Findings for All Sections (insert in text boxes like figures)

Finding 1-1: Modeling results predict that the conditions on Mars are in general slowly warming, but that the mean martian surface temperatures are not expected to increase by more than 0.2K over the next 500 years.

Finding 2-1: Modern Mars environments may contain molecular fuels and oxidants that are known to support metabolism and cell division of chemolithoautotrophic microbes on Earth.

Finding 2-2: We cannot definitively rule out any terrestrial microbial taxon from being included in the potential "passengers" on a spacecraft to Mars.

Finding 2-3: Notwithstanding extensive spacecraft biodiversity studies, it is necessary for this analysis to use knowledge drawn from all Earth organisms, and not from only a currently identified subset or "passenger list."

Finding 2-4: Organic compounds are present on Mars (or in the martian subsurface); although in very low concentrations in samples studied to date. Such detections are not used to distinguish Special Regions on Mars.

Finding 3-1: Cell division by Earth microbes has not been reported below -18˚C (255K).

Finding 3-2: Cellular metabolic activity has not been demonstrated below -33˚C (240K), although some biophysical processes may be functional at lower temperatures.

Finding 3-3: Chaotropic compounds can lower the temperature limit for cell division below that observed in their absence. There exists the possibility that chaotropic substances could decrease the lower temperature limit for cell division of some microbes to below -18°C (255K), but such a result has not been published.

Finding 3-4: There is no evidence of either cell division or metabolism taking place in Earth organisms below an a_w of 0.60.

Finding 3-5: The amount of O_2 found in the martian atmosphere today has been shown to be sufficient to support the growth of some aerobic microorganisms on Earth—although this fact is not used to distinguish Special Regions on Mars.

Finding 3-6: Most Earth bacteria tested fail to grow below 2,500 Pa. However, a small subset of bacteria have now been identified that can reproduce (on rich hydrated agar media) in a "Mars" atmosphere (anoxic, CO_2) at average Mars pressure (700 Pa) and 0˚C. This fact is not used to distinguish Special Regions on Mars.

Finding 3-7: The Mars UV radiation environment is rapidly lethal to unshielded microbes, but can be attenuated by global dust storms, and shielded completely by < 1 mm of regolith or by other organisms.

Finding 3-8: From MSL RAD measurements, ionizing radiation from GCR at Mars is so low as to be negligible. Intermittent Solar Particle Events (SPE) can increase the atmospheric ionization down to ground level and increase the total dose, but these events are sporadic and last at most a few (2-5) days. These facts are not used to distinguish Special Regions on Mars.

Finding 3-9: The effects on microbial physiology of more than one simultaneous environmental challenge are poorly understood. Communities of organisms may be able to tolerate simultaneous multiple challenges more easily than individual challenges presented separately. What little is known about multiple resistance does not affect our current limits of microbial cell division or metabolism in response to extreme single parameters.

Finding 3-10: Determining the continuity/heterogeneity of microscale conditions over time and space is a major challenge to interpreting when and where Special Regions occur on Mars.

Finding 3-11: Some Earth organisms (lichens) can conduct metabolism (net photosynthesis) by using water vapor as their only source of water (at a relative humidity as low as ~70%, specifically with algal photobionts).

Finding 3-12: We have not found definitive evidence that any terrestrial organism can utilize ambient humidity alone to achieve cell reproduction. In experiments published and examined to date, liquid water is needed at some point in an organism's life cycle to reproduce. Nonetheless, there does not appear to be a fundamental barrier to microbial reproduction under these conditions.

Finding 3-13: Although the existence of thin films on grains in the shallow subsurface are predicted, they are not interpreted to be habitable by Earth microbes under the environmental conditions currently on Mars.

Finding 3-14: Mars average atmospheric pressure allows for liquid water when it exceeds that of the triple point of water, and at lower altitudes (e.g., Hellas and Argyre Basins) that is commonly the case. Higher temperatures and/or insolation may allow melting or condensation over limited areas for short time periods.

Finding 3-15: a) Some environments support microsites where fluid can be trapped and retained preferentially for longer than is predictable on the basis of simple volatile behavior in the bulk environment, and b) some microorganisms have mechanisms that enable them to retain liquid water. Either situation could slightly widen the zone within which habitable temperatures may overlap the time during which available trapped water may be present and usable by organisms.

Finding 4-1: Although no single model currently proposed for the origin of RSL adequately explains all observations, they are currently best interpreted as being due to the seepage of water at >250 K, with a_w unknown, and perhaps variable. As such they meet the criteria for Uncertain Regions, to be treated as Special Regions. There are other features on Mars with characteristics similar to RSL, but their relationship to possible liquid water is much less likely.

Finding 4-2: Some martian gullies (Gully Type/Taxon 1) have been observed to be currently active, but at a temperature far too low to be compatible with the involvement of liquid water—a CO_2-related mechanism is implied in their formation.

Finding 4-3: Some martian gullies appear to have formed by th emelting of past water ice (Gully Type/Taxon 2). In cases where ice no longer remains, there is negligible potential for the presence of liquid water during the next 500 years. However, in circumstances where residual ice still remains, there is some potential for liquid water to be present there during the next 500 years.

Finding 4-4: It is possible for young, large craters to retain enough impact-generated heat so that impact-caused hydrothermal activity would persist to the present. Although crater formation ages are highly uncertain, we have not identified any existing craters that have the combination of size and youthfulness necessary for this to be found today.

Finding 4-5: Outflow channel events seen in the martian geologic record, but are incompletely understood. They may have resulted from the breeching of an existing reservoir of groundwater or may have been created by the melting of ground ice due to a rapid and localized heating of the crust. Based on the observed geologic record, they are rare and unpredictable, and unlikely to happen within the next 500 years.

Finding 4-6: Within the bounds of several limitations of the MARSIS and SHARAD radar surveys (including attenuation, location-specific surface clutter, relatively low spatial resolution, saturated porosity, and areal coverage), groundwater has not been detected anywhere on Mars within ~200-300 m of the surface. This does not preclude the existence of groundwater at greater depths, which should be considered as an Uncertain Region (and a potential Special Region) until further geophysical investigation proves otherwise.

Finding 4-7: We cannot rule out the possibility of near-surface water that may be present at a vertical and/or horizontal scale finer than that detectable by MARSIS and SHARAD.

Finding 4-8: The 2006 Special Regions analysis did not consider dark/light slope streaks to be definitive evidence for water. Recent results have strengthened that conclusion for non-RSL slope streaks.

Finding 4-9: Polar dark dune streaks are considered extremely unlikely to involve liquid water warmer than 253K (-20°C), and most likely do not involve liquid water at all, given the low surface temperatures present when they are active.

Finding 4-10: Over a decade of thermal IR mapping by the THEMIS instrument has not resulted in the detection of any local hot spots or warm zones that may represent a geothermal zone, at 100 m spatial resolution.

Finding 4-11: On Earth, special geomorphic regions such as caves can provide radically different environments from the immediately overlying surface environments providing enhanced levels of environmental protection for potential contaminating organisms. The extent of such geomorphic regions on Mars and their enhancement (if any) of habitability are currently unknown.

Finding 4-12: Environmental conditions at the Phoenix site, both at the surface (measured) and in the regolith (modeled) are incompatible with cell division. Note, however, that both sufficient water activity (as a vapor) and warmer temperatures may be present in the summer within the same 24-hour cycle, but never simultaneously.

Finding 4-13: Variations in inferred brine chemistry cannot at present be used in Special Regions analysis—there is not currently the means to predict or map different brine compositions on Mars.

Finding 4-14: Natural deliquescence of calcium perchlorate, the mineral with the lowest eutectic temperature relevant to Mars, is predicted for short periods of time each day at each of the three landing sites for Viking 1, Phoenix, and MSL (where we have measurements) and presumably at many other places on Mars.

Finding 4-15: The environmental conditions associated with deliquescence at the MSL, Phoenix, and Viking 1 landing sites are all significantly outside the boundaries of the conditions required for reproduction of terrestrial organisms.

Finding 4-16: Snow may be deposited in polar or equatorial regions and elsewhere, although its volume is thought to be negligible. It is expected to fall during the coldest part of the night and may disappear (by sublimation or melting/evaporation/boiling) soon after the day begins on Mars. It is unknown whether this process could create a Special Region on Mars.

Finding 5-1: Thermal perturbation of the local environment by a spacecraft could induce localized Special Regions.

Finding 5-2: Tropical mountain glacial deposits may contain residual ice. However, these deposits are interpreted to be covered with an ice-free sublimation lag that is > ~5 m in thickness.

Finding 5-3: Depths to buried ice deposits in the tropics and mid-latitudes are considered to be >5m.

Finding 5-4: The mid-latitude mantle is thought to be desiccated, with low potential for the possibility of modern transient liquid water.

Finding 5-5: Fresh ice exposed by impacts indicates the widespread presence of shallow ground ice at mid- and high latitudes—in many cases nearly pure ice, but displaying geographic heterogeneity.

Finding 5-6: The presence of polygonal ground at a candidate landing site may indicate a spacecraft-inducible Special Region by virtue of shallow ground ice, particularly when taken together with other observations indicating ice.

Finding 5-7: We do not have accepted models or tested hypotheses to explain the phenomenon of "excess" ice on Mars. It is not known whether this ice was produced in the past by a process involving liquid water, or whether it is an ongoing process. The age of that ice and its implications for the next 500 years are unknown.

Finding 5-8: SHARAD has detected subsurface ice at scattered locations in the mid-latitudes.

Finding 5-9: Mineral deliquescence on Mars may be triggered by the presence of a nearby spacecraft, or by the actions of a spacecraft.