Impact on the Scientific Goals of the GLIMPSE Legacy Science Program due to the Decreased Sensitivities of IRAC Bands 3 and 4

The goals of the GLIMPSE Legacy Science program are to: provide a legacy data set by cataloging all stars detected with a reliability ≥99.5%; provide point source-calibrated mosaiced images in all four IRAC bands of the inner Galaxy; use star formation regions (SFRs) as probes of large scale Galactic structure; and, determine the stellar census and physics of SFRs. Decreases of 59% and 13%, respectively in IRAC bands 3 and 4, are unlikely to affect the number of sources expected in the GLIMPSE Point Source Catalog based on our present simulations because revised 5σ detection limits are still well below the detection limits set by the 99.5% reliability requirement. In band 3, the revised 5σ detection limit (for high back ground) will be ~1.1 mJy which is <1/2 the limit set by the requirement for a reliability ≥99.5% (~2.5 mJy). In band 4 the revised 5σ detection limit for high background will be ~0.73 mJy which is <1/5 the limit set by the 99.5% reliability requirement (~4 mJy). These estimates are based on simulations that assumed the old sensitivity limits. To determine the change in reliability based on the new sensitivity limits would require redoing the simulations, which we do not have time or personnel to do at this time, but our guess is that the revised 5σ detection limit will still likely to be below the limit set by the 99.5% reliability requirement.

In principle, the higher detection limits will increase the minimum stellar mass to which we will be sensitive for the determination of luminosity functions (LFs) and initial mass functions (IMFs) of SFRs. However, for at least 95% of all massive clusters, we will be strongly resolution limited and the change in sensitivities of bands 3 and 4 are unlikely to change the minimum mass we will be able to detect in such clusters. Based on the very strong increase in diffuse emission seen in MSX 8μm images in the neighborhood of clusters containing massive stars, it appears that our minimum detection limits will likely be determined by the background brightness produced by the combined effects of PAH, stochastic heating of small grains, and thermal dust emission. This in conjunction with the decreased sensitivities, especially of band 3, will result in fewer detected sources mostly in band 3. The increased background at 8μm is illustrated in the attached figures of RCW49 (G284.3-0.3, our OSV region) at the end of this document. We cannot quantitatively determine exactly how many sources will be missed in bands 3 and 4 due to the increased background brightness near massive stars combined with the decreased sensitivities in bands 3 and 4. It will certainly decrease the number of detected sources in band 3 near hot stars which would decrease the number of stars in the GLIMPSE Point Source Archive. It will also increase the minimum detectable stellar mass in massive star formation regions and thereby affect the minimum mass in our LFs and IMFs for massive SFRs. However, additional passes will not change the number of sources detected when the observed regions are confusion limited or background limited, so changing our observing strategy to use 3 or more passes will not significantly increase the number of detected sources in those regions (i.e. in crowded regions and near hot stars. The breadth of the science goals of the GLIMPSE survey is mostly driven by its large areal coverage. Determination of the large scale structural features of the Galaxy (number and location of the spiral arms in the inner Galaxy, star formation in the molecular ring and the nuclear bar, the stellar scale length, etc.) will be affected very little

by these limitations. Analysis of PAH features and determination of the MIR reddening law are unlikely to be significantly affected. The science goals of the GLIMPSE survey are very broad and mostly depend on large areal coverage for many categories of stars. A reduction in the number and increase in the minimum mass of stars detected in bands 3 and 4 would limit a small fraction of the science goals of the GLIMPSE survey.

The decreased sensitivities of IRAC bands 3 and 4 will result in a decreased number of sources in the GLIMPSE Point Source Archive (~5σ or best effort). However, our simulations and IOC/SV test data both indicate that most point sources will be detected in IRAC bands 1 and 2. About a factor of 4 times as many sources are expected to be detected in band 1 than in band 4. Our simulations and the IOC/SV data indicate that the large majority of sources that will populate the GLIMPSE Point Source Archive will be detected in bands 1 and 2. Nonetheless, a significant number of sources are expected to be detected in bands 3 and/or 4 and some of these will be missed due to decreased sensitivities even in regions without enhanced background emission from dust. Based on our simulated data (again, not corrected for the changed sensitivities), we estimate that the decreased sensitivities of band 3 and 4 will result in a decrease in the number of sources detected at the 5σ level of ~23% in band 3 and 6.6% in band 4. On the positive side, there will be some sources that would have saturated with the old sensitivities that will have well measured fluxes with the lower sensitivities.

In summary, the GLIMPSE Point Source Catalog is unlikely to be significantly affected by the decreased sensitivities of IRAC bands 3 and 4. The minimum mass to which LFs and IMFs can be determined in massive clusters will be increased, although it is difficult to give quantitative estimates of how much because the increased background emission near massive stars is not predictable. At any rate, regions that are either background limited or confusion limited, are unlikely to significantly improve the number of detections by observing them more times. Also, the decreased sensitivities in bands 3 and 4 will result in a small decrease (~3-4%) in the total number of sources that appear in the GLIMPSE Point Source Archive independent of the issue of increased background emission near massive stars. Due to the broad nature of the science goals of the GLIMPSE survey, most of which depend on large areal coverage, only a small fraction the GLIMPSE science goals are expected to be impacted by the decreased sensitivities of bands 3 and 4. The OSV observations will be able to address some of the issues discussed here, but at this juncture it would be a very bad trade-off to sacrifice areal coverage (by taking more passes) for marginal gains in the number of sources detected and somewhat improved sampling of the PSF.

Left Panel: A 3-color 2MASS image of the RCW49 massive star formation region. Note the extent and intensity of the diffuse dust emission. The extent and morphology of the NIR diffuse emission closely corresponds to radio continuum emission probably indicating that it is primarily due to B and possibly HeI 2.06μm line emission.

Right Panel: A 3-color image composed of the 2MASS H and K bands and the MSX 8 μm band. Note the increase in diffuse emission from the 8μm band and the greater extent of the diffuse emission than seen at NIR bands. The 8μm band contains two PAH features, 7.7 and 8.6μm.