greenland et al., 2000; Kheifets et al., 2010) report a small but consistent increased risk of childhood leukemia associated with exposures above 0.3 or 0.4 microtesla (μT).

One major source of elevated magnetic fields is high-voltage power lines. The strength of magnetic fields from power lines is strongly related to distance from the lines. A recent comprehensive pooled analysis of childhood leukemia and distance to power lines found a small but imprecise increased risk associated with having a birth residence within 50 m of a 200+ kilovolt power line that was not explained by high magnetic fields (Amoon et al., 2016). There is thus some evidence implicating both magnetic fields and distance from power lines, and the question of whether the risk is due to magnetic fields exposure as opposed to some factor associated with distance from lines remains unresolved. Other factors that have been postulated include socioeconomic status, residential mobility, residence type, viral contacts, environmental tobacco smoke, dietary agents, traffic density (as a proxy for benzene exposure), pesticides and corona ions (Amoon et al., 2018; Kheifets and Shimkhada, 2005; Swanson et al., 2014).

The magnetic field produced by a power line is a function of multiple parameters, including voltage, load, phasing of line, geometry of line, ground clearance and distance, as captured in our directed acyclic graph (Figure 1). The distance at which residences are located may in turn be influenced by parameters of the line such as its size (voltage), line geometry and ground clearance, as these factors may be linked to the width of the right of way and the patterns of housebuilding near the right of way. Distance from the line alone may act as a surrogate for other exposures. Because distance is a key component of the calculated fields from power lines, distance from lines and calculated fields from lines tend to be highly correlated, and analyses using both metrics tend to find similar associations with childhood leukemia risk. Thus analyses that focus solely on magnetic fields or solely on distance from lines are unlikely to resolve the issue of whether one or both of these exposures represents a true risk factor for childhood leukemia.

Although calculated fields are correlated with distance, it is possible to formulate and test hypotheses that would support one versus the other as the causative factor. In particular, if elevated childhood leukemia risk were caused by magnetic fields, it would not matter what combination of parameters had produced the magnetic field. For example, a given magnetic

field strength produced by a high load at a farther distance would produce the same risk as the same magnetic field strength produced by a lower load and a closer distance. Similarly, if another factor correlated with proximity to high voltage lines were the true risk factor, then subjects at equal distance from lines should have the same level of risk, regardless of magnetic field strength.

One of the largest single studies on this topic is the California Power Line Study (CAPS), a large records-based case-control study of childhood leukemia risk and exposure to magnetic fields from power lines which investigated both magnetic field and distance from power lines (Kheifets et al., 2015). Strengths of CAPS include its population-based design, a relatively large sample size of 5,788 childhood leukemia cases and 5,788 matched controls, and an improved exposure assessment. CAPS reported an odds ratio (OR) of 1.4 (95% CI 0.7 to 2.7) for childhood leukemia associated with close proximity (within 50 m) of birth address to 200+ kV power transmission lines (Crespi et al., 2016). An odds ratio of this magnitude and precision does not clearly support increased childhood leukemia risk, but could be consistent with a small increased risk associated with close proximity to lines. CAPS also did not provide clear evidence of risk associated with exposure to magnetic fields from power lines (Kheifets et al, 2017); the OR was 1.5 (95% CI 0.7 to 3.2) for the highest exposure group. Both statistical analyses followed an *a priori* developed analysis plan, which specified both main and secondary analyses.

The relatively large size of CAPS presents an opportunity to explore the relationship among magnetic fields, distance to lines, line voltage and childhood leukemia risk. In this paper, we postulate and evaluate several research questions that attempt to disentangle these relationships, focusing on whether magnetic fields are the causative factor. These research questions are:

(1) Is the risk of childhood leukemia associated with exposure to magnetic fields from power lines independent of distance to the closest high voltage transmission line? If the risk is similar for subjects with the same magnetic field exposure who are close versus far from high voltage lines, we may infer that magnetic fields are a risk factor independent of distance.

(2) Is the risk of childhood leukemia associated with exposure to magnetic fields from power lines independent of the voltage of the closest transmission line? Note that the voltage of a line is, in turn, correlated with other factors such as physical size and likely load. If the leukemia risk associated with high fields is similar for subjects with the same magnetic field exposure whose fields are due to high voltage lines (over 200 kV) versus lower voltage lines (under 200 kV), we may infer that magnetic fields are a risk factor independent of voltage.

(3)Does risk decrease at the same rate as magnetic fields decrease with distance, or does it decrease more rapidly or less rapidly? In this study, as the results presented below show, magnetic fields fall roughly as inverse distance (d^{-1}), so a stronger association of risk with d or with d^{-2} or a similarly rapidly decreasing function might indicate that a factor other than magnetic fields is contributing to the observed risk.

2. Methods

2.1. Overview

The CAPS study has been described in previous publications (Kheifets et al., 2015; Vergara et al., 2015). Briefly, CAPS included childhood leukemia cases (born in and diagnosed in California 1986-2008, identified from the California Cancer Registry, diagnosed at less than 15 years of age) matched to population-based controls on age and sex, selected from the birth registry. Birth addresses of subjects were geocoded and distance from residence to transmission lines was estimated using geographic information systems, aerial imagery, and additionally site visits for residences sufficiently close to power lines to possibly have elevated magnetic fields exposure. For site-visited residences, we calculated magnetic fields at birth addresses using distance and historical information on load and phasing. Calculated fields accounted for all lines over 100 kV and some lower voltage lines. For all other residences, magnetic fields attributable to power lines were assumed to be <0.1 μT. For this paper, analyses were restricted to childhood leukemia cases and primary controls meeting our threshold for good geocoding accuracy, namely, geocoded to the street segment or parcel level.

2.2. Statistical Analyses

To characterize the relationship between distance from lines and calculated fields, counts of subjects in distance and calculated fields categories were summarized in a contingency table. We also used penalized regression splines to obtain a nonparametric estimate of the conditional mean of calculated fields as a function of distance from closest 200+ kV line, and compared this curve to regression models that modelled calculated fields as a function of linear distance (d), inverse distance (d^{-1}) and inverse distance squared (d^{-2}) in order to estimate the rate at which calculated fields decreased with distance from lines in our dataset and the proportion of the variation in calculated fields that was attributable to distance from 200+ kV lines.

To address the first research question (whether the risk of childhood leukemia associated with exposure to magnetic fields is independent of distance to the closest high voltage transmission line), we used logistic regression to model childhood leukemia risk as a function of distance and calculated fields, separately and together. Independence of the effects of magnetic fields and distance on risk implies the absence of an interaction. Therefore, we next examined models including an interaction between distance and calculated fields, focusing on the high exposure categories of each.

For the second research question (whether the risk of childhood leukemia associated with exposure to magnetic fields from power lines is independent of the voltage of the closest high voltage transmission line), we conducted analyses stratified on presence/absence of 200+ kV lines near the residence. In one set of analyses, observations were stratified on whether the line closest to the residence was higher or lower than 200 kV. These analyses included all observations. A second set of analyses was restricted to site-visited residences, which had detailed information collected on line configuration near the residence. For these analyses, we defined two groups, residences with only lines <200 kV nearby and residences

with only lines >200 kV nearby. Thus the second set of analyses exclude residences with nearby lines that included both <200 and >200 kV lines. Both sets of analyses consisted of logistic regression models for childhood leukemia with calculated field categories as predictors, controlling for age, sex, child race and socioeconomic status (SES).

For the third research question (whether risk decreases linearly with distance from lines or more rapidly), we fit and compared logistic models for childhood leukemia that modeled distance (out to 150 m) as d, d^{-1} and d^{-2} The fit of the models was compared using a significance test of the regression coefficient for the distance variable, the Hosmer-Lemeshow goodness of fit test (p-value<0.05 suggests lack of fit), the C-statistic (also known as the area under the ROC curve; higher is better), and AIC and BIC (lower is better). An AIC or BIC difference between two models of less than 2 provides little evidence for one over the other, while an AIC or BIC difference of 10 or more is strong evidence (Dziak et al, 2012).

All logistic regression models controlled for age, sex, child race and SES. SES was coded using a composite index of several variables (Crespi et al., 2016). To avoid dropping subjects in analyses, multiple imputation was used for missing values of child race (n=217, 2.2% of observations) and SES (n=253, 2.6% of observations). Analyses were conducted using Stata/SE 15.1 and R (R Core Team, 2016).

CAPS was reviewed and approved by University of California, Los Angeles Office for the Protection of Research Subjects.

3. Results

After restricting the data to childhood leukemia cases and primary controls with sufficient geocode accuracy, the dataset consisted of 9,714 observations (4,879 cases and 4,835 controls). Table 1 provides a cross-tabulation of calculated field levels and distance to closest power line over 200 kV. We used the same *a priori* cut points as in our previous analyses, chosen to facilitate comparison across published epidemiologic studies. There were a total of 28 subjects (cases and controls) with calculated fields ≥0.4 μT and a total of 38 subjects within 50 meters of 200+ kV lines. Sixteen subjects were both within 50 meters of 200+ kV lines and had calculated fields ≥0.4 μT. There were 31 subjects who had calculated fields ≥0.1 μT but were more than 600 meters from the closest 200+ kV line; for these subjects, the calculated fields were due to proximity to lower voltage lines.

Figure 2 provides a scatterplot of calculated field values and distance to closest 200+ kV line and a nonparametric estimate of the mean calculated fields level as a function of distance, for subjects within 150 meters of 200+ kV lines. A comparison of the spline estimate to regression models using calculated fields as a function of distance, inverse distance (d^{-1}) and inverse distance squared (d^{-2}) is also displayed. The d^{-1} model was closest to the spline model, suggesting that in our data, which included modelling of fields from lower voltages lines, calculated fields were decreasing roughly proportional to inverse distance from 200+ kV line. A linear regression model using d^{-1} as the predictor of calculated fields had an R^2

value of 0.39, indicating that about 39% of the variation in calculated fields values was attributable to (inverse) distance from 200+ kV lines.

Table 2 provides estimates of the odds ratios for childhood leukemia associated with distance and calculated fields categories, separately and together. In the distance-only model, the highest category of exposure (<50 meters of 200+ kV lines) had an odds ratio of 1.47 (95% CI 0.76, 2.82) compared to a reference category of over 600 meters. This OR remained essentially unchanged when controlling for calculated fields (OR 1.44, 95% CI 0.63, 3.29). In the calculated fields-only model, the highest exposure category (≥0.4 μT) had an odds ratio of 1.50 (95% CI 0.70, 3.23). When controlling for distance, the odds ratio was attenuated to 1.24 (95% CI 0.50, 3.05).

Table 3 provides results from a logistic regression model including an interaction between exposure categories of calculated fields and distance. Exposure groups were formed using the highest exposure categories for distance and calculated fields. In this model, elevated risk was evident only among subjects with high exposure to both calculated fields and distance (OR 4.06, 95% CI 1.16, 14.3). There were 13 cases and 3 controls in this combined high exposure category. There was no indication of elevated risk among subjects with high calculated fields but over 50 meters from 200+ kV lines (OR 0.50, 95% CI 0.15, 1.67) or subjects within 50 meters of 200+ kV lines but with calculated fields less than 0.4 μT (OR 0.81, 95% CI 0.35, 1.88).

Because the exposure group combining higher fields/closer distance (≥0.4 μT/ <50 m) could exhibit a higher risk than higher fields/further distance (≥ 0.4 μT/>50 m) combination group due to higher overall average fields, we repeated the analysis controlling for calculated fields as a continuous variable. The adjustment yielded an attenuated but still elevated risk in the dual high exposure group (OR 2.83, 95% CI 0.22, 37.1, data not shown).

Table 4A presents results stratified by whether the voltage of the closest line was less than or more than 200 kV. Among subjects whose closest line was low voltage, there was no evidence of excess risk associated with high calculated fields (OR 0.31, 95% CI 0.06, 1.54), but numbers of subjects in this cell were small. In contrast, among subjects whose closest line was high voltage (200+ kV), the odds ratio was 3.02 (95% CI 1.09, 8.36). Results for this stratification were similar when restricted to the site-visited subset (data not shown). Detailed information about lines was collected for the site-visited residences, allowing for an analysis restricted to residences with only low or only high line voltages. In these analyses (Table 4B), there was no evidence of elevated risk associated with calculated fields ≥0.4 μT among subjects with only low voltage lines near the home (OR 0.66, 95% CI 0.10, 4.39), and an elevated OR for subjects with only 200+ kV lines nearby (OR 4.52, 95% CI 1.36, 15.1). However, again, number of subjects in the high calculated field/low voltage line category was small.

Table 5 compares the fit of logistic regression models for the outcome of case-control status using different power transformation of distance as the main predictor. Significance tests of the coefficient of the distance variable indicated that the null hypothesis that the coefficient is zero cannot be ruled out for any of these models. There was no lack of fit indicated by the

Hosmer-Lemeshow test for any of the three models, and the C-statistics were similar, with perhaps a slight advantage of the d^{-2} model over the d^{-1} model. The d^{-2} model had AIC and BIC values 2-3 points lower than the other models, suggesting a possible weak advantage. However, overall, the differences in model fit were small.

4. Discussion

In these exploratory analyses of the relationship of childhood leukemia risk with calculated fields and distance from power lines, we found evidence of an interaction effect. In particular, we found that neither close proximity to high voltage lines alone nor exposure to high calculated fields alone were associated with childhood leukemia risk. Rather, elevated risk was confined to the group that was both very close to high voltage lines (< 50 m) and had higher calculated fields (≥0.4 μT). When we stratified on the voltage of the nearest line or presence/absence of high voltage lines, only subjects who were both close to high voltage (as opposed to low voltage) lines and had calculated fields ≥0.4 μT had an elevated odds ratio.

The large size of the CAPS study allowed examination of such interactions. However, unlike our previous results, this analysis was exploratory and thus should be viewed as hypothesis generating. The observed interactions could be spurious findings due to random variation, small number bias, or confounding by an unknown factor.

Calculated fields studies such as CAPS attempt to estimate subjects' historical long-term exposure to magnetic fields at their residence, which is a challenging task. When an exposure is rare, even a small number of false positives (unexposed subjects who are identified as exposed) can swamp the true positives and attenuate risk estimates. The exposure assessment in CAPS was specifically designed to achieve high specificity (i.e., a low false positive rate), using a tiered approach in which subjects tentatively identified as highly exposed were subjected to increasing levels of scrutiny (Vergara et al., 2015). We also conducted extensive sensitivity analyses to confirm high specificity. Nevertheless, an alternative explanation for our findings here is that magnetic fields are indeed the causative factor, that calculated higher fields are less prone to error when produced by closer distances or higher voltage lines, but that CAPS did not achieve high enough specificity for calculated higher fields in other situations. We cannot verify whether or not this is the case. Future work on exposure assessment could help to settle this issue.

Magnetic fields depend on distance from power lines. When we controlled for distance in the logistic regression model predicting case-control status based on calculated fields, the odds ratio for calculated fields was attenuated. This could be expected since distance from lines is a key contributor to calculated fields; others have found it explains more than 62% variation (Feychting and Ahlbom, 1994). We found that only about 39% of the variation in calculated historic field was explained by (a function of) distance to closest 200+ kV line. Thus calculated fields are not synonymous with distance, but rather also depend on load, configuration of lines and proximity to lower voltage lines, and although they are substantially correlated, they are not perfectly collinear and theoretically it should be possible to disentangle their effects.

On the other hand, when we controlled for calculated fields in the logistic regression model predicting case-control status based on distance, the odds ratio for distance remained unchanged. Calculated fields might be better predictors of retrospective magnetic fields exposure, while distance might be a better predictor of some other risk factor relevant to the development of childhood leukemia. We discuss two such factors below.

Renting rather than owning one's home is often used as a surrogate for lower SES and apartment buildings might be more common closer to large power lines, leading to confounding. Interestingly, two studies report stronger associations for single family homes than for apartments: in Sweden, the magnetic fields risk for childhood leukemia was limited to single family homes, although calculated magnetic fields were somewhat higher in apartments. In CAPS we observed a slightly higher risk for single family homes in the highest exposure group (Kheifets et al., 2017). Unfortunately, information on dwelling type was available only for a subset of subjects who were site-visited because they lived close to the power lines. We are currently collecting additional data on type of dwelling for a larger subset of subjects.

Some studies have found links between parental pesticide use or proximity to large agricultural crops and childhood leukemia (Vinson et al., 2011). In California, commercial plant nurseries, which could be a source of pesticide exposure, are often located underneath high voltage power lines. We are currently collecting data on distance to plant nurseries and use of pesticide by them to evaluate it as a risk factor for childhood leukemia and as an effect modifier for childhood leukemia.

Residential mobility has been considered a potential confounder in studies of childhood leukemia (Kheifets et al., 2017). We were not able to control for mobility in this study because CAPS has information on residential mobility only for cases. For cases, both birth address and diagnosis address were collected, whereas for controls, which were selected from birth records, only birth address was collected. However, in a case-only analysis, we found that residential mobility was not associated with distance to nearest power line or calculated magnetic fields (Amoon et al., 2018). Thus mobility is unlikely to be an important confounder in CAPS.

While the magnetic fields from a single line typically decrease with inverse distance squared from power lines (Maddock 1992), in our data which incorporates field and distance values from multiple lines, magnetic fields decreased more slowly with distance, on the order of d^{-1}. Our calculated magnetic fields incorporated not just high voltages lines but also the contributions of lower voltages lines. However, when we repeated the modelling after excluding residences with nearby low voltage lines, the relationship was similar (data not shown). A possible alternative explanation could be that subject residences are differentially distributed at larger distances from lines producing larger fields compared to lines producing smaller fields.

Magnetic fields in our data decreased roughly proportional to d^{-1}. When we compared models for childhood leukemia risk that included d, d^{-1} and d^{-2} as predictors, there was a

slight suggestion that the model with d^{-2} was a better fit for the data; however, we did not find that one model was clearly better than the others, and the findings were inconclusive.

5. Conclusions

In summary, our key finding is that, in this study, neither distance nor magnetic field alone predict risk, but only the combination of both, and risk is likewise confined to magnetic fields produced by higher voltage lines, not by lower voltage lines. While potentially informative, we suggest cautious interpretation of this observation as the analysis was exploratory. Furthermore, despite the relatively large size of CAPS, some cell counts were low. Further investigation of potentially important factors, including ground clearance and geometry, might be informative. For instance, ground clearance might impact calculated fields only at close distances with no impact at further distance. Moreover, we recognize the potential from uncontrolled residual confounding from an unknown or combination of unknown factors in our directed acyclic graph (Figure 1).

Given the correlation between magnetic fields and distance and the small numbers of highly exposed in both exposure categories, it is difficult to fully disentangle the influence of these exposures on risk of childhood leukemia, if any. Nevertheless, within the confines of the limitations, our results argue against magnetic fields as a sole explanation for the observed association between distance to high voltage power lines and childhood leukemia, and in favor of some other explanation linked to such lines.

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Highlights

- Magnetic field strength and power line proximity are related but distinguishable
- Childhood leukemia risk was higher only when highly exposed to both
- Factors other than magnetic fields may explain higher leukemia risk near lines

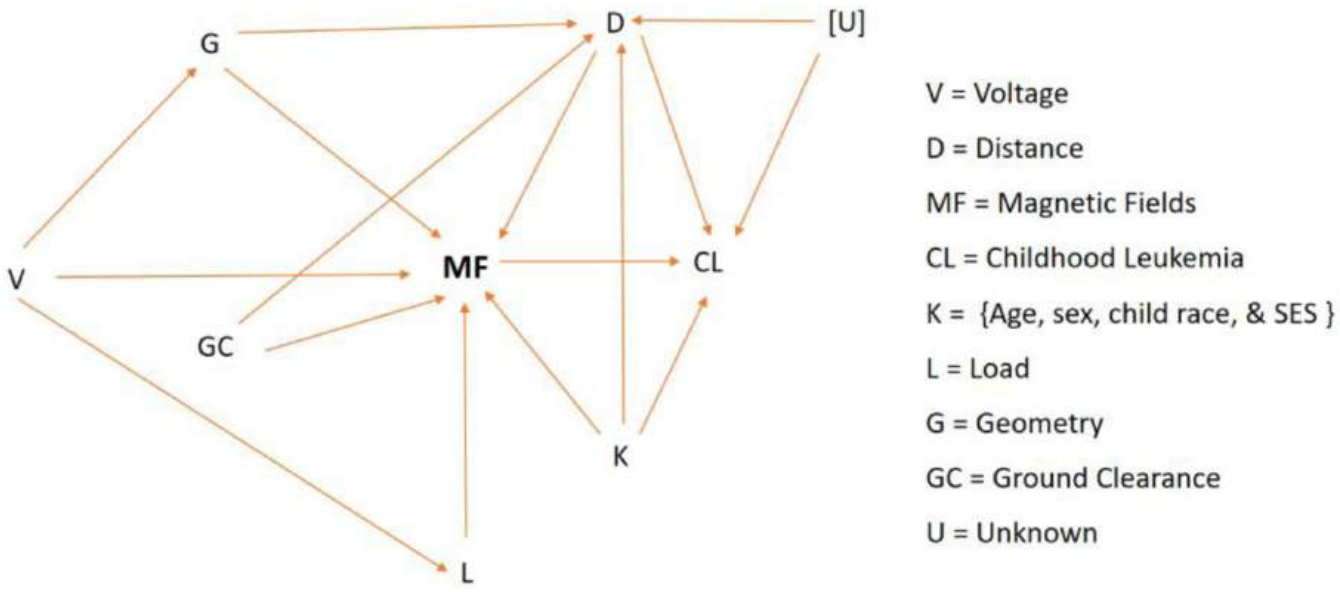

Figure 1.
Directed acyclic graph of magnetic fields and distance.

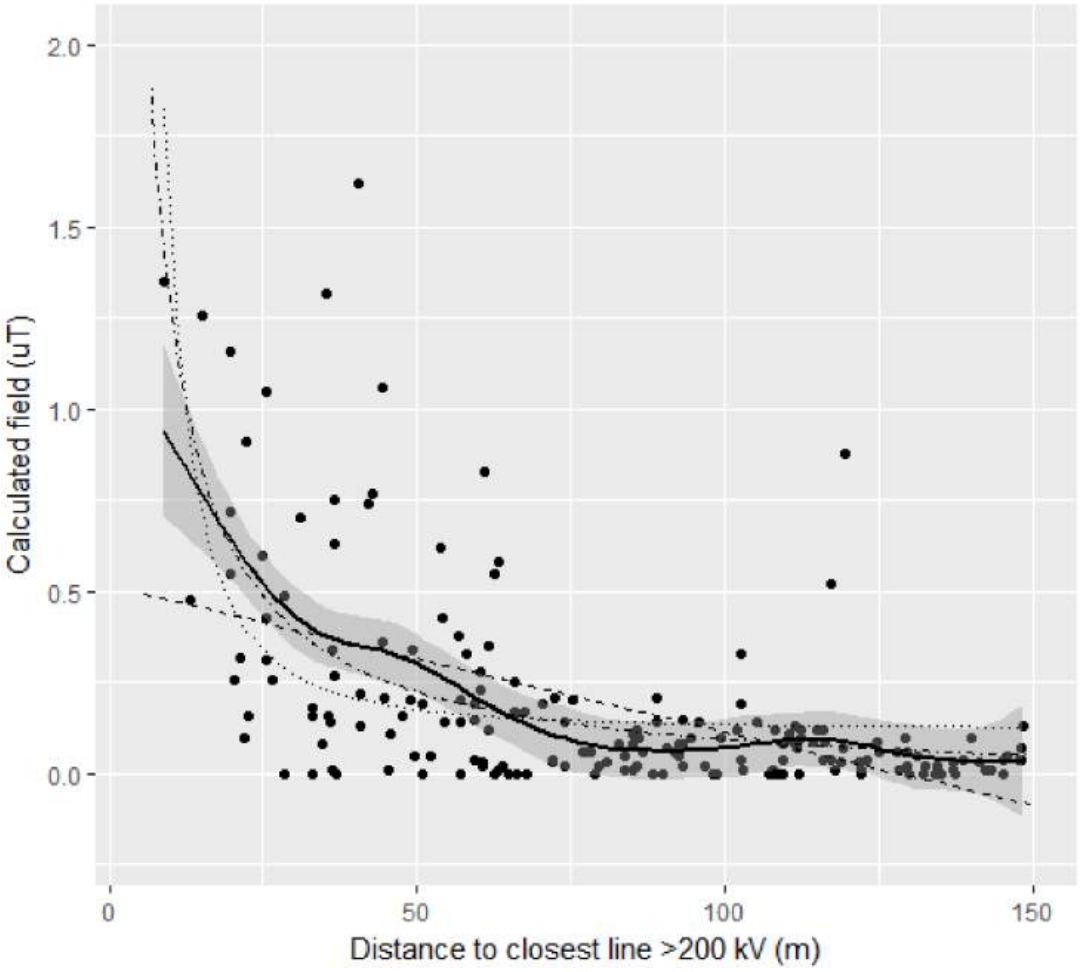

Figure 2.

Scatterplot of calculated field values and distance to closest power line over 200 kV. Solid black line is conditional mean estimated from penalized regression spline model; gray indicates standard error bar for the spline model. dashed, dot-dash and dotted lines are from linear regression models fitted using distance, distance^{-1} and distance^{-2} as predictor, respectively.

Table 1.

Number of observations in categories of calculated field and distance to closest power line over 200 kV. Childhood leukemia cases and controls (n=9714)

	<0.1 μT	**0.1-0.2 μT**	**0.2-0.4 μT**	**≥0.4 μT**	**Total**
0-50 m	4	9	9	16	38
50-100 m	31	14	9	3	57
100-200 m	106	14	2	1	123
200-300 m	130	0	0	0	130
300-400 m	132	0	0	0	132
400-500 m	115	0	0	0	115
500-600 m	122	0	0	0	122
≥600 m	8966	14	9	8	8997
Total	9606	51	29	28	9714

Table 2.

Logistic regression modeling of childhood leukemia risk as function of distance to power lines over 200 kV, calculated fields or both

	Distance only		**Calculated fields only**		**Distance and calculated fields**
Distance, m	OR (95% CI)	Ca/Co	OR (95% CI)	Ca/Co	OR (95% CI)
>600	1.0 (Ref)	4879/4835			1.0 (Ref)
500-600	1.12 (0.78, 1.60)	65/57			1.12 (0.78, 1.60)
400-500	0.86 (0.59, 1.25)	54/61			0.86 (0.59, 1.25)
300-400	1.11 (0.79, 1.57)	71/61			1.11 (0.79, 1.57)
200-300	0.86 (0.61, 1.22)	61/69			0.86 (0.61, 1.22)
100-200	0.75 (0.53, 1.08)	53/70			0.77 (0.53, 1.09)
50-100	0.94 (0.55, 1.58)	28/29			0.98 (0.55, 1.74)
<50	1.47 (0.76, 2.82)	23/15			1.44 (0.63, 3.29)
Calculated fields,μT					
<0.1			1.0 (Ref)	4824/4782	1.0 (Ref)
0.1-0.2			0.84 (0.48, 1.47)	24/27	0.85 (0.46, 1.57)
0.2-0.4			0.97 (0.47, 2.02)	14/15	0.88 (0.39, 2.00)
≥0.4			1.50 (0.70, 3.23)	17/11	1.24 (0.50, 3.05)

Models control for age, sex, child race and SES. Multiple imputation was used for missing values of child race and SES.

Table 3.

Odds ratios for childhood leukemia from logistic regression model with interaction between calculated fields and distance to closest 200+ kV line. Estimates control for age, sex, race and socioeconomic status (SES). Multiple imputation was used for missing values of race and SES.

	Risk factors			
	Line proximity	Calculated fields	OR (95% CI)	Ca/Co
>600 m and <0.1 μT	No	No	1.00 (Ref)	4509/4457
<50 m and <0.4 μT	Yes	No	0.81 (0.35, 1.88)	10/12
>50 m and ≥0.4 μT	No	Yes	0.50 (0.15, 1.67)	4/8
<50 m and ≥0.4 μT	Yes	Yes	4.06 (1.16, 14.3)	13/3

Table 4.

Odds ratios for childhood leukemia associated with calculated fields exposure stratified by voltage of lines near residence. Estimates control for age, sex, race and socioeconomic status (SES). Multiple imputation was used for missing values of race and SES.

A. All observations

Calculated fields category	Closest line <200 kV		Closest line >200 kV	
	OR (95% CI)	Ca/Co	OR (95% CI)	Ca/Co
<0.1 μT	1.00 (Ref)	1563/1598	1.00 (Ref)	3261/3184
≥0.4 μT	0.31 (0.06, 1.54)	2/6	3.02 (1.09, 8.36)	15/5

B. Restricted to site-visited residences.

Calculated fields category	Only lines less than 200 kV nearby		Only lines more than 200 kV nearby	
	OR (95% CI)	Ca/Co	OR (95% CI)	Ca/Co
<0.1 MT	1.00 (Ref)	29/36	1.00 (Ref)	30/38
≥0.4 μT	0.66 (0.10, 4.39)	2/6	4.52 (1.36, 15.1)	14/5

Table 5.

Comparison of logistic regression models predicting childhood leukemia case-control status using different transformations of distance to nearest line >200 kV. Distance out to 600 m.

	Linear distance (d)	Inverse distance (d^{-1})	Inverse squared distance (d^{-2})
P-value, test of coefficient equal to zero	.47	.27	.10
P-value, Homser-Lemeshow goodness of fit test	.65	.45	.59
C-statistic	.528	.521	.532
AIC	1010.04	1009.18	1007.06
BIC	1051.21	1050.36	1048.23