Our potential is

$$V \;=\; \frac{N}{4\pi}\left\{ -\,iD\,\ln\left|\sqrt{2}\sigma\right|^2 \;+\; \sum_{k\geq 1}\frac{(-1)^k}{k\,(k+1)}\,iD\left(\frac{iD}{\left|\sqrt{2}\sigma\right|^2}\right)^k\right\}. \tag{0.1}$$

The first term comes from Witten's superpotential. The first term of the series (with $k = 1$) is taken into account by the kinetic term. Thus we can write our effective action as

$$\begin{aligned} S \;=\; & -\frac{N}{4\pi}\int d^4x\left\{\int d^4\theta\frac{1}{2}\left|\ln\sqrt{2}\Sigma\right|^2 \;+\right. \\ & +\; i\int d^2\theta\left[\sqrt{2}\Sigma\,\ln\sqrt{2}\Sigma \;-\; \sqrt{2}\Sigma \;+\right. \\ & \left.\left. +\;\frac{1}{2}\sqrt{2}\Sigma\sum_{k\geq 2}\frac{(-1)^k}{(k-1)\,k\,(k+1)}\left(\frac{S}{\sqrt{2}\Sigma}\right)^k \;+\;\text{h.c.}\right]\right\}, \end{aligned} \tag{0.2}$$

where

$$S \;=\; \frac{i}{2}\,\overline{D}_R D_L\ln\sqrt{2}\overline{\Sigma}\,, \qquad \overline{S} \;=\; \frac{i}{2}\,\overline{D}_L D_R\ln\sqrt{2}\Sigma\,. \tag{0.3}$$

The series in the third line can be written as a D-term. We get

$$\begin{aligned} S \;=\; & -\frac{N}{4\pi}\int d^4x\left\{\int d^4\theta\,\frac{1}{2}\left|\ln\sqrt{2}\Sigma\right|^2 \;+\right. \\ & +\; i\int d^2\theta\left(\sqrt{2}\Sigma\,\ln\sqrt{2}\Sigma \;-\; \sqrt{2}\Sigma\right) \;+ \\ & \left. +\;\frac{1}{2}\int d^4\theta\,\ln\sqrt{2}\overline{\Sigma}\sum_{k\geq 1}\frac{(-1)^{k+1}}{k\,(k+1)\,(k+2)}\left(\frac{S}{\sqrt{2}\Sigma}\right)^k\right\} \;+\;\text{h.c.} \end{aligned} \tag{0.4}$$

Here we can see explicitly that the only F-term is the Witten's superpotential, while all other terms are D-terms.

The last term can be re-written as

$$\begin{aligned} S \;=\; & -\frac{N}{4\pi}\int d^4x\left\{\int d^4\theta\frac{1}{2}\left|\ln\sqrt{2}\Sigma\right|^2 \;+\; i\int d^2\theta\left(\sqrt{2}\Sigma\,\ln\sqrt{2}\Sigma \;-\; \sqrt{2}\Sigma\right) \;+\right. \\ & \left. +\;\frac{1}{4}\int d^4\theta\,\ln\sqrt{2}\overline{\Sigma}\left[\left(1+\frac{\sqrt{2}\Sigma}{S}\right)^2\ln\left(1+\frac{S}{\sqrt{2}\Sigma}\right) \;-\; \frac{\sqrt{2}\Sigma}{S}\right] \;+\;\text{h.c.}\right\}. \end{aligned} \tag{0.5}$$

The kinetic (first) term can be combined with the last D-term, to write

$$
\begin{aligned}
S \;=\; & -\frac{N}{4\pi}\int d^4x \left\{ i\int d^2\theta\, \left(\sqrt{2}\Sigma\, \ln\sqrt{2}\Sigma \;-\; \sqrt{2}\Sigma\right) \;+\right. \\
& + \;\frac{1}{4}\int d^4\theta\, \ln\sqrt{2}\overline{\Sigma} \left[\ln\left(S + \sqrt{2}\Sigma\right) \;+\right. \\
& \left.\left. +\; \frac{\sqrt{2}\Sigma}{S}\left[\left(2 + \frac{\sqrt{2}\Sigma}{S}\right)\ln\left(1 + \frac{S}{\sqrt{2}\Sigma}\right) - 1\right]\right]\right\} \;+\; \text{h.c.}
\end{aligned}
\tag{0.6}
$$