$$\frac{\partial l}{\partial \beta} = \sum_{i=1}^{m} \frac{\partial l}{\partial y_i} \quad ; \quad \frac{\partial l}{\partial \gamma} = \sum_{i=1}^{m} \frac{\partial l}{\partial y_i} \hat{x}_i$$

$$\frac{\partial l}{\partial x_i} = \frac{\partial l}{\partial y_i} \times \gamma \times \left\{ \frac{\partial \hat{x}_i}{\partial x_i} \right\}$$

$$\frac{\partial \hat{x}_i}{\partial x_i} = \frac{\partial}{\partial x_i}\left(\frac{x_i - \mu_B}{\sqrt{\sigma_B^2 + \epsilon}} \right) = \frac{\sqrt{\sigma_B^2+\epsilon}\left(1 - \frac{1}{m}\right) - \left\{ (x_i - \mu_B) \times \frac{1}{2\sqrt{\sigma_B^2+\epsilon}} \times \frac{\partial \sigma_B^2}{\partial x_i} \right\}}{\sigma_B^2 + \epsilon}$$

$$= \frac{\left(1 - \frac{1}{m}\right)}{\sqrt{\sigma_B^2+\epsilon}} - \left\{ \frac{x_i - \mu_B}{2(\sigma_B^2+\epsilon)^{3/2}} \times \frac{\partial \sigma_B^2}{\partial x_i} \right\}$$

$$\frac{\partial \sigma_B^2}{\partial x_i} = \frac{1}{m} \sum_{i=1}^{m} \left(1 - \frac{1}{m}\right) 2 (x_i - \mu_B)$$

$$= \frac{1}{m} 2 \sum_{i=1}^{m} (x_i - \mu_B) - \frac{1}{m} \times 2 \times \left(\sum_{i=1}^{m} \frac{x_i}{m} - \sum_{i=1}^{m} \frac{\mu_B}{m} \right)$$

$$= \frac{2}{m} \sum_{i=1}^{m} (x_i - \mu_B) - \frac{2}{m} \left(\mu_B - \frac{\cancel{m}\mu_B}{\cancel{m}} \right)$$

$$= \frac{2}{m} \sum_{i=1}^{m} (x_i - \mu_B)$$

$$\frac{\partial \hat{x}_i}{\partial x_i} = \frac{1}{\sqrt{\sigma_B^2+\epsilon}} - \frac{1}{m\sqrt{\sigma_B^2+\epsilon}} - \frac{(x_i - \mu_B)}{\cancel{2}(\sigma_B^2+\epsilon)^{3/2}} \times \frac{\cancel{2}}{m} \sum_{i=1}^{m} (x_i - \mu_B)$$

$$\frac{\partial l}{\partial x_i} = \gamma \times \left\{ \frac{\frac{\partial l}{\partial y_i}}{\sqrt{\sigma_B^2+\epsilon}} - \frac{\frac{\partial l}{\partial y_i}}{m\sqrt{\sigma_B^2+\epsilon}} - \frac{\sum_{i=1}^{m} \frac{\partial l}{\partial y_i} (x_i - \mu_B) \times (x_i - \mu_B)}{m \times (\sigma_B^2+\epsilon)^{3/2}} \right\}$$